# Agile Capabilities for Maximising Sustainable Supply Chain Performance: Empirical Evidence from Oil and Gas Industry

**by**

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# Abstract

Energy companies are facing rapid and unpredictable changes in their business environment. The growing competition, shifting energy demand, changing climate, technological advancements, an impending energy transition, and other social factors presented the biggest challenges for the industry. Agility capabilities and sustainability strategies have been identified as key foundations for sustained competitive advantage in new business environments. It has been established that agility could induces better operational performance, while sustainable practices could help enhance indicators of social and environmental sustainability, the interactive effects of both have not been examined. There is no empirical work investigating the role of sustainable supply chain practices in conjunction with agile supply chain capabilities.

To address this research gaps, the thesis is grounded in a capability theory combined with the dynamic capability theory and contingency perspective. The purpose was to investigate if sustainable supply chain practices have performance effects that is mediated by agile supply chain capabilities (as would be the case if the central function of the former is to develop the latter). Secondly, examine how agile supply chain capabilities and sustainable supply chain strategies jointly influence organisational performance. Thirdly, explore the efficacy of sustainable practices under different contingency variables (such as, managerial experience, business age, size, industry sector, and dynamism). Finally, explore the taxonomy of agility strategies that have the greatest impact on specific competitive priorities include social and environmental sustainability priorities. For such purposes, a conceptual model was established with proposed hypotheses deriving from existing literature.

A survey of high carbon and energy-intensive supply chains in the UK was carried out with a net of 311 respondent companies. The study uses structural equation modelling (SEM) to test proposed hypotheses. The taxonomy of agility strategies was developed with methods of cluster analysis and is based on the relative importance attached to eleven competitive priorities including social and environmental sustainability priorities. The underlying dimensions of agile capabilities along with the three strategy groups differ were investigated based on factor analysis and canonical discriminant analysis.

The results show that sustainable supply chain practices have a significant positive effect on agile supply chain capabilities and all two dimensions of performance outcomes. Also, the results indicate that agile supply chain capabilities do have a significant positive influence on both sustainability performance and operational performance. Whilst the correlation between agile capabilities and operational performance is not new, what is new here is the connection between agile supply chain capabilities and sustainability performance. In addition, the findings show that the performance effects of sustainable supply chain practices are fully mediated by agility capabilities. Also, the results reveal a positive interaction between sustainable supply chain practices and agile supply chain capabilities, suggesting that they function as complements in affecting performance outcomes. Importantly, the results show that high carbon intensive sectors positively moderate the relationship between sustainable supply chain practices and performance outcomes, while the other managerial experience do not. In other words, the research shows that agile capabilities are important enablers/facilitators for maximising the outcome of implementing sustainable practices. As such, manager who want to maximise the outcomes of sustainability campaign should consider joint implementation of sustainable strategies and agile capabilities. Further, experts should consider market turbulence as a competitive factor in line with the complementarity effect of sustainable strategies and agile capabilities. This consideration would contribute to explain better sustainable performance.

Three distinct cluster of agility strategy groups were observed across the industry surveyed: high agile companies, moderate agile companies, and less agile companies. High agile companies are characterised by high priorities on flexibility, speed, quality, innovation, social and environmental sustainability, high values attached to all performance and high importance given to flexibility and speed. Moderate agile companies are oriented towards reliability and flexibility. They do not emphasise social and environmental sustainability, and they attached low important to innovation. While less agile companies placed poor values on all performance objectives, they had the lowest percentage of the mean difference scores. At best, nonagile companies focused on benefits such as cost efficiency, quality, and delivery reliability improvements with less emphasise on flexibility and speed. They give the poorest importance to innovation and sustainability. The lack of agile capabilities could be behind the non-agile companies' lowest focus on future performance, sustainability, and innovation. This research shows to companies that competitive priorities are replaced with sustainability priorities. While social and environmental priorities contribute to competitive performance when complementing supply chain agility strategies.

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# List of abbreviations

| | |
|---|---|
| AI | Artificial Intelligence |
| AMOS | Analysis of Moment Structures |
| AVE | Average Variance Extracted |
| BEIS | Business, Energy, and Industrial Strategy |
| BOP | Blow Out Preventers |
| CBM | Common Method Bias |
| CCUS | Carbon Capture, Use and Storage |
| CFA | Confirmatory factor analysis |
| CFI | Comparative fit index |
| $CO_2$ | Carbon Dioxide |
| CR | Composite Reliability |
| EDI | Electronic Data Interchange |
| EE | Employee Empowerment |
| EFA | Exploratory Factor Analysis |
| EMP | Environmental Management Practices |
| EP | Environmental Performance |
| FAME | Financial Analysis Made Easy |
| FP | Financial Performance |
| GDP | Gross Domestic Products |
| GE | General Electric company |
| GFI | Goodness of Fit Index |
| GSCM | Green Supply Chain Management |
| IEA | International Energy Agency |
| IETF | Industrial Energy Transformation Fund |
| IFI | Incremental Fit Index |
| IR | Investment Recovery |
| ISO | International Organisation for Standardisation |
| KMO | Kaiser-Meyer-Olkin |
| LCA | Life Cycle Analysis |
| LPOs | Large Purchasing Organisations |
| MANOVA | Multivariate Analysis of Variance |
| MS | Market Sensitivity |
| NAICS | North American Industrial Classification System |
| NC | Network Collaboration |
| NFI | Normed Fit Index |
| NGOs | Non-Governmental Organisations |
| NNFI | Non-Normed Fit Index |
| NRBV | Natural Resource-Based View |
| OGUK | Oil and Gas UK |
| OPO | Operational Performance Objectives |
| PA | Process Alignment |
| RFID | Radio Frequency Identification |
| RMSEA | Root Means Square Error of Approximation |
| RO | Research Objectives |
| RQ | Research questions |
| SCM | Supply Chain Management |
| SD | Sustainable Design |
| SEM | Structural Equation Modelling |
| SIC | Standard Industrial Classification |
| SMEs | Small and Medium-Sized Enterprises |
| SMMT | Society of Motor Manufacturers and Traders |
| SP | Social Performance |

| | |
|---|---|
| SPr | Sustainable Procurement |
| SPSS | Statistical Packages for Social Science |
| SRB | Socially Responsible Buying |
| SSCM | Sustainable Supply Chain Management |
| SSP | Social Sustainability Practices |
| ST | Sustainable Transport |
| TBL | Triple Bottom Line |
| TCO | Total Cost Ownership |
| TDM | Total Design Method |
| TI | Technology integration |
| TLI | Tucker-Lewis Index |
| UK | United Kingdom |
| UKCS | The UK Continental Shelf |
| UKSIC | UK Standard Industrial Classification |

# Dedications

I dedicate this work to my parents for all their help, support, and encouragement in this PhD journey. Most importantly, in memory of my mother, who sadly passed away in December 2017. Finally, I would like to thank my children for all their support and forbearance in allowing me to pursue this research.

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# List of Academic publications and conference proceeding

## Journal articles

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Gunasekaran, A., Yusuf, Y.Y., Adeleye, E.O., Papadopoulos, T., Kovvuri, D. and Geyi, D.G. (2019) 'Agile manufacturing: an evolutionary review of practices', *International Journal of Production Research, 57*(15-16), pp.5154-5174.

Tanimu, D., Yusuf, Y. and Geyi, D.G. (2021) 'A Study of the Relationships Between Quality of Management, Sustainable Supply Chain Management Practices and Performance Outcomes', In *IFIP International Conference on Advances in Production Management Systems* (pp. 618-625). Springer, Cham.

## Conference contributions

Geyi, D. G., Yusuf, Y. and Dandutse, T. (2020) The effect of agility in promoting the performance outcomes of sustainable supply chain initiatives, the 1st Conference on Production Systems and Logistics (CPSL), 17-20 March, Stellenbosch, South Africa.

Yusuf, Y. and Geyi, D. G. (2019) Agile capabilities as necessary conditions for maximising sustainable supply chain performance: empirical evidence from oil and gas industry, the 1st Proceeding of the International Conference on Industrial Engineering and Operations Management Riyadh, 26-28 November, Saudi Arabia.

Geyi, D. G., Yusuf, Y. and Hanley, D. (2019) The mediating roles of agility on the impacts of sustainable practices on performance outcomes of oil and gas supply chains, the 3rd European international conference on industrial engineering and operations management, 23 -26 July, Pilsen, Czech Republic.

Geyi, D. G., Gunasekaran, A., Yusuf, Y. and Hanley, D. (2019) The roles of different agile enablers in increasing the outcomes of sustainability practices, the 5th PROLOG international conference on project logistics, 19-21st June, Metz, France.

Geyi, D. G. and Yusuf, Y. (2019) The influences of sustainable supply chain practices on sustainability performance of the oil and gas supply chains: the mediating role of agility, the 5th PROLOG international conference on project logistics, 19-21st June, Metz, France.

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Geyi, D. G. (2018) The impact of agility and sustainability practices on organisational performance in the oil and gas supply chain, Proceeding of the International Conference on Green Supply Chain (GSC), 2-4 July, Thessaloniki, Greece.

# CHAPTER 1: Introduction

## 1.1 Introduction

This chapter introduces the research project, which is concerned with exploring the impact of sustainable practices and agility capabilities on performance (such as, operational performance and sustainability performance) of the oil and gas supply chains. The chapter includes the research background, motivation, aim and objectives, research questions, and the thesis structure.

## 1.2 Background of the study

Businesses worldwide are facing rapid and unpredictable changes in their environments. The growing competition, shifting customer requirements, technological advancement, and shorting product lifecycles are reshaping the industry (Sauer and Seuring, 2018; Vazquez-Bustelo et al., 2007; Carvalho et al., 2018; Lin et al., 2006; Braziotis et al., 2013; Sharifi et al., 2001; Martinez-Sanchez and Lahoz-Lee, 2018; Lysons Farrington, 2020; Christopher and Holweg, 2011). Businesses have had to adapt to deal with continuous changes in their operating environments to remain competitive (Kumar and Sosnoki, 2011; Sharifi et al., 2013; Teece, 2017, 2019; Aslam et al., 2020).

Uncertainty and turbulence of the business environments have been acknowledged as the cause of failures in the global supply chains (Hines, 2014). In addition, the growing concerns about the impact of climate change and an impending energy transition has led to a focus on unsustainable patterns of behaviour in supply chains and present the biggest challenges for the industry (Schaltegger et al., 2018). There is a recognition that the climate is changing, and further change is inevitable without reducing greenhouse gas emissions such as, carbon dioxide, methane and nitrous oxide, and various fluorocarbons (Pierre et al., 2019). Broadly speaking, these emissions as they relate to supply chains' activities are often referred to as their 'carbon footprint' (Yusuf et al., 2013; Hannibal and Kauppi, 2019). As such, the industry needs to act quickly, as survival will require transformation, no incremental change.

There is a clear consensus that supply chains' carbon footprint should be reduced (Jabbour et al., 2019) and that enterprises' operations decisions have extensive impacts on the environments and resources. It is essential therefore to consider the impacts of industrial operations on the use of scarce resources and the level of waste generation across supply networks (Adham et al., 2015). Other factors such as the growing global population cause increase in demand for scarce resources like energy, water, raw materials, and land. As a result, these resources are subject to greater competition, thereby leading to resource conflict (Hofmann et al., 2018). Companies will, therefore, be pushing to use less materials, energy, water, and other inputs; make better use of alternative materials; and embrace reuse, recycling, recovery, remanufacturing of end-of-life products and producing robust products for sustainable consumption (Geissdoerfer et al., 2018; Tonelli et al., 2013). A major current challenge, thus, is about increasing sustainability of industrial production.

Given the growing magnitude of environmental constraints and ethical problems, several seminal works have raised the question about how to integrate social and environmental sustainability strategies with agile supply chain capabilities to develop unique capabilities to improve overall sustainable supply chain competitiveness (Ciccullo et al., 2018; Chen et al., 2017; Beske, 2012; Hart, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998), which this thesis wants to test it.

Numerous researchers such as Teece (2019); Hoopes and Madsen (2008); Beske (2012); Aslam et al. (2020); Schilke (2014) have suggested that surviving and prospering in high velocity and turbulence market conditions will be possible if organisations have change capabilities or dynamic capabilities to maintain competitive advantage in the new order of world business. Indeed, scholars showed that sustainable strategies in the form of sustainable design, waste prevention initiatives, and socially responsive behaviours only led to sustainability performance and competitive improvements when they are associated with the development of certain strategic capabilities (Hong et al., 2018; Beske et al., 2014; Hart, 1995; Russo and Fouts, 1997; Sharma and Vredenburg, 1998).

The capability angle combined with dynamic capabilities theory provides the theoretical underpinnings to explain the performance effects of sustainable supply chain practices and supply chain agility (Teece, 2014, 2019; Aslam et al., 2020; Hoopes and Madsen, 2008; Aragon-Correa and Sharma, 2003; Beske, 2012). The capability theory examines how certain capabilities lay a foundation for competitive advantage and superior performance (Stalk et al., 2012). The basic approach of a capability perspective is viewing the firm as bundles of skills and technologies that enables a company to provide a particular benefit to customers (Hines, 2014; Teece, 2019). The capturing of value is a function of the strength of competition, the nature of knowledge, and new business model (Teece, 2014). In this way, the capabilities view endeavour to help explain interfirm heterogeneity, enterprise evolution, and organisational longevity (Teece, 2019).

Amit and Schoemaker (1993) defined capabilities as capacities to deploy resources, usually in combination, using organisational processes, to effect a desired end. Makadok (2001) described capabilities as a special type of resources whose purpose is to improve the productivity of the other resources possessed by the organisation. In line with Winter (2003), organisational capabilities reflect high-level routines or collection of routines, skills, abilities, and expertise that, together with implementing input flows, confers upon an organisation's management a set of decision options for producing significant outputs of a particular type. The resource-based theory emphasises that each firm is characterised by its own collection of core resources competences (Barney et al., 2001). Supply chain management is thus a tool to complement these competencies. In contrast, capability theory reflects the assumption that unique capabilities exist at the supply chain level, and that supply chains can be inimitable competitive weapons (Ketchen and Hult, 2007).

Supply chain companies derive competitive advantage not only from the acquisition and/or generation of unique tangible or intangible assets, but from the ability to integrate and deploy these assets as capabilities in socially complex, and inimitable manner (Amit and Schoemaker, 1993; Barney, 1991). Capabilities are generated internally, externally, and via a mix of internal and external assets and influences (Teece et al., 1997). Some capabilities are rooted in routines and processes that are focused on external environment to help firms maintain a strategic fit with the market. Other capabilities consist more of routines and processes to generate and diffuse knowledge and learning within the organisation to increase efficiencies, improve products, and reduce costs. Yet other capabilities are arising from exploitation of complementary assets, which help companies to capitalise on profits, associated with strategy, technology, or innovation (Christmann, 2000; Sharifi et al., 2019). Organisations required these complementary capabilities when developing new product or entering new market as a set of supporting assets to help deliver products (Helfat and Lieberman, 2002).

Ulrich and Smallwood (2004) identified talent, speed of responsiveness, shared mindset and coherent brand identity, accountability, collaboration, leadership, customer connectivity, knowledge and learning, strategic alliances, innovation, and efficiency as capabilities that best value supply chains need to have. In the view of Ulrich and Smallwood (2004), when companies fall below the norm in any of those capabilities, dysfunction and competitive disadvantage will likely ensue. Teece (2014, 2019) categorised those capabilities into ordinary capabilities and dynamic capabilities. This classification of capabilities is the same with inside-out and outside-in capabilities (Moorman and Slotegraaf, 1999) internal and external integrative capabilities (Verona, 1999), ordinary (operational) and dynamic capabilities (Winter, 2003; Teece, 2007; Helfat and Peteraf, 2003) discussed in the literature.

Ordinary or operational capabilities are those that permit an organisation to 'make a living' in the short term, whereas dynamic capabilities are those that seek to explain long-term success and survival by detailing how organisations could create, extend, integrate, or modify ordinary capabilities, and managing competitive threats as well as effecting necessary transformations (Teece, 2010; Winter, 2003). Ordinary capabilities enable the production and sale of the same product, on the same scale and to the same customer population over time (Winter, 2003). It encompasses operations, administration, and governance of the firm's activities. Ordinary capabilities are routed in some combination of skilled personnel, facilities or equipment, processes or routines, and the administrative coordination needed to finish defined tasks with some degree of proficiency (Teece, 2019).

The achievement of best operational capabilities is insufficient to ensure long term success and sustainability of supply chain, expect in static competitive environments, not dynamic ones, which are characterised by high velocity and rapid changes (Teece, 2017). As such mere possession of substantive capabilities may not be enough to affect competitive disparity; rather, how these capabilities are developed, integrated, and exploited that can make a distinction leading to competitive differentiation (Allired et al., 2010; Teece, 2019). This realisation led to the focused on dynamic capabilities' theory (Teece, 2007).

The theory of dynamic capabilities has become a key topic in the strategic management literature (Aslam et al., 2020; Beske, 2012; Schilke, 2014; Easterby-Smith et al., 2009; Di Stefano et al., 2010, 2014). Teece et al. (1997, p. 516) defined dynamic capabilities as the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. As mentioned above, dynamic capabilities can be distinguished from ordinary capabilities, which pertain to the current operations of the supply chain (Parera et al., 2014). By contrast, dynamic capabilities involve the capacity of supply chains to purposively create, extend or modify its resource base (Helfat et al., 2007). This characterisation of capabilities is underpinning by organisational and managerial competencies for reading the environment and developing business models that address new threats and opportunities (Teece et al, 2016). Dynamic capabilities, thus, defines the ability to innovate, adapt to change, and create change that is favourable to customers and unfavourable to competitors (Teece et al, 2016).

Consistent with Teece (2007), dynamic capabilities can be grouped into three basic categories: sensing capability, seizing capability, and transforming capability. Sensing capability means a company's capacity to identify, develop, co-develop, and assess technological opportunities and threats in relationship to customer needs. Seizing capability represents a company's capacity to mobilise resources to address needs and opportunities and capture value from doing so. Transforming capability, on the other hand, involves continued renewal of the resource base (Teece et al., 2016). Reconfiguration reflects the ability to adjust an asset structure and to accomplish the internal and external transformations to address changing environments (Fainshmidt and Frazier, 2016; Teece, 2014).

In the context of high-velocity markets, dynamic capabilities are unstable processes that rely on rapidly created new knowledge to produce unpredictable outcomes (Eisenhardt and Martin, 2000). These capabilities can be specific processes or routines that enables combination, transformation, or renewal of resources into new competencies as market evolve (Eisenhardt and Martin, 2000). Based on this, supply chain agility and sustainable supply chain management practices can be considered dynamic capabilities that result from the ability to reconfigure supply chain level resources. Therefore, capabilities and dynamic capabilities enables understanding of how sustainable supply chain practices and agile supply chain capabilities influence organisational performance (Priem and Butler, 2001).

Several scholars have reported a significant positive relationship between dynamic capabilities and performance outcomes (Morgan et al., 2009; Schilke, 2014a, b; Aragon-Correa and Sharma, 2003; Stadler et al., 2013). Barreto (2009) and Allred et al. (2011) showed that dynamic capabilities contributed to competitive performance in rapidly changing markets.

Other studies have examined how dynamic capabilities affect operational performance (Ju et al., 2016), economic performance (Aslam et al., 2018; Eckstein et al., 2015; Blome et al., 2013), as well as social and environmental performance (Beske, 2012; Hong et al., 2018). Because the notion of dynamic capabilities is significant for performance outcomes, it is important to understand how sustainable supply chain strategies could positively help in building and adapting agile supply chain capabilities (Beske, 2012; Defee and Fugate, 2010; Hong et al., 2018; Beske et al., 2014). Some capabilities researchers have suggested that organisations do so by utilising second-order capabilities that operate on the first-order dynamic capabilities. A distinction can be made between first- and second-order dynamic capabilities. First-order dynamic capabilities are routines that reconfigure the organisational resource base while second-order dynamic capabilities are routines that reconfigure first-order dynamic capabilities (Schilke, 2014). This classification of dynamic capabilities appears to be accepted in the literature (Robertson et al., 2012; Schilke, 2014; Ambrosini et al., 2009; Easterby-Smith and Prieto, 2008; Easterby-Smith et al., 2009) there is lack of understanding of how agile supply chain and sustainable supply chain practices are intertwined. Particularly, there is no empirical work investigating the role of sustainable supply chain practices in conjunction with agile supply chain capabilities (Ciccullo et al., 2018; Chen et al., 2017), which this research aims to address the gap.

The notion of the agile supply chain is advocated as a new way forward for business networks to succeed in the highly changing and turbulent business environments. The primary emphasis is managing businesses in network structures with an adequate level of agility to quickly respond to changes, as well as proactively anticipate changes and seek emerging opportunities (Ismail and Sharifi, 2006). According to Sharifi et al. (2006), agile supply chains are those with the ability to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network. Agile supply chain is positioned as dynamic capability because supply chain partners can collaborate to develop an adaptive capability, in order to thrive and prosper in a changing, uncertain, and unpredictable business environment, and to sustain its position in markets (Eckstein et al., 2015; Aslam et al., 2018; Gligor and Holcombe, 2012). Agility, as a dynamic capability, entails the exploitation of existing internal and external capabilities, developing new ones, and renewing them to respond to shifts in the environment (Blome et al., 2013; Tavani et al., 2013). The speed of responsiveness to the rate of changes and uncertainties in supply chain environment are recognised as the driver of agility (Sharifi et al, 2006; Sharma et al., 2017).

Agile methods focus on integrating people, technology and processes while collaborating with customers and adapting to change (Serrador and Pinto, 2015) to take advantage of windows of opportunities. It is a business model that allows companies to use market knowledge and partnerships to exploit profitable opportunities in a volatile marketplace (Naylor et al., 1999, p.108). This idea has been extended beyond organisation's boundaries to include the activities of supply chains, emphasising the need for strategic alliances, knowledge transfer, information sharing, aligning resource capabilities and strong leaderships across supply chains (Dyer et al., 2018; Dyer and Singh, 1998). According to Lee (2004), agile supply chains is about being responsible or adaptable to the customer requirements while the risk of supply chain disruptions is avoided. Supply chain agility is the ability of firms to sense short-term, temporary changes in supply chains and market environment as well as to quickly adjust to those changes (Aslam et al., 2018; Eckstein et al., 2015). Some researchers have linked agile supply chains with practices such as risk hedging, flexibility, and responsiveness – flexible sourcing, flexibility in product design, flexibility in production and the use of supply chain knowledge for innovation (Swafford et al., 2006; Lee, 2002). Agile supply chain capabilities have been extensively researched and linked to superior organisational performance. However, whilst it has been established that agility, on the one hand, induces better operational performance and sustainability, on the other hand, could potentially enhance indicators of environmental and social sustainability, the interactive effects of both have not been examined. In fact, Ciccullo et al. (2018) called for the development of a conceptual model that integrates sustainability practices with agility practices and advocated for empirical studies of the relationships between the two set of practices. Therefore, this study explored agility as a mediator of sustainability and examined the roles of agile capabilities in maximising the transformation of sustainable practices into social and environmental sustainability performance.

Sustainable supply chain, according to Roy et al. (2018), involves 'the management of financial and non-financial measures within the supply chains.' Similarly, Marshall et al. (2015) contends, it is a set of practices aimed at minimising the environmental impacts and enhancing the social wellbeing of different stakeholders while contributing to the long-term financial growth of the entities within the supply chain. Azevedo et al. (2012) and Dües et al. (2013) distinguish between green and sustainable supply chain paradigms and contend that green supply chain paradigm involves practices aimed at minimising the environmental impacts of the supply chain whilst sustainable supply chain encompasses the triple-bottom-line of environmental, social, and economic objectives. In furtherance of this, a number of works have examined the relationship between adoption of sustainable supply chain practices and organisational performance. Such work includes Golicic and Smith (2013); Rao and Holt (2005); and Paulraj et al. (2017) who have demonstrated a positive correlation between sustainability and organisational performance. However, there are contrasting reports (Esfahbodi et al., 2017; Winn et al., 2012; Green et al., 2012a; Hahn et al., 2010) of sustainability having a negative impact on firms' profitability indicating a need to find ways to maximise the performance advantage of implementing sustainability practices. The challenge for organisations, thus, is how to integrate social and environmental sustainability practices with agile supply chain capabilities to develop unique capabilities to improve their sustainability competitiveness (Ciccullo et al., 2018; Chen et al., 2017), which is the subject of investigation of work reported in this thesis.

## 1.3 The sector of the study: Oil and Gas Industry

The oil and gas industry is facing substantial changes and uncertainty in their business environment (Bergman et al, 2021). The COVID-19 pandemic has significantly shifted energy demand curve, fluctuating oil prices, escalating cost of exploration, development and production of energy resources, and technological advancements are reshaping the industry (Shuen et al., 2014; Garcia et al., 2014; EY, 2020). In addition, a finite global carbon budget, an impeding energy transition, and changes in customers' practices and landscape present the biggest challenges for the industry (Bergman et al, 2021). It is occurring at a time when companies face immense pressure to enhance shareholder return while reducing their social and environmental impacts, which creates more uncertainty and turbulence of business environment, affecting the existing competencies to managing this uncertainty (Shuen et al., 2014; Garcia et al., 2014). The industry needs to respond quickly; success and sustainability require a transformation of all aspects of organisations, not incremental change (Shuen et al 2014). Wood (2014) posit several dimensions of oil and gas supply chain design, including strategic vision, competitive strategies, core competencies, organisational processes, and structures.

This study focused on higher carbon and energy-intensive supply chains in the UK. The targeted industries are those involved in the extraction of crude petroleum and natural gas; production, coke, and refined petroleum products; facilities, cement; steel; wells and drilling rigs, fabricated metal products; nitrogen fertilisers; construction; rubber and plastics;

chemicals; automatic components; and other transportation equipment. These industries are major contributors to global carbon footprint and key consumers of natural resources and therefore, prime candidates for the study of sustainability and related practices of agility.

Naturally, these industries use large amount of fuel or electricity in their manufacturing processes. They account for 56% of the UK industrial energy use, and emissions were estimated to be 448.5 million tonnes of carbon dioxide ($CO_2$) equivalent in 2018 (OGUK, 2020). In line with the department of Business, Energy, and Industrial Strategy (BEIS (2019)), carbon dioxide emissions estimated to account for about 81% of total UK anthropogenic greenhouse gas emissions (OGUK, 2020). So, the entire energy-intensive supply networks were adopted as a unit of analysis to explore the effects of agility and sustainability practices on sustainable supply chain performance. Broadly, these sectors are more concerned with sustainability issues than other industries, therefore, most suitable for this study.

Given the fact that the consumption of resources, waste generation, and the implementation of sustainable practices related to industrial supply chains (Villena and Gioia, 2018; Ciccullo et al., 2020). The survey focused on UK oil and gas supply chains. In an attempt to further narrow the unit of analysis, the oil and gas supply chain is appropriate. Because of the contributions of the sector to the economy and security of energy supply justified focus for sustainability studies (Wood, 2014). Over the years, the UK oil and gas industry has grown and evolved. The sector now has contributed more to the treasury than other industrial sectors. In 2018, the industry supported over 280,000 jobs within supply chains (OGUK, 2019). While investment in the offshore oil and gas accounted for over £5.6 billion or £7 billion capital expenditure on oil and gas projects (OGUK, 2019). Likewise, the sector contribution to gross domestic products (GDP) was 3.2% (EY report 2019). Of this, oil and gas extraction accounted for 34%, electricity was 37%, and natural gas was 18% (see BEIS, 2019 for details).

### 1.3.1 The oil and gas supply chain

The oil and gas supply chain encompasses the extraction and the transformation of crude oil and natural gas to supply energy and other essential products to international consumers (Hussain et al., 2006). The oil and gas industry involved in a global supply chain that includes domestic and international transportation, ordering and inventory visibility and material handling, import/export facilitation and information technology (Chima, 2007). The industry offers a classic model for implementing sustainable and agile supply chain techniques (Yusuf et al., 2013, 2014; Lakhal et al., 2007).

In the context of supply chains, a company is linked to its upstream suppliers and downstream distributors as materials, information, and capital flow through the supply chain (Chima, 2007). Such supply chain link in the oil and gas industry includes extraction of crude oil and natural gas, production, refining, marketing, and consumers (Chima, 2007; Acha, 2002). These links represent the interface between companies and materials that flow through the supply chain (Weijermars, 2010). Exploration and extraction supply chain includes seismic, geophysical, and geological contractors, and data interpretation consultancies (Chima, 2007). Production operations include wells and drilling such as well services contractors, drilling contractors, well engineering consultancies, and drilling/well equipment design (Brigs et al., 2012). Facilities engineering are those from engineering, operation, maintenance and decommissioning contractors, specialist steels and tubulars, engineering services and support contractors, plant design, structure and topside design and fabrication (Acha, 2000). Marine and subsea supply chain consist of marine/subsea contractors, heavy lift/pipe lay contractors, floating production, subsea manifold/riser design, and subsea inspection services. Refining is a complex operation, and its output is the input to marketing (Chima, 2007). Marketing includes the retail sale of gasoline, engine oil, and other refined products (Brigs et al., 2012). While other support services are catering/facility management, transportation, warehousing/logistics, communications, training, health, safety and environmental services, information technology, and energy consultancies (EY, 2020; Chima, 2007). Each stage of the link can be a separate company or a unit of an integrated firm.

According to Yusuf et al. (2013); Tseng et al. (2016), the production and consumption of hydrocarbons give rise to sustainability issues in the oil and gas supply chain. These include the combustion to provide electrical power and drive compressors and pumps, the flaring of excess gas for safety and/or during well testing, tank loading and incidental releases from firefighting and refrigeration equipment, transportation, as well as decommissioning operations. The industry has complex supply chain processes in which the reduction of social, environmental and health impacts are paramount. The combustion and flaring of hydrocarbons result in emissions of carbon dioxide ($CO_2$), carbon monoxide (CO), methane ($CH_4$), Oxides of nitrogen (NOx), Nitrous oxide ($N_2O$), and sulphur ($SO_x$), amongst others. These emissions not only contribute to global warming, but also the acidification of the ocean. Greenhouse gases associated with oil and gas supply chains defines their carbon footprint. Other potential impacts of combustion emissions of hydrocarbon include a reduction in air quality and exposure of workers to pollutants. The oil and gas supply chain companies recognise that health and social impacts that may result from its activities are connected to the environmental impacts.

Dauda (2008) argued that some of the supply chain challenges plaguing the downstream sector of the oil and gas industry are the cost of operations, as operators are striving to reduce the cost of extracting the crude oil as well as lowering the long lead time of delivery services by the constrictors which can affect the competitiveness of the supply chain. Since the upstream sector of the oil and gas industry can influence its entire supply chain, it is worthwhile to adopt this sector as the unit of analysis

## 1.4 Research Gaps

Social and environmental sustainability has become important aspects of competitive differentiation and superior performance. Empirical studies such as Golicic and Smith (2013), shows that sustainable practices can reduce costs, with sustainable management of supply chains resulting in improved financial performance of organisations. Other studies such as Hasan (2013); Luthra et al. (2015); Rao and Holt (2005); and Paulraj et al. (2017) have demonstrated a positive correlation between sustainability practices and organisational performance. Pullman et al. (2009) explored the impact of sustainable supply chain practices on performance. They provided evidence that sustainability practices are related to environmental performance, and social practices are linked to quality performance. However, environmental performance improvements lead to improved quality performance, which in turn improves cost performance (Pullman et al., 2009). Rao and Holt (2005) found that greening the different aspects of the supply chain led to integrated green supply chain practices, which positively associated with competitiveness and economic performance. Relevant insight also comes from research by Vachon and Klassen (2008) and Vachon (2003), who showed that the degree of adopting green supply chain practices can improve delivery and flexibility performance. Finally, Perry et al. (2013); Sancha et al (2015) analysed the impact of social supplier development practices on supply chain performance in terms of social, and operational performance. They found a positive relationship between supplier development practices and social performance as well operational performance success of the organisation. However, there are contrasting reports (Esfahbodi et al., 2017; Winn et al., 2012; Zhu and Sarkis, 2004;

Green et al., 2012a; Hahn et al., 2010) of sustainable practices having a negative impact on firms' profitability indicating a need to find ways to maximise the performance advantage of implementing sustainability practices.

In short, these studies have made important contributions to the understanding of the nature of sustainable practices of supply chains. However, these studies failed to provide evidence for a mediated model, in which sustainable supply chain practices would affect agile supply chain capabilities; rather, these studies investigated only the effect of sustainable supply chain practices on performance outcomes. Put differently, even though, these studies were able to establish some positive link between sustainable supply chain practices on performance outcomes, they did not show whether the sustainability performance enhancements are indeed because of change in agile supply chain capabilities, or whether the sustainable supply chain practices have a direct performance effect that is largely independent of agility capabilities.

This thesis concurs with Schilke and Helfat (2018) and Ambrosini et al. (2009), who emphasised the importance of understanding the distinctive mechanism through which dynamic capabilities exert an effect. In the opinion of Schilke and Helfat (2018), only by establishing that sustainable supply chain practices influence performance through the development of agile supply chain capabilities then can one be sure to get at the entire sustainable supply chain performance. In other words, Hazen et al. (2011) indicate that one of the distinctive features of sustainable supply chain practices is that these practices do not improve performance directly but rather work indirectly by promoting agility capabilities into the supply chain. This logic suggests a mediation model, with agility capabilities mediating the linkage between sustainable supply chain practices on performance outcomes. Dubey et al. (2017) argued that sustainable practices may influence the competitiveness of supply chain via intervening linkages. In the capability-based view, dynamic capabilities can mediate the resource base to enhance performance (Lin and Wu, 2014). Other studies such as Kim and Han (2012) showed that dynamic learning skill can facilitate the performance effect of sustainable supply chain practices.

Besides, this possible two-step causal chain (from sustainable supply chain practices - agile supply chain capabilities - performance outcomes), another interesting question is whether these capabilities also have interactive effects on performance. Two different models are examined here. Whereas the mediation model tests if sustainable supply chain practices lead to an increase in agile supply chain capabilities, the interaction/moderation model tests if sustainable supply chain practices affect the effectiveness of agile supply chain capabilities in increasing performance. While such a structure has never been proposed, a moderation model can be derived from extant discussions. More specifically, two opposing perspectives can be constructed regarding how agile supply chain capabilities and sustainable supply chain practices jointly influence performance: they could either work as complements or substitutes (Schilke, 2014; Amit and Schoemaker, 1993; Rothaermel and Hess, 2007; Hult et al., 2007; Najafi-Tavani et al., 2016).

Broadly speaking, two activities are understood to be complements if the marginal value of each of the activities increases in the presence of the other activity (Rothaermel and Hess, 2007). In contrast, two activities are understood to interact as substitutes if the marginal advantage of each of the activities decreases in the presence of the other activity. In statistical terms, two variables are complements if their interaction term has a positive effect and are substitutes if their interaction term has a negative effect. A positive interaction between sustainable supply chain practices and agile supply chain capabilities might be considered likely because sustainable supply chain practices may help organisations better understand and thus better implement their agility capabilities (Hart, 1995; Sharma and Vrendbury, 1998). More prominent sustainable supply chain practices might thus produce greater knowledge of approaches and specific ways of achieving agile supply chain capabilities. In addition to increasing effectiveness, collection of sustainability knowledge into procedures and technologies may also make temporal change routines easier, and thus more efficient, to apply (Cepede and Vera, 2007). Further, sustainable practices may enable supply chain not only to better identify agile capabilities but prevent their misuse (Heimeriks et al., 2012). These views indicate that agile capabilities are more effective in supporting competitive performance if combined with sustainable supply chain practices.

In contrast to this view, there is also reason to believe that two types of dynamic capabilities may function as substitutes for each other. The theoretical foundation for this argument is that both dynamic capabilities (sustainable supply chain and agile supply chain) are employed to attain the same end of strategic change and thus may exhibit some element of equifinality (see Rothaermel and Hess, 2007). Perhaps more important, while sustainable supply chain practices could expand agile capabilities, such expansion may come at the risk of disturbing the smooth execution of agile practices, thus decreasing their effectiveness on the margin. Like the thinking that evident agile capabilities hamper resource effectiveness if they cause too much change in the resource base (Schilke, 2014; Winter, 2003; Zahra et al., 2006), sustainable supply chain practices may cause disruption in the ongoing practice of agile supply chain. The above arguments, indicate a substitute effect between agile supply chain capabilities and sustainable supply chain practices.

In summary, researchers have developed a sound theoretical understanding of what sustainable supply chain practices are. Most notably, they have brought attention to sustainable design, waste prevention initiatives, and socially responsive behaviours as relevant type of sustainable supply chain practices. These studies have also shed initial light on their performance effects, examining the direct relationship between sustainable supply chain practices and organisational performance outcomes. From a theoretical perspective, however, such an effect should be explained by agile capabilities, suggesting a structure of a mediation model, which so far remained unexplored. Another question regarding the consequences of sustainable supply chain practices pertains to their interaction with agile supply chain capabilities: specifically, do agile capabilities and sustainable practices work as complements or substitutes in enhancing sustainable supply chain performance? While conceptual arguments for both views can be identified, deciding on the more appropriate account on theoretical grounds is difficult.

Eckstein et al. (2015, p. 3028) argued that the direct performance effects are often crucial, but they seem incapable of capturing the complexity of the business reality. Sousa and Voss (2008) observed that the performance effects of certain supply chain practices depend upon the environmental context. The effect of sustainable supply chain practices and agile supply chain capabilities are conceptualised as dynamic capabilities of the supply chain (Aslam et al., 2020; Beske et al., 2014; Hong et al., 2018; Blome et al., 2013). Environment dynamism is a key situational parameter in dynamic capabilities theory (Schilke and Helfat, 2018), which suggests that the variance of competitive advantage generated through exploitation of organisational capabilities hinge on turbulence of business environment (Eisenhardt and Martin, 2000; Chen et al., 2015). This view is reflected in contingency theory (Lawrence and Lorsch, 1967). Eckstein et al. (2015); Aragon-Correa and Sharma (2003) stated that conceptual and empirical studies on sustainable supply chain practices and supply chain agility have largely neglected the effects of relevant contextual factors. Other studies such as Chen et al. (2015); Wamba et al. (2020) argued that empirical works on capabilities has ignored the effect of market dynamism. Prior literature indicated that a turbulence environment can enhance or no enhance critical supply chain competences (Afuah, 2001). This study adopts the theoretical lens of contingency theory to assess the conditions under which sustainable supply chain practices and agile supply chain capabilities are effective. This study expects that the influence of sustainable practices on success and sustainability performance will be enhanced in high velocity markets. The premise of this argument is grounded in extant research that espouse the idea that information and knowledge sharing can lead to greater variance in performance outcomes when faced with dynamic environment (Chen et al., 2015; Aragon-Correa and Sharma, 2003). This study suggest that the market dynamism creates pressure on organisations to exploit sustainable knowledge and experience to guide the courses of action (Droge et al., 2004).

## 1.5 Aims of the study

As noted above, this study set out to develop and test conceptual models about the relationship between sustainable practices and agility capabilities and their impacts on performance of the oil and gas supply chain. Whilst it has been established that agility, on the one hand, induce better operational performance, sustainability, on the other hand, could help enhance indicators of social and environmental sustainability, the interactive effects of both have not been examined. In particular, it is not clear if agility serves as effective mediator of sustainability performance. Moreover, which individual practices or group of practices have the biggest impacts on specific performance objectives. These are the key issues this study intended to investigate and clarify.

## 1.6 Objectives of the study

Considering the overall aims, the research objectives are to:

i. Investigate the influence of sustainable supply chain practices and agile supply chain capabilities on supply chain performance in terms of operational and sustainability performance.
ii. Examine the interaction between sustainable supply chain practices and agile supply chain capabilities.
iii. Examine the mediating roles of agility capabilities on the impacts of sustainable supply chain practices on operational performance and sustainable performance.

iv. Examine the moderating effect of managerial experience and industry type on the relationship between sustainable supply chain practices and sustainable supply chain performance.
v. Explore individual practices and group of practices that have the greatest impacts on specific organisational performance.

## 1.7 Research questions

This study aims to answer the following research questions:

i. What are the distinct and joint effects of sustainable supply chain practices and agile supply chain capabilities on operational performance and sustainability performance in the UK oil and gas industry?
ii. Do agile capabilities mediate the impact of sustainable supply chain practices on sustainability performance and operational performance?
iii. What are the moderating effects of managerial experience and industry on the relationships between sustainable supply chain practices and operational performance/sustainability performance?
iv. Which individual practices or group(s) of practices have the greatest impacts on specific performance measures?

## 1.8 The geographical setting of the study

The UK was chosen as the empirical setting of this study because of its significant share of total global manufacturing outputs and resource demands. According to a most recent report by West and Lansang (2018), the UK, in 2015, was the 9th manufacturing country in the world with an output of US $244 billion that accounted for 10% of its national output and 2% of the global manufacturing output.

In the context of scarce resources, minimising the level of resources consumption is important for British businesses to maintain low carbon and resources future. British businesses account for two third of the UK industrial carbon emissions. As such, there is a need for more understanding and clarification of agility and sustainability objectives of supply chains in the UK. The UK government was considering the most effective ways to help cut industrial carbon emissions, as part of £315 million investment drive in decarbonising heavy industry to help reach net zero by 2050 (OGUK, 2020. These policies can improve the energy efficiency of supply chains. The industrial energy transformation fund (IETF) will also help businesses with high power use to cut their bills and carbon emissions through investing in efficiency measures (BESIS, 2019). The UK is already cutting emissions faster than other major economy and the first to legislate to end contribution to climate change (BESIS, 2019). Eliminating emissions from industrial supply chains is key to achieving this goal but doing so does not have to mean compromising operations success.

To improve sustainable supply chain policies such as sustainable transportation, the UK government has enacted stringent sustainability regulations to limit the use of non-renewable resources like coal, petrol, diesel, and gas (Yu and Ramanathan, 2015). Again, a reduction in carbon taxes was offered to encourage small and medium-sized enterprises to undertake sustainable initiatives. British businesses that use renewable energy in their modes of transportation can benefit from these incentives (SMMT, 2015). The UK's location is appropriate for this study, given the importance of sustainability issues and resource scarcity and the extensive knowledge of the agility and sustainability in the region. Ensuring that industries are equipped with low-emission technologies will not only help the transition to net-zero but will also ensure these businesses are more agile and sustainable competitiveness.

## 1.9 The significant contributions of the study

This thesis aims to advance knowledge of sustainable supply chain practices and clarify the importance of agility capabilities for achieving sustainable supply chain performance. This section presents the academic and managerial implications of this research.

### 1.9.1 Theoretical implication

The growing competition for resources and a changing climate has forced manufacturers to act in order to safeguard their future competitiveness. The dynamic capability theory (Beske et al., 2014; Aslam et al., 2018; Blome et al., 2013) can offer important support to the progress of competitive advantage. This is envisaged because sustainable competitive objectives depend largely on the organisation’s ability to integrate, build, and reconfigure internal and external resource competencies to address rapid changing business environment. In this regard, the significant contribution of this study is the development of a single integrated conceptual model of the links between agility practices, sustainable practices, and a broader set of competitive objectives. The research further advances the knowledge of sustainability and operations strategy by exploring the performance effects of agility and sustainable supply chain practices. The finding confirms that sustainable supply chain practices are drivers of agile capabilities. Further, the result indicates that agile practices, in turn, have impacts on both sustainability performance and operational performance. It can be suggested that the implementation of the respective dimensions of sustainable practices including sustainable products design, waste reduction initiatives and socially responsible behaviours are supporting organisations to reach expected sustainable competitive objectives. This result has important implications both for operations strategy and sustainability field. Thus, this study contributes to the wider literature in operation strategy and sustainability discipline by providing empirical evidence on the influence of a set of agility and sustainable practices on the overall organisational performance. More importantly, it breaks new grounds by examining the sustainability performance enhancement and amplification role agility plays as a mediator in the relationship between sustainable practices and the duo of operational performance and sustainability performance.

### 1.9.2 Managerial implication

This study provides several insights into how organisations can adapt to social and environmental changes in the supply chain. A shift to more sustainable manufacturing will be critical, requiring manufacturers to use less material, water, energy, and other inputs, make better use of alternative materials. Sustainable products design will be important in helping the economic sustainability and competitiveness of organisations and will make valuable contributions to social and environmental sustainability. Managers should implement sustainable practices and agile strategies concurrently to optimise the development of agile capabilities.

This study further emphasises the importance of suppliers' involvement in sustainability initiatives. Therefore, the study argues the need for close collaborative relationships amongst suppliers, customers, and other stakeholders in order to resolve social and environmental problems. In conclusion, this research examined the intervening effect of agile practices in the links between sustainable practices and sustainable supply chain performance. As resources are increasingly becoming scarce, using advanced technology will reduce energy, water, and raw materials usage. Sustainable technologies will allow companies to reduce material or energy use to levels considered sustainable in the longer term. It will provide clean energy to everyday products, which can improve sustainability performance. Finally, managers who want to maximise the outcomes of their sustainability campaigns should consider the concurrent implementation of both sustainable practices and agile practices**.**

## 1.10 Research methodology

The study follows a positivist epistemological position, in that, the social world exists externally, and its properties should be measured through objective approaches and not subject to the scope of interpretation (Easterby-Smith et al., 2018; Bell et al., 2018). The positivism paradigm used was a survey research strategy (Dillman et al., 2014). Survey research is suitable for gathering reliable empirical data from a large population size (Wilson, 2014) and because it involves developing and testing hypotheses, it is considered a deductive approach. After a review of the literature on agility and sustainability in supply chains, four constructs were identified. These constructs include agility practices, sustainable supply chain practices, operational performance objectives and sustainability performance measures.

A questionnaire was developed around these constructs. Further, multiple items were used for the measurement of each construct - the scales were developed in accordance with the procedure suggested by Pallant (2013) for developing measures. The questionnaire survey involved five-point Likert scale questions, which are important measures for defining the interactions between the practices and performance measures.

As these practices and performance measures were objective and not being inferred subjectively through social construction (Easterby-Smith et al., 2018), a mixed-mode approach of data collection was used in accordance with Dillman et al., (2014) suggestions. That is, both mailed portal and web-based survey were adopted in collecting data. The aim was to mitigate any prejudice of using the individual method and enhancing the quality of the data beyond the single survey method while eliminating the possibility of bias (Frankfort-Nachmias and Nachmias, 2007). Based on Dillman et al. (2014) suggestion, a total design approach was used to gather data via a mailed postal and QuestionPro surveys from September to November 2018. Before the main data collection, a draft of questionnaire was sent to two academics and supply chain managers with strong interests in agility and sustainable manufacturing before it was distributed to the respondents. A single answer per organisation was requested. This is in line with similar studies in this area (Esfahbodi et al., 2017; Bottani, 2010; Aslam et al., 2018; Blome et al., 2014; Eckstein et al., 2015; van Hoek et al., 2001).

In considering the objectives of this study, the analysis of the questionnaire data was carried out using statistical packages for social science (SPSS and SPSS AMOS). These software packages are the most widely used for statistical analysis in social sciences. The data were then analysed using statistical techniques of structural equation modelling (SEM) to explore a set of relationships amongst independent and dependent variables. Here structural equation modelling was used as a confirmatory approach to data analysis, which tests the hypothesised model to confirm the degree to which the suggested model is consistent with the data. Such analysis specifies the direct and indirect correlation among variables (Byrne, 2016).

Another statistical technique employed was multivariate analysis of variance (MANOVA) techniques. These techniques were used to help test for significant differences amongst groups. In this regard, Post-hoc analysis helps to determine if there is a significant difference amongst groups of agile companies. The post-hoc comparison allows the researcher to explore which groups of agile companies have the greatest impact on specific performance objectives. Of the two forms of the post-hoc test, Scheffe test was used to reduce the risk of type 1 error. The effect size was calculated using the techniques as recommended by Cohen (1988, p. 22.). Effect size is the strength of the association (Tabachnick and Fidell, 2014, p. 55). That is, a set of statistics, which indicates the relative magnitude of the differences between mean values, or the amount of the total variance in the dependent variables that are predictable from knowledge of the levels of the independent variables (Tabachnick and Fidell, 2014, p. 54).

## 1.11 The structure of the study

This study is divided into six main chapters, including this introductory chapter. It introduces the background of the research and justifies why it is necessary. The aims of the study were then stated, followed by its objectives and research questions/hypotheses. It justified the choice of the UK industry as the empirical setting of the study. It also outlines the significant contribution of the study and concludes by explaining the methodology adopted and how the work was structured.

Chapter 2 – Literature review

This chapter begins by looking at how supply chain management is understood. Then, the chapter reviews the extant literature on supply chain agility, sustainable supply chains, operational performance, and sustainability performance measures.

Chapter 3 – The theoretical framework and hypotheses development

Following from existing literature, the chapter provides discussion of the capability theory and dynamic capability theory and discusses individual hypotheses and justified the conceptual model.

Chapter 4 – Research methodology

This chapter discusses the methodology adopted in this study, including an overview of research philosophy, research logic, approaches, and research methods. This chapter justifies the choice of quantitative approach. It also defines measures of constructs, the sampling procedure, as well as the ethical considerations. The chapter concludes with details of the pilot testing techniques and the full-scale survey.

Chapter 5 – Data analysis and results

This chapter is devoted to the survey data analysis, results and hypotheses testing. The data analysis was carried out using statistical packages for social science (SPSS and SPSS AMOS). This chapter also provides a detailed discussion on descriptive statistics; non-response bias; reliability, validity test; common method bias (CMB) and causality test. This section assesses the fit of the model before testing the hypotheses. A structural equation modelling (SEM) technique was used to test the hypothesised model and report whether the proposed hypotheses were accepted or rejected.

Chapter 6 – Discussions and implications

The chapter discusses the results of the study. It draws on the detail findings of individual and combined hypotheses, informed by the results presented in chapters 4. The chapter provides critical interpretations of the insight concerning the research questions, explaining the causal interaction among agile practices, sustainable practices, operational performance objectives and sustainability performance. This chapter also discusses whether the findings are consistent with existing works and explains the rationale where inconsistent results exist. The chapter concludes by outlining a range of the theoretical and managerial implications of the study.

Chapter 7 – Conclusions

This chapter revisits the research objectives and provides answers to research questions as well as outlines the main findings of the study. This chapter presents the significant contributions and states research limitations and further research directions.

## 1.12 Summary

This chapter introduces the background of the study and explains why its matters to look at the impact of agility and sustainable practices on sustainable supply chain performance objectives. It sets out the research objectives and research hypotheses. The chapter explains and justifies the research methodology adopted and outlines a range of theoretical implications. Finally, the chapter presents how the thesis has been structured.

In the next chapter, the study reviews the extant literature on supply chain management, supply chain agility, sustainable supply chain, sustainability performance measures and operational performance.

# CHAPTER 2: Literature review

## 2.1 Introduction

This chapter presents the theoretical bases of the thesis. The chapter is divided into six parts. The first part starts with the emergence and definitions of supply chain management. This was followed by a discussion of supply networks structures: dyad relationship, chain, and network level of analysis; supply chain responsiveness, resilience, and lean supply. Part two explores the role of agile methods. From this, the attributes and enablers of agile practices were identified. In addition, important types of agile capabilities were discussed. Part three concentrates on the nature of sustainable supply chain management; the definitions of sustainable supply chain management at each level of analysis were explained. This section also examines several different sustainable supply chain practices and how each create values for the organisation, as well as discussed, their potential contribution to sustainability performance. The barriers and enablers for the implementation of sustainable practices were also examined. Part four look at the identification of important metrics or indicators of organisational performance, namely operational performance objectives and sustainability performance criteria. Part five explains the theoretical framework and hypothesis development as well as conceptual model of the relationship between agility and sustainable practices, and their cumulative impacts on organisational performance criteria. Finally, part six presents the summary of the chapter.

## 2.2 Supply chain management

Supply chain management is evolving at a rapid pace. From the increasing social and environmental transformation to the growth of disruptive technologies, organisations are under pressure to rethink operations or supply chains, and harness agile operating models - collaborative practices, customer sensing, strategic process alignment, the integration of latest technologies and agile learning-related capabilities – to improve operational efficient, resilient, or sustainable supply chains (Lysons and Farrington, 2020; Martinez-Sanchez and Lahoz-Leo, 2018; Teece et al., 2016; Ciccullo et al., 2020; Weber and Tarba, 2014). This section looked at the basic supply chain principles, before expanding perspective on the value of broader supply networks. The section also uncovers the challenges that a volatile, uncertain, complex, and ambiguous world poses to supply networks and identified strategies for mitigating impacts on a broader perspective.

### 2.2.1 The emergence of supply chain management

The term "supply chain management" was first used by Oliver and Webber in 1982 to describe the potential benefits of integrating the internal business functions (Hines, 2004; Kotzab et al., 2011; Stadtler, 2008). Over the years, supply chain management was viewed not different from the existing understanding of operations function (Lambert and Cooper, 2000). That is, supply chain management was viewed as operations management that, according to Hill and Hill (2018), embraces the manufacturing tasks, responsibilities and decisions that transform input (such as materials, assets, energy, and information) into outputs (products and services) and, is central to what an organisation does. Recent thinking considers supply chain management more than just transforming materials, the sector carries significant benefits that impact individuals, organisations, and communities. Christopher (2016) looked at the usefulness of the traditional approach and maintained that seeking compromises among various operation functions – purchasing, manufacturing, sales, and distribution – along networks no longer linear chains, but circular or closed-loop supply chains built on collaboration, innovation, sustainability, virtual integration, or agile response (Slack and Brandon-Jones, 2018). This new paradigm allows rapid response to supply uncertainty (Lambert and Enz, 2017; Harland et al., 2001). Now supply chain management is viewed as managing complex networks of suppliers, partners, and customers (Harrison et al., 2019).

According to the earlier understanding of supply chain, Harland (1996) observed that there are four main uses of supply chain management. These include the following:

- the internal supply chain, which integrates business functions involved in the flow of materials and information from inbound to outbound ends of the business.
- the management of dyadic or two-party relationship with immediate suppliers.
- the management of a chain of businesses including an organisation, a supplier, a supplier's supplier, a customer, and a customer's customer.
- the management of a network of interconnected businesses involved in the ultimate provision of product and service package required by end customers.

There are several characteristics of supply chain management in the literature. Handfield and Nichols (1999) distinguished supply chains from supply chain management. The scholars argued that supply chain encompasses all activities associated with the flow and transformation of goods (products and services) from the initial design stage through extraction of raw materials, and on to the end user. Additionally associated information flow form part of supply chain activities (Handfield and Nichols, 1999). Supply chain management, in contrast, involves the integration and management of order fulfilment processes, organisations, and activities through cooperative organisational relationships, effective business processes, and high levels of information sharing to create high-performance value systems that provide companies, its customers and its suppliers a sustainable competitive advantage (Handfield and Nichols, 1999).

A further definition of supply chain management was given by Mentzer et al. (2001), as the systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the whole supply chain. Other studies viewed supply chain management as an integration and synchronisation of supply chain processes where internal and external parts of a supply chain work to the same time frames, allow companies to better respond to market opportunities and competitive pressure (Lambert et al., 1998; Krajewski et al., 2016).

Recently, Harrison et al. (2019) maintained that supply chain management embraces the planning and controlling of all processes involved in the sourcing/procurement, conversion, transportation, and distribution across a supply chain. Most importantly, it includes coordination and collaboration with partners, which can be suppliers, intermediaries, third-party service providers or customers. Supply chain management integrates supply and demand management within and between companies in order to serve the needs of the end-customer.

According to Jespersen and Skjott-Larsen (2005), the competitiveness of organisations is highly dependent on their ability to deliver customised products quickly and timely all over the world. Because for many firms, using supply chains as competitive weapons has become a central element of the strategic management process (Ketchen and Hult, 2007). In this regard, Christopher (2016) argued that supply chain management is the management upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the entire supply chain.

There are several academic arguments as to whether it is reasonable to view the supply chain as a chain structure – pipeline, chain, or network's structure (Lambert and Cooper, 2001; Lamming et al., 2000). Christopher (2016) argued that "demand chain management" would be more appropriate, to reflect the fact that the chain should be driven by the market, not by suppliers. The same author argued that the term "chain" should be replaced by "network" as there will be multiple suppliers and, indeed, suppliers to suppliers as well as multiple customers and customers' customers to be included in the total system.

For Manyika et al. (2012), the new era of supply chain management will be marked by highly agile networked enterprises that use information and analytics as skilfully as they employ talent and machinery to deliver products and services to diverse global markets. Managing supply chain, as stated by Deloitte (2016), integrates diverse sets of ideas, products, and services globally through the lens of highly complex, integrated, and self-morphing resources webs, highly talented skilled people are necessary to use effectively and consistently cutting-edge technology, systems thinking, smart service and processes excellence. The next section discusses some of the trends and uncover the challenges that a volatile world poses to supply chains as well as the mitigating impact of a broader network environment.

## 2.2.2 Supply network structures and tiering

### 2.2.2.1 Network structures

A network structure is a series of strategic alliances that an organisation forms with suppliers, manufacturers, and distributors to produce and market a product (Lysons and Farrington, 2020). Such structures enable an enterprise to bring resources together on a long-term basis, reduce costs and enhance quality without the high expenditure involved in investing in specialised resources, including research and design, and technology or the engagement of managers and operators (Harrison et al., 2019).

Harland (1996) defined a network as a specific type of relationships that connect a set of persons, objects, or events. Ford et al. (2003, p. 18) observed that a network is not a world of individual and isolated transactions. It is the result of complex interactions within and between companies in relationships over time. In the view of Ford et al. (2003), the time dimension of a relationship requires managers to shift their emphasis away from each discrete purchase or sale towards tracking how things unfold in the relationship over time and changing these when appropriate. Network structures allow organisations to bring resources together on a long-term basis to reduce costs, which is why enterprises are increasingly turning to global supply chain networking as a means of gaining access to low-cost overseas inputs. Networks relate to all aspects of the supply chain, including suppliers, design, sourcing, make, delivery, customers, and returns of products.

Supply networks are in effect a complex web of interconnected ‘nodes’ and ‘links.’ The nodes represent the entities or actors such as suppliers, producers, customers, distributors, factories, and service providers. The links are how the nodes are connected – these links may be raw material flows, information flows or financial flows (Harrison et al., 2019). Relationships between actors are like bridges as they give one actor access to the resources and competences of another. Harland (1996) points out that some researchers use the term network to describe a network of actors, while others use it to discuss a network of processes or activities. The study of networks can therefore be related to networks of actors (organisations or individual), activities (or processes) and resources. Harland et al. (2001) differentiates among the components of networks actors, resources, and activities. Actors may range from individuals to groups of companies, but they all aim to increase their control of the network. Actors are defined by the activities they perform; they coordinate resources either alone or jointly. Resources are tangible and intangible assets and human resources. They are owned by actors and are either used in the performance of activities or are the subject of those activities. Activities include those concerned with transformation and those with transaction. Activities use and act on resources and are performed by actors.

The vulnerability of a supply network is determined by the risk of failure of these nodes and links. As there will be different nodes and links, the challenge to supply chain management thus is how to identify which of suppliers are not critical. In other words, how severe would the effect of failure be on the outcome of the entire supply chain. Companies need to be able to identify the critical paths that must be managed and monitored to ensure continuity.

Critical paths are likely to have several attributes: i) such as, long lead-time, which is the time taken to replenish components from order to delivery; ii) A single source of supply with no short-term alternative; iii) dependence on information systems, or transport modes; iv) a high degree of concentration amongst suppliers and customers; v) bottlenecks or ‘pinch points’ where material or product must flow; and vi) high levels of indefinable risk, that is, supply, demand, process, social and environmental issues (Christopher, 2016).

The articulation of supply networks, as an extension of supply chains, seeks to accommodate, and explain the commercial complexity associated with the creation and delivery of goods and services from the source of raw materials to their destination in end-customer markets. Christopher (1992) suggested that the supply network describes a network of connected and interdependent organisations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end user. Put differently, it encompasses the upstream and downstream activity, with a focal firm as the point of reference (Lamming et al., 2000). The next section review some of the classifications of supply networks.

#### 2.2.2.2 Classifications of supply networks

Research on interorganisational networks lacks a comprehensive classification framework (Lamming et al., 2000; Harland et al., 2006). Most studies have tended to focus on different issues rather than investigate a broad set of issues. There is limited works (Miemczyk et al., 2012; Harland et al., 2001; Snow et al., 1992; Lamming et al., 2000; Harland et al., 1996; Craven et al., 1996) that attempt to develop a set of models of supply networks. Hinterhuber and Levin (1994) distinguish among vertical, horizontal, and diagonal networks while also recognised that networks may be internal or external. Internal network firms own most of the assets associated with the business and endeavour to capture entrepreneurial and market benefits without engaging in much outsourcing. Harland et al. (1995) identified four aspects of networks. These include competitive position in networks, definitions of components of networks, network structure, and network performance.

Networks are dynamic (Snow et al., 2000), and differ in terms of degrees of integration (Robertson and Langlois, 1995). In stable networks, assets are owned by several firms but dedicated to a particular business. The suppliers nestle round the prime enterprise, either providing supplies or distributing products. In dynamic networks, there is extensive outsourcing. The leading firm identifies and assembles assets owned by other enterprises on whose core skills it relies. Core skills are research and development, product design and assembly (Snow et al., 2000). In dynamic organisations, key managers create and accumulate resources controlled by outside resources and can therefore be thought of as brokers. Some enterprises purely rely on suppliers and are therefore virtual organisations (Snow et al., 2000). In virtual organisations, an enterprise designs and markets a product but outsources manufacturing to specialist providers and distributors (Snow et al., 2000).

Lamming et al. (2000) suggested that there are three factors driving the way that supply networks should be managed: i) supply networks of "innovative-unique" and "functional product". An innovative product is one with unpredictable demand and a short product life cycle; ii) supply networks of "unique" products – that is, valuable, rare, and difficult to imitate; and iii) supply networks of products with varying degrees of complexity. Campbell and Wilson (1996) distinguished value-creating networks from other forms of networks, such as social networks, bureaucratic and proprietary networks, placing more emphasis on joint creation and the importance of interfirm networks.

Craven et al. (1996) identified four types of networks – flexible, hollow, virtual, and value-added – according to the dimensions of volatility of environmental changes and the type of interorganisational relationship involved (collaborative or transactional) relationships. Transactional linkages mean discrete exchanges of value where a major issue is price, typified in the economics model of buyer-seller relationships. Transactional links are most likely to occur between partners that do not require collaboration. Collaborative links involve various forms of inter-organisational cooperation and partnering, including the development of strategic alliances and joint ventures. It also considerate interactions between organisations to achieve common objectives; continuing relationships between the partners that are likely to involve strategic alliances as a networking method. Craven et al. (1996) recognised the variations in market structure, technological complexity, core competency of the coordinating organisation, and the network members core competency, in each of the four types of networks. While these studies provide useful classification of networks, it appears that there is little guidance on what type of supply network is appropriate for situations.

In order to resolve this issue, Harland et al. (2001) proposed a model for classifying networks based on a matrix of supply network in accordance with two aspects - the degree of focal firm supply network influence and the degree of supply network dynamics. Harland et at (2001) further provides a taxonomy of supplier networks based four dimensions, which can be listed as follows: i) dynamic/low degree of focal firm influence; ii) dynamic/high degree of focal firm influence; iii) routinized/low degree of focal firm influence; and iv) routinized/high degree of focal firm influence.

Christopher (2005) advocated that the development of supply networks requires respond to three major challenges:

- Collective strategy development – the organisations in a supply chain must work together, as part of a marketing network, and must develop strategies that are in the best interest of the network, and not just each individual organisation.
- Win-win thinking – the organisations need to "break free of the often-adversarial nature of buyer-supplier relationships' that have existed in the past. While win-win means that benefits of the improved performance should be shared among the members of the network.
- Open communication – supply chain companies must share information in order for the network to become innovative, flexible and agile. This includes information about costs, quality, delivery, and sustainability data. Information can no longer be thought of as flowing only "upstream" in the supply chain.

There are several reasons why supply chain is regarded as networks. These include: i) organisations are more likely to take a view across the supply chain when formulating strategy, and not just concentrating on first-tier suppliers and customers; ii) they should become more responsive and innovative, as the supply chain is better informed and can adapt in a consistent manner; iii) throughput times will be shortened, leading to a reduction in inventory levels throughout the chain and subsequent improvement in cash flow and margins; and iv) inter-organisation relationships are more likely to be beneficial, leading to improved sustainable competitiveness (Choi et al., 2001; Christopher, 2016; Harrison et al., 2019; Lysons and Farrington, 2020).

#### 2.2.2.3 Tiering

Critics of the supply chain concept (New and Ramsay, 1997) contented that focusing on supply chains alone do not capture the complexities of networks (Choi and Wu, 2009). Unlike traditional supply chain, the simplest form of supply network is a three-tiering system also called a "triad" (Sarkis et al., 2019). A triad can be represented by a focal organisation, its supplier level, and its customer level. Even though, the use of "triads" which may be a network does not have a linear set of tiering, which include open, transitional, and closed triads, which represent lessened to greater interactions amongst various tiers of the supply chain (Sarkis et al., 2019).

Mena et al. (2013, p. 61) developed a set of three basic supply network structures in buyer–supplier – sub-supplier triads. These network structures include i) the open triad, which represents a traditional supply chain where information and product flows are linear, and there is no direct connection between the buyer and the supplier's supplier, given that the supplier in the middle; ii) the closed structure that occurs when the buyer and the supplier's supplier have established a formal link and are directly connected. This suggests that companies have regular contact with each other, share information through regular interaction; and iii) the transitional structure is where buyer and the supplier's supplier stretch out to each other and being building a link and initiating a move toward a closed structure (Mena et al., 2013).

A basic supply network involves a focal firm, tier 1, tier 2, and tier 3 suppliers or customers. A focal firm is shown at the centre of the many possible connections with other suppliers and customers (see Figure 2.1). The focal firm is embedded within the chain, and its internal processes must coordinate with others that are part of the same chain. Materials flow from upstream to downstream. The supply chain is tiered, in that inbound and outbound can be organised into groups of partners. Such that if organisations place an assembler, inbound logistics comprises of Tier 1 suppliers of major parts and subassemblies that deliver directly to focal firm. Tier 2 suppliers deliver to tier 1, but do not sell directly to focal firm. The term tier 3 suppliers refer to suppliers of raw materials. Outbound logistics covers the supply by the plant to sales companies as tier 1 customers, which in turn supply to main dealers at tier 2, among others. Internal operations cover the planning and control of parts movements within the plant. The aim of supply chain management is to integrate inbound, outbound, and internal logistics into a seamless whole, focused on meeting end-customer need with no waste.

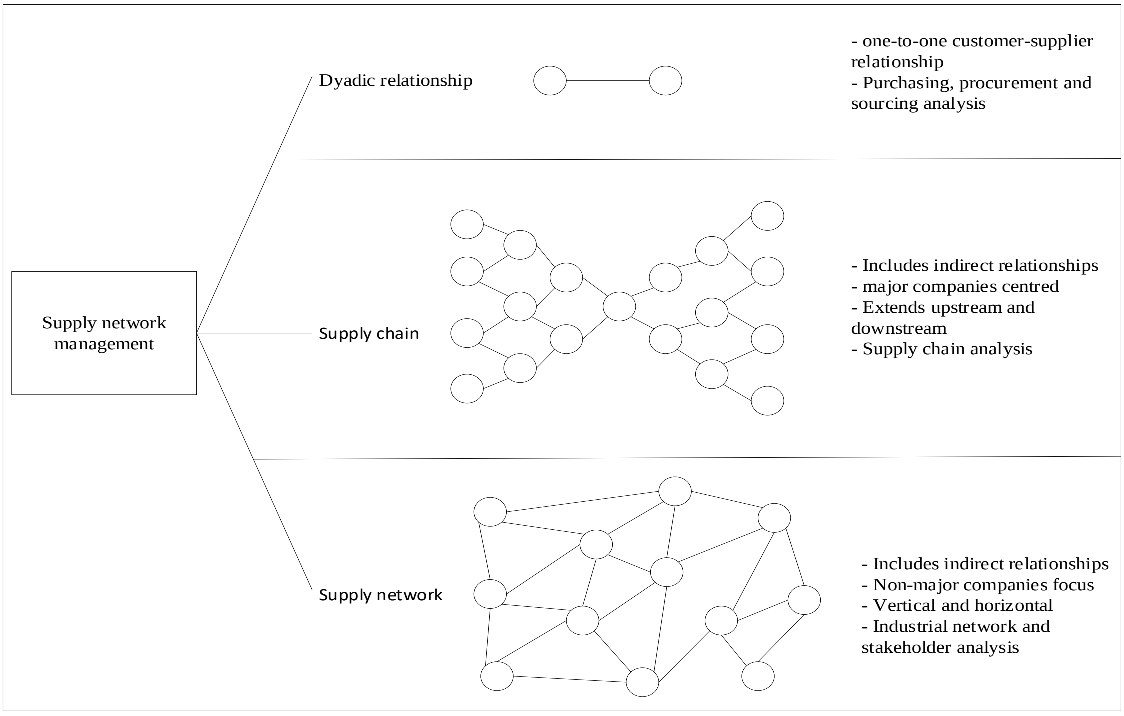


**Figure 2.1** The three levels of supply network (source: Miemczyk et al., 2012)

Lamming et al. (2000) showed that tiers may form for different reasons. Firstly, because the assembler may require first-tier suppliers to integrate diverse technologies one possessed by one organisation. Secondly, components required for systems will be specialised and, thus, made by a small number of firms, in large quantities, so it is sensible for first-tier suppliers to buy these from specialist makers. Lastly, the third level of subcontracted work covers simple, low value-added items required by first-tier and second-tier suppliers.

First-tier suppliers are direct suppliers, making high-cost, complicated assemblies. They are empowered to relay the assembler's standards to second-tier or indirect suppliers and are responsible for large number of second-tier suppliers. The responsibilities of first-tier suppliers as identified by Lamming et al. (2000) include: research and development, especially relating to technologies that are being applied to the assembler's product for the first time; management of second tier and lower-tier suppliers, including integration undertaken by the assembly; true just-in-time (JIT) supply; customer-dedicated staff who work in association with the design and production functions of the assembler; and warranties and customer claims.

#### 2.2.2.4 Some consequences of tiering

The key word at all levels of tiering levels is collaboration as much of the competitive advantage required for agility derives from the ability to deal with sub-contractors as collaborators or partners. Where tiering is carried out for either the first or second reasons stated above, the relationship between the two suppliers becomes more akin to a strategic joint venture than a procurement link. The product technology resides in both firms, so the first-tier supplier would find it just as difficult to replace the specialist second-tier supplier as vice versa. In this situation, the suppliers may even set up special companies to conduct busines as joint ventures.

It thus can be seen that the study of networks may be related to networks of actors (organisations), activities or processes and resources. Examining all these types of networks is crucial. To this point, most of the research into supply networks has focused on buyer-supplier's relationships (Wu et al., 2010; Choi and Wu, 2009). Some studies, like Rossetti and Choi (2005, 2008) explained the process of disintegration in which the supplier's supplier cuts out the wholesaler and reaches directly to the consumer. Li and Choi (2009) argued that the case of outsourcing can only be understood when considering the dynamic collaborations among the buyer, supplier, and buyer's customers. Phillips et al. (1998) considered the manufacturer-dealer-customer relationships within marketing channels. Hingley (2005) looked at triads in the UK industry and developed supply network models. The key issue now is how to consider a broader multi-tier network with complex interactions models (Sarkis et al., 2019).

In short, a responsive and innovative organisation will have agile alliances with circular or closed-loop supply chain partners and will work with them to aligned processes across the extended enterprise. It will also be close to its customers, capturing information on real-time demand and sharing that information with its partners across the network. Broadly, the benefit of supply networks, thus, includes its ability to quickly adapt to changing business environment through developing cross-sector collaboration (Christopher, 2016). Hence, the responsive business will seek to marry the sustainable or lean practices with agile paradigm through de-coupling its upstream and downstream processes, using principles of postponement. What follows is an account of supply network risk management.

### 2.2.3 Managing supply chain risks

Following Christopher (2016), supply chain risk is an exposure to serious disturbance, arising from risks inside the supply chain as well as outside the supply chain. Internal risks are those attributable to interactions between organisations in the supply chain. External risks, on the other hand, are those attributed to environmental, economic, political, and social causes, such as storms, earthquakes, terrorism, strikes, wars, and pandemic. Lyson and Farrington (2020) and Christopher (2016) identified many categories of supply chain risks. These are:

- lack of ownership due to the blurring of boundaries between buying and selling organisations arising from factors such as outsourcing and the creation of complicated networks of business relationships with confused lines of responsibilities.
- Chaos risks due to mistrust and distorted information throughout the supply chain.
- Decision risks due to chaos that make it impossible to make the right decision for entities within the supply chain.
- Just-in-time relationship risks because an enterprise has little capacity to cater for disruptions in the supply chain due to later deliveries, such as transportation breakdowns.
- Inertia risks due to lack of responsiveness by customers or suppliers to changing environmental conditions and market signals with consequential inability to react to competition moves or market opportunities.
- Globalisation of supply chains, in which advantages of sourcing abroad may be offset by extended lead time, transportation difficulties, and political events.
- The reduction of supplier base, especially single sourcing in which an enterprise is dependent on one supplier
- Acquisitions, mergers, and similar alliances that may reduce supply chain availability.

Chopra and Sodhi (2004, 2014) classified supply chain risks into different categories, along with the drivers of these risks. They also identified several risk mitigation strategies, such as the adoption of resilience and responsiveness, which can work at cross sectors. Other scholars categorised these risks into two types (Kleindorfer and Saad 2005). It is not only uncertainty about the demand that is the problem but also uncertainty about supply. Supply uncertainty may originate from material/product shortages, fluctuating commodity price, supplier disruptions, the failure of a suppliers' business, among others. At the same time, the vulnerability of supply chains to disruption and disturbance has increased, it is not only the effect of external factors such as natural disasters, pandemics, strikes, or terrorist attracts but also the impact of changes in business strategies. In the similar vein, Harland (1996) discussed six business trends. The trends are:

- a reported increasing incidence of vertical disintegration
- implementation of supplier-base reduction programmes
- focusing on operations
- outsourcing
- just-in-time approach, and
- the increasing popularity of partnering and strategic alliances.

Christopher (2016) observed that supply chain risk management starts with the identification and assessment of risks and their impact on operations. To assess risk exposure, the company must identify not only direct risks to its operations, but also the potential causes of those risks throughout the supply chain. Christopher (2016) suggests seven-step strategies. These are:

- understanding the supply chain
- improve the suppliers
- identify the critical paths (nodes and links)
- managing the critical paths
- improve network visibility
- establish a supply chain continuity team
- work with suppliers and customers to improve supply chain risk management procedures.

Lyson and Farrington (2020) listed ten ways in which to manage supply chain risk. The first three of these measures run counter to current supply chain trends:

- diversification – multiple sourcing
- stockpiling – use of inventory as a buffer against all eventualities
- redundancy – maintaining excess production, storage, handling and transport capacity
- insurance – against losses caused by supply chain disruption
- supplier selection – more careful assessment of supplier capability and risks of dealing with suppliers
- supplier development – working closely with suppliers, sharing information and collaboration initiatives
- contractual obligation – imposing legal obligations with stiff penalties for non-delivery

- collaborative initiatives – spreading risk among grouped companies
- rationalisation of the product range – companies may wish to exclude product with supply problems from their product range
- localised sourcing – reduction of risks arising from congested transport networks or intermodal transport transfer by shortening transport distances.

Faisal et al. (2006) lists many enablers to mitigate supply chain risk, including information sharing; supply chain agility; trust; collaborative relationships, among others. Likewise, Tomlin (2006) gives dissimilarities between mitigation methods, which are taken in advance of a disruption and contingency procedures or response strategies, which are only implemented in the event of a disruption. The use of supply chain resilience was viewed as a mitigation approach that provides, for possible rerouting of service providers following disruption (Tomlin, 2006). The pursuit of resilience, lean, agility and responsiveness have been mentioned as a key component in mitigating disruption risks. These themes are often used interchangeably.

### 2.2.4 Supply chain strategies

Lee (2004) described supply chain strategies as a set of targets manufacturing enterprises wants to achieve through adopting certain decisions. These strategies must be aligned with business strategies, as a pre-requisite for managing complexity in supply chains (Christopher, 2016). Supply chain strategies must be responsive to customer requirements and in that sense, organisations need to develop sustainable strategies, offering services to the customers with speedy responses, suited to the customer, quality, and relationship, which are critical factor for winning customer order or improving operations efficiency and/or better supply chain success (Hines, 2004, 2013).

In the operations and supply chain strategy literature, two core elements are central to the definition of supply chain strategy: strategic choices and the order winners (OW)/order qualifiers (OQ) that provide the link between business strategy and manufacturing strategy (Hill and Hill, 2018; Ciccullo et al., 2020; Godsell et al., 2011). Hill (2020) observed that the strategic choice is concerned with decisions about facilities, technology, ways of integration, capacity, ways of organisations, quality management, workforce policies, capacity, and information systems. In the context of oil and gas sectors, Bresciani and Brinkman (2016) classify five strategies that can transform the oil and gas supply chains. These categories include decisions about cost-cutting, integration, new revenue models; consolidation; and the use of new technology and service models.

Order qualifiers are those factors that are required to accomplish market task (Godsell et al., 2011), or the baseline to enter a competitive environment (Christopher, 2000). That is, Order qualifiers concerned with capabilities a market unit must have to compete given the overall supply chain strategy. Order winners are key factors that allows a company to win orders in the market (Godsell et al., 2011; Hill, 2020). Several researchers recognised cost efficiency, quality, delivery reliability, responsiveness, flexibility, innovation as dimensions of competitive capabilities (Godsell et al., 2011; Hines, 2013; Hill, 2020). The dimensions have also been articulated in terms of the dynamics of customer values – based on service – the ability to deliver different quantities of goods through managing capacity strategically (Hine, 2013).

A natural extension for the concept of order qualifiers and winners was in the domain of supply chain strategy (Ciccullo et al., 2020; Christopher and Towill, 2000; Mason-Jones et al., 2000). Christopher and Towill (2001) emphasised that researchers can borrow from these important ideas to develop a wider supply chain-oriented concept of market qualifiers and market winners. The notion here is that to be truly competitive requires not just the application of competitive strategy, but rather an appropriate holistic supply chain strategy is required. An important aspect that has not been considered in the studies is the emergence of agility and sustainability paradigms as new competitive capabilities (Zhang and Sharifi, 2007; Ciccullo et al., 2020). The juxtaposition of lean and agile supply chain strategies was formalised by Naylor et al. (1999). Mason-Jones et al. (2000) further developed this concept by associating different marker winners and market qualifiers to lean strategy and agile strategy. This classification gained broad acceptance in the lean-agile community (Narasimhan et al., 2006; Christopher and Towill, 2001; Aitken et al., 2005). It indicated the start of the lean-agile school of supply chain strategy.

Today, social and environmental sustainability strategies acts more as market qualifiers, but with the greater public interest and concern regarding the themes of sustainability in different fields, about sustainability challenges facing planet, amongst other factors, several researchers asserted companies will face the situation of regarding their current strategic orientation to be shifted towards considering sustainable strategies as important source of competitive capabilities (Longoni and Cagliano, 2015; Jabbour et al., 2012; Porter and Kramer, 2006; de Burgos Jimenez and Cespedes Lorente, 2001). Each of this supply chain strategy is explore in more detail in the following sections.

## 2.3 Supply chain agility

Previous sections looked at supply chain management as a key source of competitive advantage. The problem of achieving sustainability is even intensified amongst smaller businesses (Koh et al., 2017) because they often face the challenge of insufficient competencies and expertise. In such circumstance, it is no longer enough for supply chain companies to manage sustainability issues (Sarkis et al., 2019). It becomes necessary for companies to build agile supply chain capabilities to adapt quickly to unexpected changes in their business environments.

More so, the increases in market competition, fast technology shift, changes in sustainability regulations, and consumers pull for personalised products, whose requirements are difficult for individual companies, further presents the biggest challenge for supply chain sustainability. In dynamic environment, agile alliance partners will perform well because the partners can detect and respond quickly to changing market situations. Here supply chain agility is viewed as both stable and dynamic capabilities that, according to Gligor et al. (2016), reflect higher-order capabilities or complex bundles of capabilities that purposefully transform competencies to address swiftly changing market requirements. This section presents and discusses different definitions of agility and agile supply chain, and then identify various drivers, attributes, and enablers of agile supply chain capabilities.

### 2.3.1 The concept of agility

The term ‘agile manufacturing’ was first used by a group of researchers at Iacocca Institute, Lehigh University, in 1991 to describe the practices observed as important aspects of manufacturing system (Ren et al., 2003). Goldman et al. (1995) defined agility and developed four dimensions of agility, including delivering value to the customers, being ready for change, valuing human knowledge and skills, and forming virtual partnerships. Mathiyakalan et al. (2005) argued that agility is a capability of firms to detect changes in its business environment and reconfigure its resources, processes, and strategies to rapid responses to a changing environment. In line with Naylor (1999), agility involves using market knowledge and collaboration to exploit profitable opportunities in a volatile marketplace.

Organisation theorists have used the term strategic agility to describe the capacity to continuously adjust and adapt strategic direction in a core business to create value for a company (Doz and Kosonen, 2008). Weber and Tarba (2014) defined it as the ability to remain flexible in the face of new developments, to continuously adjust the business's strategies, and develop innovative ways to create value. Worley et al. (2014) outlined agility as the capability to make timely, effective, sustained organisational change. It is a repeatable organisational capability (Worley et al., 2014). In the same vein, Teece et al. (2016) referred to agility as the capacity of an organisation to redeploy/redirect resource base efficiently and effectively for value creating and value protecting and capturing higher-yield activities as internal and external circumstances warrant.

Strategic agility involves a set of actions taken by the organisation that operates in an environment characterised by rapid and unpredictable change. Sharifi and Zhang (1999, 2001) maintained that the concept of agility comprises the ability to deal with unexpected challenges, to survive unpredictable threats in the business environment, to exploit changes and take advantage of changes as opportunities. Kidd (2000) built on the overview and acknowledged that an agile enterprise is a fast moving, adaptable and robust business. It is capable of rapid adaptation in response to unexpected and unpredictable changes and events, market opportunities, and customer requirements. Such a business is founded on processes and structures that facilities speed, adaptation, and robustness and that deliver a coordinated enterprise that can achieve competitive performance in a highly dynamic and unpredictable business environment that is unsuited to current enterprise practices (Kidd (2000).

Agile organisations are those that adjust to disruptive environments. Agility requires changes that are different from other regular and routine types of changes. The changes that result from strategic agility are specified as continuous, systematic variations in an organisation's products, processes, services, and structures (Tallon and Pinsonneault, 2011). The intensity and variety of these changes are high, thus agile organisations are those that demonstrate high flexibility (Mohrman and Worley, 2009). The speed of responsiveness is needed to read the environmental changes and adequately respond (Weber and Tarba, 2014). Strategic agility requires a significant investment of resources to maintain the high levels of flexibility and speed necessary to be able to respond to sudden environmental threats and opportunities.

While the concept of strategic agility has received increasing attention, it has neither received consistent treatment nor clear articulation of its effects on overall sustainability performance (Weber and Barba, 2014). Rather, agility has remained an elusive term with many authors offering their definitions of the model across various situations. Some common themes have emerged over the years. Table 2.1 provides an overview of various highlighted definitions considered for agility, emphasising how it fits with volatile business environment.

**Table 2.1** An overview of agility definitions

| Sources | Definitions of agility and agile supply chain |
|---|---|
| Goldman et al. (1995, p. 3) | Agility is a comprehensive response to the challenges posed by a business environment dominated by change and uncertainty. |
| Sharifi and Zhang (1999) | Agility involves responding to unexpected changes, exploiting changes, and taking advantage of changes as opportunities. |
| Gunasekaran et al. (1999, p. 87) | Agility is the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services. |
| Narasimhan and Das (1999) | Agility is required when demand is volatile and the customer requirements for variety is high. |
| Naylor et al. (1999, p. 108) | Agility means using market knowledge and a virtual partnership to exploit profitable opportunities in a volatile market. |
| Yusuf et al. (1999, p. 37) | Agility is the successful exploitation of competitive bases (such as quality, flexibility, speed, innovation, proactivity, and profitability) through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast-changing market environment. |
| Christopher (2000, p. 39) | Agility is the ability of an organisation to respond rapidly to changes in demand both in terms of volume and variety. |
| Mason-Jones et al. (2000) | Agility is the use of market knowledge and virtual organisation to take advantage of opportunities in an unpredictable market. |
| Rigby et al (2000) | Agility is the ability for an organisation to prosper in a changing, unpredictable environment. |
| Van Hoek et al (2001) | Agility is a crucial element for dealing with market turbulence. A management concept centred around responsiveness to dynamic and turbulent markets and customer demands. |
| Zhang and Sharifi (2000) | Ability for an enterprise to deal with unanticipated change and to survive unanticipated business environmental threats whilst at the same time taking advantage of opportunities. |
| Sanchez and Nagi (2001) | Agility is a strategy based upon organisations prospering in volatile and changing environments and their subsequent response. |
| Menor et al. (2001) | Agility is the ability of a firm to excel simultaneously on operations capabilities of quality, delivery, flexibility, and cost in coordinated fashion. |
| Stratton and Warburton (2003) | The agile paradigm focuses on the need to deliver a variety of products with uncertain demand. |
| Stratton and Warburton (2003, p. 184) | The agile paradigm focuses on the need to deliver a variety of products with uncertain demand. |
| Brown. and Bessant (2003) | Agility involves the ability to respond quickly and effectively to changes in market demand. |

| | |
|---|---|
| Sambamurthy et al. (2003) | Agility is the ability of firms to redesign their existing processes rapidly and create new processes in a timely fashion to be able to take advantage to thrive on the unpredictable and highly dynamic market conditions. |
| Yusuf et al. (2004) | Agility is the use of market knowledge and a virtual partnership to profit in a volatile market. |
| Highsmith (2004) | Agility is the ability to create and react to change in an unsettled business environment. |
| Mathiyake et al. (2005) | Ability of an organisation to detect changes (while can be opportunities or threats or a combination of both) in its business environment and hence providing focused and rapid responses to its customers and stakeholders by reconfiguring it resources, processes, and strategies. |
| Storey et al. (2005) | Agility involves changes in the interlinked operations design, production, marketing, and organisation. |
| Rachke and David (2005) | Agility is the ability of a firm to dynamically modify and/or reconfigure business processes to accommodate required and potential needs. |
| Swafford et al. (2006) | Supply chain agility is the capability to respond in a speedy and timely manner to a changing marketplace environment. |
| Ismail and Sharifi (2006, p. 431) | Supply chain agility is the ability of the supply chain as a whole and its members to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network. |
| Zhang. and Sharifi (2007) | Agility centres on being able to compete and prosper within a state of dynamic change. |
| Vázquez-Bustelo et al. (2007) | Agility means the ability of supply chain to swiftly align the network and its operations function to adapt to turbulent requirement of the demand network. |
| Narasimhan et al. (2006, p. 443) | Agility conveys the ability to efficiently change operating states in response to uncertainty and changing market conditions. |
| Jain et al. (2008) | Agility is related to organisations creating pioneering products, operating in markets with high volatility, uncertainty, short life cycles and changeable supplies. |
| Swafford et al. (2008) | Agility is derived from three building blocks of relevancy, accommodation, and flexibility. Relevancy is the ability to maintain focus on the changing needs of customers; accommodation is the ability to respond to unique customer request. |
| Braunscheidel and Suresh (2009) | Agility involves the capability of the firm, internally, and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to a changing marketplace, contributing to agility of the extended supply chain. |
| Bernardes and Hanna (2009, p.37) | Agility is a manufacturing paradigm, which focuses on the ability to change the configuration of a system in response to unpredicted and changing market conditions, |
| Amir (2011) | Agility encompasses the need to respond efficiently to turbulent markets to meet changing customer demand volumes. |
| Yauch (2011) | Agility refers to the supply chain successes in competitive and turbulent markets. |
| Gligor and Holcomb (2012, p. 295). | Agility is the ability to thrive and prosper in a competitive environment of continuous and unanticipated change. |
| Hasani et al. (2012) | Agility is the ability to meet shifting customer demands through faster product design, manufacturing, and distribution with lower costs. |
| Pan and Nagi (2013) | Agility is the ability to work in a competitive, changing, and uncertain market environment. |
| Abbasi et al. (2014) | Agility requires the creation of alliances to respond to customer needs with quality products more quickly and at lower costs. |
| Eckstein et al. (2015) | Agility refers to the ability of the firm to sense short-term, temporary changes in the supply chain and market environment (e.g., demand fluctuations, supply disruptions, changes in suppliers' delivery times), and to rapidly and flexibly respond to those changes with the existing supply chain (i.e., reducing replacement times of materials, reducing manufacturing throughput times, adjusting delivery capabilities. |
| Tse et al. (2016) | Agility involves a firm's ability to transform the threats of market uncertainty and supply chain disruption into competitive opportunities by increasing visibility in materials and demand levels and satisfy various customer need with speed and flexibility. |
| Aslam et al. (2018) | Agility involves the ability of supply chains to rapidly respond to short-term changes in demand and adjust to long-term market changes. |

These definitions depicted enterprise agility as dynamic, context-specific, change-embracing, and growth-oriented (Goldman et al., 1995). When there is deep uncertainty, agility is a valuable organisational attribute. Understanding agility requires overall framework (Teece et a., 2016). Considering agility as dynamic supply chain capabilities will help organisations make high-quality decisions quickly and will help better understand the issues facing management in the innovation market (Aslam et al., 2020). Agility is also considered as context-specific because the business environment influences the level of agility requirement. It is change-embracing because it provides the impetus to adaptation. Lastly, agility is growth-oriented through the ability of organisations to restructuring vision, reengineering processes, regenerating strategies, and reinventing techniques, which are paths towards competitive success (Prahalad and Hamel, 1994).

### 2.3.2 The emergence of supply chain agility

The concept of agile supply chains was introduced (Harrison et al., 1999) to transfer the winning strategy of agility to supply chains as new base business competitiveness (Ismail and Sharifi, 2006). The concept of the agile supply chain is advocated as a new way forward for business networks to succeed in the highly changing and turbulent business environments (Sharifi et al., 2006). The focus is in running businesses as network structures with adequate level of agility to effectively adapt to changes, and proactively changes and seek emerging opportunities (Sharifi et al., 2006). Indeed, a key to agile response is the presence of agile partners upstream and downstream of the focal firm (Christopher, 2016). While organisations may have internal processes that are capable of rapid response, their agility will still be constrained if they face long replenishment lead times from suppliers. Since supplier agility is one of the main requirements in the creation of a more supply chain responsiveness, it is surprising that some businesses have few collaborative programmes with suppliers

(Christopher and Towill, 2000). The drivers behind the need for agility in supply chains are similar to those that drove the introduction of agility concepts and stem from the rate of change and uncertainties in the business environment (Sharifi et al., 2006). The operations dynamics of the extended supply chains contribute further to uncertainties in the business environment and hence the vulnerability of the supply chain to change (Svensson, 2000). These conditions have led to the slow success of integrated supply chains (Ismail and Sharifi, 2006).

Unlike the traditional supply chain, agile supply chains are those with the ability to rapidly align and realign network and its operations to the dynamic and turbulent requirements of the demand market (Sharifi et al., 2006). Supply chain agility is a network of teams operating in rapid learning and fast decision cycles, which are facilitated by technology, and that is guided by a powerful common purpose to co-create value for all stakeholders (McKinsey, 2018). Such agile operating models can quickly align and realign strategies, structures, people, processes, and technology while working with customers and suppliers (Serrador and Pinto, 2015**)** towards value-creating opportunities. Agile supply chains, thus, combine visibility, velocity and adaptability with stability and efficiency (Christopher 2016), creating a critical source of sustainable competitiveness in a volatile, uncertain, complex, and ambiguous business environment. Here, to reach visibility, companies rely on information sharing with supply chain partners. Superior visibility helps capture customer needs and timely communicating orders alongside suppliers. Whereas velocity refers to the speed of data processing or adaptability to changes (Christopher et al., 2004).

Agile supply chain paradigms have been extensively researched and linked to superior organisational performance. Literature, such as Eckstein et al. (2015) looked at the effects of supply chain agility and adaptability on cost performance and operational performance. Eckstein et al. (2015) found that supply chain agility and adaptability have a positive effect on both cost and operational performance. They further showed evidence for the mediating role of supply chain agility in the links between supply chain adaptability and performance. Blome et al. (2013) examine the fundamental building blocks of supply chain agility. Gligor et al. (2016) argued that market orientation has a direct impact on firm supply chain agility. But it is not enough to be market-oriented to achieve a high level of supply chain agility; instead, a strategic supplier's alignment is critical. Aslam et al. (2018) concurs with this view, showing that market-sensing capability is a source of supply chain agility. More so, supply chain agility, directly, and supply chain adaptability, indirectly, affect supply chain ambidexterity. Supply chain agility, hence, mediates the link between supply chain adaptability and ambidexterity. Whilst there is a clear indication that agile supply chain paradigms have a positive and direct influence on financial measures and operational performance (Eckstein et al., 2015; Blome et al., 2013; Yusuf et al., 2014; Tse et al., 2016; and de Groote and Marx, 2013). But the effect of agile approaches on sustainability performance required examination and clarification, despite the value of the agile supply chain paradigm for operations competitive performance **(**Gligor et al., 2016**)**. These studies stressed the importance of supply chain agility. Ciccullo et al. (2018) have suggested a lack of conceptual and empirical studies on the importance of agile supply chain practices for enhancing sustainability performance. This thesis wants to address the gap. There are other significant contributions on the modelling side. Studies such as Vinodh et al. (2010) designed an agility index measurement using a multi-grade fuzzy approach. Vinodh et al. (2011) further provide decision support for the evaluation of agility in the supply chain using fuzzy association rules mining. Table 2.2 summaries some of the earlier works on supply chain agility. In order to understand supply chain agility, it is essential to understand the roles of its drivers and enablers (Carvalho et al., 2018). The next section gives more detailed account of different drivers, attributes, and enablers of agile supply capabilities.

**Table 2.2** Illustrative literature review of empirical supply chain agility

| Study | Primary methodology | Study aim | Focus | Independent/ Dependent variables | SCA construct | Theory | Contribution |
|---|---|---|---|---|---|---|---|
| Naylor et al. (1999) | Conceptual and single case study | Understanding leanness and agility relationships | SCA | n.a. | n.a. | None | The research suggests that total supply chain strategy must consider market knowledge and a decoupling point to achieve agility. |
| Christopher (2000) | Conceptual | Development of a supply chain agility concept | Definition and antecedents of SCA | n.a. | Virtual, market sensitive, process integration, network based | None | The research provides a better understanding of a supply chain agility construct, how it is different from lean and which dimensions represent supply chain agility. |
| Mason-Jones et al. (2000) | Multiple case study | Introducing the leagile paradigm to match supply chains and marketplace | SCA | n.a. | n.a. | None | The research provides details on how firms combine leanness and agility in different marketplaces. |
| Prater et al. (2001) | Conceptual and multiple case study | Developing an SCA concept which combines uncertainty and agility | SCA | IV: External vulnerability, sourcing flexibility and speed, manufacturing flexibility and speed, delivery flexibility and speed; DV: SCA | n.a. | None | The research shows the close relation of agility and uncertainty, and the necessity to manage these jointly. |
| van Hoek et al. (2001) | Conceptual | Development of an SCA audit | SCA | n.a. | Customer sensitivity, virtual integration, process integration, network integration, measurement | None | The research provides insights which methods and tools can help the fostering of SCA. |
| Aitken et al. (2002) | Conceptual and case study | Development of an SCA enabling concept | Antecedents of SCA | IV: Principles, programmes and action variables; DV: SCA | n.a. | None | The research establishes a comprehensive SCA enabling concept based on the levels of principles, programmes and actions. |
| Mason et al. (2002) | Conceptual | Understanding the effect of outsourcing on SCA | Antecedents of SCA | n.a. | n.a. | None | The research develops a conceptual model to understand the impact of outsourcing on SCA. |

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|---|---|---|---|---|---|---|---|
| Xu et al. (2003) | Conceptual | Development of a system for enhancing supply chain agility through exception handling | Antecedents of SCA | n.a. | n.a. | None | The research develops a practice-oriented methodology to increase agility through exception handling routines. |
| Giachetti et al. (2003) | Conceptual | Development of a measurement framework for agility | Analysis of different agility measurements | n.a. | n.a. | Relational measurement theory | The research provides a comprehensive analysis of existing agility measurement methods. |
| Yusuf et al. (2004) | Survey | Investigating SCA capabilities and competitive objectives | Antecedents and outcomes | n.a. | n.a. | None | The research shows how diverse supply chain capabilities are related to each other and competitive priorities. |
| White et al. (2005) | Single case study | Explanation of how information systems enable SCA | Antecedents of SCA | n.a. | SCA measured by time taken to respond to a customer order | None | The research suggests that information technology and systems might help to increase SCA. |
| Shaw et al. (2005) | Multiple case study | Exploring key asset capabilities for agility in the process industry | Antecedents of SCA | n.a. | n.a. | None | The research adapts the SCA concept to the pro- cess industry. |
| Collin and Lorenzen (2006) | Single case study | Exploring the effect of demand planning on SCA | Antecedents of SCA | n.a. | n.a. | None | The research provides an analysis of the impact of different planning and forecasting concepts on SCA by investigating Nokia Networks, showing that supply chain agility needs continuous planning. |
| Goldsby et al. (2006) | Simulation | Understanding lean, agile and leagile supply chain strategies and their trade-offs | SCA | n.a. | n.a. | None | The research shows that lean, agile, and leagile supply chain strategies can outperform other strategies based on contingencies. |
| Lin et al. (2006) | Multi-criteria decision-making model with fuzzy logic | Development of a fuzzy agility index | Antecedents of SCA | IV: collaborative relationships, process integration, information integration, customer/ marketing sensitivity; DV: SCA | Responsiveness, competency, flexibility, quickness | Fuzzy set theory | The research provides an agility index which has been tested positively in a Taiwanese context for efficacy. |

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| Narasimhan et al. (2006) | Survey | Understanding leanness and agility relationships | SCA | n.a. | n.a. | None | The research demonstrates that he pursuit of agility might presume leanness, but the pursuit of leanness might not presume agility. |
| Swafford et al. (2006) | Survey | Explanation of the effect of supply chain process flexibilities on SCA and development of a measurement model | Antecedents of SCA | IV: Procurement/sourcing flexibility, manufacturing flexibility, distribution/logistics flexibility; DV: SCA | SCA measured by 10 items related to capacity and service-related items | RBV | The research shows that SCA is directly affected by manufacturing and procurement process flexibility, and only indirectly affected by logistics process flexibility. |
| Ismail et al. (2007) | Conceptual | Development of an SCA model based on supply chain design and the design for supply chains | Antecedents of SCA | IV: Market, contingencies, market and product strategy, supply chain classification, power and relationship, supply chain strategy; DV: SCA | n.a. | None | The research combines supply chain design and design for supply chains to enable SCA. |
| Agarwal et al. (2007) | Interpretive structural modelling | Examining inter-relationships of the variables influencing SCA | SCA | IV: Customer satisfaction, quality improvement, cost minimisation, delivery speed, new product introduction, service level improvement, and lead-time reduction; DV: SCA | n.a. | None | The research shows that SCA depends on customer satisfaction, quality improvement, cost minimisation, delivery speed, new product introduction, service level improvement, and lead-time reduction. |
| Jain et al. (2008) | Fuzzy intelligent agent-based approach | Modelling agility by a dynamic agility level index through fuzzy intelligent agents | SCA | IV: Integration, change, competence, partnership, welfare; DV: Agility | Flexibility, profitability, quality, innovation, pro-activity, speed of response, cost, robustness | None | The research provides a comprehensive measurement system for SCA. |
| Li et al. (2008) | Conceptual and literature review | Development of a theoretical model to analyse links of SCA and competitiveness | n.a. | n.a. | n.a. | Knowledge based view, dynamic capabilities, social learning theory | The research provides a theory-driven, comprehensive framework for SCA. |
| Swafford et al. (2008) | Survey | Investigating the effect of supply chain flexibility and IT integration on SCA | Antecedents, performance | IV: Information technology integration, supply chain flexibility; DV: SCA, business performance | Eight speed related items. | None | The research found a domino effect among IT integration, supply chain flexibility, supply chain agility, and competitive business performance. |

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| Khan and Pillania (2008) | Survey | Exploration of effects of strategic sourcing, SCA and performance | Antecedents of SCA | IV: Strategic supplier partnership, sourcing flexibility, supplier evaluation, trust in members of supply chain; DV: SCA | Agility in demand management and distribution, agility in manufacturing and customisation | None | The research shows the significant effect of strategic sourcing on SCA and firm performance. |
| Braunscheidel and Suresh (2009) | Survey | Explanation of cultural aspects and the impact of organisational practices on SCA | Antecedents of SCA | IV: Market orientation, learning orientation, internal integration, external integration, external flexibility; DV: SCA | Joint planning, demand response, visibility, customer responsiveness | None | The research shows that market and learning orientation affect internal and external integration as well as external flexibility which affect SCA. |
| Kisperska-Moron and Swierczek (2009) | Survey | Exploring agile capabilities of Polish firms | Antecedents of SCA | n.a. | n.a. | None | The research identifies four clusters of agile firms in a Polish context. |
| Wu and Barnes (2010) | Multi-criteria decision-making model | Development of supplier selection criteria for SCA | Supplier selection for SCA | n.a. | n.a. | Dempster–Shafer theory | The research formulates practical supplier selection criteria for selecting SCA enabling suppliers. |
| Vickery et al. (2010) | Survey | Investigating the impact of supply chain IT and supply chain organisational initiatives on SCA | Antecedents of SCA | IV: Supply chain IT, supply chain organisational initiatives; DV: Agility, firm performance | New product introduction time, manufacturing lead time, delivery speed, modification flexibility, responsiveness to customers | Theory of resource complementarities | The research shows that IT and organisational initiatives have a complementary effect on agility. |
| Blome et al. (2013) | Survey | Investigates the fundamental building blocks of supply chain agility, which are conceptualised as supply- and demand-side competence | Antecedents of SCA | IV: supply side competence, demand side competence; Mediator: SCA; DV: organisational performance | n.a. | The resource-based view of the firm and the dynamic capabilities perspective | The research provided a finer-grained understanding of the role of supply chain agility as a dynamic capability and highlighted its mediating effect in the relationship between supply chain competencies and operational performance. |
| Eckstein et al. (2015) | Survey | Investigate the effects of supply chain agility and supply chain adaptability on cost performance and | Antecedents, performance | IV: supply chain adaptability – dynamic sensing, dynamic flexibility, dynamic speed; Mediator: SCA; | Dynamic sensing, dynamic flexibility, and dynamic speed | Dynamic capabilities view and CT and the notion of fit | The results contribute to the literature by offering a more nuanced understanding of the performance implications of supply chain agility and supply chain adaptability, thereby |

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| | | operational performance using hierarchical regression analysis. | | | | | addressing the crucial question of why their benefits may or may not materialise under varying levels of product complexity |
| Aslam et al. (2018) | Survey | The purpose of this paper is to understand how dynamic supply chain capabilities interrelate and their effect on supply chain ambidexterity. | Antecedents, performance | n.a. | n.a. | Dynamic capabilities in supply chains | The contribution of this study lies in: first, identifying dynamic capability clusters relevant for achieving supply chain ambidexterity; second, evaluating performance implications of dynamic capabilities in the supply chain, specifically supply chain agility and adaptability; and third, proposing a unique measurement of supply chain ambidexterity in the light supply chain theory, and empirically evaluating the relationship between dynamic capabilities and supply chain ambidexterity. |
| Wamba et al. (2020) | Survey | The performance effects of big data analytics and supply chain ambidexterity: The moderating effect of environmental dynamism | Antecedents, performance | IV: big data analytics and supply chain ambidexterity; DV: cost performance and operational performance | Promote information flow with suppliers and customers; develop collaborative relationships with suppliers; Designs for postponement; risk management | Dynamic capability and contingency theory | The research found that the effects of BDA on SCAG/ SCAD were higher under intermediate levels of environmental dynamism but comparatively weak when the environmental dynamism is low or high. Hence, we can argue that big data analytics can help enhance supply chain agility, supply chain adaptability, and organizational performance, but these effects are contingent upon the level of environmental dynamism. Moreover, a non-linear, inverse U-shaped moderating effect of environ- mental dynamism exists. Collectively, |

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| | | | | | | | these findings provide a theory-based understanding of the organizational level of usage of big data analytics and its effects on supply chain agility, supply chain adaptability, and organizational performance. Moreover, they further shape our understanding of how big data analytics–enabled dynamic capabilities yield differential results under the moderating effect of environmental dynamism. Hence, we believe that our results will be useful for managers who are highly optimistic about the usage of these emerging technologies and their effects on supply chain characteristics. Finally, we have outlined our study limitations and offered numerous research directions |

### 2.3.3 Frameworks for achieving agile supply chains

A framework is a particular set of rules, ideas, or beliefs which researchers use to assess and test situations and support supply chain effectiveness (Teece, 2010; Hoveskog et al., 2015; Johnson, 2010; Campbell et al., 2013; Lambert and Davidson, 2012). Frameworks have changed the ways business worldwide works (Wirtz and Ehret, 2012). Zott and Amit (2008) observed that the development of framework can help provide direction to organisations that might otherwise be operating without administration processes, systems, or the interest of stakeholders (Maglio and Spohre, 2013). Such views lead to the discussion of those frameworks for supply chain agility that underpin this thesis.

The theoretical underpinnings for agility in supply chain follow the same logic applied in the original concept of agility. The existing frameworks for introducing agility in supply chain is the work by Ismail and Sharifi (2006); Ismail et al. (2011); Swafford et al. (2006); Christopher and Towill (2001); Eckstein et al. (2014); Blome et al. (2013); Yusuf et al. (2004); Sharifi et al. (2006); van Hoek et al. (2001). Harrison et al. (1999) given a holistic view of the issue leading strategies/practices of proven concepts. Christopher and Towill (2001) suggested a three-level framework summarising the view of the agile supply chain. The concept of such a framework was first advocated by Werr et al (1997). Christopher and Towill (2001) found it useful in bring together the various stands which contribute to the agile supply chain. In their integrative model, level 1 represents the key principles that underpin the agile supply chain, i.e., rapid replenishment and postponed fulfilment. Level 2 identifies the individual programmes such as lean production, organisational agility, and quick response, which must be implemented for the level 1 principles to be achieved. Finally, level 3 specifies individual actions needed to be undertaken to support level 2 programmes, such as time compression, information enrichment, and waste elimination (Christopher and Towill, 2001).

Christopher et al. (2004) presented a conceptual framework aims to identify characteristics, which supply chain companies must have to be agile. The framework involves four characteristics such as market sensitivity, process integration, virtual integration and network based. The market sensitivity capability is the ability to read and respond to real customer demands and to master change and uncertainty. Process integrations involve collaboration in product design, inventory management, and synchronisation of supply chains. Virtual integration is an information sharing capability in which supply chain companies use information technologies to share data between buyers and suppliers. Network capability is the ability to attract buyers and suppliers to work collaboratively, jointly develop products and shared information and knowledge. Though Christopher (2004) framework failed to account for the sustainable SCM competencies, which are critical success factors for the emergence of agile supply chain capabilities.

In contrast to the framework of Christopher et al. (2004), Ismail and Sharifi (2006); Sharifi et al. (2006) developed and proposed a conceptual framework, which addresses the issues of developing agile supply chains. The framework derives its structure from that of the principles of quality function deployment (Hauser and Clausing, 1988) and is driven by market needs or the voice of the customer where there are translated to product features. The framework proposes an approach that integrates aspects relating to product development and supply chain development. Sharifi et al (2006) described these as “design of supply chain” and “design for the supply chain”. For this to succeed, a calculated approach is required that considers the design of products with particular attention to the characteristics of the supply chain and its dynamics. The two aspects of supply chain design and design for supply chain interact with factors such as the marketplace dynamics, supply chain dynamics, business environment, technology, as well as with each other to support the dynamic characteristics of agile supply chains.

Swafford et al. (2006) suggested a model based on flexibility, agile capabilities, and performance. The determinants of supply chain agility are associated with flexibility in product development, procurement/sourcing, manufacturing, and logistics, and the integrative role of information technology capability. The mode is based on the resource-based view, whereby capabilities are externally focused while competencies are internally focused and considered antecedents of capabilities. The framework view supply chains agility as an externally focused capability that is derived from flexibility in the supply chain processes. Such flexibility in turn, is viewed as internally focused competencies. The framework also indicated agile supply chains has impact on delivery lead-time, return-on-assets, market share and profitability. But the integration between the agile supply chain paradigm and the overall sustainability performance is uncovered, despite the essential of agile capabilities and practices for supply chains.

As previously highlighted, agile capabilities and practices are both stable and dynamic practices used across the supply network. According to Gligor et al. (2016), agile capabilities refer to a type of dynamic capabilities that, reflects higher-order capability or a collection of capabilities. Dynamic capabilities enable supply chains to respond nimbly and quickly to new challenges and opportunities. Supply chain agility can compete and prosper within a changing business environment (Jain et al., 2008 Zhang and Sharifi, 2007; Gligor and Holcomb, 2012; Narasimhan et al., 2006; Yusuf et al., 2004; Ismail and Sharifi, 2006).

There are different conceptual models for introducing agility in supply chains (Agarwal et al., 2007). It is suggested that agility could be achieved through the adopting of sustainable practices that provide the required abilities for the supply chain to respond properly to changes in the business environment. Zhang and Sharifi (2000) proposed a conceptual model of agility, which depicted interconnections among agility drivers, agility capabilities, and agility providers. Agility drivers are the change/pressures from the business environment that necessitate a company to search for new ways of running its business to maintain competitive advantage. these drivers could force supply chain companies to modify their current strategies, admit the need to become agile, and adopt sustainable strategies. Agility capabilities, on the other hand, are the essential capabilities that the company needs to positively respond to and take advantage of the changes. These capabilities could be obtained by implementing agility practices, which are derived from organisation, technology, people, and innovation (Zhang and Sharifi, 2000, p. 497). Based on this model, supply chains experience a variety of changes/pressures in business environments, which drives the chain to identify agility capabilities that need to be enhanced to take advantage of changes. This in turn forces the supply chain to search for pathways to obtain/enhance the required capabilities. As such, different combinations of capabilities will have to be obtained for different organisations.

Besides, Yusuf et al. (2004) discussed supply chain agility in terms of two dimensions of reach and range of upstream and downstream activities covered by networking amongst supply chain companies. Figure 3 illustrates the two-dimensional framework. On the horizontal axis, the range of activities widens from electronic messaging to internet-based integration. On the vertical axis, information reach extends from partner to partner throughout the entire supply network. Accordingly, the degree of freedom in the supply chain integration widens from bill of material controls through purchasing efficiency to planning and control of supply chain operations (**Yusuf** et al. 2004).

Agile supply chains should extend to the highest levels on both dimensions of reach and range. At the highest levels of attainment of two dimensions, the conduct of internal operations will be transparent to suppliers and customers. Also, local teams of employees can think globally and take virtual initiatives with teams in other companies within the supply network. To this extent, responsiveness to changing competitive requirement becomes easier to master as a matter of routines, and with little penalties in time of cost and quality. In addition to reach and range approach, agility capability of supply chains can be assessed in terms of the stage attained on interdependent dimensions of supply chain maturity, such as, inter-firm partnership, knowledge sharing and learning, effective governance, and complementary resources competencies **(**Dyer and Singh 1998; Braunscheidel and Suresh, 2009; Lavie, 2006).

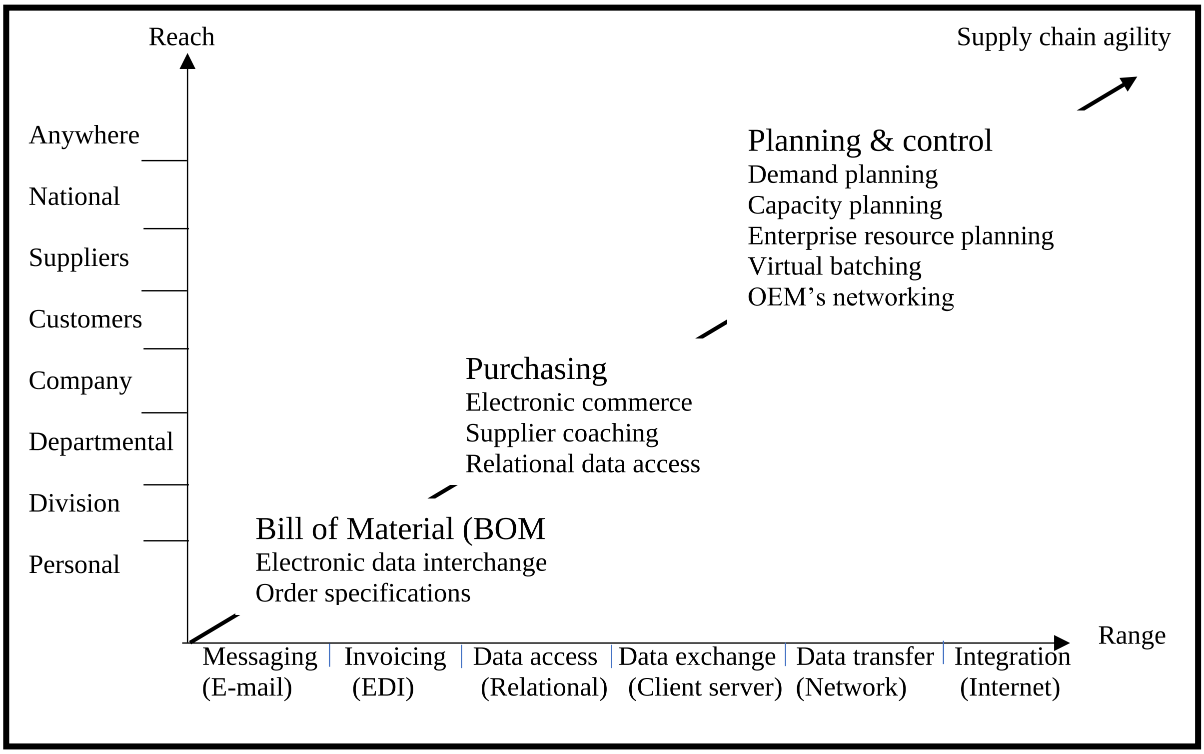



**Figure 2.2** Reach and range analysis of supply chain integration (source: Yusuf et al. 2004)

In today's volatile business environment, the challenge of agile supply chains would be to improve and ensure balance across the symbiotic dimensions shown in Figure 2.2. Relative scores on these dimensions offer a basis for testing maturity towards agile supply chains **(**Zhang and Sharifi, 2007; Swafford et al., 2006; Christopher, 2016; Brown and Bessant, 2003; Harrison et al., 2019; Narasimhan and Das, 2001**;** Khan and Wisner, 2019). Table 2.3 compared different framework of agile supply chain. Similar to those frameworks, this thesis integrates sustainable supply chain practices with agile supply chain capabilities (Cicculo et al., 2018). Being an explanatory study, this work will explore their impact on performance outcomes (see Figure 2.3).

**Table 2.3** Comparing different framework for achieving agile supply chain

| Agility drivers | Agile capabilities/practices | Performance indicators | Sources |
|---|---|---|---|
| Supply chain adaptability:<br>• Spot new supply bases.<br>• Shifting customer needs.<br>• Changing technology cycles and product life cycles.<br>• Market sensing. | • Adapting service or product.<br>• Quick respond new market design.<br>• Quick respond to demand change.<br>• Adjust product portfolio. | • Cost efficiency.<br>Supply chain responsiveness:<br>• Quick response to changing customer needs.<br>• Quick response to shifting competitor strategies.<br>• Effective response to competitor strategies. | (Aslam et al., 2018) |
| • Supply chain integration.<br>• External learning. | • Joint planning.<br>• Demand response.<br>• Customer response. | • Return on sales.<br>• Sales growth.<br>• Return on asset.<br>• Overall profitability.<br>• Return on investment. | (Tse et al., 2016) |
| • Structural sensing.<br>• Structural flexibility.<br>• Structural innovativeness. | Dynamic sensing:<br>• New technologies.<br>• Change in competition.<br>• Demand fluctuation.<br>• Changes in suppliers.<br>• Dynamic flexibility.<br>• Dynamic speed. | • Cost performance.<br>• Product quality.<br>• Service level.<br>• On-time delivery. | Eckstein et al., 2015 |
| | • Supply chain coordination.<br>• Supply chain cooperation.<br>• Supply chain communication. | • Delivery quality.<br>• Delivery reliability.<br>• Speed.<br>• Relationship with suppliers.<br>• Continuous improvement.<br>• Helps supplier perform tasks.<br>• Understanding of supplier needs. | (Gligor and Holcomb, 2012) |
| Market orientation:<br>• Customer orientation.<br>• Competitor orientation.<br>• Inter-functional coordination.<br>Learning orientation:<br>• Commitment to learning. | • Joint planning.<br>• Demand response.<br>• Visibility.<br>• Customer responsiveness.<br>• Internal integration. | No specific references. | (Braunscheidel and Suresh, 2009) |

| | | | |
|---|---|---|---|
| • Shared vision.<br>• Open-mindedness. | • External integration with key suppliers and customers.<br>• External flexibility – volume and mix flexibility. | | |
| Changes in:<br>• Competition.<br>• Customer requirements.<br>• Technology.<br>• Social factors.<br>• Suppliers.<br>• Internal complexity. | • Relationship with suppliers and competitors.<br>• Technology.<br>• People.<br>• Integration.<br>• Partnerships.<br>• Relationship with customers.<br>• Information systems. | • Proactiveness.<br>• Responsiveness.<br>• Competency.<br>• Flexibility.<br>• Quickness.<br>• Customer's satisfaction. | (Zhang. and Sharifi 2007) |
| • High dynamism.<br>• High hostility and competition.<br>• High complexity.<br>• High diversity. | • Agile human resources.<br>• Agile technologies.<br>• Value chain integration.<br>• Concurrent engineering.<br>• Knowledge management. | • Cost.<br>• Flexibility.<br>• Quality.<br>• Delivery service and environment.<br>• Return on investment.<br>• Sales volume.<br>• Customer loyalty.<br>• Responsiveness to changes.<br>• Labour productivity. | (Vázquez-Bustelo et al. 2007) |
| No specific references. | Flexibility and information technology support in each supply chain processes:<br>• Product development.<br>• Procurement/sourcing<br>• Manufacturing.<br>• Distribution/logistics.<br>• IT integration. | Supply chain performance:<br>• On-time delivery.<br>• Backbone level.<br>Competitive performance:<br>• Return on investment.<br>• Market share.<br>• Profitability, among others. | (Swafford et al., 2006) |
| No specific references | • Advanced manufacturing technologies.<br>• Cross-functional teams.<br>• Integrated product design.<br>• Advanced MRP/ERP.<br>• Supplier development.<br>• Process integration.<br>• Workforce development.<br>• JIT flow. | • Cost performance.<br>• Conformance quality.<br>• Design quality.<br>• Delivery reliability.<br>• Delivery speed.<br>• New product flexibility.<br>• Process flexibility. | (Narasimhan et al., 2006) |

| | | | |
|---|---|---|---|
| | • Supplier information sharing.<br>• Supplier partnership.<br>• Investment in technologies, among others. | | |
| No specific references | • Just-in-time manufacturing.<br>• Customer linkages.<br>• Suppliers' alliances.<br>• Information sharing.<br>• Wide range of skill training.<br>• Advanced information technologies. | • Proactive and reactive flexibility.<br>• Delivery speed.<br>• Design quality (customisation).<br>• Cost efficiency. | (Brown. and Bessant, 2003) |
| Changes in:<br>• Competition.<br>• Customer requirements.<br>• Technology.<br>• Social factors.<br>• Suppliers.<br>• Internal complexity. | • Capability to satisfy and be close to customers.<br>• Ability to thrive in anticipated changes.<br>• Ability to cope with unexpected changes.<br>• Advanced soft & hard technologies.<br>• Internal networks.<br>• Worker's empowerment.<br>• Concurrent teams. | • Delivery responsiveness.<br>• Delivery speed.<br>• Product model flexibility (customization).<br>• Product introduction flexibility.<br>• Volume flexibility. | (Zhang, and Sharifi 2000) |
| • Automation and price/cost consideration.<br>• Widening customer choice and expectation.<br>• Competing priorities.<br>• Integration and proactivity.<br>• Achieving manufacturing requirement in synergy. | • Core competences management.<br>• Capability for reconfiguration.<br>• Knowledge-driven enterprise.<br>• Virtual enterprise.<br>• Team building.<br>• Technology-based.<br>• Partnership.<br>• Education.<br>• Market knowledge.<br>• Integration. | • Cost/price.<br>• Quality.<br>• Speed<br>• Flexibility.<br>• Proactivity.<br>• Innovation.<br>• Profitability. | (Yusuf et al., 1999) |

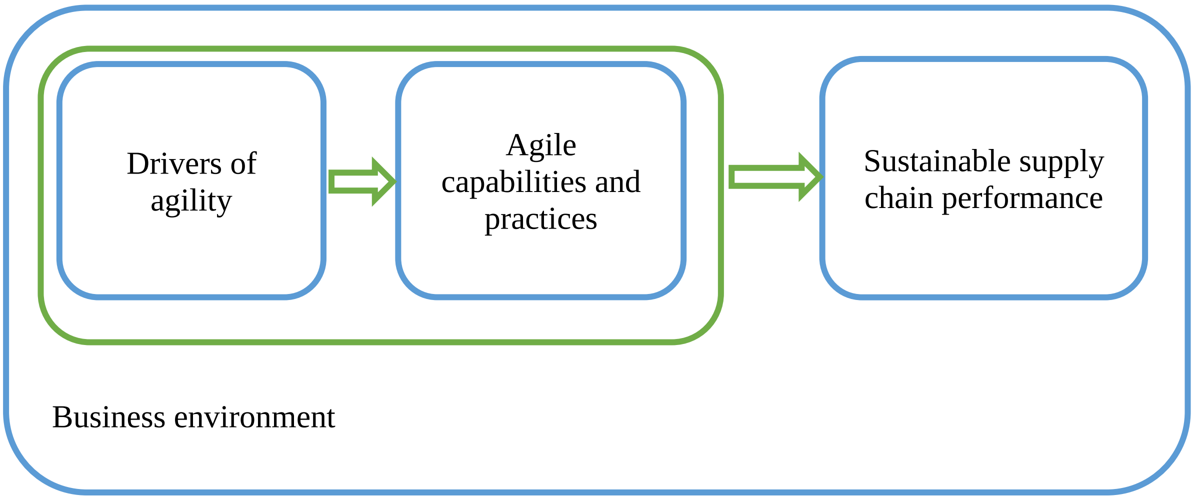



**Figure 2.3** Framework for the development and implementation of agile supply chain capabilities (Source: Cerruti, 2013)

In the following section different types of agile supply chain drivers, attributes, and enablers of agile supply chain capabilities are discussed.

### 2.3.4 Drivers of agile supply chain

The drivers are characteristics of supply chain environments, which are responsible for triggering change needs (Carvalho et al., 2018). The drivers behind the need for agility in supply chains are like those that drove the introduction of the agile manufacturing concepts and stem from the rate of change and turbulence of the supply chain environment (Sharifi et al., 2006; Ismail and Sharifi, 2006). Dynamics of the supply chain contributes further to uncertainties in the environment and hence the vulnerability of the supply chain to change (Christopher, 2016; Cicculo et al., 2020). Different companies with different characteristics and in different circumstances would experience different specific changes that are specific and unique to organisations (Sharifi et al., 2006).

Based on earlier works (Sharifi and Zhang, 2001; Yusuf et al., 1999; Christopher, 2000; Lin et al., 2006), the general business environment changes are categorised as market turbulence, intense competition, changes in customer requirements, accelerating technological change, supplier uncertainty, internal complexity, and changes in social factors (see table 2.4 for details). Lyson and Farringson (2020) listed items such as rapidly changing and unpredictable markets, the rapid rates of technological innovation, customers' requirements for customisation, and choice, competitive priorities of responsiveness, shorter lifecycles, concern for the environment and international competitiveness as the main drivers of supply chain agility. Several studies have emphasised that market turbulence represents an important agility driver, shaping the required capabilities and practices (Yusuf et al., 1999; Baramichai et al., 2007; Zhang, 2011; Zhang and Sharifi, 2000). Other researchers argued that different changes and uncertainty have impacts on capabilities required for sustainable competitiveness (Koka and Prescott, 2008; Pil and Cohen, 2006). The capabilities required to compete in high-velocity markets are different from those developed in moderately dynamic markets (Eisenhardt and Martin, 2000) and incremental innovation often act to inhibit instead of facilitating discontinuous innovation (Phillips et al., 2006, p. 452). Such differences can affect the characteristics of supply chain agility.

**Table 2.4** Turbulence of supply chain environment

| Agile supply chain drivers | Sub-factors |
|---|---|
| Change in market | - Growth of the niche market |
| | - Increasing rate of change in product models |
| | - Product lifecycle shrinkage |
| | - Market price consciousness |
| | - Increasing market needs/desire |
| | - Market fragmentation |
| | - Changes in market structure |
| Changes in competition | - Rapidly changing market |
| | - Increasing pressure on cost |
| | - Increasing rate of innovation |
| | - Responsiveness of competitors to change |
| | - Substitute for products |
| | - Increasing pressure of market competition |
| Changes in customer requirements | - Customer needs/wants change |
| | - Customer expectations for sustainable products |
| | - Quality expectation increasing |
| | - Customer desire changing |
| Changes in technology | - Technology change |
| | - Introduction of new technologies |
| | - Introduction of more efficient, faster production facilities |
| | - Inclusion of information technology in new products |
| | - |
| Changes in social factors | - Environmental pressure |
| | - Legislation pressure |
| | - Workforce expectations |
| | - Social contact changes |
| | - Government policies pressures |
| | - Economic changes |
| Changes in supplies | - Supply uncertainty |
| | - Relation with suppliers |

| | |
|---|---|
| | - Reliability/responsiveness of suppliers<br>- Product and process complexity<br>- Product design process complexity |

Source: Sharifi and Zhang (1999, 2001)

In low-turbulence markets, where uncertainty is mainly related to demand variability, require a modification of existing practices without radical changes (Christopher, 2000; Stratton and Warburton, 2003; Zhang and Sharifi, 2007; Baker, 2008). In this situation, supply chain agility represents the capacity of supply chain to act quickly to changes in real demand, in terms of variety and volume (Christopher, 2000, p. 38). The challenges that agile supply chains might face relate to design, manufacturing, logistics, and supply relationships implications of an uncertain and fragmented demand, in contrast to the stable and high-volume demand characterising the market conditions where lean is applied (Stratton and Warburton, 2003).

In high-turbulence environments, characterised by unpredictable changes in market or customer demand, challenge the existing best practices and make them inadequate (Bernardes and Hanna, 2009). Under such circumstance, Zhang and Sharifi (2000, p. 496) observed that agile supply chains primarily concerned with change, uncertainty, and unpredictability in the market and within business environment, and makes appropriate response to changes. Supply chain agility requires the ability to identify rapidly changes and respond fast to them, reactively or proactively, and recover from changes; it also requires competency, which is the extensive set of abilities that provide productivity, efficiency, and effectiveness of activities towards achieving supply chain objectives; flexibility/adaptability, which is the ability to implement different processes and use different facilities to achieve the same objectives; and quickness/speed, which is the ability to carry out tasks and operations in the shortest possible time (Lin et al., 2006; Sharifi and Zhang, 1999).

### 2.3.5 Attributes and enablers of agile supply chain capabilities

According to Ren et al. (2003), agile supply chain attributes are characteristics that can allow supply chain companies to see and respond quickly to changes in the general business environment. Yusuf et al. (1999) suggested a list of attributes of agile supply chains summarised in the Table 2.5 below. The table presents 32 attributes, in 10 decision domains of an agile supply chain, ranging from concurrent execution of activities to employee satisfaction. These attributes will be employed to test the value of agile practices across groups of agile organisations.

**Table 2.5** The attributes of agile supply chain

| Decision domain | Related attributes |
|---|---|
| Integration | • Concurrent execution of activities.<br>• Enterprise integration.<br>• Information accessible to employees. |
| Competences | • Multi-venturing capabilities.<br>• Developed business practices difficult to copy. |
| Team building | • Empowered individual working in teams.<br>• Cross-functional teams.<br>• Teams across company borders.<br>• Decentralised decision making. |
| Technology | • Technology awareness.<br>• Leadership in the use of current technology.<br>• Skill and knowledge enhancing technologies.<br>• Flexible production technology. |
| Quality | • Quality over product life.<br>• Products with substantial value-addition.<br>• First-time right design.<br>• Short development cycle times. |
| Change | • Continuous improvement.<br>• Culture of change. |
| Partnership | • Rapid partnership formation.<br>• Strategic relationship with customers.<br>• Close relationship with suppliers.<br>• Trust-based relationship with customers/suppliers. |
| Market | • New product introduction.<br>• Customer-driven innovation.<br>• Customer satisfaction.<br>• Response to changing market requirements. |
| Education | • Learning organisation.<br>• Multi-skilled and flexible people.<br>• Workforce skill upgrade.<br>• Continuous training and development. |
| Welfare | • Employee satisfaction. |

Source: Yusuf et al. (1999, 41)

There is a realisation in the literature that agile operating models encompasses different enablers (Carvalho et al., 2020). Enablers are those practices that will facilitate agile capabilities (Harrison et al., 2019). They are agility practices, which form the necessary conditions to promoter supply chain transformation (Carvalho et al., 2020). To be truly agile, organisations require a set of agile enablers. Bottani (2010) argued that agile enablers are capabilities, which allow to promptly respond to changing business environment. Agile enablers are key success factors that need to be developed, promoted, and correctly managed in order to allow a company deal with change and provide answers to the environments demands (Carvalho et al., 2017). Gunasekaran (1998) identified seven requirements of agility that are critical for businesses to become agile. These are as follows: virtual enterprise formation tools and metrics, physically distributed teams and manufacturing, rapid partnership formation tools and metrics, concurrent engineering, integrated product/production/business information systems, rapid prototyping tools and electronic commerce. Later Gunasekaran (1999) revised his previous proposal of agility enablers and grouped the different enablers into four main categories: strategies, technologies, people, and systems. At the same year, Yusuf et al. (1999) proposed the core concepts for agility – core competence management, capability for reconfiguration, knowledge-driven enterprise, and virtual enterprise.

Research by Vázquez-Bustelo et al. (2007) identified several essential enablers if supply chain agility was to be successful. These are management support, autonomy, cross- functionality of the workforce, job rotation, training and education, decentralized decision-making, and rewards/recognition to encourage innovation and adaptability. In a different scope, Doz and Kosonen (2010) provided the foundations for the success of strategic agility: leadership unity, strategic sensitivity, and resource fluidity. In terms of more general capabilities, Van Hoek et al. (2001) produced four supply chain agility enablers: market sensitivity, scale sensitivity, network integration, cooperation, virtual integration, and process integration. Lin et al. (2006) identified for essential agile supply chain requirements, such as collaborative relationships, process integration, communication and information integration, and sensitivity. Similarly, Bottani (2009) suggested supply chain management, concurrent engineering, project management, information and communication technology, team building and knowledge management as key supply chain enablers. Gligor and Holcomb (2012) listed responsiveness, change as an opportunity, flexibility, customer enrichment, mobilization of competences, integration, organizational structure, and speed as essential requirements for supply chain agility.

Other literature, such as Aslam et al. (2018**);** Eckstein et al. (2015**)**; Ketchen and Hult (2007) and Lee (2004) identified market sensing capability, supply chain alignment, and supply chain adaptation as some of the key critical factors of supply chain agility. In consonance with these requirements, Conforto et al. (2014) itemised a set of 14 agility enablers including knowledge management systems, effective communication, strong leadership commitment, learning organisation, organisational culture, multidisciplinary teams, decentralised decision-making, organisational structure type, agile mindset and work environment, emphasis on speed, entrepreneurial culture, adequate reward for agile use, resource competition, performance measuring and acceptance of agile methodology. Conforto et al. (2014) argued that these enablers may be adapted by other industries outside software industry.

In addition to the stated enablers, Vinodh et al. (2010) group agility enablers into technology and management categories. The former includes the integration of information technology, computer-aided design and production, virtual enterprise, reverse engineering, rapid prototyping. Concerning management enablers, it includes the lean approach, total product management, Kaizen, Kanban, supply network management, amongst others. Recently, Gunasekaran et al. (2019) defined agile supply chain practices in terms of five enabling competencies of transparent customisation, supply network, intelligent automation, total employee empowerment and technology integration. Table 2.6 presents the list of enablers of supply chain agility and its critical success factors.

**Table 2.6** Enablers of supply chain agility and their critical success factors

| Enablers | Critical success factors | References |
|---|---|---|
| Orientation and work environment | • Agile mindset<br>• Agile-style work environment<br>• Collaborative work<br>• Adequate reward for the use of agile tools and methods | Vazquez-Bustelo et al. (2007), Bottani (2009),<br><br>Conforto et al. (2014), Dikert et al. (2016) |
| Agile resources and capabilities | • Development and deployment of new capabilities<br>• Talent to support agility<br>• Knowledge management Job rotation systems | Vazquez-Bustelo et al. (2007), Doz and Kosonen (2010), Bottani (2009), Gligor and Holcomb (2012) |
| Process and project team | • Team dedication<br>• Autonomy and empowerment<br>• Integration and cross-functional teams and projects<br>• Team experience | Vazquez-Bustelo et al. (2007), Doz and Kosonen (2010), Conforto et al. (2014), Dikert et al. (2016) |
| Organizational structure | • Promoting a horizontal structure<br>• Decentralized decision-making<br>• Interdepartmental collaboration | Van Hoek et al. (2001), Lin et al. (2006), Vazquez-Bustelo et al. (2007), Conforto et al. (2014) |
| Manufacturing (development) flexibility | • Automation<br>• Speed<br>• Flexibility and reconfiguration Process concurrency<br>• Process integration<br>• Frequent revision cycles | Gunasekaran (1999), Gligor and Holcomb (2012), Conforto et al. (2014) |
| New product and process development | • Newness<br>• Complexity | Bottani (2009), Conforto et al. (2014) |

| | | |
|---|---|---|
| | • Balance of project management methods | |
| Technology and information systems | • Use of technology<br>• Virtual enterprise<br>• Readiness for connectivity and digitalization | Gunasekaran (1999), Vazquez-Bustelo et al. (2007), Bottani (2009) |
| Agile strategic planning | • Leadership unity<br>• Fact-based decision-making<br>• Product succession planning | Doz and Kosonen (2010), Conforto et al. (2014), Dikert et al. (2016) |
| Change management | • Strategic sensitivity<br>• Effective initiation and prioritization of change efforts<br>• Resource fluidity | Van Hoek et al. (2001), Lin et al. (2006), Doz and Kosonen (2010), Dikert et al. (2016) |
| Agile information and communication strategy | • Intensified communication<br>• Easy access to information<br>• Open information sharing | Lin et al. (2006), Bottani (2009), Conforto et al. (2014) |

Source: Carvalho et al. (2020)

### 2.3.6 Different types of agile supply chain capabilities

Agility capabilities are both operational and dynamic capabilities across supply networks (Teece et al., 2016; Yusuf et al., 2004). Some capabilities researchers have distinguished between ordinary (or operational) capabilities and dynamic capabilities (Winter, 2003; Teece, 2017, 2019; Zahra et al., 2006). Ordinary capabilities are those that enable supply chain to earn a living now. Dynamic capabilities are those that operate to modify or create ordinary capabilities (Winter, 2003, p. 992). Agile supply chains are considered as substantive and dynamic capabilities because they can succeed in changing and turbulent supply chain environments. Agile supply chain can also rapidly align network operations and realign supply chain resource base to dynamic requirements of markets. It is argued that the strategic substance of capabilities involves patterning of activity, and that investments are required to create and sustain such patterning. Supply chain companies can accomplish change by means of ad hoc problem solving, in a firefighting mode, a high-pace, contingent, opportunistic, and creative search for satisfactory alternative behaviours (Winter, 2003, p. 992).

Dyer et al. (2018) observed that supply networks critical capabilities may span beyond a single process and may be embedded in interfirm routines and processes. Lavie (2006, p. 638) argued that the focus on the firm's-controlled complementary competencies can undermines the essential contribution of capabilities of agile alliance suppliers. Given that the supply network plays a vital role in achieving agility, as it enables members to access innovative capabilities to improve their long-term performance outcomes (Swafford et al., 2008). The analysis of agile supply chain must focus on capabilities beyond the internal boundaries of an organisation. This research focuses on both capabilities and dynamic capabilities of supply chains. In this research, the capabilities that agile supply chains should have to be able to make appropriate response to changes in their business environment are grouped into five major categories. These are market sensitivity, process (re)alignment, people's empowerment, technology integration, and network collaboration capabilities (Christopher, 2004; Martinez-Sanchez and Lahoz-Leo, 2018; Lin et al., 2006; van Hoek et al., 2001; Harrison et al., 2019). The next section discussed each of the individual agile supply chain capabilities.

#### 2.3.6.1 Market sensitivity capability

Market sensitivity requires quick response to customer requirements. That is, it includes the ability to read and respond to real customer requirements (Lin et al., 2006), both in terms of demand for existing and new products and hitherto undefined products (Harrison et al., 2019). This necessitates capability in customer awareness, knowledge, and involvement with them for value creating opportunities (Gong et al., 2019). There is a recognition that it is challenging for organisations to mitigate supply chain risks without the understanding and knowledge of customers and other stakeholders (Wu et al., 2016; Christopher, 2016). Agile organisations, thus, are highly sensitive to market changes. Because sensing capabilities can help businesses understand stakeholder expectations while a lack of awareness of the broader demand/supply network may make sustainability objectives unsuccessful (Wu et al., 2016). As insights from stakeholders can help in shaping a platform that generates the maximum return on investment.

Agile organisations can invest a significant resource in improving their knowledge of changes and uncertainties. This will allow entities across the chain to proactively watch for changes in customer preferences and external environment and act on them. They will also seek stakeholder feedback and input through regular review of potential problems within multi-tiers suppliers. Agile organisations with sensing capability use customer journey map to identify a new window of opportunities and remove process complexity. They leverage on customer intelligence and technologies to: improved customer satisfaction, employee engagement, operational performance, and mitigated negative environment impacts, which, in turn, can better financial performance.

#### 2.3.6.2 Technology integrative capability

The technology-based capabilities reflect the ability to use technologies to gather and share data across supply chains (Lin et al., 2006; Yusuf et al., 2004), so creating virtual enterprises. Advances in new technologies facilitate agile supply chain organisations to collect a large amount of demand data and sharing it across the chain, such that members see the ‘real-time’ demand and not the distorted picture of demand (Harrison et al., 2019). It involves not only to the size of the data sets but also the speed at which the data is created and analysed, with the variety of tools used. This new technology transformation includes big data analytics, the internet of things, automation and artificial intelligence, cloud computing and mobile devices, embedded sensors, blockchains, robotics, and additive manufacturing processes (Gupta et al., 2019; Choudhry et al., 2016; Morrar et al., 2017). These technologies together can be seen as part of a new wave of digital technologies, which allow traceability and transparency in the chain (Pagell and Wu, 2009).

Indeed, the advances in new technologies influenced all aspects of supply chain activities. The pace of technological development is not slowing down, but it is speeding up. Yet, the idea of harnessing technology to make manufacturing operations more effective is not new. The use of some form of automation to replace human activities has been for years. What is new here is the sheer scope, sophistication and combination of these new technologies that are being deployed or developed to be part of operations or supply chains activities that is crucial (Slack and Lewis, 2019). It has important implications for operations and supply chains approach, as technological development becomes more rapid, and any strategic thinking becomes more problematic. In this regard, the supplier strategy cannot assume a stable technological future. Instead, it must develop skills that enable emerging technologies to swiftly implement as they emerge.

There is evidence suggesting that agile organisations that harness these new technologies could drive innovation, productivity growth (Gunasekaran et al., 2017; Giannakis et al., 2019), improved customer satisfaction, enhanced employee engagement and safety (Pierdicca et al., 2017); enhanced operational performance, increased financial performance (Oesterreich and

Teuteberg, 2016); while boosting social and environmental sustainability performance outcomes (Stock and Seliger, 2016; Bai et al., 2020; Lin et al., 2018; Ralston and Blackhurst, 2020). They can also help increase efficiency (Choudhry et al., 2016), influence new product and services, enable new business models, and blur the boundaries of industries (Rüßmann et al., 2015; Ramadan et al., 2017). But the question is how do industrial sectors use these new technologies to achieve sustainability? (Bresciani and Brinkman, 2016; Brinkman et al., 2016). Moreover, the adoption of these new technologies could have significant barriers, like misapplication of AI-algorithms, privacy breach, and data accessibility (Spanaki et al, 2019). The use of these technologies also comes with challenges or risks in the business environment that could lead to being misused, resulting in distrust and raise privacy and ethical concerns (Jones et al., 2019; Baryannis et al., 2019a, b; Spanaki and Sklavos, 2018).

#### 2.3.6.3 Processes realignment capabilities

Processes integration-based capability means that the supply chain is a confederation of partners linked into a network (Lin et al., 2006). Here, agile supply chains can be viewed as a system of business processes, in which, if integrated and synchronised can avoid the time, cost, and quality penalties associated with 'stand-alone' processes (Harrison et al., 2019). Where the component delivery process not synchronised with the manufacturing process, the penalty will be a high inbound component inventory.

Over the years, academics and authorities have documented strategic alignment as a greater agile capability (Harrison et al., 2019; Christopher, 2016; Yusuf et al., 2004). As noted above, strategic alignment requires that the operations of an organisation be aligned to collectively work towards competitive objectives. Several executives now understand that their enterprise should be aligned. They also know that strategies, resources, skills, and leadership practices should all readjusted to support sustainable competitive objectives. But the challenge is that managers tend to focus on one facet of operation or supply chain to the exclusion of others. However, what matters for the overall organisational performance is how supply chain processes all fit together. Trevor (2019) showed how strategic alignment can enhance performance outcomes. The researcher argued that poor alignment is preventing global supply chains from reaching sustainability performance. Strategic alignment ensures that each element of the supply chain is arranged to fulfil performance objectives. These operations should be capable of adapting to sustainability changes, as agile organisations are often the best aligned regardless of outside factors and can emerge from severe disruption stronger.

Because an organisation is only as strong as its weakest link its members can share information through alignment; synchronisation denotes that all parties in the supply chain have a common system. In other words, through shared information and strategic alignment, there will be one schedule for the entire supply chain (Christopher, 2016). This approach is becoming more serious, as web-based technology enables different entities in a network to share real demand, inventory, and resources information in a collaborative context.

Those businesses that can adapt rapidly to changing customer requirements tend to focus on managing processes. Processes are the horizontal, market-facing sequences of activities that create value for customers. They are cross-functional by definition and are best managed through the means of interdisciplinary teams (Christopher, 2016). The way businesses are organised can have a significant impact on supply chain agility. Those industrial sectors with cumbersome, multi-level decision-making processes tend to be far slower to respond to market changes than agile organisations who give autonomy to self-managed process teams. A further reason why process management is critical to agility across the wider supply chain is that processes alignment between entities in that chain is facilitated if organisational structures are horizontal rather than vertical (Christopher, 2016).

#### 2.3.6.4 Network collaboration capability

Network collaboration, which encompasses the capability to attract buyers and suppliers to work collaboratively, jointly develop products and shared information (Lin et al., 2006). It involves a network of supply chain partners that cooperate to meet the end-customer needs and demand by making available their resources to each other (Harrison et al., 2019). Here, a much higher level of collaboration and partnerships with suppliers is regarded as essential enabler of agile supply network (Lin et al., 2006; Christopher and Towill, 2001). Supply chain collaboration can play a critical role, as it allows businesses to access new resources to increase responsiveness and time to market (Zhang and Sharifi, 2007; Brown and Bessant, 2003; Khan and Pillania, 2008; Swafford et al., 2006). According to Christopher (2016, p. 126), in today’s challenging world, the route to sustainable competitiveness lies in being able to make the best use of the respective strengths and competencies of network partners to achieve greater responsiveness to market needs.

Agile supply chain relationships can be described as stable and dynamic supply alliances, which may often be reconfigured (Gadde and Dubois, 2010; Christopher et al., 2004; Eckstein et al., 2015). Cerruti et al. (2013) investigated the characteristics of supply partnerships to achieve agility. Cerruti et al. (2013) found that types of strategic supply partnerships (stable long-term or agile short-term) are focused on the characteristic of the component/services and the degree of turbulence an agile approach is designed to address. Literature, such as Christopher et al. (2004); van Hoek et al. (2001) Goldman et al. (1995) suggested a short-term collaboration, whereas other researchers recommended long-term partnering and alliances (Yusuf et al., 2004; Brauchiedel and Suresh, 2009; Zhang and Sharifi, 2007).

A major opportunity exists for reducing in-bound lead-times through close working with key suppliers. Because in recent time, there was a view that suppliers should be held at ‘arm’s length’, many opportunities for improving responsiveness have been missed (Christopher, 2016). As supplier agility is one of the main requirements in the creation of a more responsive supply chain, it is perhaps surprising that some businesses now still have few collaborative programmes with suppliers (Christopher, 2016).

Using collaborative practices to explore opportunities will have a strong effect on the overall responsiveness and can yield significant outcomes. As businesses have designed processes in a vacuum, it is not surprising to ascertain that those processes do not align with their supply chain partners. Agile enterprises have gained competitive benefits by allowing their suppliers access to their information and scheduling systems. Besides, supply chain intelligence can be improved if the operators are willing to work together with suppliers to pool their knowledge and insights into potential sources of sustainability risk in the wider supply network.

Because of the interdependencies that exist in the supply network, a key driver of agility is a high level of collaboration and partnerships among supply chain partners. Creating a collaborative approach is becoming essential, as visibility or shared information are fundamental to the development of supply chain agility. Network collaboration can help to check for deviations from the strategy. Effective supply management will only be possible if there is a willingness among partners to share information (Hannibal and Kauppi, 2019; Gong et al., 2019).

Collaborative efforts can help businesses to reduce negative sustainability impact and improve sustainability performance (Ehrgott et al., 2013; Lu et al., 2012). There is much evidence that collaborative practices have a positive impact on improving the environmental and social performance (Lu et al., 2012; Zhu and Sarkis, 2007; Sancha et al., 2016). When supply chain members jointly try to solve problems, they will be capable of obtaining superior performance benefits (Ghijsen et al., 2010). Network of teams can help operators and suppliers understand the strength and weakness of both parties (Ross et al., 2009). This increased knowledge can enable businesses to broaden the scope of their sustainability risk and to mitigate such risk. Again, collaborative practices can help organisations obtain a level of sustainable innovation (Chiou et al., 2011; Zhu and Sarkis, 2004). Christopher (2016) concludes that the value of collaborative practices includes improved quality, innovation, reduced costs, and better operational excellence. It is now well established that collaboration approach plays a large role in close and strategic supply chain relationships. But Um and Kim (2019) stated that not all collaboration led to sustainability performance. As such the influence of collaborative network on sustainability and operational performance objectives has remained unclear.

#### 2.3.6.5 People empowerment

People working in supply chains play an essential role in the way organisations create and capture value to customers. There is a considerable agreement that employee empowerment is crucial for businesses in unstable markets (Yusuf et al., 2004; 2014; Gunasekaran et al., 2019). Part of this consensus is the industry transformation from linear to network structure. An agile organisation empowers professional and shop floor employees. It also invests in learning and training of entities within supply networks. According to Meade and Sarkis (2001), ‘an agile organisation sells its ability to convert the knowledge, skills and information embodied in its personnel into solution products for its customers’. Employee empowerment, thus, requires a full alignment or realignment of governance relations in which managers focus on interdisciplinary teamwork, shared values, and motivation for knowledge diversity (Gunasekaran et al., 2019).

In market environments where demand is uncertain, the levels of variety are high, and volume is low. Then, collective learning to adapt quickly to implement a new business model or other changes is integral to the strength or weakness of an agile supply chain. In many cases, the ability to leverage the knowledge and skills of people might be the factor that differentiates strong agile companies from nonagile companies. Operating in the agile learning area requires employees to have multiple skills and the ability to adapt to sudden changes in what is required of them.

Agile learning or training approach requires continuous training of people and involvement of employees in all aspects of the supply chain activities. In addition to putting in place concurrent engineering structures that allow workers to operate in self-organising teams. For workers to perform effectively, a considerable amount of training and retraining is required in area such as, reusability, interpersonal skills, communication technologies applications, sustainability issues, and multi-skilling in operations. Harrison et al. (2019, p. 301) identified several skills required for agile learning operations. These are as follows:

- partners should be trained in multiple operations.
- they should have the ability to work to standard procedures.
- they must obtain ability to deviate from standard procedures to allow for customisable options.
- ability to use skills and creativity to complete task to correct quality.
- ability to problem-solving.
- they can respond quickly to change.
- they are highly responsible.

Team processes can help sustain organisation health and performance. It facilitates job assignment, execution, and delivery as it supports integrative conduct of activities (Goldman et al., 1995). A team behaviour will be easier to nurture in the supply chain, which have embraced teaming as a system underpinned by the principles of multidisciplinary collaboration inherent in concurrent engineering (Yusuf et al., 2014). A team-based concurrent engineering structure empowers employees, and so enhances the knowledge base available for profitable and sustainable customisation (Narasimhan et al., 2006). So, smaller groups of employees will be responsible for resources and outcomes, and leadership focus would shift from functional work unit to project teams.

Agile teams in supply chains exhibit an entrepreneurial drive, taking ownership of team goals, decisions, and performance. Agile supply chains attract people who are motivated by an intrinsic passion for their work and who aim for excellence. In addition, talent development in an agile model is about building new capabilities through varied experiences. Agile supply chains allow and expect role mobility, where employees move regularly between roles and teams, based on their personal development goals. An open talent marketplace supports this by providing information on available roles, tasks, or projects as well as people's interests, capabilities, and development goals. Though, there are reports that team practices in leaner supply chains have become cumbersome, exploitative, and punitive because of focus on strong leadership, seniority-based pay, peer-surveillance, and unending pressures for continuous improvement. In this situation, teaming perhaps strip workers of their personal rights, specialist skills and autonomy rather than empower them. The above-mentioned problems are avoidable in agile organisations where operations are more decentralised and less linear. Instead, operations are project and niche network-based and virtual in character (Gunasekaran et al., 2019).

Leadership in agile organisations serves the people in the organisation, empowering and educating them. Rather than planners, directors, and controllers, they become visionaries, architects, and coaches that empower the people with the most relevant competencies so these can lead, collaborate, and deliver exceptional outcomes. Such leaders are catalysts that motivate people to act in team-oriented ways and to become involved in making the strategic and organisational decisions that will affect them and their work. This, according to McKinsey (2018), reflects shared and servant leadership.

Agile organisations put people at the centre, which engages and involves individual companies in the supply chain. This involvement manifests itself in several ways including, obstruction of production flow on observation of irregularities, adaptation of work teams to variations in job duties and in the production flow, commitment to continuous improvement and innovation through knowledge sharing and education, and better opportunities to influence decisions (Gunasekaran et al., 2019). They are the main enablers of quickly creating competitiveness, as advances in digital technologies and viable practices modify job structures and extend workers' scope of discretion and responsibility (DeGroote and Marx, 2013)**.** For these reasons, agile supply chain organisations invest in a wide range of management training, which empowers and develops its people, a strong community that supports and grows mindset, and the underlying people processes, which foster the entrepreneurship and skill upgrading needed for agility to occur. Gunasekaran et al. (2019) stated that agile team's approach will ensure people understood their new role and the operating model, as well as to give them the opportunity to ask questions and learn from one another. Gunasekaran et al. (2019) concluded that five things are critical in agile teams. These are:

- communication and engagement are critical. An agile transformation affects the day-to-day experience of every employee. It is critical to be transparent about what people can expect.
- Changing mindset. It is easy to change a reporting line, but changing behaviour is far more difficult. An agile transformation succeeds or fails with leaders showing up as role models.
- Provide people with training options. It is important to give employees the space needed to adjust. There are new roles, new ways of working, and changed expectations. Rather than pushing a lot of training, agile supply chain made courses available online in a self-service format so people could access the right training depending on the maturity of their squad.
- Support with robust change management. In agile supply chain, risk and safety are always top of mind. Throughout the transformation, companies must keep focus on safety-critical processes and roles to maintained highest standards.
- Build the supporting systems and processes. Once the agile supply chain is set up, systems must support the new ways of working rather than complicating them.

The relative focus on training, teaming, and involvement of workers as dimensions of employee empowerment and as determinants of agile supply chain capabilities would differ in practice. Empowerment outcomes could be insignificant for all aspects. In order to survive effectively with the challenge of change as well as marshal the skills required to operate intelligent technologies and deliver sustainable customised solutions ahead of competitors, workers empowerment should be multi-dimensional and total. So, maximum utilisation of personnel' knowledge capability is crucial as a means of boosting the ability to manipulate intelligent technologies (Blome et al., 2014).

In short, agile supply chains has become essential conditions for succusses and prosperity in today's rapid changing business environments. The battle of necessity for becoming agile is intensifying and the spectrum of supply chain companies that need agile attributes are widening. Like other approaches, agile supply chains are adaptive capabilities, with their level of implementation contingent upon the requirement for individual entities in the supply network. The building of such agility capabilities can be materialised with the implementation of new sustainable supply chain practices, which provide the identified capabilities. As such, supply chain agility may be achieved through strategic utilisation of sustainable best strategies/practices (Teece, 2014, 2017, 2019, Teece et al., 2016). The next section, discussed in detail some of the sustainable supply chain management practices.

## 2.4 Sustainable supply chain management (SSCM)

Sustainable supply chain is a growing global concern. Production and consumption of goods/services are the cause of these pressing sustainability issues (Tseng et al., 2016). So, the interactions between organisations and the natural environment have been exposed to several powerful changes. Growing populations have raised the demand for scarce resources. Climate change is increasing the vulnerability of supply chains. Consumers are pulling for products that meet higher sustainability values, and governments are increasing the use of sustainability regulations and carbon tax. People are becoming more aware of social and environmental issues and, as a result, businesses need to act more sustainable about their stakeholder requirements (Orji et al., 2019; Sarkis et al., 2019; Kusi-Sarpong et al., 2019; Bai et al., 2019).

More so, organisations are required to strive for greater less use of materials, energy, water, and land, which will offer flexibility to the resulting volatility in the price and availability of resources (Geyi et al., 2020; Khan et al., 2018). Industries will also need to explore new ways of doing business, by expanding into the circular or closed-loop supply chain, where the end-of-life products are reused, recycled, and remanufactured, or by producing robust products for collaborative use.

This section first looks at the development of sustainable supply chain management. Then identify different practices of sustainable supply chain and their effects on performance outcomes. Finally, the barriers, enablers, and contingencies for diffusion of sustainability approaches throughout supply networks are identified.

### 2.4.1 The development of sustainable supply chain management

The growing concern with the environment, most importantly, the possibility of climate change through global warming, has led to a focus on how human and economic activity has the potential to influence sustainability. The Brundtland report first coined the term ‘sustainability’ in 1987 to describe ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Yusuf et al., 2013). In recent time, the United Nations Global Compact has developed a set of principles that support sustainability. These philosophies covered areas such as human rights, labour practices, and environmental issues (Christopher et al., 2018).

It has become more common and accepted knowledge that for companies to remain competitive, and in some cases to survive, a proper balance of economic, environmental, and social sustainability needs to be managed in their supply chain companies (Sarkis and Zhu, 2018; Kwon and Lee, 2019). These three dimensions of sustainability, known as the 'triple bottom line' (TBL) was developed by Elkington (1994) and is central to sustainable supply chain performance objectives (Sarkis and Dhavale, 2015).

According to Elkington (2018), the success or failure of sustainability objectives cannot be measured only in terms of profit and loss. It must also be measured in terms of the wellbeing of people and the health of the planet, and that the sustainability sector's record on those objectives has been mixed (Elkington, 2018). With social and environmental issues now playing a powerful role in defining supply chain practices, businesses can no longer take responsibility (Elkington, 2018). As such, the influence of organisations on society and environment is not only delimited by its own four walls but stretches across the entire supply networks (Lamming and Hampson, 1996).

Over the years, there is a growing realisation of operating cost and social issues interconnected. It is not a short-lived concept; cost metrics are driving businesses to care about sustainability issues; due to the scarce resources (Christopher, 2016). So social sustainability is undertaken not out of legal obligation, but as a necessity (Marshall et al., 2015). Today, sustainability is forcing businesses not only to consider the short-term financial interest of their shareholders (Santibanez Gonzalez et al., 2018, 2019; Bai and Sarkis, 2018), but also to determine how to meet the social and environmental sustainability requirements of stakeholders. Being able to meet customers' social and environmental consideration is an order-winner or order-qualifier in most markets (Sarkis et al., 2019), as customers are becoming increasingly aware of social and environmental issues and are making choice based on sustainability (Zissis et al., 2018).

Numerous studies, such as Jabbour et al. (2019); Touboulic and Walker (2015) presents an overview and synthesis of sustainability. They offer insights into the state of the sustainable supply chain literature. Seuring and Muller (2008, p. 1700) argued that sustainable supply chain relates to "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, that is, economic, social and environmental, which are derived from customer and stakeholder requirements." Carter and Rogers (2008) and Pagell and Wu (2009) suggests that true sustainability happens at the intersection of all three dimensions. Carter and Rogers (2008) argued that there are other components of sustainability but not often included in the definitions of sustainable supply chain management. These are risk management, transparency, collaborative mindset shifting, and business culture underpinned by strong leadership approach (Carter and Rogers, 2008, p. 365). These characterisations of sustainability highlight the importance of social and environmental components of sustainable practices, and the demand for collaboration and partnerships across supply networks, to meeting the stakeholder needs (Touboulic and Walker, 2015).

It appears that the concept of sustainable supply chain management has occurred at different levels of analysis: dyadic relationships, chains, or network (Miemczyk et al., 2012; Tachizawa and Wong, 2014). Organisations might not handle the unsustainable behaviours of their sub-sectors, as customers could link suppliers' negative behaviours to them (Jabbour et al., 2019). Therefore, focusing on supply networks, organisations could play a central role in the entire network.

Consistent with this theory, Miemczyk et al. (2012) proposed three levels of defining sustainable supply chain management: namely, at the dyadic, supply chains, and supply network level (see Table 2.7). They discover that the internal or dyadic issues are in focus and the tendency to deal with environmental, as opposed to social sustainability. Despite the need to look beyond the dyad offer the challenges linked with the extended network, few studies do so in any of the sustainability aspects (Miemczyk et al., 2012).

**Table 2.7** The main definitions of sustainability at the dyad, supply chain, and supply network levels.

| Sources | Definitions |
|---|---|
| **Sustainability at the firm or dyad level** | |
| Walker et al. (2008, p. 75) | "Supply management activities that attempt to improve the environmental performance of purchased inputs, or of the suppliers that provide them". |
| Walker and Brammer (2009, p. 128) | "Sustainable procurement (SPr) is procurement that is consistent with the principles of sustainable development, such as ensuring a strong, healthy, and just society, living within environmental limits, and promoting good governance". |
| Eltantawy et al. (2009, p. 101) | "Managing the optimal flow of high-quality, value-for-money materials, components or services from a suitable set of innovative suppliers in a fair, |

| | |
|---|---|
| | consistent, and reasonable manner that meets or exceeds societal norms, even though not legally required”. |
| Green et al. (1996, p. 188) | “Green supply refers to the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment”. |
| **Sustainability at the supply chain level** | |
| Carter and Carter (1998, p. 660) | “Environmental purchasing is defined as the purchasing function’s involvement in supply chain management activities in order to facilitate recycling, reuse, and resource reduction”. |
| Beamon 1999 (p. 337) | “The fully integrated, extended supply chain contains all of the elements of the traditional supply chain . . . but extends the one-way chain to construct a semi-closed loop that includes product and packaging recycling, re-use, and/or remanufacturing operations”. |
| Zhu and Sarkis (2004, p. 267) | “Green supply chain management (SCM) practices include internal environmental management, external green SCM, investment recovery, and eco-design or design for environment practices”. |
| Darnall et al. (2008b, p. 33) | “GSCM practices involve organisations assessing the environmental performance of their suppliers, requiring suppliers to undertake measures that ensure environmental quality of their products, and evaluating the cost of waste in their operating systems (Handfield et al., 2002). However, GSCM practices also extend to the entire value chain (from supplier to consumer) when organisations inform buyers of ways to reduce their impacts to the natural environment (Handfield et al., 2004)”. |
| Srivastava (2007, pp. 54-55) | Defines green SCM as “integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as end-of-life management of the product after its useful life”. |
| Carter and Rogers (2008, p. 368) | Defines sustainable supply chain management “as the strategic, transparent integration and achievement of an organisation’s social, systemic coordination of key inter-organisational business processes for improving the environmental, and economic goals in the long-term economic performance of the individual company and its supply chains”. |
| Mollenkopf et al. (2010, p. 31) | “In order for firms to effectively implement green and lean supply chain strategies in a global context, managers must move beyond their silos, considering the entire supply chain and all of its participants”. |
| **Sustainability at the supply network level** | |
| Maignan et al. (2002, p. 642) | SRB (socially responsible buying) can be defined as the inclusion of the social issues advocated by organisational stakeholders in purchasing decisions. In this perspective, stakeholders are the agents that bring broad social demands to the attention of individual firms. |
| Hall and Matos (2010, p. 128) | The sustainable supply chain discourse differs from mainstream supply chain management, as it involves the recognition of stakeholders within and beyond the supply chain. |
| Worthington et al. (2008, p. 320) | “The practice adopted by some large purchasing organisations (LPOs) of promoting greater diversity in the supply chain by intentionally providing selling opportunities for traditionally under-represented suppliers (e.g., small firms, ethnic minority businesses, women-owned enterprises), a process known as supplier diversity”. |
| Bansal and McKnight (2009 p. 26) | Industrial symbiosis involves the use of one firm’s residual resources and by-products as feedstock for another (Chertow, 2000). |
| Hughes et al. (2007, p. 491) | Ethical trade, involving codes of conduct for minimum labour standards in supply chains, contrasts markedly with the more radical, developmental project of fair trade, which has the goals of producer empowerment and equitable trading. However, there can be a blurring of the boundaries between the two movements in some cases (Smith and Barrientos, 2005). |
| Font et al. (2008, p. 260) | SSCM: “. . . a philosophy of management that involves the management and integration of a set of selected key business processes from end user through original suppliers, that provides products, services and information that add value for customers and other stakeholders through the collaborative efforts of supply chain members (Ho et al., 2002, p. 4422)”. |

| | |
|---|---|
| Ahi and Searcy (2013, p.339) | "The creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organisational business systems designed to efficiently and effectively manage the material, information, and capital flows associated with the procurement, production, and distribution of products or services..." which are: "... to i) meet stakeholder requirements, ii) improve the profitability and competitiveness and, iii) improving resilience of the organisation over the short- and long-term". |

In effect, the expectations of customers and stakeholders driven sustainable supply chain management (Rebs et al., 2017; Glover et al., 2014), including the reactions to the violation of the expectations by any supply chain members according to the so-called chain liability effect (Hartman and Moeller, 2014). This effect of stakeholders' pressure on the focal firm in response to supplier misconduct applies independently of the focal firm's knowledge about a supplier or its influence on the suppliers. The focal firm's define sustainability requirements and try to ensure their implementation in the supply chain (Schaltegger and Burritt, 2014; Hartmann and Moeller, 2014; Wilhem et al., 2016b).

This development toward more interorganisational scrutiny for sustainability has been documented in some industries in which sustainable supply chain management has gained traction (Sauer and Seuring, 2018a). These industries range from the extractive industries (Sauer and Seuring, 2017, 2018b; Hofmann et al., 2018; Silvestre, 2015) and electronic and high-tech products (Cucchiella et al., 2014; Brix-Asala et al., 2018), the food sector (Mena et al., 2013; Beske et al., 2014; Grimm et al., 2014), and retailing (Petljak et al., 2018). The sustainable supply chain management is moving from a focus on industrial contexts towards investigating sub-suppliers (Yawar and Kauppi, 2018; Jia et al., 2018; Petljak et al., 2018; Khalid et al., 2015).

The extension of sustainability to lower-tier supply chain means that the investigation of firm relations beyond a dyadic relationship and moves the focus to sub-or lower-tier suppliers (Tachizawa and Wong, 2014; Mena et al., 2013). The supply chain has long been conceptualised as multi-tiered (Seuring and Muller, 2008; Miemczyk et al., 2012), sustainable supply chain management literature has been limited to buyer-supplier dyad (Miemczyk et al., 2012; Choi and Wu, 2009; Soosay and Hyland, 2015).

There are numerous factors that hindered moving from traditional supply chains to sustainable supply chain. Some of these principal reasons for unsuccessful implementation of sustainability are related to inadequate information sharing (Kembro et al., 2017); a lack of robust knowledge and understanding of sustainable initiatives across supply chains (Sarkis and Dou, 2018); misalignment of operation processes and limited visibility of sub-suppliers (Busse et al., 2017a, b; Blome et al., 2014), as well as their competitive performance (Maestrini et al., 2017 Koh et al., 2017, 2018). Other literature identified organisation legacy structures, outdated ways of working, poor leadership commitment and process complexity, onerous procurement processes and a lack of the right number of skilled resources as main barriers to sustainable supply chain management (Sajjad et al., 2015). Many academics and practitioners have made effort to tackle these barriers. However, how far organisations can influence their sub-tier suppliers to address these pressing broader sustainability issues will determine the diffusion depth level of broader supply chain sustainability practices. Sustainable supply chains management can help in addressing these important issues (Sarkis et al., 2019). It requires organisations to share knowledge or learning, with strong leadership to extend sustainability initiatives to sub-suppliers (Jia et al., 2019; Tachizawa and Wong, 2014). This indicates a need to further understand the various sustainable initiatives within supply networks. Mena et al. (2013) argued that a focal firm engages their suppliers if it wants to compliance with environmental and social standards in the supply chain.

Another limitation of sustainable supply chain management research has been the focus on environmental sustainability (Wilhelm et al., 2016a; Ashby et al., 2012; Miemczyk et al., 2012), while the argument of insufficient investigations into social sustainability can now be rejected, as the social aspect is attracting major attention in the research community (Yawar and Seuring, 2017; Nakamba et al., 2017; Quarshie et al., 2016). There is still a lack of research on social sustainability at the supply network level (Nakamba et al., 2017). Some sustainable supply chain management scholars have started extending the boundaries of the investigation toward all the three dimensions of sustainability, as well as further up the supply chain, to cover the full complexity of interrelations of supply chain partners in a sustainable supply chain (Tachizawa and Wong, 2014; Grimm et al., 2016; Hofmann et al., 2018). The coverage of sustainability dimensions is more relevant in supply network, as social misconduct remains largely invisible in the network, which makes it a major supply and reputational risk (Wilhelm et al., 2016a,b).

Tachizawa and Wong (2014, p. 651) have reviewed sustainable supply chain literature and offers a typology of sustainability implementation approaches including “direct”, “indirect”, “working with third parties (competitors/NGOs/Government, etc.)”, and “don’t bother” types of management. This thesis does not discuss "don't bother" since the approach means that the major firm pays attention only to the first-tier suppliers and has no intention to influence sub-suppliers' sustainability performance.

Direct approaches mean a bilateral actions among focal firm and suppliers, such as training, direct sourcing, and monitoring (Mena et al., 2013). In some industries, which have strict components quality and service requirement for lower-tier suppliers, the major company often selects and certifies critical sub-suppliers. The major company may require its direct suppliers to use certified sub-suppliers (Mena et al., 2013; Choi and Hong, 2002). When qualified sub-suppliers are not available in a market, the major company may also have direct access to sub-suppliers. To produce sustainable products to sustained competitive advantage, Kogg (2003) reports that companies can directly interact with multiple tiers of suppliers to motivate sub-suppliers to comply with the criteria for sustainable products.

Indirect approaches cover the training of first-tier suppliers to enable them to monitor lower-tier suppliers against criteria provided by the focal firm (Tachizawa and Wong, 2014). It also indicates that a focal firm would influence sub-suppliers' sustainable practices through other suppliers, normally direct suppliers. Indirect approaches have the same attributes to the open multiple-tier supply chain structure (Mena et al., 2013). It can be seen as a mid-range solution, which outsources the managerial effort for developing and sustaining the sustainability performance of sub-suppliers to the tier-1 supplier. Though the direct approach gives advantages like minimising information asymmetry, that approach may be costly, requiring substantial resources, as the number of sub-suppliers becomes larger. In practices, several major companies would depend upon their direct suppliers to manage sub-supplier sustainability performance. As organisations often require first suppliers to transfer code of conduct to sub-suppliers (Wilhelm et al., 2016).

Working with third parties relates to the situation in which neither the focal firm nor the tier-1 suppliers can pressure, train, or monitor the lower-tier suppliers, the supply chain need to buy-in external knowledge from non-governmental organisations (NGOs), certification bodies or industry association through collaboration with third parties to monitor sub-suppliers (Villena and Gioia, 2018; Tachizawa and Wong, 2014). Grimm et al. (2014) added to this argument by identifying the involvement of business partners and their knowledge as an important factor in sustainable supply chain management. Using third parties' knowledge, the organisation can shift some responsibilities and have an unbiased source of information and support. Third parties that an organisation chooses to cooperate with may have significant influence or reputation and be part of a certification scheme (Villena and Gioia, 2018). With third parties, major companies can build legitimacy via the coalition, helping them to buffer risks and criticisms from poor sustainability performing sub-suppliers (Schaltegger and Burritt, 2014; Hartmann and Moeller, 2014; Wilhelm et al., 2016). Kogg (2003) argues that organisation work together with its key competitors to develop criteria for sustainable sourcing/procurement. Finally, the "don't bother" approach means deliberately bypassing the active management of a sub-supplier and relying on tier-1 suppliers or pressures outside the supply chain (Tachizawa and Wong, 2014). This approach is either redundant with the indirect method or implies that the focal firm has no information about lower-tier suppliers (Tachizawa and Wong, 2014, p. 652). This is in contrast with this study's focus on operators-supplier relationship and will not be discussed further.

Sauer and Seuring (2018b) added the cascaded approach to sustainable supply chain management debate. This approach combines two or more sub-suppliers into a cascade of supply chain segments, i.e., multiple buyer-supplier-subsupplier relationships. In this cascade, each supply chain segment drives those sustainability challenges that it can best address. For managing suppliers and sub-suppliers, sustainable supply chain approaches are applied (Tachizawa and Wong, 2014). Similarly, the focal firms of each supply chain segment coordinate the mutual supply chain objectives and the overarching strategy (Sauer and Seuring, 2018b, p. 10). The next section discussed in detail some of sustainable SCM practices.

### 2.4.2 Sustainable supply chain practices

As explained earlier, the supply chain is "a network of connected and interdependent organisations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end users" (Christopher, 2016, p. 3). It is a strategic management tool used to enhance overall customer satisfaction, which is intended to improve the profitability and competitiveness of organisations. In short, Supply chain management embraces the integration of all key business processes across the supply chain (Lambert and Enz, 2017). Given the growing magnitude of environmental and social problems, however, this traditional supply chain models have become inadequate, as a basis for identifying important emerging sources of sustainable competitive objectives. (Ageron et al., 2012; Grimm et al., 2014; Hofmann et al., 2018; Wong et al., 2018). Unlike the traditional supply chain model, sustainable supply chain considers the social and environmental impacts of the production processes as goods flow through the supply chain (Marshall et al., 2015). In other words, sustainable supply chain paradigm is a set of supply chain initiatives aiming at reducing the environmental impact and improving the social condition of different members of the chain, while boosting innovation, resource-efficiency, reputation, and market share (Sancha et al., 2016; Stindt et al., 2016).

Over the years, the concept of sustainable supply chain management has evolved to include activities such as, ISO 14001, SA 8000, and codes of conducts (Darnall and Edwards, 2006; Orzes et al., 2017; Treacy et al., 2019) in addition to due diligence in supply of conflict minerals (Hofmann et al., 2018) and restriction of the use of hazardous materials (Blome et al., 2014a, b). Some studies also have looked at the implementation of proactive sustainable product design within multi-tier supply chains (Morais and Silvestre, 2018; Grimm et al, 2014; Wilhelm et al., 2016). While others consider sustainable procurement (Zsidisin and Siferd, 2001; Paulraj et al., 2017; Zhu et al., 2013; Morali and Searcy 2013); sustainable transport (Vachon and Klassen, 2006) and, investment recovery (Zhu et al., 2013, Zhu and Sarkis, 2007; Nasir et al., 2017) as sustainability practices. Recently, Marshall et al. (2015), Mani et al. (2016, 2018); and Zhu and Lai (2019) maintained that it is important also to understand the social issues that influence each level of supply chain and their stakeholders. These include health and safety management procedures, workers' welfare, human rights violations, product and process safety amongst others (Marshall et al., 2015; Chin et al., 2015). Given the multi-characteristics of sustainable supply chain practices, this research focuses on six major sub-constructs of sustainable practices. These are sustainable products and process design, sustainable procurement, sustainable transport, investment recovery, environmental protection systems, and social sustainability practices. These practices relate to the main internal and external activities and operations in sustainable supply chain management, as suggested by Zhu et al. (2008, 2013) and others (Paulraj et al., 2017; Su et al., 2015). The next section explained each of these practices.

#### 2.4.2.1 Social sustainability practices

Social sustainability practices are about managing the social issues within the entire supply chains (Mani et al., 2018). Marshall et al. (2015) grouped social practices into two categories. These are basic category, which includes human right issues, safety, and health impacts, whilst advanced category involves product and process related issues. The social impacts related with industrial supply chain operations are more complex. The connections between social sustainability practices and sustainable supply chain performance are still understudied (Rothenberg et al., 2001; Walker et al., 2014). Researchers have focused on incorporating leaner sourcing with environmental sustainability and neglecting the social sustainability (Martinez-Jurado and Moyano-Fuentes, 2014).

Understanding and addressing the social issues of workers, suppliers, customers, communities, and other stakeholders affected by supply chain operations is an important aspect of designing and executing successful sustainable supply chain projects. A lack of engagement and involvement with communities can result in project disruption, failure, and a potential increase in social issues. Successful engagement with stakeholders may help to enhance the wellbeing, and economics of local communities. This highlights the importance of stakeholder involvement and development. Zhu and Lai (2019) investigated the social responsibility of the multinational enterprises and show that multi-ties suppliers including cooperation and interaction have influence on the social sustainability implementation. In addition, social supplier skills development and interaction with employees are crucial (Zhu and Lai, 2019).

Social supplier development can be defined as collaborative efforts by a buyer to help supplier reduce their negative social/environmental impacts and improve sustainability performance and achieved profitability (Sancha et al., 2015b; Bai and Sarkis, 2014). Sancha et al. (2015b); Marshall et al. (2015) argued that there are different categories of social supplier development. These include the provision of training and education to suppliers; the inclusion of NGOs, community, and social groups in the decision-making process; defining health and safety management procedures with suppliers; and the protection of human rights of individual and communities. Other practices include social supplier monitoring such as implementing health and safety and well-being system in the workplace and with supplier; social investment and development of local communities; visit to the suppliers' premises; and transfer of knowledge and information in term of social issues (Krause et al., 2009; Sancha et al., 2015a). Social new product and process development practices, which refer to the development of products and processes to ensure its safety is also important (Ciccullo et al., 2018; Marshall et al., 2015).

Supplier development can help in the environments where customer expectations are changing. So, it is no surprise that social supplier development is also a major precursor for sustainable supply chain management (Wu et al., 2009). Usually, supplier development activities are aimed at helping suppliers to meet the needs of buyers, which may play a key role in enhancing sustainable supply chains (Pagell et al., 2009). Though, sustainable supply chain initiatives include other supplier development activities in which the organisation helped their suppliers to a better member of the community (Pagell et al., 2009). These approaches help suppliers to contribute to the well-being of the chains and the wider community. More so, involvement with members of the supply networks can improve more sustainable supply chains (Zhu and Sarkis, 2004). While education of, involvement with, and ensuring safety of workers and communities rely on effective information sharing. Pagell and Wu (2009) identified traceability and transparency having a direct connection with sustainable supply chains. Achieving social sustainability requires sharing information amongst supply chain members regarding the use of child and force labour practices to optimise social performance and reduce environmental risks.

Despite progresses in operations and supply chain literature, however, the relevance of social aspect of sustainable supply chains has been overlooked (Kleindorfer et al., 2005; Sancha et al., 2015a; Mani et al., 2016, 2018; Gimenez et al., 2012; Akamp and Muller, 2013). According to Page and Wu (2009), the investment in workers and communities to support a social objective can led to high levels employee engagement. This commitment can be translated into sustainable supply chain performance (Sancha et al., 2015a, b; 2016). Mani et al. (2018) explore the social issues pertinent to suppliers. The researchers report a positive relationship between supplier social sustainability practices and supply chain performance. While some studies have also shown a positive effect of social practices on performance (Akamp and Muller, 2013; Klassen and Vereecke, 2012), other studies has found no support, at best the result were mixed (Sancha et al., 2015; Gimenez et al., 2012; Hollos et al., 2012; Gallear et al., 2012). These inconsistencies results suggest further investigation.

#### 2.4.2.2 Sustainable product and process design

Sustainable design means the integration of environmental aspect or “external stakeholders” perspectives, into products design with the aim of improving sustainability performance of the product throughout its whole life cycle (Sarkis and Dou, 2018; Srivastava, 2007). Here, companies are required to supply information regarding the environmental aspects of a product to its players. Sustainable design was developed from the concept of concurrent engineering and design for manufacturing and assembly (Green et al, 2012b; Zhu et al., 2008). Concurrent engineering requires that the related functions, such as product design, manufacturing, and logistics, work concurrently on the product design, and not over the wall approach (Harrison et al., 2019). Decisions taken regarding the design of the product can have a significant impact across the supply chain (Dües et al., 2013). This is true when considering the supply chain's resource footprint. Several companies are seeking ways to reduce the use of packaging materials, but there can be any way to improve resource sustainability. If those supply chain managers responsible for new product development are not aware of the resource effects of their design decisions, which may cause the launch of products with a bigger resources' footprint (Christopher, 2016).

Sustainable product and process design, thus, aimed at making products that use less energy and generate fewer wastes (Esfahbodi et al., 2016), and the use of recycling materials; design and production of products that can be reused (Dües et al., 2013). One tool for assessing all the environmental impacts associated with every step of the supply chain is life cycle analysis (LCA) (Mena et al., 2014). The life cycle analysis has a much broader focus, as it compiles a list of all the inputs and outputs across the supply chain and then assess the potential environmental impacts from 'cradle to cradle' (Sarkis and Dou, 2018). Here, cradle to cradle requires that all ingredients used and produced across the supply chain be renewable materials, which can be decomposed organically, or technical materials, which are non-toxic materials that have no negative environmental impact (Mena et al., 2014). The implementation of sustainable design approach is critical, because the most effective way for reducing pollution or waste is through waste prevention by better design (Sarkis and Zhu, 2018). Most of the environmental influence is locked in at the design stages when the materials and architecture of product are determined.

Sustainable product and process design approaches vary and have been grouped into the following: product design for minimised the use of non-renewable materials and energy; design of product to avoid the use of toxic materials; design product for use of renewable resources under their rate of replenishment; the product in use must have a low environmental impact; and designing for easily composted, reused, or recycled at the end of its useful life (Sarkis and Dou, 2018).

Beyond life cycle analysis, sustainable design also requires that businesses must take an environmental initiative to raw material and component suppliers, which aimed at minimising the environmental impact of the entire supplier system (Sarkis, 2006). Sustainable design implementation needs extensive involvement of employees, environmental experts, end-customers, suppliers, and even community representatives in the process (Esfahbodi et al., 2016). If the environmental impact of the product-in-use is to minimise, and the spent product reused or recycled.

Sustainable design seeks to reduce negative impacts of pollution and waste on the environment and the safety of products across the supply network (Seuring and Muller, 2008; Zhu et al., 2008). By minimised material inputs and energy use as well as proper managing of waste, companies can realise significant savings, resulting in a cost reduction, relative to their competitors (Green et al., 2012b; Hart, 1995). In fact, sustainable design may save not only cost, but it also may increase productivity and efficiency (Hart, 1995). Less waste means better use of inputs, resulting in lower costs for raw materials and waste disposal (Zhu et al., 2008). Sustainable design may also minimise cycle time by removing unnecessary steps in production processes (Hill and Hill, 2012). Sustainable design provides opportunities to cut emissions and reducing the companies' compliance and liability costs (Green et al., 2012b). Hence, sustainable design approach should enable lower costs, which in turn, should result in enhanced cash flow and profitability for the organisation. Such practices should thus provide companies with the opportunity for improving sustainable competitiveness.

#### 2.4.2.3 Sustainable procurement

Sustainable sourcing is emerging as a fundamental element of best-practices procurement, whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment (Slack and Brandon-Jones, 2018). It involves green procurement initiative, which focus on a set of environmental aspects of procurement that facilitate reduction of material use and the reuse of material (Carter et al., 2000), while the ethical procurement or ethical sourcing relate to the social aspects of procurement. Naturally, sustainable procurement strategies consider all the three dimensions of sustainability throughout supply networks. It aimed at the elimination of waste, effluents, and pollution from the entire chain operations of manufacturing, transportation, use, reuse, recycling, re-manufacturing, and disposal (Sarkis and Dou, 2018). Besides waste reduction is a key aspect of decreasing the environmental impact of the entire supply chain operations. So, a reliable and efficient sourcing-based approaches are correlated to improved environmental performance (King and Lennox, 2001; Curkovic et al., 2000).

Several tools are available to tackle sustainability challenges in procurement. Min and Galle (2001) classified these approaches into two main categories: waste elimination and source reduction approaches. Waste elimination, on the one hand represents biodegrading, scrapping, or dumping, and nontoxic incineration, whereas source reduction involves recycling (onsite or offsite), reuse, and source changes and control. In contrast, Tachizawa et al. (2015) identified two basic types of sustainable procurement approaches. These are environmental supplier monitoring practices and environmental supplier collaboration practices. Environmental collaboration approaches are joint efforts with suppliers to improve supplier's environmental performance, including the joint development of cleaner production processes and sustainable products, to influence legislation in cooperation with suppliers, amongst others. While environmental supplier monitoring approaches relates to monitoring supplier's practices and policies such as supplier compliance auditing, product eco-labelling, and content requirement, and implementing environmental management systems (such as, ISO 14000 certification) to reduce pollution and waste (Rajesh and Ravi, 2015).

Implementing sustainable procurement approaches requires alignment and realignment of supply chain processes; from the definition of specifications, through to the selection, negotiation, monitoring, and evaluation of suppliers of goods and services (Mena et al., 2014; Rajesh and Ravi, 2015). The inclusion of suppliers in the early stages of new sustainable material or product sourcing have been discussed as an opportunity to influence performance (Petersen et al., 2005; Paulraj et al., 2008). This is important for sustainability, as it requires expertise in the selection of sustainable materials and products (Mena et al., 2014). Previous Defra report 2006 have identified a lack of leadership commitment, poor incentive systems, mixed communication, a lack of clarity and proliferation of priorities, a lack of cross-functional team, failure to manage supply chain risk, a lack of information sharing and training, and a focus on short-term efficiency savings at expense of sustainability benefits as some of the impediments to sustainable procurement across supply networks (Defra, 2006).

Perhaps the most significant impact procurement can have on sustainability is in supplier's selection and negotiation (Rajesh and Ravi, 2015). To deliver on this, it is necessary to have a robust supplier selection process that includes sustainability criteria such as use less energy and water, reduce greenhouse gas emissions and waste (Christopher et al., 2018). The important given to these criteria will have to a greater degree determine the overall impact procurement can have on sustainability across the supply chain (Carter and Dresner, 2001). Given that procurement and supply chain managers have a major impact on sustainability, it is likely to maintain that there is great potential for sustainable procurement practices to delivering real value for money or efficiency and sustainable competitiveness (Mena et al., 2014). In their analyses, Esfahbodi et al. (2016) shows how a focus on sustainable procurement can help to identified efficiency savings that would have otherwise been ignored or remained hidden.

Sustainable procurement can also have a range of benefits than is immediately apparent. Recycled materials and products have long been recognised as making an important contribution to sustainability through reducing landfill; thereby eliminating methane emissions as well as conserving non-renewable resources, but existing report show that full life cycle of a product also have an important part to play in reducing carbon dioxide emissions (Govindan et al., 2014). Leaner and more efficient sourcing require fewer inputs - raw materials, energy, and water (Dües et al., 2013). Capturing the benefits of sustainable procurement will contribute to ensuring the overall environmental, social, and economic gains.

By sourcing more efficiently companies can reduce their environmental impact while instantaneously lowering the costs of inputs and waste disposal (Porter and van der Linde, 1995; Hart and Dowell, 2011). The economic benefits make efficiency initiative easy to justify through traditional return on investment (ROI). Esfahbodi et al. (2016) identified the need for more efficient energy or resource consumption and waste generation as a key issue in procurement strategies. While ignoring environmental and social considerations in sourcing can expose an organisation to reputational risks (Hill and Hill, 2012). The industrial sector has a dual role to play to enhance sustainability both as a consumer of non-renewable resources and a major influence on the behaviour of suppliers and so stimulating product development and innovation. To deliver sustainable procurement, customer must challenge the need to purchase at all. As one of the most effective ways to reducing social and environmental harm is not to buy, so organisations can help suppliers deliver on their sustainability commitments.

Sustainable technology is one of the main markets in which procurement can have an impact. The emerging international markets will become a major potential consumer of sustainable materials or products; the UK businesses need to be able to compete in these sustainable markets. In line with DTI-Defra survey, the UK industries sector is growing fast, yet, it has a smaller share of global market. As such the UK government has a role in stimulating higher sustainability standards and bringing innovations to marketable scale. Manufacturers and government can work together in motivating innovation through sustainable procurement.

Despite the benefit of sustainable procurement approach on performance outcomes, Tachizawa et al. (2015) survey indicated that collaboration strategies have a direct effect on performance, while monitoring practices has only an indirect relationship through collaboration practices. Esfahbodi et al. (2017) stated that both sustainable procurement strategies were found to have a strong positive effect on environmental and economic performance.

#### 2.4.2.4 Investment recovery

Investment recovery is an essential aspect of sustainable supply chain practices. This sustainability practice can be facilitated, amongst other approaches, via creating closed-loop supply chains - a circular way of doing business where wastes are recycled as raw materials and/or with the end-of-life products reused as input (De Angelis et al., 2018; Zhu et al., 2013; Kleindorfer et al., 2005; Wang et al. 2019). Investment recoveries include reverse logistic - the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, products, and related information from the point of use back to the point of origin for the purpose of recapturing or creating value or proper disposal (Rogers and Tibben-Lembke, 2001). Typically, reverse logistics separate, durable products that contribute to solid waste management aspects (Lai et al., 2013).

Carter and Ellram (1998) distinguish among reuse, remanufacturing, recycling, and recovery approaches. Recycling involves extracting a product’s raw materials and using them for new products; that is, the process of collecting used products and processing them into recycled products. Reuse mean redeploying a product without the need for refurbishment. Re-manufacturing represents returning a product to the performance specification of the original equipment manufacturer and giving a warranty close to that of a newly manufactured equivalent (Wang et al. 2019). Recovery involves using a product’s materials for a basic, low value purpose such as road base or combustion to produce heat (Sarkis and Dou, 2018).

These practices concerned with reducing negative environmental impacts by attempting to integrate obsolete, and excess capital assets back in to reverse logistics processes so that assets may be recovered or disposed of (Zhu et al., 2008). This shift in thinking is likely to generate real competitive benefits and differentiation (Chen et al., 2019; Awasthi et al., 2019). It can also help organisations to maximise cost savings (Wang et al., 2019; Taleizadeh and Moshtagh, 2019). A circular approach provides companies with an alternative pattern of resource use and creating more value from each unit of the resource through recovery and regenerating products at the end of their service lives (Choi and Hwang, 2015). However, re-use or recycling approach requires supply chain capabilities and operational models and will need new technologies to deliver sustainability performance and overall organisational performance objectives (Ciccullo et al., 2018).

#### 2.4.2.5 Sustainable transportation

The term "sustainable transport" reflects environmental principles that seek to manage the environmental burden of all stages of transportation system (Sarkis, 2006). It involves sustainable delivery of products that meet the requirement of customers. Decisions on the mode of transport will affect the carbon footprint of a supply chain as will the extent to which transport capacity is efficiently used (Christopher, 2016). However, the nature of the delivery network (i.e., the number, location and design of distribution centres, the use of hub and spoke arrangements, the extent of cross-docking, etc.) can have a wider impact on supply chain sustainability.

The increases in global sourcing have led to products travelling greater distances (Fahimnia et al., 2015). As a result, these activities have deepened energy-intensity of transportation throughout the global supply chain (Rondinelli Berry, 2000). Energy intensity is the amount of energy per unit of output, including energy efficiency changes. In the context of transport sector, transport-intensity reflects the miles or km travelled per unit of product shipped (Christopher, 2016). Consistent with the rapid development of transport industry, so is the rapid increases in energy consumption (Dai and Gao, 2016). In line with the International Energy Agency (IEA, 2017) report, about 34.64 percent of global energy use is from the transport sector: road tankers, rail cars, shipping, pipeline, and air that distribute products to consumers use significant amount of oil and gas.

Achieving sustainable transport solution requires rapidly technological shift; use of renewable energy in modes of product transport and in the process of product packaging; electric vehicle technology and using less energy in product delivery (Green et al., 2012b; Zhu et al., 2008). Implementing these approaches, organisations can make progress towards carbon reduction objectives. However, whilst technology alone will not deliver sustainability; collaborative mindset shifting will also be required (Esfahbodi et al., 2016).

More so, to mitigate the adverse environmental impact of transportation, businesses can adopt numerous sustainable delivery initiatives. According to Sarkis and Dou (2018), these practices can be classified into three groups: i) green transportation, which consist of selecting greener transport modes, developing energy-efficient warehouse, route optimisation, and selecting green third-party logistic providers; ii) green inventory relates to green packaging and inventory management; and iii) green facility, which are greening facility location decisions and developing energy-efficient warehouse. Equally, Christopher (2016) identified five steps that organisations can take to reduce the transport-intensity of supply chains. These include reviewing product design and use of material; sourcing strategy; reviewing transport options; improve collaborative transport use; and use postponement strategy.

#### 2.4.2.6 Environmental management systems

The potential impacts or risks of sustainable operations need to be managed throughout the lifetime of the project through manufacture, operations, and decommissioning. The main framework for managing operation risk is the management system, which is a business-wide framework that outlines a systematic process to ensure a consistent approach to managing risks. Environmental management systems (EMSs) are an approach of managing environmental performance and ensuring that supply chain operations meet legislative and corporate requirements. EMSs are internal controls that demonstrate how an organisation complies with laws and regulations, which eases the implementation of sustainability policies. Supply chain members use integrated management systems for operating management systems (OMS).

Operating management systems are specific aspects, which underpin how risk management will be achieved. These include specific strategies such as the environmental, social and health management plan, as well as procedures such as monitoring, inspection and audit that are used to measure performance against operations actions. To help organisations develop and manage sustainable supply chains, the international organisation for standardisation has devised ISO 14000 standards for environmental management systems, and ISO 26000 for guidance on social responsibility. ISO 14000 family of standards offers tools for organisations to assess their suppliers' environmental responsibilities and reduce the risks of supplier non-compliance in quality and delivery. Specifically, ISO I4001:2015, addresses environmental management systems by indicating what organisations do to minimise harmful impacts on the environment due to supply chain activities, and to boost environmental performance. It requires supply chain members to keep track of their natural resources use, treatment, and disposal of hazardous wastes. In the context of sustainable supply chain, ISO certification is used to assess the risk of suppliers using dangerous material inputs, violating sustainability regulation, not following a code of ethical conduct, amongst others.

ISO 14001:2015 covers numerous aspects, including: i) environmental management system, which requires a plan to improve performance in resources use and pollutant output; ii) the use of environmental performance evaluation, which specifies guidelines for the certification of companies; iii) environmental labelling that defines recyclable, energy efficiency, and safe the ozone layer; and, iv) life-cycle assessment, which evaluates the lifetime environmental impact from production, consumption, and disposal of a product.

Environmental management approach stipulates that manager need to be committed to sustainability throughout supply chains, in order to make meaningful progress towards achieving sustainable performance. Pagell and Wu (2009) suggested four activities for creating and maintaining commitment to sustainability. Firstly, the economic and non-economic aspect of sustainability need to be aligned. That is, sustainable supply chain leaders should design supply chain where the execution of social and environmental ambitions further financial performance. Secondly, sustainability should be part of the daily conversation. Leaders must discuss social and environmental issues as part of their daily conversation in the integrated supply chain, and not a standalone issue. Thirdly, businesses have a guiding principle and value. This principal offers a succinct method for network partners to define their values and how it conducts activities. Finally, sustainability is everyone’s responsibility (Sarkis, 2001). Entities within the network is responsible for making the chain more sustainable. This commitment should be translated into employee training and engagement to boost sustainability objectives (Pagell and Wu, 2009) without leadership support, employees will pursue traditional financial measures (Handfield et al., 2001), and executing sustainability initiative will be unsuccessful.

Despite the expense and commitment involve in environmental protection systems, it bestows significant benefits (krajewski et al., 2010). One of the benefits come from the potential sales advantage that organisations compliance with standards. Organisations could select a supplier that has demonstrated compliance with ISO documentation standards. Today, many organisations are seeking certification to gain a competitive advantage. More so, the implementation of EMSs can help organisations to increased profitability and improve market access. The British standards institute estimates that most ISO-registered firms experience a reduction in the cost of producing products and services because of the quality improvements.

Certification in ISO 14001 requires organisations to assess and document actions, which may be required for implementing total quality management (Daily and Huang, 2001).

In the diffusion of environmental management system and its effect on environmental performance, Prajogo et al. (2014) argued that EMS diffusion has a positive effect on green products, processes, and supply chain performance. The deeper the EMS diffusion, the more embedded environmental successes in organisations. Dam and Petkova (2014) investigated environmental sustainability programme, and how the stock price fluctuates when leaders announce their commitment to sustainability initiatives. They demonstrated that the market responded towards such supports, and that industries face consumer pressure are more likely to adopt EMS.

Broadly, the above discussions provide insights to what constitutes sustainable practices and attributes of sustainable supply chain management. The identified practices of sustainability in supply chain management are summarised in Table 2.8 below. The table displays 44 attributes in six dimensions of sustainable supply chain management. These includes practices such as sustainable design, sustainable procurement, sustainable transport, investment recovery, social sustainability practices and environmental management systems. These practices relate to the main internal and external activities and operations in sustainable supply chain management, as suggested by Zhu et al., 2008, 2013 and others (Paulraj et al., 2017; Su et al., 2015; Zhu and Lai, 2019; Marshall et al. 2015; Formentini and Taticchi, 2016).

To successfully implement most of these practices, a number of enabling factors need to be considered in managing operators-suppliers' relationships: strategic process alignment; network collaboration; robust understanding of customers; involvement of suppliers; supplier training and development; managing critical suppliers and the development of new technologies capabilities (see section below for details).

**Table 2.8** Essential dimensions and practices of sustainable supply chain management

| Dimensions | Related practices | Sources |
|---|---|---|
| Sustainable design | Design of products for reduced consumption of material.<br>Design of products for reduced consumption of energy.<br>Design of products for reuse, recycle, re-manufacturing, and recovery of material, and component parts.<br>Design of products to avoid or reduce use of hazardous material in manufacturing process.<br>Design of processes for minimisation of waste.<br>Cooperation with customer for eco-design.<br>Design of products for easy disassembly. | (Zhu et al., 2008; 2013; Beske et al., 2014; Esfahbodi et al., 2017; Paulraj et al., 2017; Grote et al., 2007; Marshall et al., 2015) |

| | | |
|---|---|---|
| | The use of recycle materials in production. | |
| Sustainable procurement | Providing environmental requirements for purchased items.<br>Supplier environmental questionnaire.<br>Product eco-labelling.<br>Requiring suppliers to have environmental management systems.<br>Suppliers environmental compliance auditing.<br>Product stewardship.<br>Supplier collaboration in design.<br>Educating suppliers for environmental issues.<br>Joint development of cleaner production with suppliers.<br>Influencing legislation in cooperation with supplier.<br>Cooperation with suppliers for sustainability objectives.<br>Cooperation with suppliers to reduce packaging.<br>Require supplier be certified with ISO 14000. | (Min, H. and Galle 2001; Tachizawa et al., 2015; Esfahbodi et al., 2017; Zhu et al., 2008; 2013; Zhu and Sarkis, 2004; Marshall et al., 2015; Koh et al., 2012; Alvarez et al., 2010; Plambeck et al., 2012; Plambeck, 2012; Simpson et al., 2012; Mena et al., 2013; Esty and Winston, 2006, 2009; Lee et al., 2012a,b; Paulraj et al., 2017 ) |
| Sustainable transport | The use of renewable energy in product packaging process.<br>The use of renewable energy in product transportation.<br>Cooperation with customers for using less energy during product delivery.<br>Cooperation with customer for sustainable packaging. | (Green et al., 2012a; Esfahbodi et al., 2017; Zhu et al., 2008) |
| Investment recovery | Sale of excess capital equipment.<br>Sale of excess materials or inventories.<br>Sale of scrap and used material or by-product.<br>Collecting and recycling end-of-life products and materials.<br>Establishing a recycling system for used and defective products.<br>The used of waste as resources. | Zhu et al., 2008, 2013; Emmett and Sood, 2010; Esfahbodi et al., 2017; Marshall et al., 2015) |
| Social sustainability practices | The use of Health and safety systems with suppliers.<br>Social supplier development.<br>Respect for human risk.<br>Process safety.<br>Product responsibility.<br>Community involvement and development.<br>Health and safety management procedure. | Marshall et al., 2015; Zhu and Lai, 2019; Mani et al., 2018; Pagell and Wu, 2009; Parmigiani, et al., 2011; Castka and Balzarova, 2008; Klassen and Vereecke, 2012; Sancha et al., 2015a; Ciliberti et al., 2009; Huq et al., 2016) |
| Internal environmental management | Commitment of sustainable practices from senior managers.<br>ISO 14000 certification.<br>Support of sustainable practices from mid-level managers.<br>Education and training of suppliers on sustainability issues.<br>Evaluation of supplier commitment to sustainability improvement.<br>Cross-functional teamwork for environmental improvement. | Zhu et al., 2013; Hsu et al., 2013; Green et al., 2012b; González et al., 2008; Mueller et al., 2009; Wittstruck and Teuteberg, 2012; Pagell and Wu, 2009; Prado, 2013; Peters et al., 2011) |

### 2.4.3 The Benefits of sustainable supply chain practices implementation.

As earlier mentioned, there are potential benefits available to organisations engage in sustainable supply chain practices. Earlier research has argued that sustainable supply chain practices are means for lowering costs, enhancing product differentiation, and innovation strategies (Christmann, 2000; Orlitzky et al., 2011; Prajogo et al., 2014; Dangelico and Pujari, 2010). Carter et al. (2000) investigates the impact of environmental purchasing on the financial performance. There are studies suggesting that sustainability in supply networks has helped organisations to achieve better performance (Yusuf et al., 2013; Tsoulfas and Pappis, 2006; Plambeck et al., 2012). Sustainable supply chain initiatives such as using less energy, waste management and minimised materials input and product remanufactured, can lead to significantly costs reduction (Christmann, 2000; Wang et al., 2019). By modifying packaging, businesses can cut down transport costs and raw material use. In the same vein, when organisations use recyclable material, there is possibility of improving operational efficiency (Lai et al., 2013). Empirical studies shown that social and environmental sustainability can reduce costs, with sustainable management of supply chains resulting in improved financial performance of an organisation (Golicic and Smith, 2013; Orlitzky et al., 2011; Klassen and Vereecke, 2012; Mani et al., 2018).

Implementing sustainable supply chain initiatives can help prevent reputational damage and remove unwanted attention from regulators, governments, and public knowledge (Sancha et al., 2015a). Several major companies have built on ethical values and can benefit from building a reputation for integrity and best practices (Hill and Hill, 2012). Sustainable initiatives are likely to be measured and managed to provide clear information for stakeholder. This will be part of the mechanism for capturing value from sustainability. Hill and Hill (2012) argued that when companies undertake social and environmental initiatives, they can persuade governments and societies that they take seriously issues such as health, safety, diversity, and the environment. This, in turn, can help reduce the level of governmental interference in their business through aspects such as taxation and regulation. Besides, stakeholder involvement can help increased market access; and, implementing ethical practices can make it easier to recruit and retain good employees, thereby enhanced employee engagement (Hill and Hill, 2012).

Empirical reports have found that social and environmental initiatives have a damaging impact on organisational performance objectives (Esfahbodi et al., 2017; Winn et al., 2012; Green et al., 2012b; Hahn et al., 2010). Esfahbodi et al. (2016) examined the impact of sustainable supply chain implementation on cost and environmental performance. They found that sustainable supply chain practice can help improve the environmental performance, but such practices do not necessary lead to improved cost performance. These contradictory results may be because of different measures of costs and environmental sustainability performance constructs; or because other measures of sustainability performance have been neglected. This suggests the need to find ways to maximise the outcomes of sustainable practices.

### 2.4.4 Barriers to the implementation of sustainable supply chain practices

Barriers are those factors that could inhibit embracing sustainability in the supply network. Walker et al. (2008) grouped these barriers into external and internal categories. The internal barriers relate to financial resources constraints, a lack of trust-based collaboration or misalignment of onshore and offshore teams, a lack of information flow and insufficient knowledge sharing, low level of skilled resources or expertise, legacy organisation structures, and poor leadership commitment as well as processes complexity as some of the major barriers to sustainability (Koh et al. 2012; Raut et al., 2017; Sajjad et al. 2015). A lack of customer awareness and understanding about sustainability initiative of supply chain partners often makes sustainability efforts without success (Klassen and Vereecke, 2012; Kaur et al., 2018). Other barriers are beyond the control of individual organisation. These factors include lack of supplier capabilities and adaptive capacity, inadequate government support, insufficient use of new technologies, and a lack of customer need for sustainable products (Seuring and Muller, 2008; Walker et al., 2008).

Busse et al. (2016) identified five relative barriers to sustainable supply chain practices: complexities in the sustainability concept, social-economic differences, spatial distance, linguistic distance, as well as social differences between buyers and suppliers. Firstly, there were various understanding of sustainability concepts, and no aligned definition of sustainability was found either in the buyer or in its suppliers. Secondly, buyers and suppliers are at different social and economic development stages. Thirdly, the long distance between buyers and suppliers also acts as a key barrier. Fourthly, the cross-language communication may lead to lower efficiency and impedes the expression of intention. Fifthly, cross-cultural communication may be prone to misunderstanding.

Sajjad et al. (2015) considered the motivator of and barriers to sustainable supply chain management implementation. They revealed that a lack of suppliers' awareness, negative perceptions and inadequate government support are barriers for the sustainability implementation in supply chain. More so, Narimissa et al. (2020) identified key drivers and barriers to creating and improving sustainability in oil and gas supply chains. Walker and Jones (2012) examined several factors that influence the sustainable practices adoption in the British multisector. They identified several factors that could hampered the execution of sustainability in supply chains. Govindan and Hasanagic (2018) looked at drivers and barriers for the implementation of circular economy approach in the context of supply chains. Mangla et al. (2017) observed barriers pertaining to the execution of sustainable production and consumption in supply chain. In a study of the UK public sector procurement practices, Walker and Brammer (2009) reported financial constraint as a leading barrier to sustainable procurement. While Correia et al. (2013); Zhu and Sarkis (2004) concluded that legal and administrative complexity, a lack of skills resources, education and empowerment of procurer and supplier are some of the important issues inhibiting the execution of sustainable supply chain practices.

As mentioned above, these barriers can be internal to the supply chain but also beyond the control of individual organisation. Noting these variations and risks associated with potential hurdles is critical for a comprehensive programme that seeks to implement sustainability practices across operations and supply networks. The other side of the coin is that enablers also exist to help in sustainable supply chain practices implementation and having these enablers will be just as important as removing barriers (Grimm et al., 2014; Sarkis and Dou, 2018).

### 2.4.5 Enablers of sustainable supply chain practices

An enabler is a factor that assists organisations in implementing sustainable supply chain programs. According to Lee and Klassen (2008), the presence of enablers simplified the implementation of sustainable supply chain practices or boost the positive impact of sustainable initiatives on sustainable performance. Whereas their absence may hinder the achievement. Literature such as Rajesh and Ravi (2015); Yang et al. (2011); Shibin et al. (2016); Ciccullo et al (2018) argued that numerous established supply chain practices can help businesses to execute sustainable practices. The next section discussed some of identified enablers in literature.

#### 2.4.5.1 Adequate information technology support

When organisations embed information technology into its supply chain processes, it can develop better supply chain capabilities, that is, more information exchange, more efficient coordination, and increased responsiveness (Wu et al., 2006, 2016). The important role of information technology has been recognised in promoting information visibility, transparency, traceability and in enhancing the collaboration network amongst supply chain companies (Subramani, 2004; Gupta et al., 2019; Lechler et al., 2019; Mejías et al., 2019). Investments in inter-organisation information technology such as electronic data interchange (EDI), digital technology, integrated sensor, block chains, radio frequency identification (RFID), and other new technologies have been identified to have significant impacts on sustainable supply chain performance (Dao et al., 2011; Saberi et al., 2019). So, with adequate information technology support, sustainable supply chain practices would be more likely to be successful.

#### 2.4.5.2 Better understanding of supply chains partners

It is difficult to implement a sustainable supply chain practices successfully without a robust understanding of, involvement in, and knowledge of the supply chain companies (Gong et al., 2019; Wu et al., 2016). Part of this understanding is knowing 'sphere of influence'. This understanding is necessary to help determine the type of relationship to try to develop with supply chain companies. The knowledge base capability can help in understanding the expectations of customers whilst the lack of it could render sustainable practice unsuccessful (Wu et al., 2016). By building knowledge in these technologies, they can better understand and even contribute to the development of supply chain companies' capabilities.

#### 2.4.5.3 Availability of resources outside the supply chain

Most supply chain companies are likely to be small and medium-sized enterprises (SMEs), and they often face the challenges of insufficient human resources and expertise, at the initiation of sustainable supply chain programmes (Sarkis and Dou, 2018). In many cases, the support from major companies is not enough to successfully improve suppliers' sustainability performance. Under this situation, the role of external resources outside the supply chain may become essential. Lee and Klassen (2008) have presented successful cases of small suppliers receiving timely support from several third party – sector sources to improve their sustainability.

#### 2.4.5.4 Promoting an openness among supply chains

Oftentimes organisation have different understandings of environmental and social issues when seeking to implement a sustainable supply chain practice. The establishment of a transparent and visibility via sharing information cooperatively, discussing challenges and managing with a growth mindset will mitigates the vagueness related to sustainability issues. This openness also helps to reach a common understanding of supplier improvement goals and to exchange the necessary information to frontline employees in both parties (Busse et al., 2016). An openness can cultivate more effective communication among parties. Developing and building teams, focussing on personal interactions, and moving towards building human connection at work as well as educating people about sustainability goal and measures, are likely to support the implementation of sustainable supply chain practices.

#### 2.4.5.5 Establishing a trust-based relationship with buyers and suppliers

Trust-based relationship is critical for sustainable supply chain implementation approaches. It can lead to more knowledge exchange and interfirm learning amongst network members because confidence creates a belief that information sharing increases not only the size of the pie but also everyone's share of it (Selnes and Sallis, 2003). There is also confidence that the information being shared is reliable and accurate. Narasimhan et al. (2006) argues that trust-based relationship building activities should occur before investing in sustainable practices. So, building a trust-based relationship can enables the implementation of a sustainable supplier's processes.

### 2.4.6 The contingencies of sustainable approaches implementation

In recent time, another theorising and study on sustainable supply chain practices rest on the recognition that the effect of sustainable practices tend to be highly context specific (Tachizawa and Wong, 2014). Existing studies have started to follow a contingent approach (Aragón-Correa and Sharma, 2003). Many of these contingent variables are the same with enablers, but additional factors outside collaborative relationships also play a role. Such factors include industry dynamism, stakeholder forces, knowledge resources, material criticality, and dependency, amongst others.

The dependency of the major company on its sub-suppliers may mitigate its relative influence and force it to adopt an approach like cooperation or working with competitors. Closeness to suppliers also affects the implementation of sustainable approaches. As distance from sub-suppliers increases, a major company may intend to adopt an "indirect" approach.

Stakeholders' involvement plays a significant role in sustainable supply chain implementation. The greater the presence of third parties that are strategic business partners, the stronger the link between sustainable practices and sustainable supply chain performance. So many companies are pressured by NGOs to implement sustainable practices shows that major companies tend to use a "direct" approach when facing strict stakeholder pressures.

Another key contingent factor is the dynamic of industry environment. Industry environments play a critical role. Those organisations operating in carbon and energy intensive industry may prefer to adopt a proactive approach towards sustainability implementation. More so, major companies in static industries may have more investment in sustainable practices than those in dynamic industries; that is, in high velocity, quickly changing industries, the relationships across the supply chain may be fragile. Supply chain companies may not respond to major company desires for sustainability due to their short-term and highly volatile relationships.

Besides, organisation with insufficient technical expertise and knowledge resources would have to cooperate with NGOs or other third parties to implement sustainable supply chain practices. Complexity of materials is an interesting product flow characteristic that may also cause variations in the relationships to be implemented (Cheng and Sheu, 2012). The advents of personalised product or bespoke materials, whose requirements are difficult for individual organisations, have create the greatest problems for sustainable supply chain implementation approaches. The development of complex products often needs intensive technological skills and rapid response to a variety of customer requirements.

In the context of supply chain management, the complexity of products also influences the range of sustainable supply chain implementation approaches. The higher the product complexity, the scarce are the resources of the supply chain companies, and the more likely is the failure of sustainability values. The lack of rapidly respond to different customer requirements may also cause strength social and environmental issues. Dynamic capabilities theory emphasises the usefulness of pooling scarce resources and realignment of business process. Therefore, it is reasonable to suggest that collaborative networking practices with other organisations may be appropriate to manage sustainability issues.

The ability of detecting supplier’s noncompliance along the different tiers is a capability factor that influence implementation. Sustainable supply chain requires that social and environmental issues are visible and traceable. The more open and traceable the sustainability information is, the more likely it is that indirect implementation approaches can be used in sustainable supply chain management. Less traceable sustainability information is more likely to lead to a direct approach or working with third parties for implementation. Another significant enablers or contingencies of sustainable supply chain management is supply chain agility.

## 2.5 Sustainability performance measurement

Performance measures are important to companies in the supply chain in order to assess performance against set objectives and identify loopholes in performance (Yusuf et al., 2018). The ability to create a baseline is a necessity for any performance measurement system (Beske-Janssen et al., 2015). A performance measurement system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions (Neely et al., 2005). There appears to be a growing recognition that the measures of performance that companies have traditionally used are inappropriate for manufacturing supply chains (Yusuf et al., 2018; Neely et al., 2005). This may have been because they: encourage short-termism; lack strategic focus, and do not provide data of social and environmental issues; and it fails to provide information on what their customers want and what their competitors are doing (Kaplan and Norton, 1992). Therefore, it is important that today's performance measurement system must address the three sustainability dimensions without giving primacy to the economic outcomes over social and environmental effects (Pagell and Shevchenko, 2014).

### 2.5.1 Environmental performance

Environmental sustainability performance pertains to reducing the natural resources consumption such as materials, water, energy, and the atmosphere, amongst others. Whilst there is an understandable concern that the supply chain's carbon footprint should be minimised, it must be recognised that suppliers' decisions have a wider impact on resources generally. Besides, it is important to consider the effect of human and economic activities on the source of raw materials across the entire supply chain. Yusuf et al. (2013) termed this as the protection of scarce resources required to satisfy people requirements. Waste, including external waste, inflicts internal cost (Sarkis et al., 2011). Even in the absence of laws, wasteful use of materials, water, energy, and neglect of greenhouse gases are not only harmful to the environment but changing climate is likely to increase the vulnerability of global supply chains and thus exerting pressures on manufacturers to reduce their greenhouse gas emissions. There is an overwhelming agreement that the climate is changing, and further change is inevitable without reductions of greenhouse gas emissions such as Hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, carbon dioxide, methane, and nitrous oxide. The multiple consequences that come with a warmer climate have escalated the kind of attention given to environmental performance. Environmental performance indicators may also comprise of minimised air emissions, reduced material input, increased energy efficiency, reduced discharge of solid and toxic waste, and decreased use of natural resources, amongst others (Paulraj et al., 2017; Zhu et al., 2008; 2013; Zhu and Sarkis, 2004).

### 2.5.2 Social performance

The importance of social sustainability performance has been emphasised in the literature (Beske-Janssen et al., 2015; Walker et al., 2014). Social performance is the means to the twin objectives of achieving environmental and economic sustainability (Yusuf et al., 2013). Chen et al. (2017) grouped social performance into two basic categories: social capital and human capital. Social capital, on one hand, concerns respecting the rights of the communities in which the resources are located, improving better quality of lives of people without damaging the environment and not overexploiting the resources contained in it (Chin et al., 2015; Yusuf et al., 2013). This also involves humane working conditions at suppliers' plants, fair treatment of customers (product and process safety), and social investment at communities where suppliers operate (Krause et al., 2009; Sarkis et al., 2010). The human capital, on the other hand, concerns improved health and safety of workers, fairness in the working environment, workers diversity and inclusions, sustainable skills development of workers, welfare of workers and the level of employee commitment, amongst others (Jennings, 2013; Carter and Rogers, 2008; Porter and Kramer, 2006; Krause et al., 2009).

### 2.5.3 Financial/economic performance

The economic performance focuses on achieving sales growth and increasing profitability. Here, the critical linkage is the impact that social and environmental action can have on sales volume and customer satisfaction. There are studies that indicate a positive connectedness between sustainability factors and sales growth (Sarkis et al., 2011). For example, Paulraj et al. (2017) show that sustainable supply chain practices improve economic performance such as profit as a percentage of sales, return on assets, and increase in market share. This can be through the efficient use of resources, where products use a smaller number of materials and energy.

It can also be argued that good social and environmental activities may strengthen the likelihood that customers will remain loyal to the supplier. The higher levels of customer retention led to greater sales and profit. Naturally, this occurs because satisfied customers are more likely to place a greater proportion of their purchases with the supply chains. Nonetheless, to sustain the supply chain, productivity improvement is important in order to boost market share. Market share is an indicator of financial performance (Yusuf et al., 2013; 2014). Just as powerful and important is cash flow. Strong positive cash flow has become as much a desired objective of management as profit. The pressure on most organisations is to improve the productivity of capital to make the resources liquid. In this regard, it is usual to use the concept of return on investment where it is defined as the ratio between the net profit and the capital that was employed to produce that profit.

### 2.5.4 Operational performance objectives

Operational performance objectives arise from the ways in which a firm chooses to compete in the marketplace and the types of markets it pursues (Porter, 2004). In competitive markets, customers drive markets and markets drive organisational behaviours. Customers make purchasing decisions for a variety of reasons such as cost or service attributes relating to a purchase. Organisations must position themselves to meet the buyer's requirements. There are numerous important operational competitive attributes that determine the competitive position of an organisation in the marketplace. These may include cost, quality, delivery reliability, speed of delivery, flexibility, and innovation (Yusuf et al., 2007; 2014).

A low-cost position allows the company to use aggressive pricing and high sales volume (Hart, 1995). The organisation keeps the cost of products and services low to provide its customers with better value for money. Focus on this attribute will be important when an organisation is in competition with low-price competitors. Low cost alone may not be enough to attract and keep customers and the company may need to compete on other dimensions too. The quality objective is the ability to deliver on quality conformance. There are two aspects of quality, these include product/service quality and process quality. Process quality is important for all organisations competing in the market because no customer wants products with defects. It determines the reliability of the product/service. Continuous improvement of quality and reliability of products and services offered will be essential in the market being served. The operational objectives must be to specify product/services quality at the level acceptable to the market and consistently conform to specifications.

Reliability performance objective means adherence to the terms and conditions earlier agreed with the customer. Delivery on time or ahead of time may help the organisation to establish a competitive advantage, which may be critical to securing a competitive position in the market (Yusuf et al., 2014). Failure to deliver on time may lead to a loss of trust. The emphasis on reliability has increased because of instability in the market environment (Gordon and Sohal, 2001).

It is important for manufacturers to deliver on cost, quality, and reliability objectives. The increase in competition and rapid technological change have shifted attention to speed. The speed at which a product or service can be delivered may determine the competitive advantage in some market. Speed means timely fulfilment of scheduled orders and developing new solutions ahead of competitors. Enhanced operations speed requires the elimination of non-value-added activities in supply chain business processes (Gordon and Sohal, 2001). Increasing speed encourages waste reduction, while materials spend less time in inventory, thereby minimising operational costs.

There is emphasis on operational flexibility and for companies to accept the challenge of delivering an expected product/service, despite a sudden change in customer demand. In the present social and environmental changes, flexibility entails being able to change products or production processes quickly. Manufacturers may need to develop and introduce new products swiftly for its customers. Innovation, new design, access to capabilities in managing new technologies and process reconfiguration may all be part of being flexible. Another measure of organisational performance is innovation. Innovation involves the thoughtful application of information, imagination, and initiative to deliver values from resources. In the context of business, innovation is achieved when an idea is applied to further satisfy the needs and expectations of customers (Guisado-González et al., 2016). The financial, operational, environmental, and social performance measures discussed above are summarised in Table 2.9.

**Table 2.9** Summary of the dimensions of sustainability and operational performance measures

| Dimensions | Indicators | Sources |
|---|---|---|
| **Financial performance** | • Increase in Sales.<br>• Increase in Profit.<br>• Increase in return on investment.<br>• Increase in overall market share.<br>• Increase in customers' satisfaction.<br>• Improvement in firm's Reputation. | (Yusuf et al., 2013, 2014; Golicic and Smith, 2013; Paulraj et al., 2017) |
| **Operational Performance** | • Costs.<br>• Quality.<br>• Speed.<br>• Reliability.<br>• Flexibility.<br>• Innovation. | (Yusuf et al., 2014; Zhu et al., 2013; Ren et al., 2003; Blome et al., 2013; Eckstein et al., 2015) |

| | | |
|---|---|---|
| **Environmental performance** | • Reduction in solid wastes.<br>• Increased use of renewable resources.<br>• Increased energy efficiency.<br>• Reduction in water usage.<br>• Reduced air pollution.<br>• Decrease in consumption toxic chemicals.<br>• Decrease in frequency for environmental accidents.<br>• Improvement in an enterprise environmental situation. | (Paulraj et al., 2017; Zhu et al., 2013; Wong et al., 2012; Esfahbodi et al., 2017; Blome et al., 2014a, b) |
| **Social Performance** | • Increase in community development.<br>• Improvement in employee wellbeing.<br>• Improvement in health and safety of workers.<br>• Improvement in community safety.<br>• Respect human rights.<br>• Improved product safety.<br>• Improved process safety.<br>• Improvement in social investment. | (Paulraj et al., 2017; Jennings, 2013; Krause et al., 2009; Sarkis et al., 2010; Chin et al., 2015; Klassen and Vereecke, 2012) |

## 2.6 Summary

This chapter gives an overview of supply chain management and the emergence of sustainable supply chain management. The chapter reviewed the literature concerning the conceptualisation of sustainable supply chain practices, and several aspects of sustainable supply chain practices (namely, sustainable product and process design, sustainable procurement, sustainable transport, investment recovery and social sustainability practices) were discussed. The impacts of these practices on outcomes were explained. The chapter also identified the different issues facing the successful implementation of sustainable supply chain practices, including barriers and enablers associated with the adoption, implementation, extension, maintenance, and performance outcomes. The key question is how to communicate, invest in, and develop sustainable practices across the entire supply networks. The role of agile capabilities takes on a bigger emphasis in the network collaboration, business process (re)alignment, market sensitivity, knowledge management and information technology were examined.

The importance of the measurement and the use of sustainability indicators constitute very vital aspects of sustainability performance. Several indicators of sustainability performance and operational performance objectives were identified and discussed. Following this, existing studies have demonstrated the effectiveness of sustainability strategies and their impacts on organisational performance and on improving the quality of the environment (Yusuf et al., 2013).

Nevertheless, the impacts of agility and sustainability practices on sustainable competitiveness is a confusing issue in the literature. Studies such as Golicic and Smith (2013), Rao and Holt (2005) and Paulraj et al., (2017); Yusuf et. al. (2020) has demonstrated a positive correlation between sustainable practices and organisational performance. Whereas there is a lack of consensus regarding the performance effect of sustainable supply chain practices. Several researchers reports that sustainable practices have a negative impact on firms' profitability (Esfahbodi et al., 2017; Winn et al., 2012; Tachizawa et al., 2015; Green et al., 2012b; Hahn et al., 2010; Gallear et al., 2012; Hollos et al., 2012; Sancha et al., 2015a). such inconsistent or contradictory empirical results can be explained by the fact that none of these works consider the mediating role of agile capabilities on the impacts of sustainable practices and organisational performance. It is also evident that contingent situations may contribute to the mixed results reported (Zhu et al., 2013; Esfahbodi et al., 2017), which highlights the importance of agile supply chain capabilities for sustainable supply chain performance.

However, whilst, the challenge is how to integrate social and environmental initiatives with agile supply chain capabilities to develop unique capabilities to improve their overall sustainability competitiveness. Indeed, recent work by Ciccullo et al. (2018) identified a lack of empirical study examining the influence of agile practices on the extent to which organisations could translate sustainable practices into sustainability performance. In this circumstance, the interaction between agile practices, sustainable practices, operational performance objectives and sustainability performance criteria require further investigation.

# CHAPTER 3: Theoretical Framework and Hypotheses

## 3.1 Theoretical underpinning

This chapter presents the underpinning theories of this research and set the foundation for the development of research hypotheses. Several organisational theories were identified, which contribute to the foundation of supply chain agility and sustainability in the literature (Beske, 2012; Teece, 2007, 2017, 2019; Aslam et al., 2020; Ketchen and Hult, 2007; Winter, 2003; Hoopes and Mandsen, 2008; Schilke and Helfat, 2018). These are a capability theory, dynamic capability theory, contingency theory, and configuration perspective. These perspectives contribute to explain the competitive effects of sustainable supply chain practices and supply chain agility capabilities.

### 3.1.1 A capability theory

The capability-based view explores how certain assets and capabilities serve as a base for competitive advantage and superior performance (Dosi et al., 2008). This theory suggests that achieving sustained competitiveness is largely predicated on developing bundles of capabilities that utilise and mobilise competencies (Barney, 2001). The focus on developing capabilities as a base for advantage is linked to organisations having adaptable structures that are responsive to changes in the competitive environment (Teece, 2019). Amit and Schoemaker (1993, p. 35) defined capabilities as a firm's capacity to deploy resources, usually in combination, using organisational processes, to effect a desired end. They are information-based, or invisible processes that are developed over time through complex interactions among the firm's resources. They can be thought of as ‘intermediate goods’ generated by the firm to provide enhanced productivity of its resources, as well as strategic flexibility and protection for its final product or service. Miller (2003, p.691) described capabilities as complementary competencies such as tacit knowledge, administrative skills, routines, and other assets with the flexibility to generate adaptative valuable outputs. Complementary competencies are those capabilities that help firms capitalise on the profits and outcomes associated with a technology, strategy, or even innovation (Christmann, 2000). These complementary capabilities are required when developing certain product or entering new market, as a set of supporting assets to help deliver products (Helfat and Lieberman, 2002).

Stalk et al. (2012) identified four principles of capabilities-based competition: firstly, the building blocks of competitive strategy are not products but business processes. Secondly, competitive success depends on transforming a company’s key processes into strategic capabilities that provide superior value to the customer. Thirdly companies create these capabilities by making strategic investments in a support technology that link together go beyond operations functions. Lastly, because capabilities cross functions, the champion of a capabilities-based strategy is a chief executive officer (Stalk et al., 2012).

Winter (2003) explained a capability as a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organisation’s management a set of decision options for producing significant outputs of a particular type. The routine is a behaviour that is learned, highly patterned, repetitious, or quasi-repetitious, founded in part in tacit knowledge (Winter, 2003). This definition casts learning, experience, processes, and routines as inputs to capabilities as detailed by (Zollo and Winter, 2002).

Capabilities are firm-specific sets of skills, processes, routines, developed within the operations management system, that are regularly used in solving its problems through the means of configuring its operational resources - [they] emerge gradually over time, tacit, path dependent, and can be validated through the application to problems faced by a firm (Wu et al., 2012). Routines, on the other hand, are specific procedure, organisational arrangements, protocols, tools, techniques, and other ways of doing things - situation generic, highly structured sets of activities that can be transferred across organisations and industries to help operations management personnel address similar operational problems (Wu et al., 2012, p. 123). Dosi et al. (2008) and Peng et al. (2008) argued that organisational routines and processes are the building blocks of capabilities.

Ulrich and Smallwood (2004) observed that organisational capabilities are collective skills, abilities, and expertise, that enables organisations to perform sorts of activities. In the opinion of Ulrich and Smallwood (2004), these capabilities are the outcome of investments in staffing, training, compensation, communication, and other human resources management. Ulrich and Smallwood (2004) identified 11 capabilities that well managed supply chain companies must have. These are talent, speed, shared mindset and coherent brand identity, accountability, leadership, collaboration, customer connectivity, learning, strategic alliances, innovation, and efficiency (Ulrich and Smallwood, 2004). When companies fall below the norm in any of those capabilities, dysfunction or competitive disadvantage will likely ensue (Ulrich and Smallwood, 2004). A closer look at those capabilities and how sustainable strategies can help in building agile capabilities is required. Competing on capabilities means companies can outperform competitors on speed, consistency, acuity, agility, and innovation (Stalk et al., 1992). Management cognition has an important role to play in directing organisational learning in developing capabilities and organisational adaptation (Tripses and Gavetti, 2000).

Teece et al. (2014) viewed an enterprise capability as a set of current or potential activities that utilise the firm's productive resources to make and /or deliver products and services. According to Teece (2014) and Winter (2003), there are two important classes of capability, including ordinary and dynamic capabilities. These are amplified below.

### 3.1.2 Ordinary capabilities

Ordinary capabilities are those that permit a company to make a living in the short term (Winter, 2003). It involves the performance of administrative, operational, and governance-related functions that are necessary to accomplish tasks. Ordinary capabilities enable the production and sale of a defined and hence static set of products and services (Teece et al., 2016; Winter, 2003). Ordinary capabilities are stem from the combination of skilled personnel, assests, processes, and administrative coordination needed to get the job done. Such collective capabilities alone are not sufficient to undergird sustainable competitive performance, except in week competitive environments (Teece, 2014). Because knowledge about ordinary capabilities can acquired through consultants or a modest investment in training (Bloom et al., 2013). The current rate of changes and uncertainty in business environment require development of new change capabilities (Teece et al., 2016).

## 3.2 Dynamic capability theory

Teece et al. (1997, p. 516) first introduced the term dynamic capabilities to describe the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments. It reflects an organisation's ability to achieve new and innovative forms of competitive advantage. In the opinion of Teece et al., dynamic capabilities operate on organisational skills, resources, and functional competencies (Teece et al., 1997, p. 515). Here, organisational competencies represented managerial processes or patterns of current practices and learning (Teece et al., 1997, p. 518). Eisenhardt and Martin (2000, p. 1107) argued that dynamic capabilities involve firm's processes that use resources – specifically the processes to integrate, reconfigure, gain, and release resources - to match and even create market changes. That is, it can modify the supply chain processes. The same authors classified dynamic capabilities as product development routines, strategic alliances, acquisition, and knowledge transfer capabilities.

For Zollo and Winter (2002, p. 340), a dynamic capability is a learned and stable pattern of collective activity through which the organisation generates and modifies its operating routines in pursuit of improved effectiveness'. Likewise, Zahra et al. (2006) stated that dynamic capabilities can adjust organisation resources and routines in the way considered appropriate for decision making. Contrary to operational capabilities, dynamic capabilities are more idiosyncratic (Teece, 2017). Because such capabilities involve managerial cognition (Adner and Helfat, 2003), however, it is also embedded in organisational processes that are rooted in business behaviour (Teece, 2012).

Helfat et al. (2007, p. 4) argued that dynamic capability refers to the capacity of an organisation to purposefully create, extend or modify its resource base. Here the resource base comprises the tangible, intangible, or human resources, which have been controlled or accessed by companies on a priority basis (Helfat et al., 2007). Some of these capabilities enable enterprises to enter new markets and expand existing thinking, by adjusting strategic alliances, business models and activities. Dynamic capabilities are not just about making the right bets; they also help organisations develop new products and production processes that foster competitiveness as market growth.

In this regard, Adner and Helfat (2003, p. 1012) believe that actors – individual, manufacturers, governments, and groups – will have an important role. They used the term 'dynamic managerial capabilities' to denotes the ability of leaders to develop and transform the resource base of organisations. This ability results from previous learning and experience. Helfat and Martin (2015) and Teece and Lazonick. (2002) highlighted the importance of managerial cognitive capability that involves the ability to perform not only physical but also intellectual activities.

In the context of supply chains, dynamic capabilities can help in reviewing resource allocations, operations processes, knowledge development and transfer, and decision making (Easterby-Smith et al., 2009). To operationalise dynamic capabilities, some researchers have stated that dynamic capabilities are not just a single concept (Di Stefano et al., 2014; Eisenhardt and Martin, 2000; Helfat et al., 2007; Helfat and Winter, 2011). As a result, scholars have developed a different framework of dynamic capabilities constructs (Teece et al., 1997; Teece, 2007; Eisenhardt and Martin, 2000; Schilke et al. 2018). Teece (2007) provides a support framework that highlights the most critical capabilities required by managers to foster the evolutionary health of the enterprise. According to Helfat et al. (2007, p. 7), evolutionary ability refers to 'how well a dynamic capability enables firms to survive by creating, extending or modifying its resource base, while technical strength allows separating the performance of a process from enterprise performance.

Teece et al. (1997) classified three types of processes direct towards strategic change, including coordinating, learning, and reconfiguring. Teece (2007, p. 1319) suggests that there are three even more basic types of dynamic capabilities involved as being the capacity to: (1) sense and shape new opportunities and threats; (2) seize new opportunities through business model design and strategic investment; (3) maintain competitiveness through enhancing, aligning, and when necessary, realigning or reconfiguring the business models and processes. Following Teece (2007) perspective, enterprises with strong dynamic capabilities are not only adapting to changing business environment, but also shape them through acquisition, coordination and collaboration with customers, suppliers, government, and other stakeholders.

A recent study by Helfat and Raubitschek (2018) identified three basic types of dynamic capabilities that are necessary to managers in creating and capturing value, including technology-related capability, scanning/sensing, and integration capabilities. Innovative technological capabilities contribute to capturing and reconfiguring capabilities by assisting the organisation in developing innovative products and processes, which could aid in empowering the workforce. Scanning capabilities add to meaningful opportunities and challenges. Besides, integration capabilities contribute to detection, seizure, and reconfiguration activities. In the next section, discusses some useful dynamic capabilities that can help organisations to sustain competitive benefits.

### 3.2.1 Sensing capabilities

Sensing capabilities relate to the ability to identify critical threat and opportunities. Sensing or shaping new opportunities is linked to scanning, creating, learning, and interpreting activities (Teece, 2007). Supply chain processes like exploration and development and scanning activities are sources of identifying opportunities. In large businesses, established routines can support research and scanning activities (Teece, 2016); this is the same for sensing opportunities that focus on entrepreneurial activities. It is linked to opportunity recognition, as described by (Teece, 2016). Identifying opportunities include not only identifying customer needs, technological developments, and sustainability risk, but also understanding latent demand and structural change in industries and markets, as well as understanding suppliers and competitors' responses (Teece, 2007).

### 3.2.2 Seizing capabilities

Seizing capabilities represents how organisations address the sensed opportunity. It includes making a strategic investment in opportunities and business models (Teece, 2007; Helfat and Peteraf, 2009). Once supply chain professional identified opportunities, there is a need to understand how to interpret new activities and progresses, the use of new technologies, and identify critical consumers (Teece, 2007). Several leadership roles simplified this capability (Teece, 2016). Besides, selecting the product design and related business models can help in defining how the enterprise delivers value to customers. Businesses should also develop the revenue and cost structure that can help meet the requirement of customers. These abilities can improve business models to create value for supply chains (Teece, 2016).

### 3.2.3 Transforming capabilities

Transformation capability enables organisations to realign its resource base, structure, and processes to take advantage of opportunities. That is, reconfiguration entails combination and recombination of key supply chain processes (Teece, 2014, p. 333). It also rooted in the selection of technologies, product quality, and learning cycles (Weerawardena and O'Cass, 2004). Transforming the resources base is critical to reaching profitability and sustainable growth. In this regard, Ringov (2013); Sirmon and Hitt (2009); Eggers (2012) and Maritan (2001) highlighted the importance of effective governance. They argued that when managers match resources, they can see a maximum return on investment (Sirmon and Hitt, 2009). Other literature alludes to either this typology or Teece et al. (1997) typology of coordinating activities, learning, and reshaping the organisation.  In line with Teece (2017, p. 4) when these capabilities are strong, organisations will be more innovative, flexible, and agile.

In this era of business turbulence, managers generate dynamic capabilities by providing a shared purpose and vision for supply chains. Managers may initiate processes by demonstrating a willingness to reallocated resources to create dynamic capabilities (Teece, 2016). These mechanisms include structuring research and development, information technology supporting codification, problem-solving processes, sharing procedure, market knowledge development, and absorptive mechanisms. Many writers mentioned the importance of shared mindsets of leadership (Macher and Mowery, 2009; Zollo and Winter, 2002).

The maturation of operational capabilities can help create dynamic capabilities. Newey and Zahra (2009) show that operational capability can help in shaping the dynamic capabilities. Helfat and Peteraf (2009); Schilke et al. (2018) indicates that these abilities and business strategies are interconnected. In this way, dynamic capabilities can simplify the implementation of business strategies such as sustainability practices (Teece, 2014; Augier and Teece, 2009). Literature such as Beske et al. (2014); Land et al. (2015); Eckstein et al. (2015); Aslam et al. (2018) noted the value of dynamic capabilities in enhancing sustainability performance. Helfat and Martin (2015) highlighted the importance of dynamic managerial capabilities in strategic change and organisational performance in terms of increasing market share, new product innovation, and operational excellence.

### 3.2.4 The value of dynamic capabilities

As noted earlier, the benefits of dynamic capabilities are associated with their nature. Businesses can gain a sustainable competitive advantage using resource bases. Such capabilities could enable firms to lower operating costs and increasing knowledge sharing, thereby enhancing value creation and firm performance (Helfat and Martin, 2015; Peteraf and Barney, 2003). Given the growing magnitude of social and environmental problems, organisations must look outside for other firms that have complementary skills (Dyer et al., 2018). In support of this, numerous studies have found that high level of dynamic capabilities coincides with cost efficiencies, product quality, flexibility, innovation, and overall supply chain performance (Aslam et al., 2018; Blome et al., 2014a, b; Eckstein et al., 2015; Augier and Teece, 2009). Generally, these studies show that dynamic capabilities can enhance a variety of operational performance outcomes.

Zollo and Singh (2004) reported a positive effect of integrative capability on performance outcomes. Su et al. (2014) suggested that learning capability will help in increasing the level of product quality performance, whereas capabilities for sensing may increase efficiency and resilience. Golgeci and Ponomarov, (2013) shown that the adaptation capability might contribute to improving supply chain resilience.

Dynamic capabilities focus on the understanding of critical suppliers, the alignment, and transformations of these business processes, to increase organisational performance and competitive advantage. According to Teece (2007), dynamic capabilities of identifying opportunities and investments in these opportunities can lead to new social wellbeing, which can influence the performance of the industry in terms of revenue growth, improved profitability, and competitive benefits. Following investments, dynamic capability can further recombine and modify the accumulated resource base of organisations, leading to a robust impact on organisational performance and competitiveness (Teece, 2007).

A number of literature on supply chain management has found a positive relationship between the development of dynamic supply chain capabilities and firm performance. Ju et al. (2016) found that dynamic supply chain capabilities positively influence technological innovation and operational performance. Other researchers have found that dynamic supply chain capabilities positively influence the sustainability of supply chains (Beske, 2012; Beske et al., 2014; Hong et al., 2018). Beske (2012) found that dynamic supply chain capabilities can enhance sustainability performance through the protection of rare resources and their inimitability by building long term relationships and trust with supply chain partners. The same scholar Beske et al. (2014), later argued that dynamic supply chain capabilities improve a firm's environmental and social performance by enhancing the transparency and traceability of supply chain practices. in a contradictory study, Hong et al. (2018) found that dynamic supply chain capabilities positively affect a firm's environmental performance but have no effect on social and economic performance. Eisenhardt and Martin (2000) argued that it is difficult to gain competitive advantage through dynamic capabilities. Other works Sampson (2005); Goerzen, (2007) have shown a negative relationship between integration capability and performance. Examining the value creation and value capture within supply networks using dynamic capability theory will help resolve these inconsistent and paradoxical findings (Dyer et al., 2018).

The dynamic capabilities perspective has become one of the most used theoretical lenses in operations strategy and sustainability field, critics have argued that the lack of empirical knowledge of dynamic capabilities is a major concern (Schilke et al., 2018). In short, dynamic capability theory suggest a new range of capabilities to implement new strategies and make appropriate use of limited resources (Eisenhardt and Martin, 2000). As such, agile and sustainable supply chain can be posited as dynamic capabilities because:

i. it meets the criteria for higher-order capabilities (Collis, 1994; Winter, 2003, 2008; Danneels, 2008),
ii. it focused on transforming supply chain processes (Zollo and Winter, 2002),

iii. it can facilitate resource reconfiguration (Teece, 2016),
iv. it enables the understanding and exploitation of sustainability problems and opportunities (Teece, 2007),
v. it enables the supply chain to respond quickly to uncertain and changing business environment, and to sustain its position in the market (Teece, 2016, 2019).
vi. It allows the supply chain to develop and exploit adaptive capabilities to thrive and prosper in a changing, uncertain, and unpredictable business environment (Aslam et al., 2020; Weber and Tarba, 2014).

The sensing capabilities of agile supply chain, enable members to gain and use knowledge and information from other stakeholders for improving sustainable competitiveness (Weber and Tarba, 2014). That is, supply chain agility acknowledges information and knowledge sharing as a sources of sustainability competitiveness (Prahalad and Ramaswamy, 2000). Having agile capabilities will allow organisations to work together with customers and suppliers, thereby enhancing the ability of addressing quickly social and environmental challenges and hence expand transformation capabilities (Handfield and Bechtel, 2002). Because it is difficult to copy dynamic capabilities, sustainable and agile supply chain practices can help organisations achieve sustainable supply chain performance objectives (Dyer et al., 2018). The next section discusses how sustainable practices, agile practices, operational performance objectives and sustainability performance are related.

## 3.3 Contingency theory

The contingency theory is a midrange theory that involves identifying and matching context setting with firm setting (Thompson, 1967; Lawrence and Lorsh, 1967). It posits that firms should adapt structures and processes to achieve fit with the environment to attain superior performance (Donaldson, 2001). Managers should analyse the firm’s environment, taking internal firm characteristics into account and adapt practices accordingly (Volberda, 2012). Contingency theory has been recognised as a key theoretical lens to understand the contextual conditions under which supply chain and operations management practices are effective (Sousa and Voss, 2008), contributing to the theoretical precision of research (Boyd et al., 2012).

In contingency research, different concepts of fit can be employed and should be explicitly considered when conducting such research (Sousa and Voss, 2008). Based on Venkatraman (1989). Following Eckstein et al. (2015), Hult et al. (2007), and Ketchen and Hult (2007), this study employs a contingency perspective that is operationalised within a moderation concept of fit, which presumes that the different effect of a predictor variable on an outcome variable relies upon the level of another third variable, the moderator.

## 3.4 Conceptual framework and hypotheses

Building on the above theoretical bases, the researcher first directly links sustainable supply chain practices and agile supply chain capabilities to operational performance and sustainability performance, investigating the role each concept has in enhancing performance. This research expects a joint effect of agile capabilities and sustainable supply chain practices on performance while develop hypotheses on the contingency effects of managerial experience and industry type. Finally, the research addresses the mediating role of supply chain agility capabilities in the relationships between sustainable supply chain practices and operational performance and sustainability performance in order to better understand the interrelationships of these two important and interrelated capabilities.

From the sustainable supply chain literature, the research drawn on the work of Esfahbodi et al. (2017), Hasan (2013), Zhu et al. (2013), Norazlan et al. (2014), Sancha et al. (2015), Paulraj et al. (2017), Zailani et al. (2012), and Blome et al. (2014). These studies examine different dimensions of sustainable supply chain management practices and how these practices affect social, environmental, and economic performance of organisations. From supply chain agility literature, the research drawn on studies of Aslam et al. (2018), Beske et al. (2014), Blome et al. (2013), Ketchen and Hult (2007), Sharifi et al. (2006), Zhang and Sharifi (2007), Eckstein et al. (2015), Hong et al. (2018), Christopher and Towill (2001), van Hoek et al. (2001), and Hartinez-Sanchez and Lahoz-Leo (2018). These researchers argued that earlier works on capabilities-based view have been limited to static capabilities and have been firm-centric, which neglect today's rate of changes and uncertainty in supply chain environments. Secondly, the combination of agility capabilities and sustainable supply chain management enable supply chain responsiveness, quickness, and flexibility/adaptability, which creates success and sustainability for industries (Sharifi et al., 2006; Christopher and Towill, 2001; Swafford et al., 2008). Agile supply chains involve the ability to detect changes and adapt quickly to them while transform the supply chain resource base (Teece et al., 2016; Blome et al., 2013).

Beske et al. (2014) and Beske (2012) acknowledged that sustainable supply chain practices are contingent upon dynamic capabilities (agility capabilities) and that there needs to be an alignment between the two capabilities to maximise sustainable supply chain performance. In the same vein, Varges and Mantilla (2014) maintained that dynamic capabilities constructs should be included in the field of sustainable supply chain management. Teece et al. (2016), Kirci and Seifert (2016), and Aslam et al. (2020) observed that dynamic capabilities are the main foundation of sustainability competitiveness for supply chain companies. One of the distinctive features of dynamic capabilities perspective is the idea that such adaptation can be based on organisational routines – learned, repetitious behavioural patterns for supply chain actions (Di Stefano et al., 2014; Winter, 2003; Teece et al., 2016; Schilke, 2014).

If dynamic capabilities represent change routines, how do supply chain companies build and adapt such routines? Some capabilities scholars have suggested that they do so through employing second-order dynamic capabilities that operate on first-order dynamic capabilities Zollo and Winter, 2002; Schilke, 2014; Tavani et al., 2014). Here, a distinction can be made between first-order dynamic capabilities and second-order dynamic capabilities. First-order dynamic capabilities are those routines that reconfigure the supply chain resource base. While second-order dynamic supply chain capabilities are those routines that reconfigure first-order dynamic supply chain capabilities. This type of dynamic capabilities appears to be accepted in the literature (Robertson et al., 2012; Teece et al., 2016; Blome et al., 2013; Eckstein et al., 2015; Ambrosini et al., 2009; Easterby-Smith et al., 2009; Schilke et al., 2014; Aslam et al., 2018; Hong et al., 2018; Beske et al., 2014). Researchers argued that agile supply chain can be achieved with the implementation of different viable supply chain strategies, which provide unique capabilities (Sharifi et al., 2006; Hong et al., 2018; Beske et al., 2014; Teece et al., 2016; Weber and Tarba, 2014). But there is still lack of knowledge of exactly how agile supply chain capabilities and sustainable supply chain practices are intertwined. Particularly, there is little empirical work investigating the role of sustainable supply chain strategies in conjunction with agile supply chain capabilities (Ciccullo et al., 2018; Teece et al., 2018).

Ciccullo et al. (2018) called for the development of a model that integrates agility capabilities with sustainable practices and advocated for empirical studies of the relationships between the two set of capabilities. As mentioned earlier, this study explores whether the performance effects of sustainable supply chain practices are mediated by agile supply chain capabilities (as would be the case if the central function of sustainable practices is to develop agile capabilities). Secondly, the research further examines how agility capabilities and sustainable supply chain practices jointly influence supply chain performance outcomes. A series of hypotheses is presented to explained how the characteristics of business environment will moderate the connections between sustainable practices and performance outcomes. The purpose of this thesis is to investigate the relationships between sustainable supply chain practices, agility capabilities, operational performance, and sustainability performance of oil and gas supply networks, and develop models that describes the synergies/linkages among these four constructs.

Figure 3.1 below shows the major relationships between sustainable supply chain practices, agile supply chain capabilities, contingency variables, and organisational performance in terms of operational performance and sustainability performance, resulting from the literature. The first model argue that the implementation of sustainable supply chain practices has a direct influence on operational performance and sustainability performance. The mediation model incorporates the mediating factors (agile capabilities), which seek to tests whether sustainable supply chain practices lead to an increase in agile supply chain capabilities. Here, sustainable supply chain practices are portrayed as antecedents to agile supply chain capabilities and performance. While agile supply chain capabilities play a role as important enablers of success and sustainability. The link between sustainable practices and organisational performance is assumed to be mediated by agile capabilities. In addition, the interaction model tests the joint influence of sustainable supply chain practices and agile supply chain capabilities on performance outcomes. The moderation model, on the other hand, examines how each of the contingency variables will moderate the linkages between sustainable practices and performance outcomes. The research examines the influence of supply chain environment using two characteristics of managerial experience and industry sectors (Schilke et al., 2018). This thesis acknowledge that other characteristics of business environments (such as uncertainty and turbulence of business environment) could also moderate the relationship between sustainable practices and performance. Based on the theoretical base described above, Figure 3.1 represents the conceptual framework of this thesis.

In view of the underlying rationale, the following subsections presents the detailed explanation of each hypothesis.

### 3.4.1 The effects of sustainable supply chain practices on organisational performance

Sustainability performance measures are indicators of how successful the implementation of sustainable practices in an organisation (Paulraj et al., 2017; Marshall et al., 2015; Morali and Searcy, 2013). The measures indicate the degree to which sustainability practices have led to overall organisational performance. In addition to the economic performance, increasing number of companies now consider social and environmental sustainability performance as a competitive advantage (McWilliams and Siegel, 2001; McKinsey, 2013). In fact, existing literature has linked the implementation of sustainability practices to cost, differentiation and innovation strategies (Crittenden et al., 2011; Orsato, 2006; Porter and van der Linde, 1995; Orlitzky et al., 2011; Dangelico and D. Pujari, 2010; Prajogo et al., 2014). In particular, Prajogo et al. (2014) suggested that the effective development of green and social products relates to differentiation strategies whilst, according to Orsato (2006), environmental sustainability practices can lead to cost savings. Klassen and Vereecke (2012) stressed that social and environmental sustainability are means for improving innovation whereas Christmann (2000) contended that the higher a firm's level of innovation in pollution prevention technologies, the larger the cost advantage it gains from environmental sustainability practices. Therefore, sustainable practices can result in better operational performance objectives of innovation, cost, quality, and reliability.

Hart (1995); Hart et al. (2000) argued that environmental opportunities in the future would become a major source of revenue growth and competitive advantage to organisations. Extending this viewpoint, one can argue that, sustainability strategies, when successfully deployed, provide organisations with competitive advantage through, for example, environmentally differentiating products (and or markets) relative to the competition. Such practices as pollution prevention and control, waste minimisation and efficient use of resources or the broader corporate social responsibility initiatives should bring about diminished impacts of the operations of a firm on the environment and increased social and reputational capital. The implementation of sustainability practices therefore can result in better sustainability performance objectives.

In light of the above, the following hypotheses are thus proposed:

$\boldsymbol{H_{01}}$: There are no associations between sustainable supply chain practices and operational performance.

$\boldsymbol{H_{02}}$**:** There are no associations between sustainable supply chain practices and sustainability performance.

### 3.4.2 The influences of agile supply chain capabilities on organisational performance

Agile supply chains are those with the ability to rapidly align the network and its operations to the dynamic and turbulent requirements of the dynamic network. The idea of agility in the context of supply networks focus on speed of responsiveness (Christopher and Towill, 2000). The ability to adapt quickly to rapid environments makes ability a dynamic capability (Blome et al., 2013; Teece et al., 2016; Parera et al., 2014; Gligor and Holcomb, 2012; Weber and Tarbar, 2014). Agile supply chains enable market sensitivity (Lin et al., 2006, van Hoek et al., 2001), rapid innovation, reduce delivery lead times, and exploit sudden changes in supply chain environments (Parera et al., 2014; Sharifi et al., 2006). Agility is a supply chain-wide capability that aligns organisational structures, people, information systems, processes, and mindsets (Harrison et al., 2019, p. 303).

Previous studies have established that agile supply chain practices have positive and direct impacts on financial performance measures and operational performance measures (Tse et al., 2016; Eckstein et al., 2015; Gligor and Holcomb, 2012; Yusuf et al., 2014; de Groote and Marx, 2013; Blome et al., 2013). Thus, while there has been some progress made concerning the links between agility practices and economic sustainability measures. There is no work done on the impacts of agility on social and environmental sustainability measures and yet, according to Gligor et al (2016), social and environmental sustainability practices are evolving as part of the range of activities of the agile supply chain operations.  In fact, recently, Ciccullo et al. (2018) identified a lack of empirical study examining the influence of agile supply chain practices on the extent to which organisations could translate sustainable practices into sustainability performance. Therefore, the interaction between agile practices, sustainability practices, operational performance and sustainability performance require further investigation.

Consistent with Parera et al. (2014), the enhancement of sustainability requires dynamic capabilities, as supply chain companies need to identify social and environmental sustainability expectations of their customers via working together with various stakeholders, which is nothing but the sensing capability. When these requirements are identified, organisations need to develop new sustainable product to capture such opportunities, this exercise is called the seizing capability. Teece et al. (2016) highlighted the importance of creating transformation capability to be truly sustainable supply chain. It was acknowledged that in order to achieving sustainability, supply chain needs dynamic capabilities such as agility, which require developing and exploiting new knowledge and information. Govindan et al. (2014) showed that agility of supply chain influence sustainability performance.

The ability to share information across the supply chain will minimise waste, thereby positively influencing environmental performance (Cabral et al., 2012). In the same way, working together collaboratively with suppliers for sustainable procurement and product development has been shown to reduce usage of hazardous materials in production (Zhu and Sarkis, 2007). As Large and Thomsen (2011) demonstrated, improved knowledge transfer helps suppliers to eliminate waste, minimise pollution and emission, so enhancing companies' reputation and increasing environmental performance. As resources are increasingly becoming scarce, using advanced technology, as Yusuf et al (2014) contended, will reduce energy, water and raw materials used in manufacturing. Besides, it provides considerable opportunities for improving health and safety, and operational efficiency. In this, therefore, some of the established agility attributes of information and knowledge management, partnership, and collaboration (Yusuf et al, 2014) can be linked to sustainability performance. Thus, the following hypotheses were proposed:

$\boldsymbol{H_{03}}$**:** There are no associations between agility capabilities and operational performance.

$\boldsymbol{H_{04}}$**:** There are no associations between agility capabilities and sustainability performance.

### 3.4.3 Synergy between sustainable supply chain practices and agile supply chain capabilities on performance outcomes

Following on from above, agile supply chain capabilities mediate the performance effects of sustainable practices because the later set of practices influence and impact on the former ones. Sustainable supply chain practices would bring short term organisational competitive performance, which in turn would amplify further development of agile capabilities (Hall et al., 2012). Studies incorporating sustainable supply chain practices and agile supply chain capabilities are rare, especially in empirical investigation. Handfield and Bechtel (2002) argued that collaborating with suppliers and other key stakeholders will enhance the abilities of sensing the customer expectations for social and environmental sustainability and adapting quickly to them and hence lead to renewal of agility capabilities. Prahalad and Ramaswamy (2000) demonstrated that customer orientation and involvement in sustainable supply chain practices provide all kinds of knowledge and information to supply chain members, and to some degree promote agility capabilities for improving sustainable supply chain performance. Ciccullo et al. (2018, 2020) and Villena and Gioia (2018) showed that investments in sustainability learning will facilitate the creation and reformation of agility capabilities for supply chain. Prieto et al. (2009) found that support and trust of supply chain partners is vital to agility capabilities of supply chains.

According to Rajesh and Ravi (2015) environmental and social practices are considered prerequisites of the other attributes for the selection of suppliers in the context of an agile supply chain paradigm. Environmental protection system certification (ISO 14001), as well as safety practices, are considered necessary practices to maintain competitiveness in an agile supply chain environment. More so, the capacity to design and create new sustainable products in response to customer requirements can result in the company increasing agile capabilities

(Sharma et al., 2007). Hart (2004) argued that customer expectations for social and environmental performance will force firms to implement viable strategies. Innovative sustainability strategies, in turn can lead to the development of agile supply chain capabilities, which can be a base for sustainable competitive success (Hart, 1995). Sharma and Vredenburg (1998) found that the greater the degree to which companies adopts sustainable practices, the greater the likelihood that agility capabilities will emerge. Thus, as sustainable supply chain practices induce process and product innovations that contribute to the overall agility of supply networks.

Many of the drawbacks in success and sustainability of supply chains relate to the segregation of sustainable and agile practices. Following the above discussions, this study proves that there are synergies in how agility and sustainable practices can influence the entire sustainability performance of supply networks. The combined contributions are limited to the work of Yusuf et al. (2020). It is further suggested that the integration of agility and sustainable practices can help strengthen waste management, minimised material inputs, increased energy, and cost-efficiencies, and boost operational excellence (Yusuf et al., 2020). Azevedo et al. (2012); Hong (2012) and Hieuwenhuis and Katsifou (2015) concur with this view. The increases in sustainability values of social and environmental initiatives are functions of the rising rates of agile approaches implementation across supply chains. The joint implementation of agility and sustainable practices will enable cost efficiencies, innovation, speed, flexibility, delivery reliability, quality of product across supply chains (Ciccullo et al., 2018 and Gorane and Kant, 2017).

For Carvalho et al. (2017), agility and sustainable supply chain paradigms combined have a positive effect on the level of service performance because they increase the level of sustainability transformations across supply chain entities. In the opinion of Carvalho et al. (2017), the level of assimilation linked to the minimisation of sustainability risks; the degree of reverse material and information flow across supply chains; the presences of agile alliances, transparency and profit-sharing. Carvalho and Cruz-Machado (2011) established that these paradigms concurrently affect the organisational performance indicators. Other capabilities scholars have highlighted the importance of organisational knowledge or learning routines, as a relevant integrator of sustainable strategies and agility capabilities in supply networks (Beske et al., 2014; Wu et al., 2012; Hong et al., 2018; Beske, 2012). The key problem here is whether these capabilities have interactive effects on performance outcomes. More specifically, how do agility capabilities and sustainable practices jointly affect success and sustainability performance of supply chains: they could work either as complements or substitutes in enhancing success.

Broadly speaking, the firm’s strategic capabilities may further exhibit complementarity in deployment or application (Amit and Schoemaker, 1993). That is the strategic value of each capability’s relative magnitude may increase with an increase in the relative magnitude of other strategic capabilities (also known as positive externalities (Dierickx and Cool, 1990). Under complementarity, the combined value of the firm’s resources or capabilities may be higher than the cost of developing or deploying each capability individually. Conversely, the strategic value of the firm’s resources or capabilities declines to the extent that they are substitutes (Amit and Schoemaker, 1993). From this view, there is an expectation of a synergistic interaction between sustainable practices and agility capabilities. It is also consistent with Day’s (1994) inside-out and outside-in capabilities perspective, which centre on the strategic interaction between superiority in process management. In other words, neither sustainable supply chain practices nor agile supply chain capabilities in sufficient to enhancing sustainable supply chain performance. Instead, the reinforce each other for a stronger strategic effect than alone can provide. Based on this logic, the following hypothesis is posited:

$\boldsymbol{H_{05a}}$**:** There is no interaction effect between sustainable supply chain practices and agile supply chain capabilities on operational performance.

$\boldsymbol{H_{05b}}$: There is no interaction effect between sustainable supply chain practices and agile supply chain capabilities on sustainability performance.

### 3.4.4 The effects of sustainability performance on operational performance

There is a substantial body of literature that theorises the importance of sustainability (Gladwin et al., 1995), and how pursuing social and environmental sustainability should be profitable (Hart, 1995). Though, theoretical discussion of sustainability covered all three aspects of the triple bottom line. Studies, however, focused on the relationship between environmental performance and operational performance or social performance and operational performance. But the robust and concurrent examinations of all three elements of the triple bottom line are absent (Ciccullo et al., 2018). Understanding the relationship between operational, financial, social, and environmental performance when implementing management practices might be the basis for developing decision-making models when pursuing sustainability objectives. In the context of operation strategy and supply chain, researchers have focused on environmental sustainability issues, while neglecting the social sustainability concerns (Martínez-Jurado and Moyano-Fuentes, 2014; Kleindorfer et al., 2005). Examining the combination with social sustainability will help businesses understand how to address the complete set of sustainability performance measures.

Overall, there is literature (Christmann, 2000; Melnyk et al., 2003; Pagell et al., 2004) who have demonstrated that by using less energy, minimising waste, and reducing material inputs and packaging should boost operational efficiency. Developing a mindset of doing the right thing could prevent reputation from damaged and remove fines. Though, there are conflicting reports (Beck, 2008; Hoffman et al., 1999) of environmental performance having a damaging effect on the operational performance of organisations. Social performance, on the other hand, have not been fully addressed in the literature. When social issues are considered, it appears to operationalise differently. Though, studies indicate a positive correlation between social performance and economic performance. At the highest levels of abstraction, social responsibility is linked to a positive organisational performance (Orlitzky et al., 2003; Bauer et al., 2005). Increased investments in social supplier development, are linked to enhanced operational performance outcomes (Collins and Clark, 2003; Hitt et al., 2001). Notwithstanding, direct evidence does not exist at operations or supply chains level of analysis. Das et al. (2008) and Brown et al. (2000) claimed that protecting and promoting employee wellbeing via health and safety will enhance operational performance and increased employee engagement, suggesting that some efforts at increasing the social performance of the suppliers will have a positive effect on economic performance. Other studies have found linkages between sustainability performance and firm performance measures (Gonzalez-Benito and Gonzalez-Benito, 2005; Goyal et al., 2013). In line with Pagell and Gobeli (2009), increased social and environmental performance can lead to improved operational performance objectives. Though, the direction of this association is still not clear as there is uncertainty whether operational performance is a direct result of the implementation of sustainable practices, or it is those firms that are performing well have adopted sustainable strategies (Panigrahi et al., 2018). Thus, we posit that:

$\boldsymbol{H_{06}}$. Sustainability performance has no effect on operational performance.

### 3.4.5 Mediating role of agility capabilities

Several enabling factors can help in sustainable supply chain practices (Esfahbodi et al., 2016; Song et al., 2016; Huq et al., 2016; Luthra et al., 2016). Many of these enablers are closely aligned with agile methods and practices (Gunasekaran et al., 2019). Agile approaches focus on people, technology that works well, working with customers and adapting to change. It is difficult to implement sustainability practices successfully without a robust understanding of, involvement with, and knowledge of customers and other stakeholders. The market sensing capability of an agile organisation can help in understanding the expectations of customers whilst the lack of sensing capability could render sustainability initiatives unsuccessful (Wu et al., 2016). As insights from customers can help shape platforms that create maximum return for organisations, agile organisations with market sensing capabilities can quickly leverage on the understanding of customers and information technology to develop sustainable supply chain practices. Collaboration across supply networks and multi-stakeholder partnerships are also indirect capabilities for advancing sustainable objectives in industries. Sustainability issues are more challenging and complex to tackle alone (Chen et al., 2017). Collaborative network capabilities will increase the influence of sustainable supply chain practices by extending the reach, pooling resources and avoid conflicting communication (Jadhav et al., 2019). Collaborative practices provide a way for supply chain members with fewer resources to take actions and contribute to advance sustainable supply chain practices. Collaboration with suppliers on sustainability issues, for example, can foster product innovation leading to new added features to existing products and even newly developed ones. The combination of market sensing and network collaborative dimensions of agility facilitate sustainability practices. Further, whilst sustainability practices are direct sources of competitiveness on their own, their performance impacts are enhanced when facilitated or mediated through agile practices. Therefore, the following hypotheses were proposed:

$H_{07}$: Agile capabilities will not mediate the relationships between sustainable supply chain practices and operational performance.

$H_{08}$: Agile capabilities will not mediate the relationships between sustainable supply chain practices and sustainability performance.

### 3.4.6 Moderating effects of managerial experience and industry sector

Although the research assert that sustainable practices have a direct impact on sustainable supply chain success, in terms of operational performance and sustainability performance, these relationships are also subjective to some moderator impacts that must be considered as part of this research. Various contingency variables (such as managerial experience and industry type) are used in this research, which are likely to moderate sustainable practices – sustainable supply chain performance relationships.

#### 3.4.6.1 Moderating effects of managerial experience

Managerial experience is a form of dynamic capabilities, which concerned with the role of managers in refreshing and transforming the resources base of the supply chain, so that it maintains and develops its competitive advantage and performance outcomes (Ambrosini and Altintas, 2019). In the strategic management field, top management team members with greater experience and knowledge are more adept at implementing strategies, working together collaboratively, and performing tasks efficiently (Pinto et al., 1993). Teece (2016) indicates that managers are the pillars behind dynamic capabilities. Teece (2016) further explained that beyond their administrative role, which is about the development of current activities, managers have two roles that underpin dynamic capabilities: entrepreneurial and leadership roles. An entrepreneurial role involves the ability to detect and capture opportunities and adapt business model. Leadership role requires propagating the vision and values of the organisation, aligning people with strategy, and motivating them (Teece, 2007). This research sought to assess whether top management team experience was a significant moderator of the degree to which sustainable supply chain initiatives could improve sustainable supply chain performance.

Teece (2007, p. 1325) indicated that top management leadership skills are required to sustain dynamic capabilities because, some elements of dynamic capabilities are rooted within organisations, the ability to transform the resource based is the responsibility of top management (Teece, 2012). Esty and Winston (2006) posited that the lack of managerial knowledge is an important incentive for lead firms to collaborate with third parties on the design and implementation of sustainable practices in the supply chain. Similarly, Plambeck and Denend (2011) argued that even big multinational firms may lack the technical expertise to manage sustainability of their suppliers and, thus, need to associate with other stakeholders to implement sustainability in their supply chains. Alternatively, firms with less technical resources may adopt a traditional strategy, implementing sustainable practices after leading firms, lowering their risks (Simpson et al., 2007; Delmas and Montiel, 2009).

Given that top management knowledge is a critical determine of sustainable supply chain management, managerial experience becomes a key contingency of sustainable practices – performance relationship. It is contended that the knowledge embodied in prior management experience with sustainability initiatives, either individually or jointly, will influence the performance effects of sustainable supply chain practices. As such, the researcher suggest that managers experience from their earlier job will moderates the relationship between the implementation of sustainable practices and performance outcomes.

Prior managerial experience benefits the supply chain in three ways. Firstly, importing aspects of previously established routines substantially decreases the costs of experimentation with new solutions or trial attempts to arrive at optional solutions. Secondly, importation can decrease the time taken to enact sustainability strategies and can reduce the number of opportunities lost or missed. Finally, prior experience may also provide access to networks and positional advantages in the industry social structure based on prior status, trust, and reputation (Crespin-Mazet and Dontooll, 2012; Sarkis, 2012). Positional advantages may allow access to other resources, such as distribution channels or sourcing suppliers, and include market-related knowledge of competition and consumer preferences that help overcome sustainability obstacles (Mena et al., 2013; Planbeck and Demand, 2011). Thus, managers' experience from their previous careers with sustainability reduces the time and costs associated with first adopter, increasing both operational and sustainability performance (Planbeck et al., 2012; Sarkis, 2012; Lee et al., 2012a, b).

Empirical evidence supports the idea that prior managerial experience provides prehistory talents or routines. In a study of high-technology start-ups, Gong et al. (2004) found that managerial teams imported bundles of routines into new venture by sharing their prior contextual experiences – that is, situation-specific actions and their resultant outcomes. These researchers also observed that when managerial experiences were dissimilar across operating environments, they were scrutinised before implementation. Thus, when sustainable routines are lacking, managers are likely to import and internalise routines from previous experiences by sharing their contextual experience and its outcomes. In subsequent entries, however, the firm is likely to develop new capabilities for achieving sustainability and to rely less on managerial prehistory experience. Studies have shown that the speed with which a firm develops experience-based knowledge positively influences the subsequent probability of profitability, survival, and growth (Crespin-Mazet and Dontooll, 2012; Planbeck et al., 2012).

In short, theoretical reasoning and empirical evidence suggest that firms' initial attempt to enter new markets may be aided by managers' prior experience with sustainability. When prior individual experiences are shared within the supply chain, they can reduce the time and expense of learning. Managers' prior experience also provides the firm positional advantages that may be leveraged to sustain and growth operations. Hence, the following hypotheses were suggested

$\boldsymbol{H_{09a}}$: Managerial experiences will not moderate the relationship between sustainable supply chain practices and operational performance.

$\boldsymbol{H_{010a}}$: Managerial experiences will not moderate the relationship between sustainable supply chain practices and sustainability performance.

#### 3.4.6.2 Moderating effects of industry sector

An industry can be defined as a group of companies within a sector offering products or services that are close substitutes for each other (Lysons and Farringdon, 2020). The industry effect on competitiveness of an enterprise practices has been studied within the industry (Fisher, 1997). In the context of supply chain management, studies suggest that industry influence is critical (Castka and Balzarova, 2008). Wiengarten et al. (2012) demonstrated that firms in static industries invest a higher amount, more productively, in sustainable practices than firms in dynamic ones. This is especially important when considering lower-tiering suppliers, because, by definition, they produce more basic raw materials. Therefore, sustainability standards may be less effective when there is significant technological change within the supply network (Pilbeam et al., 2012). Chavez et al. (2012) studied the effect of industry clock-speed on the relationship between supply chain management and performance.

Schneider and Wallenbury (2012) characterise the industries into several archetypes, based on the emphasis of environment, social or economic sustainability. The chemical industry adopts an environmentalist profile, whereas the textile sector follows a social activist approach. Another potential industry classification refers to pollution level. Simpson et al. (2012) argued that when firms operate in high pollution industries (e.g., chemical, oil refining, cement), stakeholders' pressures for social and environmental performance improvement is often more intense, so they tend to develop organisational capabilities and adopt a more proactive approach. Alternatively, firms that operate in low-pollution sectors face less intense stakeholder pressures and tend to wait longer to adopt new sustainability practices. More so, Zhu and Sarkis (2004) found significant differences among green supply chain practices adoption in the power generation, automobile, and electronics. Huang et al. (2015) proved that different sector from small and medium enterprises differ in the adoption of green supply chain management. So, the following hypotheses were proposed

$\boldsymbol{H_{09b}}$: Industry sectors will not moderate the relationship between sustainable supply chain practices and operational performance.

$\boldsymbol{H_{010b}}$: Industry sectors will not moderate the relationship between sustainable supply chain practices and sustainability performance.

#### 4.3.5.4 Controlling variables (Firm age, firm size, and environmental dynamism)

Hannan et al. (1998) states that the older and larger an organisation, the more standardised be its behaviour, policies, and procedures. Because of these factors, social and environmental changes are difficult to implement in older and larger organisations than in small and medium enterprises. Other studies such as Sapienza et al. (2006) and Autio et al. (2000) concurred that younger firms tend to adopt more innovative approaches to sustainability than older firms.

These writers also hypothesised that, in terms of leveraging opportunities for growth, younger firms possess some learning advantages of newness over older firms. This learning advantage is similar to the literature on the liability of senescence in the older firms (Hannan, 1998), where capabilities become increasingly insufficient and resistant to change over time. Uncertainty to pursue opportunities dynamically as a firm gets older may arise from cognitive, structural, and positional causes. These perspectives suggest that firm age may also moderate the effects of sustainable practices on sustainability performance and operational performance.

Over time, the effective pursuit of sustainability can be hampered by competency traps (Ambrosini and Altintas, 2019). Firms can get locked out of certain types of knowledge if they do not acquire it quickly (Teece et al., 2016). Competency traps become acute over time because of path-dependent nature of knowledge, and limit firms to the pursuit of a narrow set of opportunities suited to their existing capabilities (Ahuja and Lamper, 2001; Shuen et al., 2014). These traps not only constrain what can be pursued but also limit firms' ability to recognise and exploit new opportunities. Wu et al. (2012) maintained that sustainable supply chain companies must unlearn routines before new practices are implemented. The difficulty of unlearning existing routines increases over time because of inertial constraints as firms grow older. New knowledge must contend with embedded approaches to operations that constrain exploitation of growth opportunities.

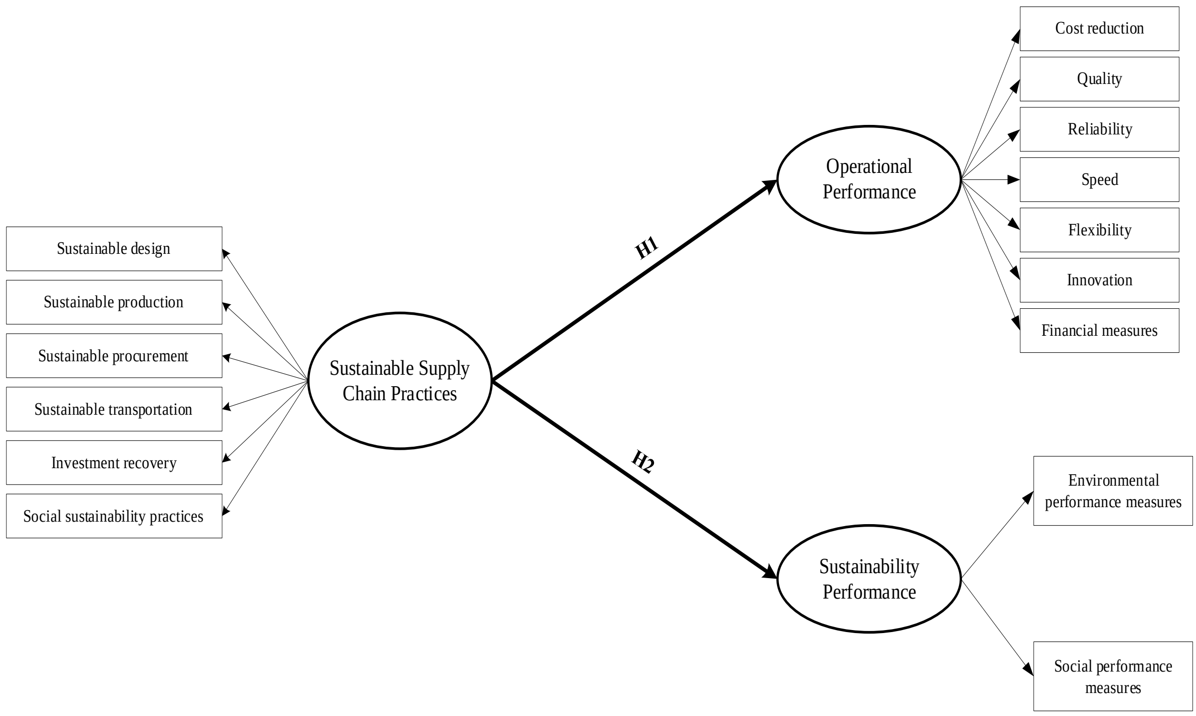
Young firms are likely to possesses some structural advantages when pursuing sustainability opportunities in new markets. At start-up, managerial roles are undifferentiated, and lines of authority and responsibility shared (Sapienza et al., 2006; Ambrosini and Altintas, 2019). For the new project, this lack of differentiation allows executives to share knowledge across and between functional areas. As firm matures, managerial roles become increasingly differentiated and may reduce shared knowledge and the intensity of communication across the chain (Sapienza et al., 2006). The propensity of managers to seek new knowledge also becomes hampered over time (Autio et al., 2000).

In short, sustainable supply chain practices has a positive influence on operational and sustainability performance for supply networks, but this performance effect is likely to be greater the earlier companies adopt sustainable efforts. These arguments assume increasing inertial constraints with age that act as obstacles to reconfigure routines for pursuing sustainability growth opportunities. Lu and Beamish (2001) discovered that firm age negatively moderated the relationship between sustainable practices and subsequent growth of small and medium enterprises provides some empirical support for these arguments. Thus, we posit the following.

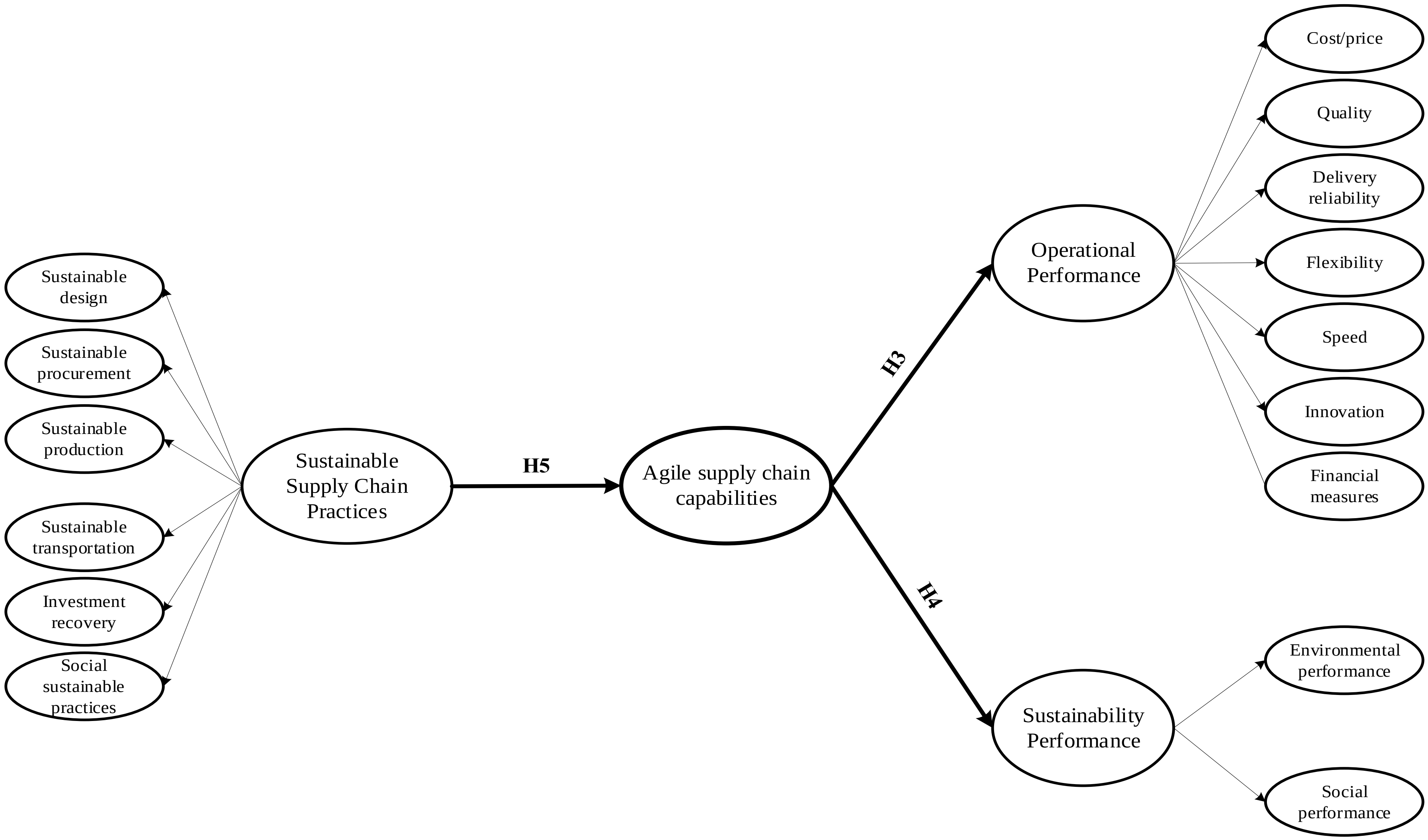
Previous studies suggested that as the level of resources allocated to the development of organisational strategic capabilities differs for large and small firms, the size of the supply chain company can influence the sustainability effectiveness resulting from the development of these capabilities (Hofer et al., 2012; Zhu and sarkis, 2004; Menyk et al., 2003). Large firms tend to be more concerned with active in the development of sustainable practices (Sarkis et al., 2010; Raymond et al., 2008; Zhang et al., 2008). Because their operations are more likely to be visible to a wider range of stakeholders (Wagner, 2011). Unlike smaller firms, lager firms tend to adopt several social and environmental initiatives, while smaller firms tend to focus on regulatory compliance, due to resources constraints (Schrettle et all., 2014). Zhu et al. (2008) acknowledged that an organisation size has significant impact on the implementation of sustainable practices. Vanpoucke et al. (2014) argued that firm size can influence the implementation of environmental practices as large firms have more available resources and receive greater environmental pressure than smaller or start-ups firms. Interfirm collaboration aims to resolve interfirm conflicts and integrate various sustainable effects and decisions across the supply chain in order to shared goals (Carter and Jennings, 2002). The advantage of sustainable practices is expected to be more valuable to lager firms with more resources than smaller firms. Thus, the effectiveness of sustainable practices for achieving sustainable supply chain performance is expected to differ for firms with different size.

Environmental dynamism reflects the rate and magnitude of changes external to the organisation (Rosenzweig, 2009; Rojo et al., 2018). It is characterised by unpredictability and instability (Kovach et al., 2015; Miller and Friesen, 1983; Schike, 2014). Hence, the dynamic nature of the business environment can be assessed through the rate of change in product design, technology, and customer preferences (Achrol and Stern, 1988; Dess and Davis, 1984; Miller and Friesen, 1983). It includes changes because of digitalisation, variations in customer preferences due to different economic circumstances or green purchasing behaviour, as well as fluctuations in product demand and material supply due to higher levels of supply and demand risks (Wang et al., 2011). Prior studies clearly indicate that a turbulent external environment can either enhance or destroy a firm’s most critical competencies (Afuah, 2001). Therefore, these dynamic changes require that companies adjust their supply chain (Bozarth et al., 2009).

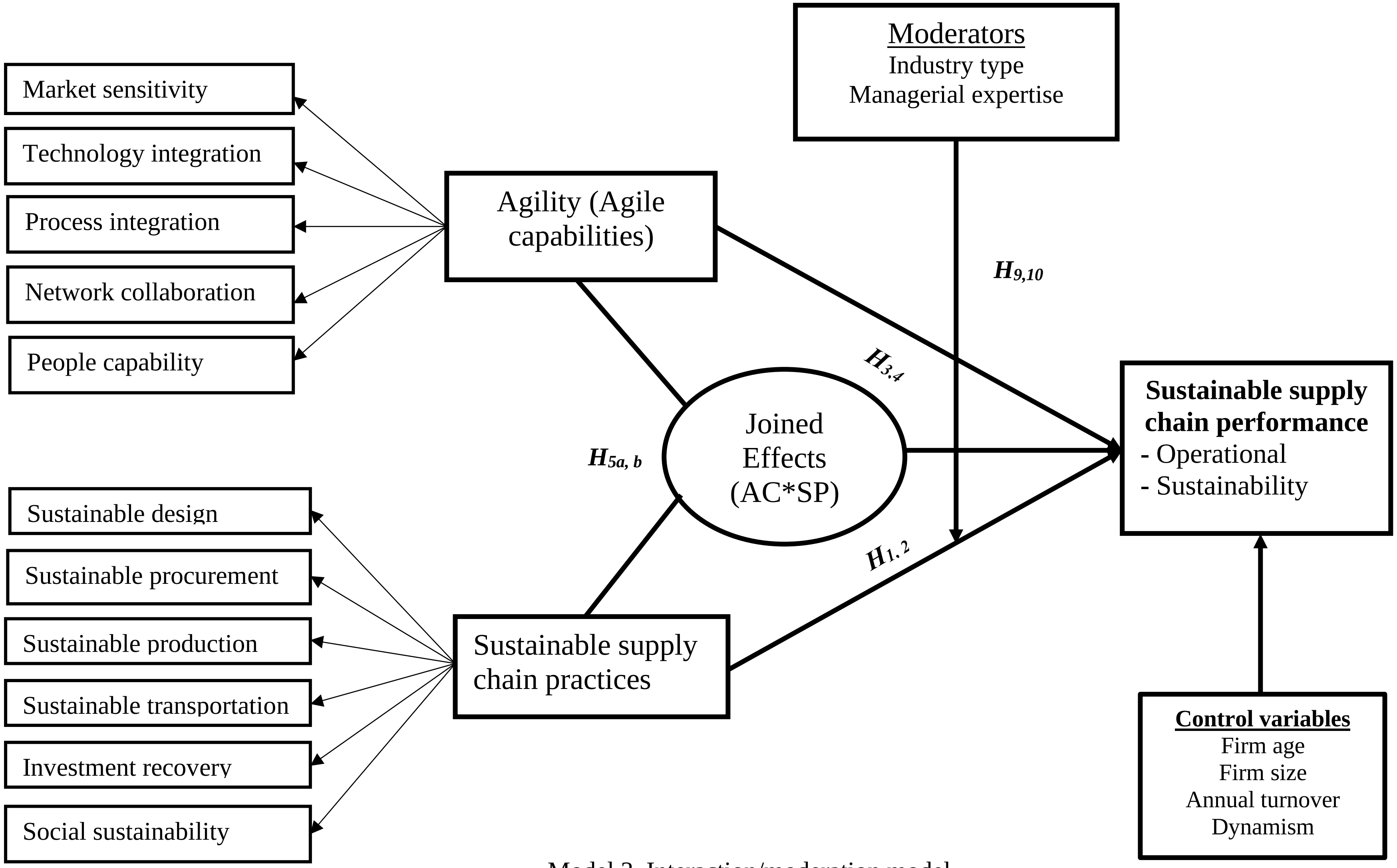
Environmental dynamism is a key factor in dynamic capabilities theory (Schike, 2014), which suggests that the differential effects of dynamic capabilities on organisational performance is contingent on the level of dynamism of the supply chain environment (Chen et al., 2015; Rojo et al., 2018; Boyle et al., 2008; Gligor et al., 2015; Eisenhardt and Martin, 2000). Levinthal (2000) stated that the benefit of dynamic capabilities depends not just on the existence of underlying organisational routines but also on the context in which capabilities are deployed. Eisenhardt and Martin (2000) maintained that in moderately dynamic markets, organisations follow predictable and linear paths (these markets are characterised by stable industry structures with defined market boundaries). Effective dynamic capabilities in moderate dynamic environments relies on exploiting existing knowledge. In contrast, changes in high-velocity markets are nonlinear and less predictable (these markets are characterised by volatile, uncertain, complex, and ambiguous structures) (Alexander et al., 2018). Chen et al. (2015) stated that the unpredictable nature of environmental dynamism on organisational performance outcomes provides greater opportunities for supply networks to implement sustainable practices. Based on Afuah's (2001) arguments, this study suggest that environmental dynamism will improve the effects of sustainable practices on organisational performance.




Model 1. Direct relationship model




Model 2. Mediation model




Model 3. Interaction/moderation model

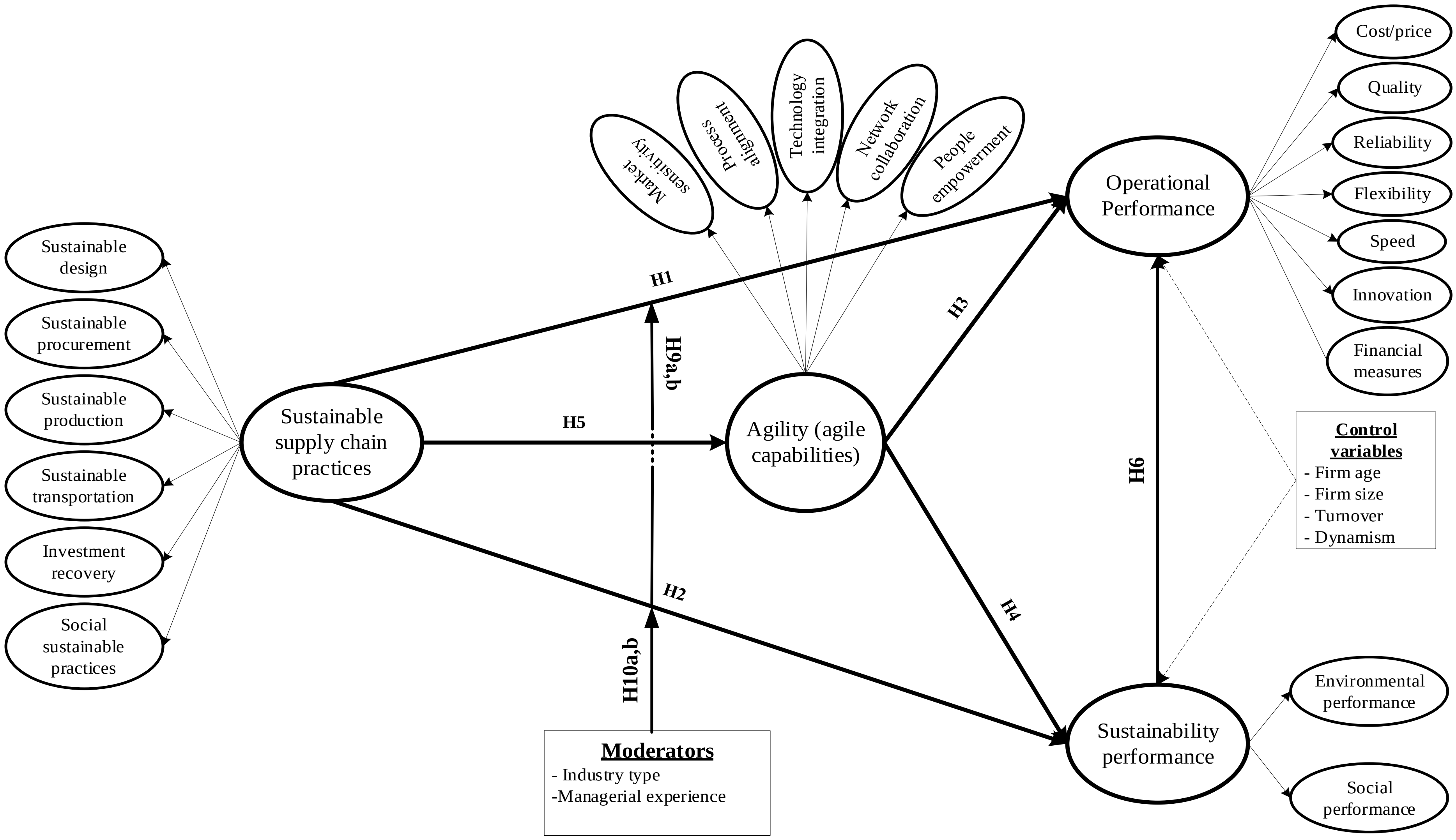



Figure 3.1 Final conceptual model

## 3.4 Summary

The conceptual model presented in Figure 3.1, shows the hypothesised relationships amongst four constructs, including sustainable supply chain practices, agile supply chain capabilities, operational performance, and sustainability performance. The resulting null ($H_0$) and alternative ($H_a$) hypotheses are shown in Table 3.1 as follows.

Table:3.1 Summary of research hypotheses

| **Hypotheses** | **Descriptions** |
|---|---|
| **The null hypotheses are:** | |
| $H_{01}$ | There are no associations between sustainable supply chain practices and operational performance |
| $H_{02}$ | There are no associations between sustainable supply chain practices and sustainability performance. |
| $H_{03}$ | There are no associations between agility capabilities and operational performance |
| $H_{04}$ | There are no associations between agility capabilities and sustainability performance |
| $H_{05a}$ | There is no interaction effect between sustainable supply chain practices and agile supply chain capabilities on operational performance |
| $H_{05a}$ | There is no interaction effect between sustainable supply chain practices and agile supply chain capabilities on sustainability performance |
| $H_{06}$ | Sustainability performance has no effect on operational performance |
| $H_{07}$ | Agile capabilities will not mediate the relationships between sustainable supply chain practices and operational performance |
| $H_{08}$ | Agile capabilities will not mediate the relationships between sustainable supply chain practices and sustainability performance |
| $H_{09a}$ | Managerial experiences will not moderate the relationship between sustainable supply chain practices and operational performance |
| $H_{010a}$ | Managerial experiences will not moderate the relationship between sustainable supply chain practices and sustainability performance |
| $H_{09b}$ | Industry sectors will not moderate the relationship between sustainable supply chain practices and operational performance |
| $H_{010a}$ | Industry sectors will not moderate the relationship between sustainable supply chain practices and operational performance |
| **The alternative hypotheses ($H_a$) are:** | |
| $H_{a1}$ | There are associations between sustainable supply chain practices and operational performance |
| $H_{a2}$ | There are associations between sustainable supply chain practices and sustainability performance. |
| $H_{a3}$ | There are associations between agility capabilities and operational performance |
| $H_{a4}$ | There are associations between agility capabilities and sustainability performance |
| $H_{a5a}$ | There is interaction effect between sustainable supply chain practices and agile supply chain capabilities on operational performance |
| $H_{a5b}$ | There is interaction effect between sustainable practices and agility capabilities on sustainability performance |
| $H_{a6}$ | Sustainability performance has effect on operational performance |
| $H_{a7}$ | Agile capabilities mediate the relationships between sustainable supply chain practices and operational performance |
| $H_{a8}$ | Agile capabilities mediate the relationships between sustainable supply chain practices and sustainability performance |
| $H_{a9a}$ | Managerial experiences moderate the relationship between sustainable supply chain practices and operational performance |

| | |
|---|---|
| $H_{a10a}$ | Managerial experiences moderate the relationship between sustainable supply chain practices and sustainability performance |
| $H_{a9b}$ | Industry sectors moderate the relationship between sustainable supply chain practices and operational performance |
| $H_{a10b}$ | Industry sectors moderate the relationship between sustainable supply chain practices and operational performance |

# CHAPTER 4: Research methodology

## 4.1 Introduction

A research methodology is a combination of methods used to enquire into a specific situation. It encompasses the strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes (Crotty, 1998). This chapter is a move towards an empirical study that offers solutions to research questions or hypotheses. The chapter considers the main philosophical perspectives that underlie the designs of survey research. In other words, how do philosophical factors affect the delivery of satisfactory outcomes from the research activity?

The chapter begins by discussing the philosophical perspective of this research and justifies the choice of a positivist epistemological position. The chapter introduces the research logic and strategy. The distinction between quantitative and qualitative research is examined in terms of the philosophical considerations and the choice of the quantitative approach is justified. Following this, the research process, the survey research design, and methods were explained. This includes important stages: the development of research protocols, sample frame, the design of a questionnaire, the development of scales and measures, ethical issues, pilot test, and full-scale administration of data for theory testing. The final parts complete with the chapter summary.

## 4.2 Research philosophy

The term "research philosophy" refers to a system of beliefs and assumptions about the development of knowledge and the nature of knowledge (Saunders et al., 2019, p. 30). Creswell (2014, p. 6) see it as the 'worldview', which means "a basic set of beliefs that guide action".

Other writers, such as (Denzin and Lincoln, 2005; Mertens, 2014; Burrell and Morgan, 2019) viewed it as ‘paradigms’, which has been used to reflect a cluster of beliefs and practices that influence what should be studied, how research should be done, and how results should be interpreted (Bryman and Bell, 2015; Morgan, 2013). These assumptions underpin the main elements of the research strategy and methods of a study (Saunders et al., 2009). In short, a research philosophy describes how data about knowledge should be collected, analysed, and used (Burrell and Morgan, 2019).

According to Easterby-Smith et al. (2018, p. 60), there are four reasons why an understanding of philosophical issues is useful. Firstly, researchers must understand the philosophical underpinnings of their research to have a clear sense of their instinctive role in research methods. Secondly, understanding the philosophical bases of research is essential for clarifying research designs. This involves considering not only what kind of evidence is required and how it is to be gathered and interpreted, but also how this will provide good answers to the basic questions being investigated in the research. Thirdly, knowledge of philosophy can help researchers to recognise which designs will work and which will not. Fourthly, it can help researchers to identify, and create research design that may be outside their previous experience. It may also suggest how a research designs can be adapted to the limitations of different subject areas or knowledge structures (Easterby-Smith et al., 2018).

Recent studies, such as Saunders et al. (2019); Bell et al. (2018); Burrell and Morgan (2019) have recommended different methods of thinking about the philosophy of social science research. They assert that the research philosophy can be defined with the help of the research paradigms. Burrell and Morgan (2019) conceptualised social science research in term of four sets of philosophical assumptions related to ontology, epistemology, human nature, and methodology (Figure 4.1). Bryman and Bell (2015) argued that these assumptions are developed under the umbrella of research paradigms. They concurred with the above classifications of research paradigm but added axiology stance (Saunders et al., 2009).

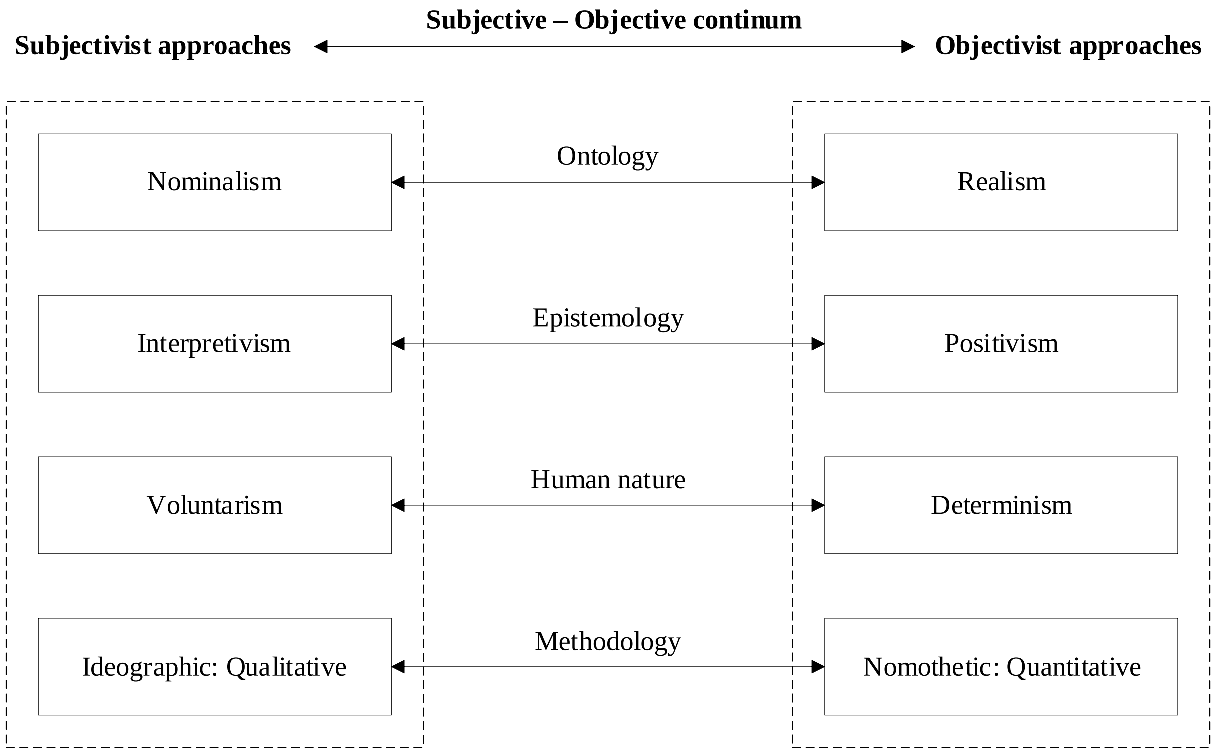



**Figure 4.1** Assumptions about the nature of ontology and epistemology in social science (Burrell and Morgan, 2019, p. 13)

In essence, the research paradigm is at the heart of the research methodology for social science research and concerned with "the world view" (Creswell and Creswell, 2017). The term paradigm derived from Kuhn's 1970 analysis of revolutions in science. In line with Bryman (1988, p. 4), a paradigm is a cluster of beliefs and dictates that for scientists in a particular discipline influence what should be studied, how research should be done, and how results should be interpreted. In similar viewed, Gummesson (1999, p. 18) defined research paradigm as "people's value judgments, norms, perspectives, theories, ideologies, standards, myths, and approved procedures that govern their thinking and action". Based on the idea of the research paradigm, accord to Kuhn (1970), people see the world differently (Mangan et al., 2004). Many studies, Bryman and Bell (2015); Saunders et al. (2019) maintained that researchers may design their study differently and therefore could apply different research philosophies. It is important to state the philosophical perspective and to justify the choice of an approach as opposed to the alternative (Johnson and Clark, 2006). The section below discusses each of the philosophical assumptions in depth.

The term ‘ontology’ is derived from the Greek words ***on***, which means ‘being’, and ***logos***, which means ‘theory’ (Delanty and Strydom, 2003). It concerned with theorising about the nature of reality (Bell et al., 2018). Ontology involves assumptions about what it means for something to exist (Crotty, 1998). This idea of ontology shapes how the researcher sees research objects. Objects here means individuals or organisations behaviour (Saunders et al., 2019). Ontology related to the questions of whether the social phenomena can be understood as an objective, existing external to observers; or they can be ‘made real’ through the activities of humans and meanings that observers attach to them (Bell et al., 2018, p. 26). Considering this position, the importance of ontology can be understood through a detailed account of realism and nominalism.

Like ontological issues, the term “epistemology” was coined from the Greek words: ***episteme***, meaning knowledge, and ***logos***, meaning theory (Delanty and Strydom, 2003). It focuses on the theory of knowledge (Easterby-Smith et al., 2018), and how researchers enquire into the physical and social world. The epistemological position is about how we best understand what we know. A primary concern of epistemology is whether, it is possible to identify and communicate knowledge as being hard, real, and capable of being transmitted into tangible form, or whether ‘knowledge’ is of a softer, more subjective, based on experience and insight of a unique and human nature (Bell et al., 2018; Burrell and Morgan, 2019). In other words, the assumption of epistemology provides a useful account of whether knowledge is something which can be acquired, on the one hand, or is something which must be personally experienced on the other hand (Burrell and Morgan, 2019). In the opinion of Bell et al. (2018), epistemological positions can be classified into positivism and interpretivism.

The study of different research paradigms could guide the choice of suitable research design. In this regard, several studies, such as Bell et al. (2018); Easterby-Smith et al. (2018); Saunders et al. (2019); Burrell and Morgan (2019); Creswell (2014) identified clusters of important philosophical positions that are most represented in business and management research. These include positivism, realism, nominalism, interpretivism/constructionism, and pragmatism.

### 4.2.1 Realism and nominalism ontology position

Realism is an ontological position often refers to objectivism, which postulates that the physical or social world exists independently of any observation made about them (Easterby-Smith et al., 2018; Saunders et al., 2019). It is not something that the individual creates. It exists 'out there'; it is before the existence and consciousness of any single human being (Burrell and Morgan, 2019). This view of realism shares two features with positivism (Bryman and Bell, 2015, p. 29). A belief that both the natural and social sciences can use the same method to data collection and explanation, and a commitment to the view that there is a reality that is separate from our descriptions of it. In short, realist emphasises that the social world is concrete and hard, and that science can progress only through observations that have a direct correspondence to the phenomena being investigated (Easterby-Smith et al., 2018; Bryman and Bell, 2015).

In contrast, nominalism considers that the social order and structures of social phenomena are created by researchers and other social actors using language and discourse (Saunders et al., 2019). It suggests that the labels and names attached to individual experience and events are crucial (Easterby-Smith et al., 2018). For nominalists, there is no underlying reality to the social world beyond what people attribute to it, and, because individual perceives reality differently, it makes more sense to talk about multiple realities, and not just a single reality (Saunders et al., 2019). This position of nominalism is often equated with subjectivism, which asserts that social phenomena and their meanings are socially constructed through social interaction (Saunders et al., 2019). That is, social phenomena and categories are not only produced through social interaction but are also in a constant state of revision (Bell et al., 2018, p. 27).

### 4.2.2 Interpretivism and positivism epistemological position in social science

Interpretivist and positivist epistemological positions are the two key research philosophies that have been adopted in operations and supply chain management literature (Golicic and Davis, 2012; Mangan et al., 2004). These positions have both played an important role in supply chain literature because of the multi-disciplinary nature of this area (Mangan et al., 2004).

#### 4.2.2.1 Interpretivism

Like nominalism, interpretivism/constructionism asserts that reality is not objective and exterior but is socially constructed and is given meaning by people in their daily interactions with others (Easterby-Smith et al., 2018; Burrell and Morgan, 2019). This position of interpretivism, according to Berger and Luckmann (1967); Lincoln, (2007) and Shotter (1992), reflects the ways that people make sense of the world – through sharing their experiences with others. Unlike positivism, interpretivism embraces nominalism, where researchers are trying to understand and appreciate the different experiences that people have, and not just search for external causes and fundamental laws to explain behaviours (Creswell, 2013). Because human action arises from the sense that people make of different situations, not as a result of a direct response to external stimuli. So, the role of researchers should not be to gather facts and measure patterns of behaviour, but to understand the different constructions and meaning that people place on their experience (Easterby-Smith et al., 2018).

In contrast to positivism, the research methods of interpretivist' researchers are qualitative. Focus groups and unstructured interviews enable them to collect rich data, oriented to the contextual uniqueness of the world that is being investigated. In fact, interpretivists are more concerned with understanding a specific case than the generalisation of their findings (Mangan et al., 2004). As opposed to the positivist approach, the interpretivists argued that there is no objective reality to generalise, rather the research cannot avoid influencing the social phenomena under investigation (Saunders et al., 2019).

#### 4.2.2.2 Positivism

By contrast, positivist epistemological position asserts that the social world exists externally, and its properties should be measured through objective approaches and not subjective to the scope of interpretation (Easterby-Smith et al., 2018; Bell et al., 2018). According to this position, Positivists believe that there is an objective truth out there – to understand the world well enough so that we can predict and control it (Bougie and Sekaran, 2020). Knowledge is of significance only if it is based on observations of this external reality. For positivist, the world operates by laws of cause and effect that we can understand if we use a scientific approach to research (Bryman and Bell, 2015). Positivists are concerned with the rigor and replicability of their research, the reliability of observations and generalisability of findings (Quinlan, 2011). They carry out deductive research by putting forward theories that can be test using a fixed, predetermined research design and objective measures. The key approach of positivist researchers is the experiment, which allows them to test cause-and-effect relationships through manipulation and observation. Some positivists believe that the role of researchers is to explain and predict what happens in the social world by searching for regularities and causal relationships between its constituent elements (Burrell and Morgan, 2019). For them, knowledge of anything beyond that – such as emotions, feelings and thoughts – is impossible.

Bell et al. (2018, p. 30) classified five principles of positivism, which are: i) only phenomena, and hence knowledge confirmed through the senses, can genuinely be warranted as knowledge; ii) the purpose of the theory is to generate hypotheses that can be tested and that will allow explanation of laws to be assessed; iii) knowledge is arrived at via gathering facts that provide the basis for laws; iv) science must be conducted in a value-free; and v) there is a clear distinction between Scientifics and normative statements.

At the same time, Easterby-Smith et al. (2018, p. 69) list several principles of positivism. These include: i) independent in which the observer must be independent of what is being observed; ii) value-freedom, where the choice of what to study, and how to study it, can be determined by objective criteria, not human beliefs, and interest; iii) causality for which the aim of the social sciences should be to identify causal explanations and fundamental laws that explain regularities in people behaviour. Other principles are iv) hypothesis and deduction, meaning science progresses through a process of hypothesising fundamental laws and then deducing what kinds of observations will demonstrate the truth or falsity of these hypotheses; v) operationalisation, which concepts need to be defined in ways that enable facts to be measured quantitatively; vi) problems as a whole are better understood if they are reduced to the simplest possible elements; amongst others (Easterby-Smith et al., 2018).

As noted above, positivists are concerned with the rigour and replicability of their research, the reliability of observations, and the generalisability of findings. They use deductive reasoning to put forward theories that they can tested using quantitative research design and objective measures. This will enable the examination of cause-and-effect relationships (Sekaran and Bougie, 2013). More so, positivists are concerned with developing a conceptual model and hypothesis testing with empirical data (Bell et al., 2018). According to Mangan et al. (2004), the positivist epistemological approach has contributed to the supply chain management research, in term of theoretical implications and managerial insights, owing to focus on hypothesis testing.

#### 4.2.2.3 The comparison between positivist and interpretivist approaches

The principles of positivist research can be contrasted with those attributes of interpretivist research, as concise in Table 4.1. Figure 4.1 above also depicted that there is a link between ontology and epistemology, with positivism fitting with realist ontologies, and interpretivism fitting with nominalism (Easterby-Smith et al., 2018). In fact, Burrell and Morgan (2019) argued that the ontological and epistemological perspectives of the researcher define the choice of methods. In figure 3.1, the positivism is linked with the methodological position of quantitative whereas the interpretivism is corresponded with qualitative methods.

Likewise, Interpretivism considers that there should be different realities, and hence the researcher needs to gather multiple perspectives using an inductive approach and to collect the views and experiences of diverse individuals and observers (Quinlan, 2011). The positivist position, on the other hand, assumed that there is a reality that exists independently of the observer, and hence the role of the researcher is to discover the laws and theories that explain this reality. This is achieved via a deductive approach that eliminates the scope of interpretation and allows key factors to be measured to verify or falsify a set hypothesis (Easterby-Smith et al. 2018).

In addition, interpretivists' perspective asserts that there is no pre-existing reality, and the role of the researcher is to understand how people create structures to help them make sense of, and influence, what is going on around them. So, much attention is given to the language and discourse that can be used both to create meanings and to influence or enact the environment. Interpretivism also recognised that the researcher can never be separated from the sense-making process. In contrast, positivism accepts that reality cannot be accessed directly. The researcher, thus, needs to infer the nature of this reality indirectly through conducting surveys of large samples of individual, activities, and organisations. Data will be expressed in quantitative form. This should enable patterns and regularities in behaviour to be identified, so, allowing hypotheses to be tested and new ideas to be developed.

Because the type of data involved in operations and supply chain management research is quantifiable or measurable. A positivist epistemological position is more suitable for this study. This is because, it is based on the review of existing literature to determine theoretical concepts and generate hypotheses (Forza, 2002). These hypotheses were based on the proposed connections between the study constructs identified in a conceptual model. The study then tests the validity of these hypotheses using empirical data.

**Table 4.1** The differences between interpretivism and positivism **(source:** Easterby-Smith et al. 2018)

| | **Interpretivism** | **Positivism** |
|---|---|---|
| Researchers | are part of what is being observed, cannot be separated and so will be subjective | must be independent of the data and maintains an objective stance |
| Human interest | Are the main drivers of knowledge | Should be irrelevant |
| Explanations | Aim to increase general understanding of the situation | Must demonstrate causality |
| Research progresses through | Gathering rich data from which ideas are induced | Hypotheses and deductions |
| Concepts | Should incorporate stakeholder perspectives | Need to be defined so that they can be measured |
| Unit of analysis | May include the complexity of whole situation | Should be reduced to the simplest terms |
| Generalisation through | Theoretical abstraction | Statistical probability |
| Sampling requires | Small numbers of cases chosen for specific reason | Large numbers of data |
| Method | Qualitative approach | Quantitative approach |
| Theory of truth | Truth as intentional fulfilment: interpretations of research object match lived experience of object | Correspondence theory of truth: ono-to-one mapping between statements and reality |
| Validity | Defensible knowledge claims | Certainty: data truly measures reality |
| Reliability | Interpretive awareness: researchers recognise and address implications of their subjectivity. | Replicability: research results can be reproduced |

### 4.2.3 Strengths and weaknesses of positivism and interpretivism principles

The strengths and weaknesses of the interpretive approaches and the related constructionism paradigm are similar. They, therefore, have strengths in their ability to view change processes over time, understand the meanings of human behaviour, adapt to new issues and ideas, and contribute to the development of new theories (Bryman and Bell, 2015). They also provide a way to collect data that appears natural, not artificial. However, data collection can take a lot of time and resources (Easterby-Smith et al. 2018). Analysing and interpreting data can be difficult and depends on the intimate, tacit knowledge of the researchers. Interpretive approaches often feel messy because it is more difficult to control its pace, progress, and endpoints. There is also the problem that many people policymakers, may give poor credibility to studies based on subjective opinions (Easterby-Smith et al. 2018).

One of the main strengths of positivist approaches is that they can offer broad coverage of the situation; they can be quick and economical. When statistically analysing data from large samples, their results can be of considerable relevance to policy decisions. On the debate side, these methods are rather inflexible and artificial (Easterby-Smith et al. 2018). They are not effective in understanding processes, or the importance people attach to actions. They do not help generate theories, and because they focus on what has happened recently, they make it difficult for the policymakers to conclude what changes and actions should take place in the future (Easterby-Smith et al. 2018). Besides, much of the data collected may not be relevant to real decisions, although it can still be used to support the decision-makers hidden goals (Easterby-Smith et al. 2018). Table 4.2 summarises the strengths and weaknesses of each position.

**Table 4.2** Strengths and weaknesses of different epistemologies (positivist and interpretivist)

| | **Positivism** |
|---|---|
| Strengths | • It can provide highly compelling conclusions.<br>• Can provide wide coverage.<br>• It is potentially fast and economical.<br>• Earlier to provide justification of policies. |
| Weaknesses | • It is hard to implement social experiments and to control for alternative explanations of results.<br>• It focusses may be narrow.<br>• It is inflexible and artificial.<br>• It is not good for process, meanings, or theory generations for action not obvious. |
| | **Interpretivism** |
| Strengths | • It accepts value of multiple data sources. |

| | |
|---|---|
| | • It enables generalisations beyond present sample.<br>• Greater efficiency, including outsourcing potential.<br>• Good for processes, and meanings.<br>• It is flexible and good for theory generation.<br>• Data collection less artificial. |
| Weaknesses | • Access can be difficult.<br>• Cannot accommodate institutional and behavioural differences.<br>• There are problems reconciling discrepant information.<br>• Can be time-consuming.<br>• Analysis and interpretations are difficult.<br>• May not have credibility with policymakers. |

**Source:** Easterby-Smith et al. (2018)

### 4.2.4 The justification for choice of positivist epistemological approach

This study follows a positivist epistemological position, in that, the social world exists externally, and its properties should be measured through objective approaches and not subject to the scope of interpretation (Easterby-Smith et al., 2018; Bell et al., 2018). The positivist paradigm employed was survey research strategy (Dillman et al., 2014). This approach is suitable for gathering empirical data from a large population size (Wilson, 2014) and because it includes developing and testing hypotheses, it is considered a deductive approach. That is, the positivist approach will allow for a review of existing literature to develop hypotheses that can be confirmed or refuted, leading to further generations of theory (Haig, 2014). Consistent with the aims of this study, which seek to develop a single integrated conceptual model of the relationships between agility and sustainability and their impacts on organisational performance criteria. Using a positivist approach will allow investigating the interaction effects between agile practices and sustainability performance measures to determine if agility enables sustainability. It will facilitate the examination of cause-and-effect relationships. A positivist epistemological position is appropriate as it allows for validity and generalisability of findings.

## 4.3 Research logic

In the context of business and management, the research approach could be divided into deductive, inductive, or abductive logic (Bryman and Bell, 2015; Saunders et al., 2019). The characteristics of these approaches are listed in Table 4.3.

Deductive reasoning is associated with a positivist paradigm and quantitative research (Bryman and Bell, 2015). It involves the development of a theory, which is, then subjected to a rigorous test via a series of hypotheses, which can be confirmed or rejected (Saunders et al., 2019). Sekaran and Bougie (2016) lists steps of the deductive approach, including (1) identifying a broad problem area, (2) defining the problem statement, (3) hypothesising, (4) determining measures, (5) data collection, (6) data analysis, and (7) interpretation of the results.

**Table 4.3** The characteristics of the research approaches

| | **Deductive** | **Inductive** | **Abductive** |
|---|---|---|---|
| Logic | In a deductive inference, when the premises are true, the conclusion must also be true. | In an inductive inference, known premises are used to generate untested conclusions. | In an abductive inference, known premises are used to generate testable conclusions. |
| Generalisability | Generalising from the general to the specific. | Generalising from the specific to the general. | Generalising from the interactions between the specific and the general. |
| Use of data | Data collection is used to evaluate propositions or hypotheses related to an existing theory. | Data collection is used to explore a phenomenon, identify themes and patterns, and create a conceptual framework. | Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection. |
| Theory | Theory verification or falsification. | Theory generation and building. | Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory. |

Source: Saunders et al. (2019, p. 153)

In the same way, Blaikie and Priest t (2019) lists six sequential steps in which a deductive approach will progress: (i) put forward a tentative idea, a hypothesis or set of hypotheses to form a theory; (ii) by using existing literature or specifying the conditions under which the theory is expected to hold, deduce a testable proposition; (iii) examine the premises and logic of the argument that produced them, comparing this argument with existing theories to see if it offers an advance in understanding; (iv) test the premises by collecting appropriate data to measure the concepts or variables and analysing them; (v) if the results of the analysis are not consistent with the premises, the theory is false and must either be rejected or modified and the process restarted; (vi) if the results of the analysis are consistent with the premises then the theory is confirmed.  Along with Bell et al. (2018), the sequence of the deductive logic can be represented as a series of steps, as shown in Figure 4.2. While the weakness of deductive reasoning is that it based on stick logic that tests and confirms or falsifies hypotheses.

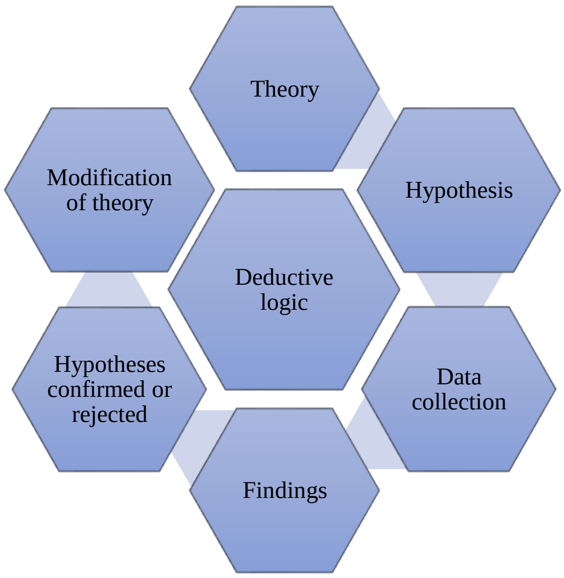



**Figure 4.2** The process of deduction (source: Bryman and Bell, 2015, p 23)

In contrast, the process of induction involves drawing generalisable inferences out of observations (Bryman and Bell, 2015). It starts with empirical observations towards theory building or abstract generalisation (Creswell, 2014). This based on the interpretivism paradigm and qualitative research strategy (Saunders et al., 2019). In inductive reasoning, the researcher generalising from specific to the general (Sekaran and Bougie, 2016). The difficulty with inductive reasoning arises from the criticism that no amount of empirical data will enable theory-building (Bell et al., 2018).

Unlike deductive and inductive approach, abduction is used to draw logical conclusions and build theories about the world. It is proposed as an approach to overcome the limitations of inductive and deductive logic. It based on the pragmatist perspective (Bell et al., 2018; Saunders et al., 2019).

### 4.3.1 The justification for the choice of deductive logic

As mentioned above, this study follows a positivist worldview, accordingly, the corresponding research logic is deductive. The study develops hypotheses from existing literature (Forza, 2002). The deductive approach enables these hypotheses to be tested and confirmed or refuted (Bryman and Bell, 2015). This is based upon the fact that agility and sustainability constructs in the supply chain can be measured (Sarkis et al., 2019; Bottani, 2010). In line with the aim of this study, the thesis investigates the fundamental building blocks of supply chain agility, which is conceptualised as sustainable supply chain competencies. The model further assesses the influence of supply chain agility on operational performance and sustainability performance as well as its mediating role in the relationship between sustainable practices and performance outcomes. Within the frameworks, three contingency variables are viewed as enablers (moderators) on the relationships among constructs. The inductive approach is not suitable to achieve this goal (Hong et al., 2018; Beske et al., 2014; Ketchen and Hult, 2007; Schiklke, 2014). In contrast to inductive research, deductive research can be complete faster, although time must be spend designing the study before data collection and analysis. It can be a lower risk strategy, though there are risks that questionnaires will not be returned. In addition, several managers are familiar with deduction and are likely to trust the conclusions that result from this approach.

## 4.4 Research approaches

Research refers to the method take in research project (Bell et al., 2019). That is, research approaches are plans and procedures that span the steps from general assumptions to detailed methods for data collection, analysis, and interpretation (Saunders et al., 2019; Denzin and Lincoln, 2018). This plan includes several decisions about which approach to use to study a topic. This decision should include the philosophical assumptions that the researcher brings into the study; procedures of inquiry; and specific research methods for data collection, analysis, and interpretation. The selection of a research approach is also based on the type of the research problem or hypotheses addressed, the personal experiences of the researchers and the audiences for the study. According to Creswell (2014), there are three research approaches in business and management research, including (1) qualitative, (2) quantitative, and (3) mixed-methods research.

### 4.4.1 Qualitative research

In the 1990s century, the field of qualitative research has undergone quantum leaps (Denzin and Lincoln, 2005, p. xi). Qualitative research consists of a set of interpretive practices that transform the world visible (Denzin and Lincoln, 2011, 2018; Burrell and Morgan, 2017). It is an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem (Creswell, 2013). The qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin and Lincoln, 2011, p. 3). The data is analysed inductively, building from details to general themes, and the researcher interprets the meaning of the data. The report is structured flexibly. Those who deal with this form of inquiry support view research that considers an inductive reasoning, a focus on individual meaning, and the importance of reporting the complexity of a situation (Creswell, 2013, p. 44).

Qualitative research is at best an umbrella term associated with a variety of interpretive approaches (Denzin and Lincoln, 2005). Creswell and Poth (2018 p. 67) identified five qualitative approaches to inquiry. These include ethnography (Fetterman 2010; Wolcott, 2008; Denzin and Lincoln, 2018), grounded theory (Charmaz, 2014; Corbin and Strauss, 2015); narrative inquiry (Riessman, 2008; Clandinin, 2013); case studies (Stake, 1995, 2005; Yin, 2014, 2018); phenomenological method (Moustakas, 1994; Van Manen, 2016); and action research (Coghlan and Brannick, 2014).

Case studies are a design of inquiry found in many fields, in which the researcher develops an in-depth analysis of a case, often a program, event, activity, and process, amongst others. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period (Yin, 2015, 2018; Stake, 1995).

Narrative research is a design of inquiry from the humanities in which the researcher studies the lives of individuals and asks one or more individuals to provide stories about their lives (Riessman, 2008). This information is then often retold or restored by the researcher into a narrative chronology. Often, in the end, the narrative combines views from the participant's life with those of the researcher's life in a collaborative narrative (Clandinin and Connelly, 2000).

Grounded theory is a design of inquiry from sociology in which the researcher derives a general, abstract theory of a process, action or interaction grounded in the views of participants. This process involves using multiple stages of data collection and the refinement and interrelationship of categories of information (Corbin and Strauss, 2015; Charmaz, 2006, 2014).

Phenomenological research is a design of inquiry coming from philosophy and psychology in which the researcher describes the lived experiences of individuals about a phenomenon as described by participants. This description culminates in the essence of the experiences for several individuals who have all experienced the phenomenon. This design has strong philosophical underpinnings and typically involves conducting interviews (Giorgi, 2009; Van Manen, 2016; Moustakas, 1994).

Ethnography is a design of inquiry coming from anthropology and sociology in which the researcher studies the shared patterns of behaviours, language, and actions of an intact cultural group in a natural setting over a prolonged period. Data collection often involves observations and interviews (Creswell, 2014).

Despite the relevance of qualitative research strategies, there have been a lot of criticisms on its roles in business and management research. Bell et al. (2018, p., 374) have expressed concern raised about qualitative researchers. These include i) qualitative research is too impressionistic and subjective; ii) it is difficult to replicate; iii) it is impossible to know how findings can be generalised to other settings; and it is sometimes difficult to establish from qualitative research what the researcher did and how they arrived at the study's conclusions (Bell et al., 2018, p. 374-375). Other writers, Denzin and Lincoln (2018) mentioned that qualitative research is unscientific, exploratory, subjective, and flouts scientific principles of value-free objectivism. It is sometimes term fiction–non-verifiable truths and nothing but journalism (Denzin and Lincoln, 2005). The strengths and weaknesses of qualitative research are summarised in Table 4.4.

**Table 4.4** The strengths and weaknesses of qualitative research

| **Qualitative research** | |
|---|---|
| Advantage | • The data are based on the participants' own categories of meanings.<br>• It is useful for studying a limited number of cases in-depth.<br>• It is useful for describing complex phenomena.<br>• Provides individual case information.<br>• Can conduct cross-case comparisons and analysis.<br>• Provides understanding and description of people's personal experiences of phenomena (i.e., insider' point of view).<br>• Can describe, in rich detail, phenomena as they are situated and embedded in local contexts.<br>• The researcher identifies contextual and setting factors as they relate to the phenomena of interest.<br>• The researcher can study dynamic processes (i.e., documenting sequential patterns and change).<br>• The research can use grounded theory to generate inductively a tentative but exploratory theory about a phenomenon.<br>• Can determine how participants interpret 'constructs' meaning.<br>• Data are collected in naturalistic settings.<br>• Qualitative approaches are responsive to local situations, conditions, and stakeholders' needs.<br>• Qualitative researchers are responsive to changes that occur during the conduct of a study and may shift the focus of their studies as a result.<br>• Qualitative data in the words and categories of participants lend themselves to exploring how and why phenomena occur.<br>• One can use an important case to demonstrate vividly a phenomenon to the readers of a report.<br>• Determine ideographic causation (i.e., determination of causes of an event). |
| Disadvantage | • Knowledge produced may not generalise to other people or other settings (i.e., findings may be unique to the relatively few people included in the research study).<br>• It is difficult to make quantitative predictions.<br>• It is more difficult to test hypotheses and theories.<br>• It may have lower credibility with some administrators and commissioners of programmes.<br>• It takes more time to collect the data when compared to quantitative research.<br>• Data analysis is often time consuming.<br>• The results are more easily influenced by the researcher's personal biases and idiosyncrasies. |

Source: Johnson and Onwuegbuzie (2004, p. 20)

### 4.4.2 Quantitative research

In the late 19th and 20th centuries, the research approaches associated with quantitative research were those based on the positivist worldview (Creswell, 2014; Easterby-Smith et al., 2018). It is an approach for testing objective theories by examining the relationship among variables (Creswell, 2014). These variables can be measured on instruments. Quantitative researcher concerned with collecting and working with data that is structured and that can be numerically analysed (Bell et al., 2018). The report has a set of structure consisting of introduction, literature and theory, methods, results, and discussion (Creswell, 2014). Those who deal with this form of investigation have assumptions about testing theories deductively, incorporating bias protections, seeking counterfactual explanations, and being able to generalise and replicate the findings (Creswell and Creswell, 2017; Robson and McCartan, 2016). Quantitative research includes experimental research and survey research strategies (Creswell, 2014; Bell et al., 2018; Saunders et al., 2019).

#### 4.4.2.1 Experimental research

Experimental research seeks to determine if a specific treatment influences outcome. The researcher assesses this by providing specific treatment to one group and withholding it from another and then determining how both groups scored on an outcome. Experiments include true experiments, with the random assignment of subjects to treatment conditions, or quasi-experiments that use nonrandomised assignments (Creswell, 2014).

The key benefit of experimental research is that they encourage clarity about what is to be investigated and should eliminate many alternative explanations because the random assignment ensure that the experimental and control groups are identical in all respect, except for the focal variable. It is also easier for another researcher to replicate the study, and hence any claims arising from research can be subjected to public scrutiny. One of the limitations with experimental research design is that there is the danger that volunteers will be harmed; hence stringent ethical guidelines have been developed, which are now filtering into business and management research.

#### 4.4.2.2 Survey research

A survey is a system for collecting information from or about people to describe, compare or explain their knowledge, attitudes, and behaviour (Fink, 2003). The survey research is popular in operations and supply chain management research (Forza, 2002; Flynn et al., 2018; Malhotra and Grover, 1998), because it allows the researcher to collect quantitative data on many types of research questions. Surveys are used in explanatory (confirmatory), exploratory, and descriptive research to collect data about people, events, organisations, or situations (Oakshott, 2016; Bougie and Sekaran, 2020). Survey research involves cross-sectional studies using instruments such as self-administered questionnaires, structured interviews, or observation for data collection with the intent of generalising from a sample to a population (Creswell, 2014; Fowler, 2013). Survey research can contribute to the development of knowledge in different ways (Forza, 2002) see section 3.5 for more details.

Notwithstanding the benefit of quantitative research strategies, there is a lot of criticism of quantitative research from qualitative research. Bell et al. (2018) asserts that quantitative research does not distinguish people and social institutions from 'the world of nature'. Its measurement process has an artificial and spurious sense of precision and accuracy. The reliance on instruments and procedures hinders the connection between research and everyday life. Besides the analysis of relationships between variables creates a static view of social life that is independent of people's lives (Bell et al., 2018). The strengths and weaknesses of quantitative research are summarised in Table 4.5.

**Table 4.5** The strengths and weaknesses of quantitative research

| **Quantitative research** | |
|---|---|
| Strengths | • Testing and validating already constructed theories about how and to a lesser degree, why phenomena occur.<br>• Testing hypotheses that are constructed before the data are collected. Can generalise research findings when the data are based on causal samples of sufficient size.<br>• Can generalise research finding when it has been replicated on many different populations and subpopulations.<br>• Useful for obtaining data that allow quantitative predictions to be made.<br>• The researcher may construct a situation that eliminates the confounding influence of many variables, allowing one to more credibly assess cause and effect relationships.<br>• Data collection using some quantitative methods is relatively quick.<br>• Provides precise, quantitative, numerical data.<br>• Data analysis is relatively less time-consuming software (using statistical package for the social sciences -SPSS, Amos). |

| | |
|---|---|
| | • The research results are relatively independent of the researcher.<br>• It may have higher credibility with many people (e.g., administrators, politicians, and policy makers).<br>• It is useful for study large numbers of people or organisations. |
| Weaknesses | • The researcher's categories that are used may not reflect local constituencies' understandings.<br>• The researcher's theories that are used may not reflect local constituencies' understandings.<br>• The researchers may miss out on phenomena occurring because of the focus on theory or hypothesis testing not on theory or hypothesis generation (called the confirmation bias).<br>• Knowledge produced may be too abstract and general for direct use to specific local situations, contexts, and individuals. |

Source: Johnson and Onwuegbuzie (2004, p. 19).

### 4.4.3 Differences between quantitative and qualitative research

Several writers have explored the contrasts between quantitative and qualitative research (Bryman and Bell, 2015; Bryman, 1988; Hammersley, 2017) Table 4.6 draws out the contrasting features.

#### 4.4.3.1 Numbers versus words

Qualitative researchers are seen as using words in the presentation of analyses of society, although, as have been emphasised, qualitative researchers are also concerned with the analysis of visual data, while quantitative researchers are often portrayed as preoccupied with applying measurement procedures to social life (Bryman and Bell, 2015).

#### 4.4.3.2 Point of view of researcher versus points of view of participants

In qualitative research, the perspective of those being studied – what they see as important and significant – provides the point of orientation. In quantitative research, the investigators are in the driving seat. The set of concerns that he or she brings to the study structures the investigation (Bryman and Bell, 2015).

#### 4.4.3.3 The researcher is distant versus researcher is close

The qualitative researcher seeks close involvement with the people being investigated so that he or she can approach a genuine understanding of the world from their perspective. In quantitative research, researchers are uninvolved with their subjects and in some cases, as in research based on postal questionnaires or interviews conducted by hired assistants, may have no contact with them at all. Sometimes, this lack of relationship with the subjects of an investigation is regarded as desirable by quantitative researchers because they feel that their objectivity might be compromised if they become too involved with the people they study (Bell et al., 2019).

#### 4.4.3.4 Theory and concepts tested in research versus theory and concepts emergent from data

In qualitative research concepts and theoretical elaboration tend to emerge out of data collections, whereas quantitative researchers typically bring a set of concepts to bear on the research instruments being employed, so that theoretical work precedes the collection of data (Bell et al., 2019).

#### 4.4.3.5 Static versus process

Qualitative research is often depicted as attuned to the unfolding of events over time and to the interconnections between the actions of participants of social settings. Quantitative research is frequently depicted as presenting a static image of social reality with its emphasis on relationships between variables. Change and connections between events overtime tend not to surface, other than in a mechanistic fashion (Bell et al., 2019).

#### 4.4.3.6 Structured versus unstructured

In qualitative research, the approach is invariably unstructured, so that the possibility of getting at actors’ meanings and of concepts emerging out of data collection is enhanced; quantitative research is typically highly structured so that the investigator can examine the precise concepts and issues that are the focus of the study (Bryman and Bell, 2015).

#### 4.4.3.7 Generalisation versus contextual understanding

Whereas the qualitative researcher seeks an understanding of behaviour, values, beliefs, and so on in terms of the context in which the research is conducted, quantitative researchers want their findings to be generalisable to the relevant population (Bell et al., 2019).

#### 4.4.3.8 Hard, reliable data versus rich, deep data

Qualitative researchers claim, by contrast, that their contextual approach and their – often prolonged – involvement in a setting engender rich data. Quantitative data are often depicted as 'hard' in the sense of being robust and unambiguous, owing to the precision offered by measurement (Bell et al., 2019).

#### 4.4.3.9 Macro versus micro

Qualitative researchers are concerned with small-scale aspects of social reality, such as interaction, whereas quantitative researchers are often depicted as involved in uncovering larger-scale social trends and connections between variables (Bryman and Bell,2015).

#### 4.4.3.10 Behaviour versus meaning

It is sometimes suggested that the qualitative researcher with the meaning of action and the quantitative researcher is concerned with people's behaviour (Bell et al., 2019).

#### 4.4.3.11 Artificial setting versus natural setting

Whereas qualitative researchers investigate people in the natural environment, quantitative researchers investigate a contrived context (Bell et al., 2019).

**Table 4.6** Contrasting characteristics of quantitative and qualitative research approaches

| **Research strategies** | |
|---|---|
| **Qualitative research** | **Quantitative research** |
| Interviews, focus group, and documents review. | Surveys, structured interview. |
| Nominalist. | Realist. |
| Interpretivist. | Positivist. |
| Subjectivism. | Objectivism. |
| Words. | Numbers. |
| Point of view of participants. | Point of view of researcher. |
| Researcher is close. | Researcher is distant. |
| Inductive; generation of theory. | Deductive; testing of theory. |
| Theory emergent. | Theory testing. |
| Process. | Static. |
| Unstructured. | Structured. |
| Contextual understanding. | Generalisation. |
| Rich, deep data. | Hard, reliable data. |
| Micro. | Macro. |
| Meaning. | Behaviour. |
| Natural settings. | Artificial settings. |

Source: Bell et al. (2019, p. 377).

## 4.4.4 Similarities between quantitative and qualitative research

It is also worth bearing in mind how quantitative and qualitative research are similar and not different. Hardy and Bryman (2004); Bryman and Bell (2015) and Bell et al. (2018) identified the following similarities:

### 4.4.4.1 Both are concerned with data reduction

Both quantitative and qualitative researchers collect larger amounts of data. These large amounts of data represent a problem for researchers because they then must cleanse the data. By reducing the amount of data, they can then begin to make sense of it. In qualitative data analysis, researchers develop concepts out of their often-rich data. In quantitative research, the process of data reduction takes the form of statistical analysis – something like a mean or frequency table is a way of reducing the amount of data on large numbers of people (Bryman and Bell, 2015).

#### 4.4.4.2 Both are concerned with relating data analysis to the research literature

Both quantitative and qualitative researchers are typically concerned to relate their findings to points thrown up by the literature relating to the topics on which they work. In other words, the researcher's findings take on significance in large part when they are related to the literature (Bryman and Bell, 2015).

#### 4.4.4.3 Both are concerned with variation

In different ways, both quantitative and qualitative researchers see to uncover variation and then to represent the variation that they uncover. This means that both groups of researchers are keen to explore how organisations (or whether the unit of analysis) differ and to explore some of the factors connected to that variation, although, once again, the form that variation takes differs (Bryman and Bell, 2015).

#### 4.4.4.4 Both treat frequency as a springboard for analysis

In quantitative research, frequency is a core outcome of collecting data, as the investigator typically wants to reveal the relative frequency with which certain types of behaviour occur or how many newspaper articles emphasise a certain issue. In qualitative research, issues of frequency arise in the fact that, in reports of findings in publications, such terms as 'often' or 'most' are commonly employed. Also, when analysing qualitative data, the frequency with which certain themes occur commonly informs which ones tend to be emphasised when writing up findings (Bryman and Bell, 2015).

#### 4.4.4.5 Both seek to ensure that distortion does not occur

Few business researchers nowadays subscribe to the view that it is possible to be an entirely objective and dispassionate student of organisational life. As discussed in chapter 2, personal values often play a significant role in the selection of research topics and approach to study taken by business researchers. However, that does not imply that 'anything goes. Researchers seek to ensure that 'wilful bias's (Hammersley and Gomm, 2000) or what Hardy and Bryman (2004, p. 7) call 'consciously motivated misrepresentation' does not occur.

#### 4.4.4.6 Both argue for the importance of transparency

Both quantitative and qualitative researchers seek to be clear about their research procedures and how their findings were arrived at. This allows others to judge the quality and importance of their work. In the past, it has been suggested that some qualitative researchers were opaque about how they went about their investigation, but increased transparency is an expectation (Bryman and Bell, 2015).

#### 4.4.4.7 Both must address the question of error

For the quantitative researcher, the error must be reduced as far as possible so that the investigator can be confident that any variation uncovered is real, and not the product of problems with how questions are asked or how research instruments are administered. In qualitative research, the investigator seeks to reduce error by ensuring that, there is a good fit between his or her concepts and the evidence that has been amassed (Bryman and Bell, 2015).

#### 4.4.4.8 Research methods should be appropriate to the research questions

Hardy and Bryman (2004) stated that research approaches must be suitable to research question. Researchers should seek to ensure that, when they specify research questions, they select research methods and approaches to the analysis of data that are appropriate to those questions.

These tend to be rather general points of similarity, but they are an important corrective to any view that portrays the two approaches as completely different. There are differences between quantitative and qualitative research, but that is no to say that there are not points of similarity (Bryman and Bell, 2015).

### 4.4.5 The justification for the choice of quantitative research approach

The operations and supply chain management are viewed as a normative science whereby reality is perceived to be objective and quantifiable. This study adopts a positivist epistemological position that is fits with quantitative research approach. This predicted upon the fact that the research questions or hypotheses call for: the identification of practices that influence an organisational performance; the use of intervention variable; understanding the best predictors of organisational performance (Creswell, 2014). As such, quantitative research was the best approach. The study proceeds to develop multiple attributes and indicators from existing literature on agility and sustainable supply chain. This assumes that there are agility and sustainable supply chain practices whose implementation by organisations could bolster their operational performance objectives and sustainability performance. These indicators are all measurable and quantifiable. If research involves quantifiable indicators, survey research approach was particularly suitable (Collins and Cordon, 1997; Malhotra and Grover, 1998). As a result, survey by questionnaire was used for data collection.

More so, quantitative approach is useful for establishing relationships amongst variables. It can enable developing and testing hypotheses and the ability to generalise research findings tends to separate quantitative methodology from qualitative approach (Bell et al., 2018; Saunders et al., 2009; Easterby-Smith et al., 2015). Still, quantitative approach will be useful for gathering unique and reliable numerical data that allow measurable predictions to be made (Saunders et al., 2019). It can allow the researcher to construct a situation that eliminates the confounding influence of many variables, allowing to assess cause-and-effect-relationships (Bell et al., 2018). Quantitative approaches can provide wide coverage of the range of situations; they can be fast and economical; and with statistical analysis of data from larger sample, their outcomes may be of considerable relevance to policy decisions (Easterby-Smith et al., 2018, p. 75).

Furthermore, research methodology represents a systematic process of selecting suitable methods to address research questions/hypotheses (Quinlan et al., 2019). The research method adopted may depend upon the discipline area of the researcher (Creswell, 2014). The researcher training and experiences also influence the choice of approach. A researcher trained in operational and analytical modelling would be most likely to choose the quantitative research. Given that the analytic and operations research community and the majority of works within supply chain management are analytical and quantitatively focused, it is appropriate that the present study is also of this choice. Quantitative methodologies rely on regression and confirmatory approaches to evaluate theories or hypotheses. This study uses confirmatory or correlative approaches of structural equation modelling techniques to analyse data. Thus, the results will be more likely to have higher credibility with policymakers.

## 4.5 Survey research strategy

This section looked at the survey research process pursued in this study. The hypothesis testing survey research is a process that presupposes the pre-existence of a conceptual model. It includes several associated sub-processes: the process of translating the theoretical domain into the empirical domain; the research design and pilot testing processes; the process of collecting data for hypothesis testing; the data analysis process; the process of interpreting the results and discussion and theoretical implications (Frankfort-Nachmias and Nachmias, 2007; Forza, 2002) Figure 4.3 illustrated the theory testing survey research process.

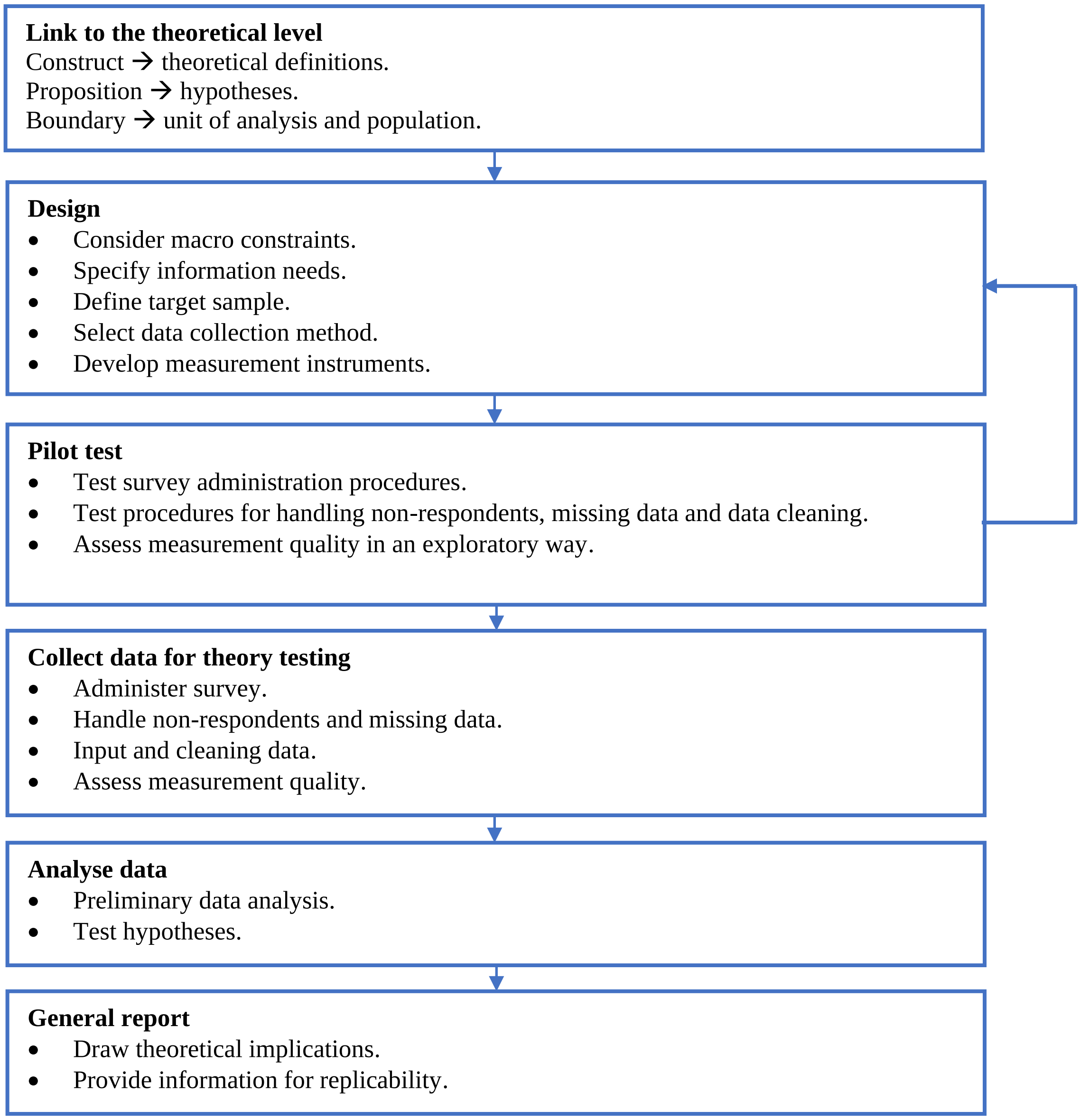



**Figure 4.3** Theory testing survey research processes (source: Forza, 2002)

## 4.6 Survey research design

The dominant epistemology underlying survey research methods is positivism. As explained previously, this assumes that there are regular, verifiable pattern in organisational practices (Stangor, 2006; Creswell, 2014; Goodwin, 2007; Bell et al., 2018; Easterby-Smith et al., 2018). Survey research design is an essential part of the research process that has impacts on the quality of information needed. It includes activities that precede the gathering of data. The focus on survey research is to advance knowledge and develop theory.

Survey research has several attributes. It involves the collection of data from large population size. The data could come from responses to survey by questionnaire (using mailed or web-based survey), information collected from interviews, coded observations of actual behaviour, or objective measurements of output or performance. The data are only as good as the instrument used to collect them and the conceptual model that guides their collection.

Survey research is a quantitative approach that requires standardised information to explain or to examine the relationships between variables (Malhotra and Grover, 1998). The ability to generalise with statistical confidence based on sampling frame tends to differentiate survey research design from other research methods such as case studies design, focus groups, ethnographic methods (Grix, 2010). For example, case studies are not quantitatively oriented, the variables are often not pre-defined, and such studies involve examining a phenomenon in-depth within their natural setting, thereby precluding any attempt at generalisation (Malhotra and Grover, 1998).

There are several types of survey research design in the literature (Stangor, 2006; Malhotra and Grover, 1998; Forza, 2002). Forza (2002) distinguish among exploratory research, descriptive, explanatory (or confirmatory) survey research employed in operations and supply chain management research. These survey research designs produce different types of information. As summarised in Table 4.7, each survey design has a unique set of advantages and disadvantages. In short, they contribute to the gathering of knowledge, and necessary for a complete study of agility and sustainability in the supply chain. What follows is an account of the types of survey research:

Exploratory survey research takes place during the early stage of research into a phenomenon when the purpose was to gain initial insight on a topic and offers a basis for more in-depth studies on the topic or subject (Robson, 2002; Forza, 2002). It focuses on identifying patterns within the data (Saunders et al., 2009). While descriptive survey research is aimed at further understanding of the phenomenon and provide the distribution of the phenomenon in a population (Malhotra and Grover, 1998). Although it does not target at theory development, the facts described can be useful for theory building and revision (Wacker, 1998).

Another survey research design is confirmatory research often referred to as explanatory research approach. This is the survey methodology where attempt is made at hypothesis testing via concepts, frameworks, and prepositions (Forza, 2002; Byrne, 2016). It is used to establish causal relationships amongst variables (Saunders et al., 2009). This research technique is useful when knowledge in an area has established and confirmed to the degree in which a hypothesis linking constructs can be suggested and data obtained to verify or reject the relationships (Forza, 2002; Malhotra and Grover, 1998). The results are then interpreted and in turn, contribute to knowledge (Forza, 2002; Stangor, 2006).

**Table 4.7** Characteristics of research design

| **Research design** | **Aims** | **Advantages** | **Disadvantages** |
|---|---|---|---|
| Exploratory | To discover what is happening and gain insights about a topic of interest. | It is flexible and adaptable to change; it allows for more in-depth studies of the subject. | Cannot be useful theory testing. |
| Confirmatory | To establish causal relationships between and among two or more variables. | It is useful for hypotheses testing and making of predictions. | Cannot be useful for theory building. |
| Descriptive | To create a snapshot of the current situation. | Provides a relatively complete picture of what is occurring at a given time. | Cannot be used to assess relationships among variables. |

Source: Stangor (2006)

### 4.6.1 The justification for the choice of confirmatory research design

This study aims to examine the impacts of agility and sustainable practices on operational and sustainability performance objectives, Confirmatory research approach was, therefore, adopted to answer the research questions/hypotheses. Using this technique enables causal relationships between study constructs to be established. It can also be useful for hypotheses testing. In this case, it can be said that neither an exploratory nor a descriptive study meets the objectives of this study. As exploratory studies are linked to case studies and qualitative work that use subjective opinions to assess the phenomena and are not quantitative. Likewise, its variables are often not pre-defined, and such studies involve an in-depth analysis of a phenomenon in a natural setting, thereby precluding an attempt to generalise the results. The confirmatory survey is adopted because it is consistent with the methodology in the analytics and operations research community. Agility and sustainability are both measurable indicators (Esfahbodi et al., 2017; Kamble et al., 2020; Balhadi et al., 2020; Wamba et al., 2020). If a study contains quantifiable indicators, confirmatory or explanatory survey research is the best design (Malhotra and Grover, 1998; Forza, 2002). It can allow the use of structural equation modelling to analysed data.

### 4.6.2 Cross sectional research design

Cross-sectional research involves a study for which data are gathered just once (Bougie and Sekaran, 2020; Saunders et al., 2019; Bell et al., 2018). The purpose of the study was to collect data that would be pertinent to find the answer to research questions. Data collection at one point in time was enough. Cross-sectional research often employs a survey research strategy. It seeks to explain how constructs are related in different organisations (Saunders et al., 2019). It is financially feasible and relatively cheap, time-efficient, and simple (Bryman and Bell, 2015). However, whilst cross-sectional research is fit with quantitative research approach, it may also use qualitative or mixed methods research strategies (Yin, 2018).

In contrast, longitudinal research requires the researcher to study people or phenomena at more than one point in time to answer the research question (Bougie and Sekaran, 2020). The main strength of longitudinal research is its capacity to study changes and development (Saunders et al., 2019). This type of research design may also offer researchers with a measure of control over some of the variables being studied. It allows enough time for observing a phenomenon under investigation and thus it is often used to map change (Bryman and Bell, 2015). It can provide an in-depth insight of the concept under studied, which is linked to case studies (Yin, 2018). Nevertheless, longitudinal studies are more likely to follow an interpretivism epistemological position (Bell et al., 2018). It is the expansion of cross-sectional design, with the ability to keep track of certain factors over a period to assess improvements or to detect possible causal connections, though more expensive, but might offer good insights (Sethi et al., 2001; Bougie and Sekaran, 2020).

#### 4.6.2.1 The justification for using the cross-sectional research design in this study

Based on the research hypotheses, the cross-sectional approach was adopted in this study. As the study is interested in a snapshot of current agility and sustainable constructs that might affect the operational performance objectives and sustainability performance. This study seeks to assess the theorised model via empirical study at a point in time. More so, this study does not intend to map any changes or progresses in agility and sustainability practices or examine their impact over long term, so the longitudinal approach was not suitable for this study.

The survey research strategy is widely used in cross-sectional research, as it can enable studying a phenomenon or phenomena at a point in time (Saunders et al., 2019). More so, the choice of a cross-sectional approach follows the positivist epistemological position and fits perfectly with the quantitative methods of data collection. The selection of cross-sectional design is also consistent with existing literature in the field (Aslam et al., 2018; Jadhav et al., 2019; Blome et al., 2013, 2014; Yusuf et al., 2013, 2014; Eckstein et al., 2015; Tse et al., 2016; Jia, et al., 2019; Gong et al., 2019; Um and Kim, 2019).

## 4.7 Sampling approaches

According to Forza (2002) and Brewerton and Millward (2001), a sample is a subset of the population, which comprises some members selected from the population. Sampling, on the other hand, involves examining a portion of the population, and inferring information about the whole population (Creaswell, 2007; Kumar, 2011). It is the process of selecting enough elements from the population so that by studying the sample, and understanding the properties of the sample subjects, the researcher will be able to generate the characteristics of the population elements (Forza, 2002). Sampling overcomes the difficulties of collecting data from the entire population, which can be impossible or prohibitive in terms of time, costs, and other human resources (Forza, 2002; Brewerton and Millward, 2001).

### 4.7.1 The unit of the analysis

The unity of analysis is the entity that forms the basis of a population. The population can be formed from individual level, firm level (Klassen and McLaugthlin, 1996) and organisations or network level (Christmann, 2000; Geffen and Rothenberg, 2000; Villena and Gioia, 2018; Rothaermel and Hess, 2007; Hult et al., 2007). Bougie and Sekaran (2020) suggested that a unit of analysis is the level of aggregation at which information is analysed and conclusions are drawn. According to Rothaermel and Hess (2007) the implementation of sustainable practices and capabilities-building are mostly started at the network levels. Based on studies such as Sharifi et al. (2006); Blome et al. (2013); Aslam et al. (2018, 2020); Eckstein et al. (2015); Grimm et al. (2014); Wilhelm et al. (2016); Hofmann et al. (2018); Mena et al. (2013); Choi et al. (2001), amongst others; this thesis adopted the organisations (supply networks) as unit of analysis rather than individuals. Here the purpose of the study was to obtain opinion and view about the influence of sustainability and agility strategies on the performance outcomes of the UK oil and gas industry. The population of the study are companies operating within the industry supply chain namely the major oil companies, operators, contractors/suppliers, consultants, and other stakeholders, using individuals could lead to biased results.

Although, the petroleum industry encompasses different types and sizes of companies, not all companies are involved in sustainability and agility. The target organisations were from those involved in the extraction of crude petroleum and natural gas, reservoir management, wells and drilling services, facilities management, marine and subsea services, coke and refining of petroleum products, chemicals, rubber and plastic products, topside maintenance, steel, gloves to pipes, valves, cranes, cement, technology development, consulting, safety and environmental management, and other support services. Those companies represent different types and sizes of businesses e.g., operators, contractors/suppliers, consultants, large companies, small and medium size enterprises etc. They are major contributors to global carbon footprint and key consumers of natural resources and therefore, prime candidates for the study of sustainability and agility. Organisations that do not adopt sustainability and agility strategies, would not be able to comment on the matters related to the topic under investigation. Those companies who have knowledge and experience of working and managing sustainability and agility strategies would be eligible to provide opinion on the matter under examination. By the specifications, companies working in the oil and gas supply chains, defined the population of this thesis. Those companies follow to the designed specification of the study, and thus were labelled as the unit of analysis.

### 4.7.2 The sample frames

The sample frame is a representation of all the elements in the population from which the sample is drawn (Bougie and Sekaran, 2020). There are two different frames from which sampling units were selected. These include entities within the UK oil and gas industry, which adopted sustainability and agility strategies, and those people who were involved in the implementation of these practices in the selected companies. This study used financial analysis made easy (FAME) and Subsea oil and gas directory as a sample frame to identify the industrial supply chain, which is available from the University of Central Lancashire library. These databases contain information on 2.8 million companies in the UK and Ireland. The databases detail the company names, Director Information, email addresses, telephone numbers, fax numbers, profit and loss accounts, balance sheets, and cash-flow. The sampling frame were also drawn from the UK industry classification codes (SIC) to facilitate the replicability of studies.

### 4.7.3 Sample design

Sample design is a critical step in the operations management surveys (Rungtusanatham et al., 2001). These are two major types of sampling design. These are probabilistic sampling and non-probabilistic sampling (Bougie and Sekaran, 2020; Bell et al., 2019; Easterby-Smith et al., 2021; Ghauri et al., 2020). In probability sampling, the elements in the population have some known, non-zero chance or probability of being selected as sampled subjects (Bougie and Sekaran, 2020; Forza, 2002). Whereas in non-probability sampling, the elements do not have a known or predetermined chance of being selected as subjects (Easterby-Smith et al., 2021). Probability sampling designs are used when the representativeness of the sample is of importance in the interest of wider generalisability (Forza, 2002). That is randomness is associated with the ability of the sample to represent the population of interest. When time or other factors prevail on generalisability consideration than non-probability sampling is generally used (Bougie and Sekaran, 2020; Easterby-Smith et al., 2021; Ghauri et al., 2020; Forza, 2002). Table 4.8 shows some basic types of sampling approaches.

**Table 4.8** Sampling approaches

| Representativeness | Purpose is mainly | Type of sampling |
|---|---|---|
| Probabilistic sampling | Generalisability | Simple random sampling, systematic sampling |
| | Assessing differential parameters in subgroups of population | Proportionate stratified random sampling (for subgroups with an equal number of elements) |
| | | Disproportionate stratified random sampling (for subgroups with a different number of elements) |
| | Collecting information in localised areas | Area sampling |
| | Gathering information from a subset of the sample | Double (or multistage) sampling |
| Non-probabilistic sampling | Obtain quick information | Convenience sampling |
| | Obtain information relevant to and available from certain experts | Judgement sampling (when looking for information that only few experts can provide) |
| | | Quota sampling (when the responses of the special interest minority groups are needed) |

Source: Forza (2002, p. 165)

#### 4.7.3.1 Probability sampling

Probability sampling encompasses the simple random sampling, systematic sampling, stratified sampling, cluster sampling, or multi-stage sampling (Oakshott, 2012; Matthews and Ross, 2010; Kumar, 2011). In simple random sampling, every member of the target population has an equal chance of being selected (Oakshott, 2012; Bougie and Sekaran, 2020; Ghauri et al., 2020). The sample random sampling required a sampling frame to randomly select the needed sample from the list (Oakshott, 2012). Systematic sampling, on the other hand, involves selecting every nth member of the population after a random first choice (Ghauri et al., 2020).

To draw a systematic sample, the researcher must, identify the number of elements in the population; identify the sampling ratio; identify a random start; and draw the sample by choosing every nth element (Bougie and Sekaran, 2020). Where the value of n is determined by the size of the population and the required sample size.

Stratified random sampling provides more information for a given sample size. Stratified random sampling involves the division of the populations into different categories, strata (Bougie and Sekaran, 2020), where simple random samples of units are chosen independently from each subset, stratum (Ghauri et al., 2020; Forza, 2002). Stata are identified based on meaningful criteria like industry type, size, performance, or other characteristics (Forza, 2002). The idea of stratified sampling is to ensures that different groups of a population are adequately represented in the sample, to increase the level of accuracy when estimating parameter (Frankfort-Nachmias et al., 2019). It also ensures high homogeneity within each stratum and heterogeneity between strata (Forza, 2002; Bougie and Sekaran, 2020). Stratified sampling enables the comparison of population subgroups and allows control for factors like industry or size, which often affect results (Forza, 2002).

Multi-stage sampling refers to the process whereby the area to be surveyed is divided into smaller areas and a number of these areas randomly selected (Oakshott, 2012). Like multi-stage sampling, cluster sampling are samples gathered in groups or chunks of elements that, are natural aggregates of elements in the population. In cluster sampling, the target population is divided into several smaller areas called clusters (Oakshott, 2012). Then, a random sample of clusters is drawn and for each selected cluster either all the elements or a sample of elements are included in the sample (Bougie and Sekaran, 2020). One advantage of cluster sampling is that the researcher does not need a complete sampling frame, just knowledge of all potential clusters and sampling frames for the selected clusters. A second advantage is that it will be easier and quicker survey units in proximate clusters than in the more dispersed population (Ghauri et al., 2020).

Based on the explanation of the types of probability sampling, there are many challenges with respect to collection of data using simple random sampling. the simple random sampling was not considered appropriate for this study because it assumes that members of the population are known with equal chance of being selected. Another drawback of simple random sampling is that it can mean that small but important parts of a population are missed altogether or sampled so little that the researcher cannot make confident statements about their results (Easterby-Smith et al., 2018, 2021). Other problems include difficulty in gaining access to senior executives. Other issues include a lack of knowledge of sustainability concerns among potential recipients of the questionnaires. Such can lead to problems where the population units are spread widely, such that the cost of approaching them can be very high (Easterby-Smith et al., 2021). Besides, the stratified sampling and cluster sampling was also no consider because the intention of the research was not to ensure that the numbers of groups selected for the sample reflect the relative numbers in the whole population or to divide them into clusters.

Based on the above problems, in this thesis, it was not possible to adopt any of the probability sampling methods, rather two non-probability sampling methods (i.e., convenience sampling and purposive sampling techniques) were employed to select the samples for the research. This was to ensure that only those companies who had experiences and knowledge on the subject matter get selected for the study (Aslam et al., 2018; Esfahbodi et al., 2017; Yusuf et al., 2013). The detail discussions of the two approaches are provided below.

#### 4.7.3.2 Non-Probability sampling

In non-probability sampling designs, the elements in the population do not have probabilities attached to their being chosen as sample subjects (Bougie and Sekaran, 2020). It is a sampling design where the likelihood of each population entity being included in the sample cannot be known (Easterby-Smith et al., 2021). It is not possible to state the probability of any member of the population being sample. As a result, it is harder for the researcher to be confident that claims made about the sample can apply to the large group that the sample is taken from.

There are several categories of non-random, or probabilistic sampling methods that are used. These are convenience sampling, quota sampling, judgemental sampling, purposive sampling, and snowball sampling (Bougie and Sekaran, 2020; Robson, 2002; Ghauri et al., 2020; Creswell, 2009; Matthews and Ross, 2010; Oakshott, 2012; Kumar, 2011; Easterby-Smith et al., 2021). Convenience sampling is the term used to describe a sample in which elements have been selected from the target population based on their accessibility or convenience to the researcher (Ross, 1978). It involves drawing sample units that are easily accessible and willing to participate in a study (Easterby-Smith et al., 2021). It enables the collection of information from members of the population who are readily available to provide it (Bougie and Sekaran, 2020). It is cheap and easy to conduct. It is used to obtain quick information (Forza, 2002; Kumar, 2011).

Convenience sampling was found appropriate for this study since there is no comprehensive, nor any standard, database of UK oil and gas industry supply chains involve in sustainability and agility. As a results, the number of these companies involved can be determined easily. Convenience sampling was used as it was not easy to determine the population of the organisations involved in agility and sustainability. Using random sampling would require that number of organisations involved is reasonably large and that the population is known (Jackson, 2011).

Instead of obtaining information from those who are most readily or conveniently available, it might sometime become necessary to obtain information from specific target groups (Bougie and Sekaran, 2020). The sampling here is confined to specific types of people who provide the desired information, either because they are the only ones who have it, or they conform to some criteria set by the researcher. This type of sampling design is called purposive sampling. Purposive sampling required the ability of the researcher to decide on who can provide the best information to achieve the objectives of the study (Matthews and Ross, 2010; Kumar, 2011). Kumar (2011) stated that purposive sampling is useful to describe a phenomenon, construct a historical reality, or develop something about which a little is known. Purposive sampling of companies with experience and expressed interest in sustainable production and agility was adopted. Expert sampling is like judgement sampling, but the main difference is that respondents must be known experts in the field of interest to be researcher. The two major types of purposive sampling are judgement sampling and quota sampling, which will now be explained.

Judgement sampling involves the choice of subjects who are more advantageously placed or in the best position to provide the information required (Bougie and Sekaran, 2020). According to the purposes of this thesis, the only people who can give first-hand information are the chief executive offers, senior managers, vice presidents, logistics and supply chain managers, and important top-level executives in the oil and gas industry. Such managers could be expected to have expert knowledge by virtue of having gone through the experiences and processes themselves and might perhaps be able to provide good data or information to the researcher.

Thus, the judgement sampling design is used when a limited number or category of people have the information that is sought. In such a case, any type of probability sampling across a cross section of the entire population is purposeless and not useful (Bougie and Sekaran, 2020).

Judgement sampling may curtail the generalisability of the findings, because there are using sample experts who are conveniently available for the investigation. It is the viable sampling method for obtaining the type of information that is required from very specific people who alone possess the needed facts and can give the information sought. In administrative settings, leaders who are very knowledgeable are included in the sample. Enlightened opinions, views, and knowledge constitute a rich data source. Judgement sampling calls for special efforts to locate and gain access to the individuals who do have the requisite information. As already stated, this sampling design may be the only useful one for answering certain types of research question.

#### 4.7.3.3 Justification for selection of convenience and purposive sampling methods

For this research, it was not possible to adopt random sampling method for the survey, rather the sample was drawn through adopting convenient and purposive sampling methods. Since this study was about 'peoples' insight on sustainability and agility methods of oil and gas industry, the ideal data would have been drawn from the total population of such industry supply chains. In practice, it was not feasible to draw a random sample from such a broad population. Instead, the thesis selected the respondents conveniently and purposively with the optimism that the selected sample would be closer to the population of interest. Although, random selection of sample can contribute to increase the external validity and the internal validity by controlling sampling and non-sampling errors, there are some situations where random sampling is neither feasible nor desirable (Cook and Campbell, 1979). For this study, if implemented random sampling procedure to choose the sample, there was no guarantee it would have selected the right organisations who had the experience and knowledge in the area under investigation and thereby would have impact in the research. In the oil and gas supply chain, not all companies are involved in agility and sustainable initiatives. Only some groups of companies are implementing these practices. In selecting the respondents by purposive or judgmental method, the researcher tried to assure that the respondents are selected from companies that are implementing sustainable and agile practices with the expectation that they can contribute better to the survey. The adopted method also increased the validity by ensuring selection of a sample that corresponds to the target population.

Cook and Campbell (1979) argued that if a randomised experiment is conducted with a sample of units that does not correspond to the population of interest, in that case randomisation may not be possible or appropriate. Although randomisation rules out many threads to internal validity, it does not rule out all of them. Cook and Campbell (1979) suggested that the case of random selection cannot be made on the grounds that it is a general facilitator of high-quality research. Rather, the case of random selection must be based on the claim that it is a better means of ruling out threats to internal validity and statistical conclusion validity than other alternatives. It is also argued that a selection procedure, which is not random may still be sufficiently suitable. A similar kind of study Aslam et al. (2018); Esfahbodi et al. (2017) and Yusuf et al. (2013) used convenience and judgemental methods to select sample from a broad population.

To ensure the external validity of a study, the characteristics of the subject must reflect the characteristics of the population that is being investigated. By adopting convenience and purposive sampling methods, it was possible to select the respondents who possessed the desired characteristics of the population. The adopted sampling method also helped to reduce and control some of the non-sampling errors in the following ways. Firstly, when judgmental method was used for selecting respondents, it will help to minimise non-sampling errors, which occur in survey research due to lack of respondents' knowledge. Secondly, adopting judgemental sampling method, the researcher can contact the potential respondents and inform them about the survey before sending the questionnaire, which helped to achieve increased response rate. This judgement sampling approach reduced the non-response error, inaccurate and incomplete response (Cooper and Schindler, 2001). Here response error is where the respondents fail to respond to questions, while response error is where the respondent does not give an accurate response or gives an incomplete response. (Serrador and Pinto, 2015) In short, the choice of sampling strategy should be primarily determined by resources available and relative benefits of alternatives. Many of the decisions would be based on the research design employed, the nature of data to be collected, statistical test used to interpret the data (Black, 1999).

### 4.7.4 Sample size

The appropriate sample size for a survey is not a straightforward decision and can sometimes be very complex. The question is one that has no conclusive answer (Bryman and Bell, 2003). There are different methods that can be used to estimate the sample size, based on the statistical power required to report significance or non-significance accurately. Brewerton and Millward (2001) projected that the required participants of a survey for various statistical test to range from 14 to 50 for a large effect size, and to range from 35 to 133 for a medium effect size. Mbugua (2000) presented a rule-of-thumb dictating a minimum of 30 responses being adequate for research based in the industry. Ghauri et al. (2020) and Bougie and Sekaran (2020) summarised the factors affecting decisions on sample size as:

- The research objectives.

- The extent of precision desired (the confidence interval).
- The acceptable risk in predicting that level of precision (confidence level).
- The amount of variability in the population itself.
- The cost and time constraints.
- The size of the population itself.

### 4.7.5 Target respondents

As mentioned above, a non-probability sampling method was used to select companies in the UK oil and gas industry. The aim was to find oil and gas professional who would be able to respond to all of the questions about agility, sustainability, and performance. For this reason, managing directors, Chief executive officers, Plant managers, Directors, Logistics managers, Operations managers, Sales managers, Supply chain managers, and Industrial waste managers and Procurement managers were targeted. These respondents consisted of highly skilled and knowledgeable supply chain professionals who play important roles in their organisations.

## 4.8 Data collection method

This study follows a positivist method, in that, the social world exists externally, and its properties should be measured through objective approaches and not subject to scope of interpretation (Easterby-Smith et al., 2018; Bell et al., 2018). The positivism paradigm employed was survey methodology (Dillman et al., 2014). The aim of the study was to obtain businesses' opinions on the effects of sustainable practices and agility capability on performance outcomes of supply chains. Considering the strengths and weaknesses of different methods discussed earlier, available resources, and the type of research questions investigated; experiment, case studies, or grounded theory approaches were not adopted for the study. Rather it was considered that survey would be the best method to collect information for the study. In line with operations strategy and sustainability community, survey research is the best method to collect real data, gathering opinions, and measuring attitudes about set of the population (Longoni and Cagliano, 2015; Oakshott, 2016; Esktein et al., 2015; Aslam et al., 2018; 2020; Blome et al., 2013; Wamba et al., 2020). Easterby-Smith et al. (2021) suggested that survey research is a method of choice for those who want to enquire the broad pattern of social phenomena.

In survey research, the instrument used to collect data is called a questionnaire (see Figure 4.4). A questionnaire is a preformulated written set of questions in which respondents record their answers (Bougie and Sekaran, 2020). Questionnaires are designed to collect large number of quantitative data (Oakshott, 2016; Bell et al., 2018). They can be administered personally, mailed to respondents, or distributed electronically. Self-administered questionnaires are less expensive and less time consuming (Bougie and Sekaran, 2020). While structured interview questionnaires are often used to collect data from smaller cases subjectively (Bougie and Sekaran, 2020). Considering the skill, funding, and personnel experience, the questionnaire survey using a self-administered questionnaire was carried out for this study, and no structured interviews were conducted (Forza, 2002; Quinlan and Zikmund, 2015). Rather it was recognised that unstructured interviews could add more value as they could allow verification of collected data, gather more information, and increase the triangulation of the research process. The greatest challenge of interview survey is that data may not adequately reveal attributes and indicators of sustainable practice, agility capabilities, and performance outcomes associated with them. So, Self-completed questionnaire was used for this research.

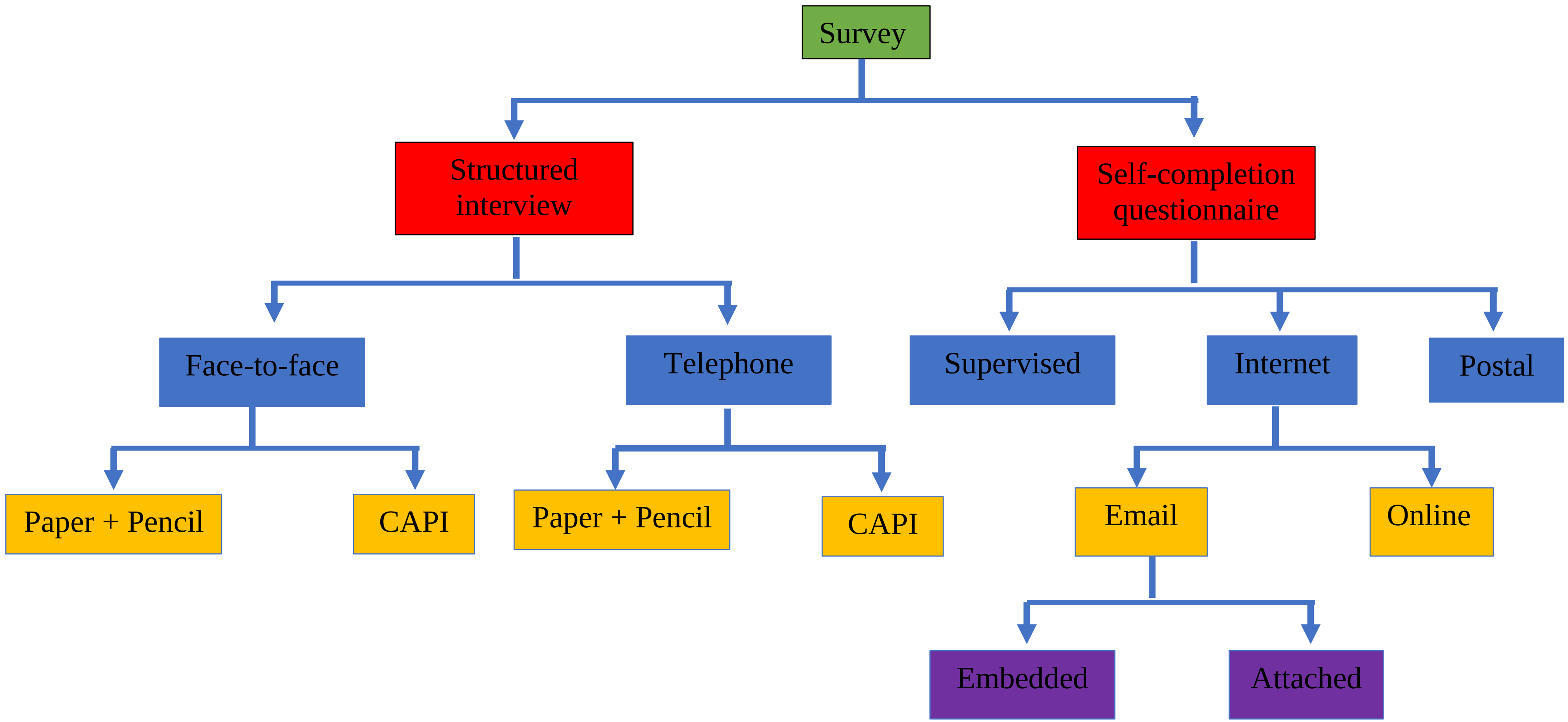



**Figure 4.4** Main modes of administration of survey (source: Bell et al., 2019)

When the survey is confined to a local area, a good way to collect data is to personally administer the questionnaires. The main advantage of this technique is that the researcher can collect all the completed responses within a short period. Any doubts that the respondents might have on any question can be clarified on the spot. The researcher also could introduce the research topic and motivate the respondents to offer their frank answer. Administering questionnaires to large sample size at the same time is less expensive and consumes less time than interviewing; equally, it does not require as much skill to administer a questionnaire as it does to conduct interviews. Wherever possible, questionnaires are best administered personally because of these advantages. However, the main disadvantage of personally administered questionnaire is that the researcher may introduce a bias by explaining questions differently to different people; participants may be in fact answering different questions as compared to those to whom the questionnaire was mailed. More so, personally administered questionnaire takes time and a lot of effort. For this reason, this study used mailed and electronic questionnaires.

Mailed questionnaire is a self-administered questionnaire that is sent to respondents via the mail or postal. This method has long been the backbone of operations and supply chain research, but with the arrival of the internet, mobile phone, and social networks, mailed questionnaire have become redundant. Often, mailed questionnaires are considered along with a web-based questionnaire. Mailed survey questionnaires are printed and sent to the respondent via post. Respondents are asked to answer questions by completing the questionnaire themselves. After completing the questionnaire, they are usually asked to return it back by post (Saunders et al., 2009; Bell et al., 2018). Mailed questionnaires offer following benefits: cost savings; they can be completed at convenience of the respondents. Other advantages include there are no time constraints; it can be prepared to give an authoritative impression; it can ensure anonymity; and it can reduce interviewer bias (Sekaran and Bougie, 2009). However, one of the weaknesses of mail survey is a lack of interviewer involvement and a lack of open-ended questions (Forza, 2002).

Online or web-based surveys has become much more common. This technique allows researchers to email a questionnaire or ask respondents to visit a website where the questionnaire can be completed and returned electronically. Web-based questionnaire is cheaper and faster to administer than other methods of data collection (Forza, 2002). Online questionnaires are often used to gain a deeper understanding of consumers' options and preferences. A big advantage of online survey research is that it makes the most of the ability of the internet to provide access to group or individuals who would be difficult to reach (Wright, 2005). Other advantage of online questionnaire is that a wide geographical area can be covered in the survey. A link to the questionnaire is sent to the respondents, who can complete it at their convenience. An automatic processing of the survey further saves time, costs, and energy researchers

However, there are also important disadvantages of using online survey methodology. When conducting web-based research, researchers can encounter problems about sampling. Self-selection and low response rates make it difficult to establish the representativeness of the sample and to generalise the findings, because those responding to the survey may not at all represent the population. Indeed, the return rates of such questionnaire are low. A 30% response rate is considered acceptable (Wright, 2005; Sekaran and Bougie, 2009). Other disadvantages of electronic questionnaires are that any doubts the respondents might have cannot be clarified; a lack of suitable population lists making it impossible to use probability sampling, and the fact that many factors may affect the appearance of online questionnaire. The advantage and disadvantage of personally administered questionnaires, mail questionnaires, and electronic questionnaire are displays in Table 4.9.

**Table 4.9** Advantages and disadvantage of different survey methods

| Model of data collection | Advantages | Disadvantages |
|---|---|---|
| Personally, administered questionnaires | Can establish rapport and motivate respondent.<br>Doubts can be clarified.<br>Less expensive when administered to groups of respondents.<br>Almost 100% response rate ensured.<br>Anonymity of respondent is high. | Explanations may introduce a bias.<br>Take time and effort. |
| Mail questionnaires | Anonymity is high.<br>Low cost.<br>Wide geographic regions can be reached.<br>Token gifts can be enclosed to seek compliance.<br>Respondent can take more time to respond at convenience. Can be administered electronically, if desired. | Response rate is low. A 30% rate is quite acceptable.<br>Cannot clarify questions<br>Follow-up procedures for non-responses are necessary. |
| Electronic questionnaire | Easy to administer.<br>Can reach globally.<br>Very inexpensive.<br>Fast delivery.<br>Respondents can answer at their convenience like the mail questionnaire.<br>Automatic processing of answers. | Computer literacy is a must.<br>Sampling issues.<br>High non-response.<br>not always possible to generalise findings.<br>Respondent must be willing to complete the survey.<br>People find invitations via email rude and offensive; emails are deleted, or people complain. |

Source: Bougie and Sekaran (2020, p. 145).

In viewed of the above discussions, a mixed-mode approach to data collection, according to Dillman et al. (2014) was used. That is, both portal and web-based survey were adopted in collecting data. The aim was to mitigate prejudice when using the individual method and to improve the quality of the data beyond the single survey method while eliminating the possibility of bias (Frankfort-Nachmias and Nachmias, 2007). Based on the modified version of Dillman et al. (2014), a total design approach was used to gather data via a mail and QuestionPro surveys (Frankfort-Nachmias and Nachmias, 2007).

Survey questionnaires is therefore best suited for explanatory and analytical investigations, since they allow the researcher to test and explain cause-and-effect relationships between variables (Saunders et al., 2019). The choice of questionnaire is also influenced by the research questions and objectives (Saunders et al., 2019; Creswell, 2014), and most importantly by the following factors: adequate sample size required for data analysis; the type of questions required to collect data; importance of reaching a certain group of respondents; the time window for the researcher to complete data collection; and feasibility of automating data collection.

In accordance with Bell et al. (2018), decisions about which method was best cannot be made in the abstract; they must be based on the requirements of specific survey as well as time, cost and resource constraints (Forza, 2002). In view of these factors, the survey by questionnaire was considered a suitable instrument, because it was cheaper to administer, quicker to administer, no interviewer effects, no interviewer variability, convenience for respondents, and an efficient tool for obtaining the necessary information to answer the research questions (Forza, 2002; Bell et al., 2018). In addition, the questionnaire technique was adopted because it is the most appropriate research instrument to investigate the mediating effects of agile practices on the link sustainable supply chain practices and operational performance and sustainability performance. Because questionnaires are use, it is necessary to explained how they are developed. What follows is a set of guidelines for questionnaire construction.

## 4.9 Development of Questionnaire

After undertaking a review of the literature on agility and sustainability in supply chains, four constructs were identified. These constructs include agility practices, sustainable supply chain practices, operational performance objectives and sustainability performance measures.

A questionnaire was developed around the constructs. Further, multiple items were used for the measurement of each construct – the scales were developed in accordance with the procedure suggested by Pallant (2013) for developing measures. As noted earlier, the questionnaire is a preformulated written set of questions to which respondents record their answers, usually within rather closely defined alternatives (Bougie and Sekaran, 2020). Questionnaires are designed to collect many quantitative data (Oakshott, 2016; Walliman, 2011).

Questionnaire design needs a comprehensive strategy in designing processes (Bell et al., 2018), which reflects a total design method (TDM). The total design method means a broad set of questions to be asked, taking account data types, analysis, and research questions to be addresses (Frankfort-Nachmias and Nachmias, 2007). Existing literature offers a set of guidelines for questionnaire construction (Churchill and Iacobucci, 2006; Bougie and Sekaran, 2020; Forza, 2002), which can maximise the quality of the data. A broad questionnaire design principle should focus on these areas.

Figure 4.5 depicted the important aspects of designing a questionnaire. The needed information regarding research questions was specified in the first stage (the wording of the questions). The next stage refers to the planning of issues concerning the goodness of measures and how the variables will be categorised, scaling and coding after receipt of the responses. The last stage pertains to the general appearance of the questionnaire. All these stages are important issues in questionnaire design because they can minimise bias in research. These issues are discussed below.

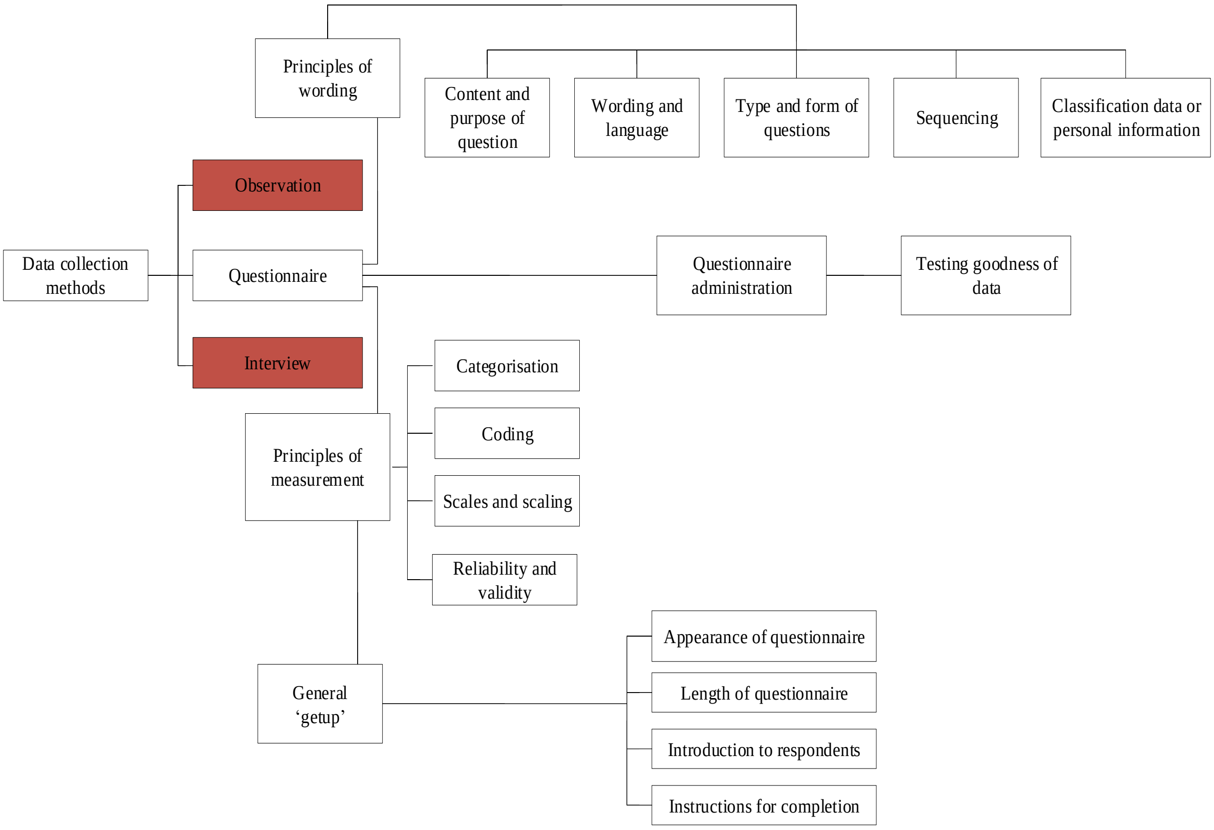



**Figure 4.5** Principles of questionnaire design (source: Bougie and Sekaran, 2020, p. 145)

### 4.9.1 Questionnaire contents

The questionnaire aims at providing empirical evidence of agility and sustainability attributes and indicators suggested in literature. To attain these aims, the questionnaire consisted of six broad categories of questions, in accordance with the scheme proposed in Appendix A. Sections 1 and 2 determined the general profile of the company and their operations including the name of companies, data of the establishment, the position of respondent, industrial sectors, the amount of annual turnover and the number of employees. These latter were chosen as size indicators because they are reported to be the most used size measure in literature (Kimberly, 1976). The third category addressed agile capabilities/attributes, in accordance with the list recommended by Yusuf et al. (1999). The fourth category addressed sustainable supply chain practices the respondents considered to implemented, such as sustainable design, sustainable procurement, sustainable transport, investment recovery, and social sustainability practices, which are the most important drivers of agile practices. The fifty-part probed investigated operational performance objectives the respondents planned to achieve; and the last part looked at the various indicators of sustainability performance as suggested by Paulraj et al. (2017); Zhu et al. (2008, 2013); Kamble et al. (2020); Belhadi et al. (2020).

### 4.9.2 Types of response

The questionnaire survey involved five-point Likert scale questions, which are important measures for defining the interactions between practices and performance measures. This Likert-type scale was adopted because it can offer interval-or-ratio-based data. Respondents were asked to rate to what extant each agile and sustainable attributes influenced his or her organisation in recent years, on a five-points Likert scale; where “1 = not important” and “5 = extremely important” for agile practices, while “1 = not at all” and “5 = to a great extent” for sustainable supply chain constructs. This five-point Likert scale is the most powerful scaling for statistical analysis and widely employed in quantitative research (Hair et al., 2014; Tabachnick and Fidell, 2014; Pallant, 2013).

### 4.9.3 Wording and language of the questionnaire

In formulating the questions, the researcher makes sure that the language of the questionnaires was in line with the level of understanding of the respondents (Bougie and Sekaran, 2020**)**. The choice of words will depend on the educational level of the respondents. The researcher tried to avoid long complex questions; double negative; double-barrelled questions; jargon; worlds with double meanings leading questions and emotionally loaded words (Pallant, 2013; Saunders et al., 2009). Thus, it is essential to word the questions in a way that can be understood by the respondents. Considering the questions asked, the language used, and the working was appropriate to tap respondents’ attributes, perceptions, and feelings. Concise explanations of each research constructs were given at the start of each set of questions relative to a construct to enhance the clarity of the questions (see detail in Appendix1).

### 4.9.4 Sequencing of questions

The sequence of questions in the questionnaire should be such that the respondent is led from questions of general natural to those that are more specific, and from questions that are easy to answer to those that are more difficult (Bougie and Sekaran, 2020). This funnel approach facilitates the easy and smooth progress of the respondent through the items in the questionnaire. The progression from general to specific questions might mean that the respondent is first asked questions of a global natural that pertain to the issue, and then asked more incisive questions regarding the specific topic. Easy questions might relate to issues that do not involve much thinking; the more difficult once might call for more though, judgment and decision-making providing the answers.

The way questions are sequenced can also introduce certain biases, often term ordering effects. Although placing the questions in the questionnaire minimises any systematic bias in the responses, it is rarely done, because of subsequent confusion while categorising, coding, and analysing the responses. The language and wording of the questionnaire focus on such issues as the type and form of questions asked as well as avoiding double-barrelled questions, ambiguous questions, leading questions, loaded questions and those involving distant recall. Questions should also not be long. Using the funnel approach helps respondents to progress through the questionnaire with ease and comfort.

### 4.9.5 General appearance of the questionnaire

Good appearance of the questionnaire is important to address issues of wording and measurement in questionnaire design, but it is also necessary to pay attention to how the questionnaire looks. An attractive and neat questionnaire with appropriate introduction, instructions and well-arrayed set of questions and response will make it easier for respondents to answer them. This research questionnaire consisted of 7 pages including the cover letter and the introductory package that clearly disclose the identity of the researcher and conveys the purpose of the survey (see detail in Appendix.). This provides respondents with a better understanding of the research scope and background. Besides, an assurance of confidentiality of the information provided by respondents will allow for less biased answers, enables them to comfortably complete the questionnaire (Saunders et al., 2019).

### 4.9.6 The review of questionnaire design

Another important principle of designing a good quality questionnaire is re-examining and modifying the questionnaire (Bougie and Sekaran, 2020). In this research a lot of attention was devoted to questionnaire design because questionnaires are the most common instrument of collecting data in operations and supply chain management research. The principle of questionnaire design relate to how the questions are worded and measured, and how the entire questionnaire is organised. To minimise respondent bias and measurement error, the questionnaire must be reviewed and modified. This allows to check for any potential errors in the questionnaire. So, all the existing stages are reviewed. Considering this, several errors are reduced, and the sequence of a few questions was modified to improve the flow of the questionnaire and eliminate any probable ambiguity. This makes it possible to ensure that a questionnaire can obtain the information related agility and sustainability necessary to answer the researcher questions.

After undertaking a review of the literature on agility and sustainability in supply chains, four constructs were identified. These constructs include agility practices, sustainable supply chain practices, operational performance objectives and sustainability performance measures. A questionnaire was developed around the constructs. Based on the modified version of Dillman et al. (2014), a total design approach was used to obtain information needed via a mailed and web-based surveys. To reach these aims, the survey instrument was classified into five sections, in accordance with the scheme suggested in appendix A: These sections are as follows:

- General overview of the company.
- Agile capabilities/practices.
- Sustainable supply chain practices.
- Operational performance objectives.
- Sustainability performance criteria.

As explained in chapter 3, sections one, concerns the demographic characteristics of the company. The general questions intended to collect information associated with the respondents' company. This information includes the name of the company, the data of establishment, the position of the respondent, the annual turnover, the total number of employees and industrial classification. These two latter were considered as control indicators, because they are reported to be useful size and industrial dynamism measures in the literature (Schilke, 2014).

Section two explores the attributes and capabilities of agile organisations; thus, linked questions reflect the 32 agile attributes as recommended by Yusuf et al. (1999). Section three was designed to gather information related to the practices that will enable these agile capabilities. These questions, which focuses on sustainable design, sustainable procurement, sustainable distribution, investment recovery and social sustainability practices were adopted from existing literature (Zhu et al., 2008, 2013; Paulraj et al., 2017; Su et al., 2015; Marshall et al., 2015; Zhu and Lai, 2019; Mani et al., 2018; Esfahbodi et al., 2017). The last section of the survey asked respondents to provide information about the performance outcomes of implementing agility and sustainability practices within their supply chains. The section investigates the organisational performance of cost, quality, speed, reliability, flexibility, innovation, and sustainability performance criteria (Narasimhan et al., 2006; Yusuf et al., 2007, 2013, Yusuf et al., 2020; Zhu et al., 2008).

### 4.9.7 The type and form of questions

The type of question can be classified into closed and open-ended questions (Pallant, 2013; Bougie and Sekaran, 2020). Open-ended questions allow respondents to answer them in any way they choice. Here the respondents have the freedom to respond in their own way, not restricted to the choice provided by the researcher. In contrast, closed questions involve offering respondents a set of defined response choices. They are asked to mark their response using a tick, cross, circles, amongst other. Unlike open-ended questions, closed questions help respondents to make quick decisions to choose among the several alternatives before them. It also helps the researcher to code the information easily for subsequent analysis.

In asking respondents a question, this study also reflect on a response format. The type of response format can have impacts on the statistical analysis. This study involve analysis such as correlation and structural equation modelling, which require scores that are continuous from low through to high, with a wide range of scores (DeVellis, 2016).

## 4.10 Scales of measurement

One of the important tasks in the research is the development of scales and measures for assessing the responses (Forza, 2002). Measurement is the process of assigning numbers or labels to the units of analysis in scientific research to represent conceptual properties (Pallant, 2020). Scaling is a method of measuring the amount of a property possessed by a class of objects and events' (Frankfort-Nachmias and Nachmias, 2007). There are four measurement scales or types of data in the context of operations and supply chain management research: nominal, ordinal, interval, and ratio level of measurement (Forza, 2002; Ghauri et al., 2020; Bougie and Sekaran, 2020). The use of measurement depends on the type of study or type of research question used for collecting data. The four levels of measurements are discussed below.

### 4.10.1 Nominal scale

A nominal scale is one that allows the researcher to assign subjects to certain categories or groups (Bougie and Sekaran, 2020; Munro, 2005). For example, if there are two possible categories (e.g., gender = male or female), then the variable may be operationalised using a dummy variable (e.g., gender = 1 if female; = 0 if male) that takes one of two possible values. If there are more than two possible categories, then additional dummy variables are required. Such nominal variables are called categorical variables, and there is no intrinsic order or ranking to the categories. Thus, nominal scales categorise individuals or objects into mutually exclusive and collectively exhaustive groups (Ghauri et al., 2020). The information that can be generated from nominal scaling is rather limited; they only statistic involved here is the frequency of individuals in each category. Thus, the nominal scale gives some basic, categorical information (Bougie and Sekaran, 2020, p. 199).

### 4.10.2 Ordinal scale

An ordinal scale provides numerical ratings for the variables under consideration. It is not only assigning objects to certain categories; it allows the researcher to rank order the objects in some meaningful way. The different with a nominal scale is thus in the possibility of ordering. This can be used when describing and displaying frequencies. The measure of agile practices in the questionnaire illustrates how the response format distinguishes individual on an ordering scale;

the level of importance categories can be ordered. When data are entered in the SPSS, numbers are often assigned to the participants responses. This is called coding the data. For example, variables such as agile practices can be assessed using Likert scale 1 = ‘not at all important’ to 5 = extremely important. Clearly a rating of 3 indicates a higher level of satisfaction than a rating of 2, and a rating of 5 indicates a higher level of satisfaction than a rating of 4. But it is not possible to say how much higher in each case, or whether the difference between the 2 and 3 ratings is greater than, or less than, the difference between the 4 and 5 ratings.

### 4.10.3 Interval scale

Interval scales involve continuous variables in which similar differences between the values are equivalent, but the scale does not have a true zero (Ghauri et al., 2020). In an interval scale, or equal interval scale, numerically equal distances on the scale represent equal values in characteristics being measured (Kumer, 2011). Whereas the nominal scale allows only to qualitatively distinguish objects by categorising them into mutually exclusive and collectively exhaustive categories sets, and the ordinal scale also allows to order objects in a meaningful way, the interval scale allows to compare differences between objects: the difference between two values on an interval scale is identical to the difference between other two neighbouring values of that scale (Bougie and Sekaran, 2020). The off-cited example is temperature in degree Celsius. The different between 100C and 200C degree is 10 degrees, as is the difference between 200C and 300C. Parametric statistical techniques such as mean, standard deviation, collection, regression, ANOVA, and factor analysis can be used for interval scale, in addition to the entire range of advanced multivariate and structural equation modelling techniques (Markham, 2001).

### 4.10.4 Ratio scale

Ratio scales involve continuous variables, but the scale does have a natural zero, and hence values can be meaningfully added, subtracted, and divided (Ghauri et al., 2020). Ratio scales overcome the disadvantage of the arbitrary origin point of the interval scale, in that it has an absolute zero point, which is a meaningful measurement point (Bougie and Sekaran, 2020). Thus, the ratio scale not only measures the magnitude of the differences between point on the scale but also taps the proportions in the differences (Bougie and Sekaran, 2020). It is the most powerful of the four scales because it has a unique zero origin and subsumes all the properties of the other three scales. An example would be firm size. A firm with 60 employees is three times the size of a firm with 20 employees, it has 40 more employees, and the two firms together employ 80 people. The ratio scale was used to measure some of the data needed in the general information of the questionnaire used for this study.

## 4.11 Measures

In this section, the measures for this research constructs are explained. Since measurement scales for the constructs used in this research have been exposed in the relevant literature, a selection of existing measures was adapted to achieve research objectives.

### 4.11.1 Dependent variables: operational performance and sustainability performance

The dependent variable is the variable of primary interest to the researcher (Bougie and Sekaran, 2020). In this survey, organisational performance was operationalised in terms of financial measures/operational performance and sustainability performance.

Operational performance is considered a proxy of long-term success indicating the actual level of operational resources that will improve future economic outcomes (Sveiby, 1997). The scales of operational performance were adopted from the previous study, which reflect the indicators of costs, quality, speed, reliability, flexibility, and innovation (Eckstein et al., 2015; Srinivasan and Swink, 2018; Kamble et al., 2020; Yusuf et al., 2007). In this research a seven items scale for operational performance was employed to measure the extent to which the supply chain company achieved its objectives. Following the study of Yusuf et al. (2007), a five-point Likert type measurement scale was employed (ranging from "very low (= 1) to very high (5) in order to assess the operational performance. To capture the innovation capability, the researcher relied on the measurement items gauge the extent to which a company carries out innovation projects aimed at entering new product domains. This measure was triangulated with archival information on R&D intensity (i.e., R&D expenditures divided by revenues), which has often been used as a proxy for innovation-related dynamic capabilities in literature (Helfat et al., 2015). Financial performance, on the other hand, was measured in terms of return on investment, sales growth, market share, customer satisfaction, and profitability in accordance with studies, (such as, Zhao et al., 2006; Ward et al., 1994; Dam and Petkova, 2014; Papke-Shields and Malhotra, 2001; Curkovic et al., 2000; and Narasimhan and Jayaram, 1998). Each type of the performance was measured using Likert scales (see appendix 1).

Sustainability performance was measured in terms of social and environmental performance. Environmental sustainability performance was measured on seven-items scale adopted from Gimenez et al. (2012); Belhadi et al. (2020); Pullman et al. (2009); Zhu et al. (2008 2013); Paulraj et al. (2017). The original number of adopted items was ten, which reduced to six after considering the item's loading values (see appendix). While these scales assess the extent to which a firm involves its main suppliers reducing energy use, consumption of toxic materials, water usage, and minimising greenhouse gas emissions, among others (Zhu et al., 2008; Belhadi et al., 2020; Paulraj et al., 2017; Esfahbodi et al., 2017). Consistent with Belhadi et al., (2020) and Esfahbodi et al. (2017), five-point Likert scoring format was used in these scales to measure items (ranging from: 1 - "not at all" to 5 - significant improvement). Likewise social sustainability performance was measured based on six indicators of improved working conditions; improved safety and well-being; community support/involvement; employee satisfactions; social reputation; and extended product life cycle (Kamble et al., 2020). These scales assess the degree to which an organisation encourage its suppliers to achieve each performance indicator. A five-point Likert scoring was employed in these scales to measure items ranging from 1 for 'not at all' to 5 'significant' improvement.

### 4.11.2 Predictor variable: sustainable supply chain practices

The predictor or independent variable is one that influences the dependent variable in a certain - positive or negative, linear, or non-linear - way (Oakshott, 2016). Sustainable supply chain practices are set of initiatives aiming at mitigating the impacts of business activities on the environment, and promoting the social wellbeing of stakeholders, while contributing to the long-term economic benefits of the entire entities across the supply chains. Following the lead of Esfahbodi et al. (2017); Blome et al. (2014a, b); Paulraj et al. (2017); Su et al. (2015); Zhu et al. (2005, 2007, 2008, 2013); amongst others, sustainable practices is conceptualised as multi-dimensional construct. This study focusses on six key practices of sustainable procurement (six attributes); sustainable product and process design (seven items); investment recovery (five items); sustainable transport (four items); environmental management (five items); and social sustainability practices (eight items). These scales assess the extent to which a firm involve its suppliers in implementing each listed practices in supply chains (Esfahbodi et al., 2017; Blome et al., 2014a; Paulraj et al. (2017; Zhu et al., 2013).

### 4.11.3 Mediating variable: agile practices

A mediating variable (or intervening variable) is one that surfaces between the time the independent variables start operating to influence the dependent variable and the time their impact is felt on it (Bougie and Sekaran, 2020). Bringing a mediating variable into play helps to model a process. The mediating variable surfaces as a function of independent variables operating in the situation and helps to conceptualise and explain the influence of the independent variables on the dependent variable (Oakshott, 2016; Bougie and Sekaran, 2020). It would be interesting to see how the inclusion of the mediating variable; agile supply chain capabilities or practices would change the model or affect the relationship between sustainable practices and organisational performance. As explained before, supply chain agility, as an externally focused capabilities, are the result of development of internal capabilities and competencies. These capabilities reflected the supply chain ability to sense changes and adapt fast to them and transform its resource base. To measure these capabilities, the researcher used the scales recommended by van Hock et al. (2001); Lin et al. (2006); Martinez-Sanchez and Lahoz-Leo (2018). These are network collaboration; process alignment; market sensitivity; technology integration; and employee empowerment. These criteria are in line with supply chain agility, which focuses on being more responsiveness, proactive, flexible, and adaptive (Aslam et al., 2018; Blome et al., 2013; Eckstein et al., 2015). These factors have been employed by prior works on agile and agility capabilities (Bottani, 2010; Narasimhan et al., 2006; Lin et al., 2006; van Hoek et al., 2001; Martinez-Sanchez and Lahoz-Leo, 2018). The respondents were asked to indicate the relative importance attributed to each agility capability by the industry supply chain. Importance is measured on a scale (ranging from 1 = not important to 5 = extreme important).

### 4.11.4 Moderating variables: managerial experience, and industry type

A potential moderator of hypothesised link between sustainable practices and organisational success is the experience level of management team. The literature has recognised importance of managers' skills and experience, which have been acquired by the education and professional experience (Kor and Mesko, 2013). The managerial experience serves as a basis for developing knowledge, experience and improving capabilities (Ambrosini and Altintas, 2019). Such experience can assist managers in sensing and seizing opportunities and threats, as well as in reconfiguring the resource base (Helfat and Martin, 2015). Managers differs in terms of their mix of skills. The research measured managerial experience in term of number of years in the job role, classifying the number of years into five categories (ranging 1-5 to 21 years above) see appendix 1. This study sought to assess if managerial experience was a significant moderator of the degree to which sustainable supply chain practices adoption could improve success. Finally, a third moderator is industry sector. The importance of the industry sector in which organisations competes as a predictor of organisation-level variables is widely recognised in the literature (Simpson et al., 2012; Pagell and Wu, 2009; Schneider and Wallenburg, 2012). Eisenhardt and Tabriz (1995) suggests that industry sector may affect the link between suppliers' initiatives and performance. The researcher controlled for some industry sectors, using a sample procedure suggested by Cohen et al. (2003) Srinvasan and Swink (2018); Wamba et al. (2020).

### 4.11.5 Control variables: company age, size, turnover, and dynamism

To set factors as control variables that might influence sustainable supply chain performance, several industry variables were considered from relevant literature. Consistent with Li et al. (2008); Schilke (2014), Hult et al. (2007); and Ketchen and Hult (2007), the thesis considered industry sector, age, and size of businesses as control variables to be included in the model. The age of business, which according to Bonner and Walker (2004) signifies the potential resources, which can influence business competitive performance as well as the degree of sustainable practices adoption (Zhu et al., 2008). Company age was measured in terms of the number of years since the establishment of the industry, classified into five categories (ranging from 1 for businesses that are younger than 1-5 years to 5 for businesses that are 50 years or more) (Schilke, 2014).

Another control variable is business size. Business size can enhance competitive performance by facilitating access to a lower cost of resources while concurrently lowering risk (Bourlakis et al., 2014). Business size may also influence the sustainable supply chain practices implementation, as big organisations have more resources to develop supply chain agility capability (Chen et al., 2015). Size was measured by the number of employees (ranging from 1 for business that have less than 49 employees to 5 for businesses that have 550 or more employees) and are used as control variable in this research.

The research also added annual turnover, as a control variable. Turnover is a vital determinant of organisational performance. Russo and Fouts (1997) observed that industry turnover growth controlled the link between environmental sustainability strategy and organisational performance, because it required riskier investments, entailed organic management structures, and promoted greater interest reputation, all of which contributed to improved organisational economic performance. Drawing on Russo and Fouts (1997) findings, the researcher expected the signs of this control (industry turnover growth) to influence the adoption of sustainable practices, which in turn enhance performance successes. Business turnover was measured based on total annual turnover of the company (ranging from 1 for business that have less than £25 million to 5 for businesses that have £51 million or more).

Environmental dynamism means the volatility and unpredictability of the firm's external environment (Schilke, 2014b). to capture dynamism, the research used items developed by Hult et al. (2007); Schilke (2014); and Wamba et al. (2020). To validating managers perspectives of environmental dynamism, the research applied two archival indexes measuring instability in sales and net assets (Schilke, 2014). To compute these indexes, the researcher regressed sales and net assets for a period of three years prior to the survey on a variable representing the period and divided the standard errors of the regression by the mean level of the dependent variable (Wamba et al., 2020).

The study also used additional items established in Esfahbodi et al. (2016, 2017); Paulraj et al. (2017); Blome et al. (2013, 2014b) literature. These measurement items were combined into the questionnaire to examine and explain the interaction effects among agile supply chain practices, sustainable supply chain practices, operational performance, and sustainability performance. Table 4.10 displayed scales and measures used in this study. It is worth mentioning that these attributes and indicators were developed for the energy intensive and heavy industrial sectors, focusing on oil and gas supply chains, refineries, chemicals, steel, cements, and transport sectors (Esfahbodi et al., 2017; Zhu et al., 2008; 2013). These asset-heavy companies are considered as major contributors to the global carbon footprint and key consumers of natural resources and so, prime candidates for the study of sustainability and related practices of agility.

In the context of operations and supply chain journals, studies such as Lee et al. (2012b); Gimenez et al. (2012); Tachizawa et al. (2015); Mani et al. (2018); Marshall et al. (2015); Zailani et al. (2012); Zhu et al. (2012, 2013); Green et al. (2012, 2015); Esfahbodi et al. (2016, 2017) adopted similar measures in their research. The fact that they have been widely used and assessed within the analytic and operations research community shows the enough validity of these attributes and indicators. Therefore, these measurement scales were employed in this study as validated indicators to examine the influences of sustainability practices and agility on sustainable supply chain performance.

**Table 4.10** Scales of measurement

| Constructs/sub-constructs | Attributes/indicators |
|---|---|
| **Agile supply chain practices and attributes (**Yusuf et al., 1999; Martinez-Sanchez and Lahoz-Leo, 2018; Lin et al., 2006; Bottani, 2010; Whitten et al., 2012; van Hoek et al., 2001; Christopher, 2000; Sharifi et al., 2006**)** Please indicate by a tick (√) the level of importance the following agile practices/attributes best reflect in your company. (Five-point scale: 1 = not important; 2 = less important; 3 = important; 4 = very important; 5 = extremely important) | |
| Process alignment (PA) | |
| PA1 | Decentralised decision making. |
| PA2 | Cross functional teams. |
| PA4 | Information accessible to employees. |
| PA6 | Concurrent execution of activities. |
| PA7 | Quality over product life. |
| Technology integration (TI) | |
| TI1 | Flexible production technology. |
| TI2 | Leadership in the use of current technology. |
| TI3 | Skill and knowledge enhancing technologies. |
| TI4 | Technology awareness. |
| TI5 | First time right design. |
| TI6 | Virtual enterprise. |
| Network collaboration (NC) | |
| NC1 | Close relationship with customer. |
| NC2 | Trust-based relationship with customers/suppliers. |
| NC3 | Multi-venturing capabilities. |
| NC4 | Rapid partnership formation. |
| NC5 | Teams across company borders. |
| NC6 | Enterprise integration. |
| Employee empowerment (EE) | |
| EE1 | Employee satisfaction. |
| EE2 | Learning organisation. |
| EE3 | Workforce skill upgrade. |
| EE4 | Multi-skilled and flexible people. |
| EE5 | Continuous training and development. |
| EE6 | Culture of change. |
| Market sensitivity (MS) | |
| MS1 | Customer driven innovation. |
| MS2 | Response to changing market requirements. |
| MS3 | New product introduction. |
| MS5 | Customer satisfaction. |
| MS7 | Strategic relationship with customers and stakeholders. |
| Environmental dynamism (Hult et al., 2007; Schilke et al., 2014; Wamba et al., 2020) Please indicate by a tick (√) the level of importance the following market turbulence influence in your company. (Five-point scale: 1 = not important; 2 = less important; 3 = important; 4 = very important; 5 = extremely important) | |
| Environmental dynamism (ED) | |
| ED1 | In our kind of business, customers' product preferences change quite a bit over time |
| ED2 | Our customers tend to look for new products all the time. |
| ED3 | We have demand for our products from customers who never bought them before |
| ED4 | New customers have product needs that are different from our existing customers |
| ED5 | We continuously cater to many new customers. |
| **Sustainable supply chain practices (**Esfahbodi et al., 2017; Zhu et al., 2008, 2013; Green et al., 2012; Esty and Winston, 2006; Paulraj et al., 2017; Blome et al., 2014b**)** | |

Please indicate the extent to which the following practices have been implemented in your company. Tick (√) as applicable. (Five-point scale: 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent)

| | |
|---|---|
| Sustainable design (SD) | |
| SD1 | Cooperation with customers for eco design. |
| SD2 | Design of products for reduced consumption of materials. |
| SD3 | Design of products for reuse, recycle, remanufacturing, and/or recovery of materials and component parts. |
| SD4 | Design of products for easy disassembly. |
| SD5 | Design of products to avoid or reduce use of hazardous materials. |
| SD6 | Cooperation with customers for cleaner production. |
| SD7 | Design of products for reduced consumption of energy. |
| Sustainable procurement (SPr) | |
| SPr1 | Sustainability audit for suppliers' internal management. |
| SPr4 | Cooperation with customer for sustainable packaging. |
| SPr5 | Cooperation with suppliers for sustainability objectives. |
| SPr6 | Providing design specification to suppliers that include sustainability requirements for their process. |
| SPr8 | Supplier' ISO 14000 certification. |
| SPr9 | Multi-tiers supplier's sustainability practices evaluation. |
| Investment recovery (IR) | |
| IR1 | We sale excess inventories or materials. |
| IR2 | We are extracting a product's raw materials and using them for new products. |
| IR3 | We returned products to the performance specification of the original equipment manufacturer. |
| IR4 | We are redeploying products without the need for refurbishment. |
| IR5 | We sale excess capital equipment. |
| Social sustainable practices (SSP) | |
| SSP1 | Health and safety training for employees. |
| SSP2 | We support community involvement and development. |
| SSP3 | Worker's Skills and capabilities development. |
| SSP4 | Respect for people rights. |
| SSP5 | Provide training for emergency preparedness program to employees, suppliers, and community. |
| SSP6 | Sustainable working conditions for employees. |
| SSP7 | We make products that protect consumers' health and safety. |
| SSP8 | We support and promote health situation in the community. |
| SSP9 | We support fair labour standard and practices |
| Sustainable production (SusProd) | |
| SusProd 1 | We monitor our suppliers' commitment to sustainability improvement. |
| SusProd 2 | Commitment of sustainability practices from senior manager. |
| SusProd 4 | We helped our suppliers obtain ISO 14001 certification. |
| SusProd 6 | Support for sustainability practices from mid-level managers. |
| SusProd 7 | We frequently visit our suppliers' premises to help improve their eco-innovation. |
| Sustainable transport (ST) | |
| ST1 | We use renewable energy in any model of product transportation. |
| ST2 | We track and monitor carbon footprint caused during product delivery. |
| ST3 | We frequently upgrade freight logistics and transportation systems. |
| ST4 | We work together with our customers for using less energy during product delivery. |

**Organisational performance (**Yusuf et al., 2007; Ren et al., 2009; Zhang and Sharifi, 2007; Eckstein et al., 2015; Srinivasan and Swink, 2018; Narasimhan et al., 2006; Kamble et al., 2020**)**

Please indicate by a tick (√), the degree to which you perceive that your organisation has achieve the following operational performance objectives. (Five-point scale: 1 = Very low; 2 = Low; 3 = Modest; 4 = High; 5 = Very high)

Operational performance (OPO)

| | |
|---|---|
| OPO1 | Low cost. |
| OPO2 | Flexibility. |
| OPO4 | Quality. |
| OPO4 | Innovation. |
| OPO5 | Reliability. |
| OPO6 | Speed. |
| Financial performance (FP) | |
| FP6 | Increase in rate of return on investment. |
| FP7 | Growth in market share. |
| FP8 | Increase in sale turnover. |
| FP9 | Increase in profitability. |
| FP10 | Increase in customers' satisfaction. |
| **Sustainability performance (**Zhu et al., 2008, 2013; Blome et al., 2014b; Esfahbodi et al., 2017; Paulraj et al., 2017; Belhadi et al., 2020; Kamble et al., 2020**)** Please indicate the degree to which your organisation has achieved the following performance measures during the past years, tick (√) as applicable. (Five-point scale: 1 = not at all; 2 = a little bit; 3 = to some degree; 4 = relatively significant; 5 = significant) | |
| Social performance (SP) | |
| SP1 | Improved overall stakeholders' welfare. |
| SP2 | Improved health and safety of the community. |
| SP3 | Improved health and well-being of workers. |
| SP4 | Improved community development. |
| SP5 | Improved awareness or protection of human rights. |
| SP6 | Improved product life cycle. |
| Environmental performance (EP) | |
| EP1 | Reduction in solid waste and wastewater. |
| EP2 | Reduction in water usage |
| EP3 | Reduction of greenhouse gas emission. |
| EP4 | Decrease in use of energy and natural resources. |
| EP5 | Decrease in consumption for hazardous/harmful/toxic materials. |
| EP6 | Decrease in frequency for environmental accidents. |
| EP7 | Improvement of an enterprise's environmental situation. |

### 4.11.6 Validity and reliability of measurement scales

According to Hair et al. (2014), all variables used in multivariate techniques must be assumed to have some degree of measurement error. Here measurement error is the degree to which the observed values are not representative of the true value (Hair et al., 2014). Thus, the researcher's goal of reducing measurement error can follow several paths. In assessing the degree of measurement error present in any measure, the researcher must address two important characteristics of a measure:

- Validity is the degree to which a measure accurately represents what it is supposed to. Ensuring validity starts with a thorough understanding of what is to be measured and then making the measurement as ‘correct’ and accurate as possible.
- If validity is assured, the researcher must still consider the reliability of the measurements (Hair et al., 2014). Reliability is the degree to which the observed variable measures the true value and is error free; thus, it is the opposite of measurement error (Hair et al., 2014). The reliability and validity of constructs, which will be amplified below, has also been discussed by Yin (2015), De Vaus (2013), Kumar (2018), amongst others.

## 4.12Research ethics

Research ethics is an important aspect of a research project. Although, operations and analytical researchers do not undertake studies that could put at risk the lives of those who take part in research, many ethical issues should be considered while collecting primary data. The first of which states that researchers expected to ensure that they do no cause harm. Secondly, when the researcher breaking rules of confidentiality may also trigger the dismissal of an informant. Informed consent and the right of confidentiality are thus also just as important for operations and supply chain management research as in other field (such as medical research). Broadly, at the PhD level, the researcher is guided by the university’s ethical guidelines, which address the key ethical issues (Bougie and Sekaran, 2020). Bell and Bryman (2007) identified ten principles of ethical practices, which were defined by at least half of the associations (Table 4.11).

In short, this study adhered to ethical issues surrounding data collection and data protection throughout the research process in conjunction with the University of Central Lancashire’s regulations, policies, and practices. While the researcher ethics committee application, code number BAHSS 430 has been granted approval by the BAHSS Ethics Committee – University of Central Lancashire prior to the pre-survey fieldwork and the full-scale administration of the questionnaire. It is envisaged that the study will cause no harm to respondents and the researcher.

**Table 4.11** key principles in research ethics

| | |
|---|---|
| • Ensuring that no harm comes to participants.<br>• Respecting the dignity of research participants.<br>• Ensuring a fully informed consent of research participants.<br>• Protecting the privacy of research participants.<br>• Ensuring the confidentiality of research data.<br>• Protecting the anonymity of individuals or organisations. | • Protection of research participants. |
| • Avoiding deception about the nature or aims of the research.<br>• Declaration of affiliations, funding sources and conflicts of interest.<br>• Honesty and transparency in communicating about the research.<br>• Avoidance of any misleading or false reporting of research. | • Protection of integrity of research community |

Source: Bell and Bryman (2007)

## 4.13 Pilot testing of the questionnaire

The last stage in developing a questionnaire is to pre-test the quality of questionnaire (Bougie and Sekaran, 2020). This process ensures that respondents understood the questions, and most importantly that it can answer the questions. It also ensures that there is no ambiguity in the questions and that there are no problems with the wording or measurement. Pretesting involves the use of a small number of respondents to test the appropriateness of the questions and their comprehension (Bougie and Sekaran, 2020). This helps to rectify any inadequacies before administering the instrument or past a questionnaire to respondents, and thus reduce bias.

Pilot studies allow the researcher to determine the adequacy of instruments to respondents completing a questionnaire (Bell et al., 2018). Put differently, pretesting helps the researcher to identify whether the instructions were clear or whether there were any problems in understanding what kind of answers were expected, and in providing answers to the questions posed; and the planned administration procedure would be effective (Flynn et al., 2018). The researcher performs a pretesting to test the contact-administration protocol, to gather data to assess the quality of the measurement, and to obtain information to define better the sample and adequacy of measures in relation to the sample.

Based on the above, this study followed the pretesting procedure recommended by Forza (2002, p. 171), which states that pre-test a questionnaire should be done by discussing the questionnaire with three types of people: academics; industry experts, or supply chain managers. Here, the research first discussed the questionnaire with a number of selected academics, research peers and a pilot study with industry experts who have strong interests in agility and sustainable manufacturing. The role of academics was to test whether the question accomplishes the study objectives (Dillman et al., 2014). On the other hand, input from industry professionals was also important to highlight certain areas that might be overlooked by the researcher (Forza, 2002).

When the participants' responses were tabulated, it became clear that the issues most frequently brough up by the respondents related to committing to a sustainable supply network design (i.e., having a supportive organisational structure; setting long term goals for the suppliers; incentivising sustainability commitment to suppliers). Other participants highlighted the importance of sustainable capabilities-building (such as, collaborating with stakeholders; offering sustainability training for suppliers; setting and enforcing sustainability expectation in contracts; and collaborating to deal with suppliers). Yet other group of respondents focused on assessing suppliers' sustainability competencies (i.e., conducting supplier sustainability assessments, and audits; managing supplies sustainability scorecard; and closing correcting action strategies). Lastly, other participants talked about managing sustainability risks and opportunities, including mapping the supply network risks, conducting a risk assessment programme and managing crisis.

A literature survey confirmed that these variables were good predictors of organisational performance and sustainable performance. In addition, agile supply chain capabilities were also found to be a key source of sustainability competitiveness. A theoretical framework was developed based on the discussions and the literature survey, and proposed hypotheses were developed.

These feedbacks were incorporated into the final questionnaire (see appendix 1). One issue observed by academics was that the industry classification should be changed from North American Industrial Classification System (NAICS) to the UK Standard Industrial Classification (UKSIC) Codes. Another change was made to the scales of sustainable supply chain practices. The questions "Please indicate the extent to which the following sustainable practices have been implemented in your company, tick (√) as applicable." Scales: "1 = not considering it; 2 = planning to consider it; 3 = considering it currently; 4 = initiating implementation; 5 = implementing successfully" were replace with "1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent." Demographic variables such business age, business size, business types, turnover, and organisational experience were also added to the questionnaire.

Following these amendments, the questionnaires were pre-tested with the UK oil and gas sector. A total of 100 questionnaires were mailed out to respondent organisations and 27 valid responses was received. The researcher carried out a preliminary analysis of the data to check the reliability and validity of the scales; Whether the answers to certain questions are too concentrated because of the choice of scale; whether the content of answers differs from what was expected; and whether the context modifies the appropriateness of questions. Based on the results from the pre-test, a full-scale survey was carried out in the UK oil and gas industry.

## 4.13.1 Pilot study analysis

### 4.13.1.1 Assessment of normality

Test of normality has been done using skewness and kurtosis values, Kolmogorov-Smirnov and Shapiro-Wilk, and Histograms. The results show that the score on each of the variables were normally distributed (see table 4.12 and Table 4.13 below). Similarly, other techniques the research used are linearity and homoscedasticity, normal and detrended Q-Q plots, and Boxplot confirmed that the data are normally distributed.

**Table 4.12** Descriptive statistic for pilot study

| | | | Statistic | Std. Error |
|---|---|---|---|---|
| Operational performance objectives | Mean | | 122.31 | 1.375 |
| | 95% Confidence Interval for Mean | Lower Bound | 119.57 | |
| | | Upper Bound | 125.05 | |
| | 5% Trimmed Mean | | 121.98 | |
| | Median | | 121.00 | |
| | Variance | | 139.834 | |
| | Std. Deviation | | 11.825 | |
| | Minimum | | 101 | |
| | Maximum | | 151 | |
| | Range | | 50 | |
| | Interquartile Range | | 18 | |
| | Skewness | | .362 | .279 |
| | Kurtosis | | -.490 | .552 |
| Sustainability performance | Mean | | 77.73 | 1.316 |
| | 95% Confidence Interval for Mean | Lower Bound | 75.11 | |
| | | Upper Bound | 80.35 | |
| | 5% Trimmed Mean | | 77.83 | |
| | Median | | 78.00 | |
| | Variance | | 128.173 | |
| | Std. Deviation | | 11.321 | |
| | Minimum | | 54 | |
| | Maximum | | 102 | |
| | Range | | 48 | |
| | Interquartile Range | | 17 | |
| | Skewness | | -.184 | .279 |
| | Kurtosis | | -.525 | .552 |

**Table 4.13** Test of normality for pilot study

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Operational performance measures | .102 | 27 | .056 | .977 | 27 | .192 |
| Sustainability performance | .091 | 27 | .200* | .983 | 27 | .423 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

#### 4.13.1.2 Assessing reliability of a scale

Internal consistency reliability was assessed to ensure questionnaire meets the research needs as suggested by (Tabachnick and Fidell, 2007). Internal consistency measures the degree to which the items of the scale related to each other (Pallant, 2013). The most used indicator of internal consistency is Cronbach's alpha coefficient (Rungtusanatham et al., 2003). DeVellis (2016) suggested that a good reliability should have the Cronbach's alpha coefficient of a scale above 0.7 (Nunnally (1978). However, Flynn et al (2010) and Forza (2002) argued that alpha level as low as (0.60) is acceptable.

According to Yusuf et al. (2014), the overall agility attributes with cluster competitiveness scale has good internal consistency, with a Cronbach's alpha coefficient reported of (0.85). In the present study, the total scale of the Cronbach's alpha coefficient was (0.901), suggesting very good internal consistency reliability see details in table 4.14 below.

**Table 4.14** The reliability results of the pilot test

| Attributes and indicators | Cronbach's Alpha Based on standardised items |
|---|---|
| The overall survey instruments | 0.901 |
| Agile practices | 0.923 |
| Sustainable supply chain practices | 0.857 |
| Operational performance objectives | 0.753 |
| Sustainability performance measures | 0.725 |

#### 4.13.1.3 Correlation for pilot study

The analysis based on the pilot study indicates that there is a strong correlation between agility capabilities and sustainability performance. Also, the correlation between sustainable practices and traditional operational and financial performance indicators was strong, which was not surprising given the existing body of work that have already indicated relationships of that nature. However, the results seem to indicate that there is no strong correlation between sustainable practices and sustainability performance measures (see table 4.15 for details). This is a surprising result and full-scale survey need to be carried out to further examine the relationships.

**Table 4.15** Correlation for pilot study

| Second-order constructs | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Agility capabilities | | | | |
| Operational performance | .573** | 1 | | |
| Sustainable supply chain practices | .522** | .411** | 1 | |
| Sustainability performance | .547** | .307** | .279* | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

## 4.14 Full scale administration of survey

As explained earlier, the full-scale administration of the questionnaire entailed sending out questionnaires to 945 recipient organisations. Given that both agility and sustainability practices plus their related performance indicators were objective and not being inferred subjectively through social construction (Easterby-Smith et al., 2018), a mixed-mode approach of data collection was used in accordance with Dillman et al., (2014). That is, both mailed portal and web-based survey were adopted in collecting data. The aim was to mitigate any prejudice of using the individual method and enhancing the quality of the data beyond the single survey method while eliminating the possibility of bias (Frankfort-Nachmias and Nachmias, 2007). Based on the modified version of Dillman et al. (2014), a total design approach was used to gather data via a mailed postal and QuestionPro surveys from September to November 2018. A single answer per organisation was requested. This is in line with similar studies in this area (Esfahbodi et al., 2017; Bottani, 2010; Aslam et al., 2018; Blome et al., 2014b; Eckstein et al., 2015; van Hoek et al., 2001).

Given the fact that the consumption of resources, waste generation and implementation of sustainable supply chain practices are mostly associated with industry supply chains, the questionnaire by survey focused on UK manufacturing supply chains. The target organisations were from those involved in the extraction of crude petroleum and natural gas; mining of metal ores, coal and lignite; manufacture of coke and refined petroleum products; manufacture of chemical and chemical products; manufacture of rubber and plastic products; manufacture of steel or irons, and fabricated metal products; manufacture of electronic and electrical equipment; manufacture of machinery, motor vehicles, trailers and other transport equipment. These industries are major contributors to global carbon footprint and key consumers of natural resources and therefore, prime candidates for the study of sustainability and related practices of agility. The UK was chosen as the empirical setting for this study because of its significant share of total global manufacturing outputs and resource demands. According to a most recent report by West and Lansang (2018), the UK, in 2015, was the 9$^{th}$ manufacturing country in the world with an output of $244 billion that accounted for 10% of its national output and 2% of the global manufacturing output.

There are many challenges with respect to collection of data using simple random sampling. One drawback is that it can mean small but important parts of a population are missed altogether and the researchers cannot make confident statements about their results (Easterby-

Smith et al., 2018). Another problem is difficulty in gaining access to senior executives. Other issues include a lack of knowledge of sustainability concerns among potential recipients of the questionnaires. Therefore, to avoid these problems, we employed convenience sampling. The convenience sampling enabled us to select sample units based on how easily accessible they are. Following other similar key informant-based research studies (Aslam et al., 2018; Esfahbodi et al., 2017; Yusuf et al., 2013), the objective was to find the right person in the organisation who would be able to respond to all questions about agility, sustainability and performance. For this reason, managing directors, Chief executive officers, Plant managers, Directors, Logistics managers, Operations managers, Sales managers, Supply chain managers, and Industrial waste managers and Procurement managers were targeted. These respondents consisted of highly skilled and knowledgeable supply chain professionals who play important roles in their organisations.

### 4.14.1 Response rate

A total of nine hundred and forty-five (945) questionnaires were mailed out to our samples taken from financial analysis made easy (FAME) database and subsea oil and gas directory. A cover letter together with return stamped envelope were enclosed in the postal mail to encourage potential recipients to return the questionnaires. The survey tool was also uploaded onto the web based QuestionPro and made visible only to respondents chosen from the sample organisations. The internet-based survey provides greater degrees of accuracy and minimises missing values (Creswell, 2014). Non-respondents were followed up two weeks after the initial mail with a reminder email and telephone calls and seven weeks later, extra questionnaires were resent to improve response rate as suggested by Frankfort-Nachmias and Nachmias (2007). In the end, 346 companies completed and returned the questionnaire, representing a response rate of 36.6%. Following Hair et al. (2010, p. 55) suggestions, 35 incomplete responses were removed from the analysis. A total of 311 usable responses were fully completed and used in the analysis.

### 4.14.2 Non-respondents

The non-response bias was investigated using the approach recommended by Armstrong and Overton (1977, p. 401), comparing early and late respondents as a proxy for non-respondents (Fullerton et al., 2014). The early respondents (n=136) were completed before the reminder email and telephone calls was made, and these were categorised as early wave, whilst those respondents (n=175) that returned the questionnaire after the email and telephone calls reminder formed the late wave. The independent-samples t-test was conducted to compare the scores for the early and late groups. As it can be seen in Table 4.16 the demographic characteristics of number of employees, turnover and agility practices, result shows that there was no significant difference between the mean values of the two groups, showing the null hypothesis that there is no statistically significant difference between respondents and non-respondents cannot be rejected. In addition, based on the two-tailed significant level and Levene's t-test there was no non-response bias.

### 4.14.3 Common method bias

Even though the research employs a reliable research instrument following various testing phases, the use of single informant for the dependent and independent variables may have caused common method bias. To test for potential existence of a common method variance (CMV) confirmatory factor analysis (CFA) technique was used; this technique is based on the comparison of fit indices between the models with different level of complexity. As a result of the test, if the fit indices of a simpler model stay on a par with the complex model common method bias could be a problem (Korsgaard and Roberson, 1995). Two models were developed, the first model was loaded with all items into on single construct, and the second model loaded each item into predefined constructs. Since the $\chi^2$ improved significantly from 1,202.2 with 119 degree of freedom (model 1) to 271.9 with 113 degrees of freedom in the model 2, this can be seen as evidence that, according to this method, no CMV problem should be expected.

To further test the possibility of CMV "the latent single method factor approach is also employed (Podsakoff et al., 2003). In this method items are loaded on their theoretical constructs, as well as on a latent common methods variance factor. To prove that the results are not due to method effects, the significance of the structural parameters is examined both with and without the latent common methods variance factor in the model. The assumption in this method is that the additional of a method to the main model must not significantly improve the model fit. In addition, all factor loadings should be significant in the new model, which contains latent common method variance. If it is no significant, the common method bias can be problematic and cast doubts on the validity of findings. Previous research (Elangovan and Xie, 1999) suggested that in such situation the difference of IFI in two models should be considered. Following this approach, the incremental fit index proposed by Bollen (1989) yield a $p$ of 0.008, suggesting an insignificant improvement which indicates that method effects are insignificant. Moreover, all factor loadings are significant in the new model, which can reduce the concern regarding the existence of common method bias in the research.

## 4.15 Data analysis

The analysis of the questionnaire data was carried out using statistical packages for social science (SPSS and SPSS AMOS). This software packages are one of the most widely used for statistical analysis in social sciences. The data were analysed using statistical techniques of structural equation modelling to explore a set of relationships amongst independent and dependent variables. Here structural equation modelling is used as a confirmatory approach to data analysis, which tests the hypothesised model to confirm the degree to which the suggested model is consistent with the data. Such analysis specifies the direct and indirect relationship among variables (Byrne, 2016).

There are several steps that make up data analysis section. These include (1) descriptive statistics to show the trends in variables, (2) check the reliability and validity of the measurement scales using exploratory factor analysis and confirmatory factor analysis, and (3) the use of structural equation modelling technique to test the research hypotheses (Pallant, 2020; Tolmie et al., 2011; Byrne, 2016).

### 4.15.1 Data preparation

Preparation of data file for analysis involves several steps. These include creating the data file and entering the information obtained in a format defined by a codebook (see appendix 2). The data file then needs to be checked for errors, and these errors corrected (Pallant, 2020).

The first step in data preparation is data coding. Data coding involves assigning a number to the participants' responses so they can be entered into the database. The data was checked before entering the database and errors that required correction were dealt with as soon as possible. Numeric codes were used for different category and sub-category of the data as SPSS packages were designed to hand this type of information. After the data were entered into the database, visual checks of printed data were performed to ensure any errors values had not occurred.

According to Hair et al. (2016), the most acceptable solution to missing value is not to have any. In this study, it was not possible to have the data set without missing value, though they were minimal. The missing values were dealt with during coding, data entry, and analysis stages. There is no problem in coding data as missing value. The SPSS software has ways of dealing with missing data when performing analysis. In the SPSS, data base missing values were coded as non-numerical missing code '.' So that they could not incorporated into analysis.

In addition, checking for outliers before data analysis is an important step in eliminating or correcting some data (Pallant, 2020). Outliers are observations that lie too far away from the rest of the data (Easterby-Smith et al., 2021; Bougie and Sekaran, 2020; Pallant, 2020). Though outliers can result from technical error, most of the time distant observations are genuine. The problem is that even outliers are not caused by error they can distort the outcomes of statistical analysis. As such, the outliers were investigated and corrected through checking the scatterplot and boxplot. Preliminary analyses were also carried out to make sure that there is no violation of the assumptions of normality, liberality, homoscedasticity, and multicollinearity (Hair et al., 2014; Pallant, 2020).

### 4.15.2 Preliminary analysis

#### 4.15.2.1 Descriptive statistics

The descriptive statistics was used to describe the characteristics of the sample; check variables for any violation of the assumptions underlying the statistical techniques used to address research questions. There are three measures of central tendency: the mean, the median, and the mode (Bougie and Sekaran, 2020). Measures of dispersion include the range, the standard deviation, the variance, and interquartile range (Bougie and Sekaran, 2020).

The mean is a measure of central tendency that offers a general picture of the data without unnecessarily inundating one with each of observations in a data set (Bougie and Sekaran, 2020). The mean is the average score of the data. It is the sum of the individual observation divided by the total number of observations (Tolmie et al., 2011). While standard deviation, which is another measure of dispersion, offers an index of the spread of a distribution or the variability in the data. It is the square root of the variance (Bougie and Sekaran, 2020). Standard deviation is used to express how much the deviation of values from the mean value of the group (Field, 2013). It determines the usefulness of mean value to explain a dataset. If standard deviation is close to the mean value, then the mean value is a good representation of the dataset.

#### 4.15.2.2 Assessing normality

Normality refers to the shape of the data distribution for an individual variable and its correspondence to the normal distribution. The basic logic of normality is that scores on each variable should be normally distributed (Tabachnick and Fidell (2007). The assessment of normality of the metric variable involves both empirical measures of distribution's shape (kurtosis and skewness) and the normal probability plots (Hair et al., 2014). Kurtosis refers to the flatness of the distribution as compared with the normal distribution, or the hight of the distribution, whereas skewness refers to the balance of the distribution. These assessments are a pre-condition for parametric analysis, such as t-test, analysis to variance (ANOVA), and correlation (Tabachnick and Fidell (2007). As Gasemi and Zahediasel (2012) noted, failing to hold to this assumption may affect the accuracy of the conclusion derive from reality. For large samples, skewness will not make a substantive difference in the analysis (Tabachnick and Fidell, 2007). Kurtosis leads to underestimation of the variance, but the risk is decreased with a large sample (more than 200 responses or cases). Because of the sensitiveness with large sample, the shape of the distribution should be inspected (e.g., using a histogram) (Hair et al., 2010). Both values can be computed using statistical programs such as SPSS.

To examine the normal probability, statistical tests can be used. The statistical value for the skewness is evaluated as follows:

$$Z - \text{skewness} = \text{skewness}/\sqrt{6/N} \text{ -------------------------------eq 1}$$

Where N= the sample size

Also, the z-score for kurtosis can be computed by using the formula:

$$Z - \text{kurtosis} = \text{kurtosis} \sqrt{24/N} \text{ ---------------------------------eq 2}$$

If the calculated z-score is higher than the specified critical value, them the distribution is non-normal, in terms of the characteristic. The most used critical values are – 2.58 or + 2.58 ($p = 0.01$) and – 1.96 or + 1.96 ($p = 0.05$).

Another statistical method employed to checked normality was the Kolmogorov-Smirnow test, which assessed the normality of the distribution, where a non-significant result ($p > 0.05$) indicates normality. However, for a large sample, the *p* value should be equal to 0.00. In case of a large sample, the curve represents normal distribution, if the values are between 0.03 and 0.6 ($p < 0.01$). The graphical methods such histogram, normal Q-Q plot, detrended normal Q-Q plot, and boxplot of scores on each variable were used to checked for normality (Tabachnick and Fidell, 2014).

#### 4.15.2.3 Linearity

Linearity assumes that the relationship between two variables should be linear. Pallant (2020) outlined linearity as the presence of a straight-line relationship between each pair of dependent variables. It could be assessed in a variety of ways, the most straightforward of which is to generate a matrix of scatterplots between each pair of variables.

#### 4.15.2.4 Homoscedasticity

Homoscedasticity assumes that the standard deviation of the prediction errors should be the same for all predicted dependent variable scores. That is, the band that includes the residuals is the same width for all values of the predicted dependent variables. In this study, the homogeneity of variance is obtained using the Levene's test, which test whether the variance of scores is the same for each of group. The Levene's test can help to assess the dispersion of variance in the main dependent variables across these groups. If, according to Pallant (2013), the significant value for Levene's test is greater than 0.05, the assumption of homogeneity of variance is not violated. The results show that significant values were greater than 0.05, so it can be argued that we have not violated the homogeneity of variance assumption.

#### 4.15.2.5 Multicollinearity

According to Pallant (2020) and Bougie and Sekaran (2020), multicollinearity is a statistical phenomenon in which two or more independent variables are highly correlated. In its most severe case if the correlation between two independent variables is equal to 1 or -1, multicollinearity makes the estimate of the regression coefficients impossible. In all other cases it makes the estimate of coefficients unrelated.

The simplest way to detect multicollinearity is to check the correlation matrix for the independent variables. The presence of high correlations (e.g., 0.70 and above) is a sign of sizeable multicollinearity (Bougie and Sekaran, 2020). When multicollinearity results from complex relationships among several independent variables, this approach may not reveal it. Pallant (2020) identified the tolerance value and the variance inflation factor (VIF – the inverse of the tolerance value), as more common measures for assessing multicollinearity. These measures indicate the degree to which one independent variable is explained by the other independent variables. A common cut-off value is a tolerance value of 0.10, which corresponds to a VIF of 10 (Bougie and Sekaran, 2020).

Multicollinearity seems not to exist when the tolerance and VIF values have met the criteria. A VIF ranging between 1.88 and 2.82 (<10), supported by the tolerance ranges between 0.36 and 0.59 (>0.10), indicates that there is no possibility of multicollinearity among independent constructs or variables.

## 4.16 Parametric and non-parametric statistical tests

Parametric statistical test is a form of hypothesis test that uses a standard reference distribution derived from probability theory whose form is defined by a small number of parameters, while non-parametric statistical test is a form of hypothesis test that uses a reference distribution derived from all possible permutations of study outcomes using ranking of data (Easterby-Smith et al., 2021). The t-test and analysis of variance are parametric statistical test because they assume a normal distribution of data. Non-parametric statistical tests do not have stringent assumptions and are more suitable techniques for smaller samples or when the data collected are measured at the ranked level (Pallant, 2020). In this study, parametric tests were used since they have more statistical power, while non-parametric tests are less sensitive for the low power.

### 4.16.1 T-tests

The t-test is one of a multitude of statistical tests. Although it is one of the most used tests, it has significant limitations. The t-test can only handle two groups or two set of data (before and after) (Easter-Smith et al., 2021). When researchers are interested in comparing more than two groups, analysis of variance (ANOVA) is a test statistic of choice (Easter-Smith et al., 2021). There are two types of t-tests (Pallant, 2020). Paired-samples t-tests (also called repeated measures) are used when researchers are interested in changes in scores for participants tested at Time 1, and then again at Time 2 (often after some intervention or event). The samples are related because they are the same people tested each time. Independent-sample t-tests are used when there are two different groups of people (males and females), and the researchers are interested in comparing their mean scores. In this case, the researchers collect information on one occasion but from two different set of people.

### 4.16.2 Analysis of variance

The respondent organisations were divided into different groups of agility practices, and analysis of variance (ANOVA) tests were conducted to see if there were differences in competitive priorities as well as social and environmental sustainability priorities among clusters. The analysis was needed to explore whether social and environmental sustainability priorities were relevant and significantly different among the configuration models to justify the subsequent steps in the research.

An analysis of variance test compares means of different groups to assess if the groups vary significantly. Analysis of variance is so called because it compares the variance (variability in scores) between the different groups with the variance within each of the groups (Pallant, 2020). If the spread of the group means (often described as between-groups sum of squares) is large than is expected from the spread of data within the groups (the within-group sum of squares) then this indicates the means differ (Hair et al., 2018).

This thesis aimed to identify the extent to which adding social and environmental sustainability priorities to competitive priorities changes the traditional configuration theory. The thesis adopted the same clustering procedure as recommended by Zhang and Sharifi (2007); Miller and Roth (1994); Narasimhan et al. (2006); Bottani (2010); Braunscheidel and Suresh (2009), and Frohlich and Dixon (2001) but added social and environmental sustainability to the competitive priorities. In short, An ANOVA was conducted to test for differences in the competitive priorities, more importantly social and environmental sustainability. To test the fit of these new ideals, the researcher analysed the business strategy by performing an ANOVA, to determine if the new theory identified achieve short- or long- term performance success.

### 4.16.3 One-way ANOVA

One-way analysis of variance is like a t-test but is used when there are two or more groups and the researcher wish to compare their mean scores. It is called one-way because it allows to evaluate the impact of one independent variable (referred to as a factor), on dependent variable (Pallant, 2020). A one-way analysis of variance will let the researcher known if the groups differ, but it would not tell where the significant difference is. So, the researcher conducted a post-hoc comparisons to find out which groups are significantly different from one another. The researcher also tests differences between specific groups, rather than comparing all groups, using planned comparisons. Like t-test, there are two types of one-way ANOVAs: repeated measures ANOVA and between-groups ANOVA (Pallant, 2020).

### 4.16.4 Two-way ANOVA

Two-way ANOVA can be used to examine the effect of two independent variables on a single dependent variable (Pallant, 2020). Note that, in this context, an independent variable is often referred to as a factor, and therefore a design that aims to examine the effect of two independent variables on one dependent variable is often called a factorial design (Bougie and Sekaran, 2020). The advantage of using a two-way ANOVA is that it enables to test for an interaction effect that exist between the independent variables (or factors). An interaction effect exists when the effect of one independent variable (or factor) on the dependent variable depend on the level of the other independent variable (factor). Two-way ANOVA also tests for main effects - that is the overall effect of each independent variables on a dependent variable. there are two different types of two-way ANOVAs: between-groups ANOVA, when the groups are different and repeated measures ANOVA, when the same organisations are tested on more than one occasion.

### 4.16.5 Multivariate analysis of variance (MANOVA)

MANOVA is an extension of ANOVA, in that ANOVA tests the mean differences of more than two groups on one dependent variable, whereas MANOVA tests mean differences among groups across several dependent variables simultaneously, by using sums of squares and cross-product matrices. Just as multiple t-tests would bias the results, multiple ANOVA tests, using one dependent variable at a time, would also bias the results, since the dependent variables are likely to be interrelated. MANOVA circumvents this bias by simultaneously testing all the dependent variables, cancelling out the effects of any intercorrelations among them. In MANOVA tests, the independent variable is measured on a nominal scale and dependent variables on an interval or ratio scale.

The null hypothesis tested by MANOVA is:

$H_0: \mu_1 = \mu_2 = \mu_3 = \ldots \mu_n$ -------------------------------------------------------------------------eq 3

The alternative hypothesis is:

$H_a: \mu_1 \neq \mu_2 \neq \mu_3 \neq \ldots \mu_n$ ----------------------------------------------------------------------eq 4

### 4.16.6 Cluster analysis

Cluster analysis was used to identify agility strategy types from respondents' capabilities profiles. The problem with cluster analysis is how to determine the most appropriate number of clusters. This study employed a combination of methods used by other researchers (Zhang and Sharifi, 2007; Miller and Roth, 1994; Zhao et al., 2006; Luz and Diaz-Garrido, 2008; Kathuria, 2000; Narasimhan et al., 2006). Hierarchical method was used to help determine the number of clusters and cluster centroids. K-means was then used to perform actual clustering as suggested by (Miller and Roth, 1994, Zhang and Sharifi, 2007). Ward's partitioning and squared Eucliden distance were used in the hierarchical stage to maximise within-cluster homogeneity and between-cluster heterogeneity, and to recover cluster structure. The dendrogram for cluster analysis was then inspected for dense branches to confirm the number of major groups formed and the incremental changes in the agglomeration coefficient during cluster combination stages were observed as an indication of whether dissimilar clusters have been merged.

Three criteria were employed to determine the final number of clusters to be used in analysis as suggested by Lehmann (1979). The first step is that the number of clusters be limited to between n/30 to n/60, where n is the sample size. Thus, only models with between three or six clusters were considered. Second stages looked for pronounced increases in the tightness of the clusters, as measured by the $R^2$ and *F-value* (Milligan and cooper, 1985). Here three cluster models seemed to be most appropriate. Finally, two approaches were used to sought interpretability of the clusters on defining variables using: ANOVA and the Scheffe pairwise comparison tests of mean (centroid) differences (Harrigan, 1985). An overall multivariate test of significance using the Wilks Lambda criterion and associated *F-value* indicated that null hypothesis that the three clusters are equal across all defining variables could be rejected ($P < 0.001$).

## 4.17 Statistical techniques to explore relationship among variables

This section examines some of the techniques for exploring relationships among variables. These techniques include correlation, regression, or factor analysis. Correlation was used to explore the association between pairs of variables while factor analysis was used to identify the structure underlying a group of related variables. The next sections described in details correlations and factor analysis techniques used in this research.

### 4.17.1 Correlation analysis

Pearson or spearman correlation analysis is used to describe the strength and direction of the linear the relationship between two variables (Pallant, 2020, p. 135; Matthews and Ross, 2010). Pearson product-moment corelation coefficient (*r*) is used to examine relationships between interval and/or ratio variables. While non-parametric tests are used to assess the relationship between variables measured on nominal or ordinal scale (Bougie and Sekaran, 2020). Spearman's rank order correlation (*rho*) and Kendell's rank collection are used to examine relationship between two ordinal or ranked variables. Spearman *rho* is useful when data do not meet the criteria for Pearson collection (Pallant, 2020).

While the correlation coefficients (*r*) could range from -1 to +1, which represents the magnitude of the association between one variable and another (Bougie and Sekaran, 2020; Pallant, 2020). The sign indicates the direction of (positive and negative) correlations. A positive correlation indicates that as one variable increases, so too does the other, while a negative correlation indicates that as one variable increases, the other variable decreases (Pallant, 2020). The size of the absolute value provides an indication of the strength of the relationship. On the other hand, a correlation of zero (0) indicates no relationship at all (Pallant, 2020; LeBlanc, 2004), a correlation of 1 indicates a perfect positive correlation, a value of -1 indicates a perfect negative correlation. The Pearson product-moment correlation coefficient was used in this study to examine the association among different variables (such as sustainable design, sustainable production, sustainable procurement, sustainable transportation, investment recovery, social sustainable practices, process alignment, technology integration, market sensitivity, network collaboration, people capabilities, financial measure, operational performance, social and environmental performance.

To interpret the degree of correlation among those variables, different authors suggest different interpretations (Cohen and Holliday, 1982); however, Cohen (1988, p. 79-81) suggested the following guidelines (Table 4.16):

**Table 4.16** Guideline for checking the level of correlation

| | |
|---|---|
| Small | $r$ = 0.10 to 0.29 |
| Medium | $r$ = 0.30 to 0.49 |
| Large | $r$ = 0.50 to 1.00 |

These guidelines apply whether there is a negative sign out the front of $r$ value. Besides, the negative sign refers to the direction of the relationship, not the strength. The strength of correlation of $r$ = 0.50 and $r$ = -0.50 is the same (Pallant, 2020).

### 4.17.2 Regression analysis

Multiple regression is a more sophisticated extension of correlation and is used to explore the predictive ability of a set of independent variables on one dependent measure. Different types of multiple regression allow to compare the predictive ability of independent variables and to find the best set of variables to predict a dependent variable (Pallant, 2014). These are standard multiple regression, hierarchical multiple regression, and stepwise multiple regression. In hierarchical regression, the independent variables are entered into the equation in the order specified by the researcher based on theoretical grounds. Variables or set of variables are entered in steps (or blocks), with each independent variable being assessed in terms of what t adds to the prediction of the dependent variable after the previous variables have been controlled for (Pallant, 2014).

### 4.17.3 Factor analysis

Factor analysis is different from many of the other techniques discussed above. This technique takes a large set of variables and identifies a way the data may be reduced, or summarised, using a smaller set of factors or components. Researchers used factor analytics techniques in the development and evaluation of tests and scales. There are two main approaches to factor analysis, including exploratory and confirmatory factor analysis.

#### 4.17.3.1 Exploratory factor analysis

Exploratory factor analysis is often used in the early stages of research to gather information about the interrelationships among a set of variables. It can also be used to reduce many related variables to a more manageable number, before using them in the structural equation modelling (Tabachnick and Fidell, 2014). There are three steps in conducting exploratory factor analysis (see Table 4.17). These include the assessment of the suitability of data for factor analysis, factor extraction, and factor rotation and interpretation (Pallant, 2013).

**Table 4.17** Steps in conducting exploratory factor analysis

| Step No: | Step name | Description | Requirement/Test | Rule of thumb |
|---|---|---|---|---|
| 1 | Suitability of the data for exploratory factor analysis. | This step is concerned with the character and composition of the variables or items included in the analysis. | Adequate sample size. | • Sample size to variable ratio (3:1, 6:1, 10:1). |
| | | | Correlation coefficient. | • Greater than 0.30. |
| | | | Barlett test of sphericity. | • Statistically significant (<0.05). |
| | | | KMO-Measure of sampling adequacy. | • Ranges between 0 and 1, with 0.50 as minimum value. |
| 2 | Factor extraction. | Represents the decision made about the method of extracting the factors and number of factors selected. | Factor extraction method. | • Principal component analysis or principal axis factoring. |
| | | | Number of factors to be extracted. | • Conceptual foundation.<br>• Latent root criterion.<br>• Scree plot criterion. |
| 3 | Factor rotation and interpretation of results. | Rotation methods helps to achieve the theoretically meaningful factor solution | • Orthogonal approaches (Varimax, Equimax, and Quartimax.<br>• Oblique approaches (Direct oblimim and promax techniques). | N/A |
| | | The factor loadings are observed to identify those most indicative of the underlying structure | • Examine the factor matrix of loadings. | • Factor loadings ≥0.50. |
| | | | • Identify the significant loadings. | • Communalities ≥0.50. |
| | | | • Assess the communities of the variables. | • Cross-loading ≥0.40. |
| | | | • Respecify the factor model if needed<br>• Label the factors. | |

**Step 1: Assess the suitability of the data for exploratory factory analysis**

There are two main issues to consider in determining whether a data set is suitable for factor analysis: sample size, and the strength of the relationship among the variables or items. While there is little agreement among authors concerning how large a sample should be, the recommendation generally is the larger, the better. In small samples, the correlation coefficients among the variables are less reliable, tending to vary from sample to sample. Factors obtained from small data sets do not generalise as well as those derived from larger samples. Tabachnick et al. (2013, p.613) review these issues and suggest that "it is comforting to have at least 300 cases for the factor analysis. However, they do concede that a smaller sample size of 150 cases should be enough if solutions have several high loading marker variables about 0.80 (Tabachnick et al., 2007). Hair et al. (2014) suggested a sample size of 100 or more. Pett et al. (2003) and Stevens (1996, p. 372) advocates that the sample size requirements to perform exploratory factor analysis have been reduce over the years as more research has been done on the topic. The scholars contend that sample size of 100 is poor, 200 is fair, 300 is good, 500 is very good and 1000 is excellent (Stevens, 2009; Pett et al., 2003).

Some authors suggest that it is not the overall sample size that is of concern but the ratio of respondents to items (Hogarty et al., 2005). Nunnally (1978) recommends a 10 to 1 ratio; that is, ten cases for each item to be factor analysed. Other suggest that five cases for each item are adequate in most situations (Tabachnick et al., 2013). In this study, the sample size of 311 is in line with (Tabachnick et al., 2007; Hair et al., 2018) recommendations.

The second issue is the strength of the intercorrelations among the items. Tabachnick et al. (2013) recommended an inspection of the correlation matrix for evidence of coefficients greater than 0.3. By contrast, Hair et al. (2010) classified the loadings in the following: 0.30-minimal, 0.40-important, and 0.50-significant. If a few correlations below this level are found, factor analysis may not be appropriate. Two statistical measures are also generated by SPSS to help assess the factorability of the data: Bartlett’s test of sphericity (Bartlett, 1954), and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974). Bartlett’s test of sphericity should be significant ($p < 0.05$) for the factor analysis to be considered appropriate. The Kaiser-Meyer-Olkin index ranges from 0 to 1, with 0.6 suggested as the minimum value for a good factor analysis (Tabachnick et al., 2013), and Hair et al. (2010) recommended 0.80 as an excellent value.

**Step 2: Extract the factors**

Factor extraction involves determining the smallest number of factors that can be used to best represent the interrelationships among the set of variables. There are different approaches that can be used to identify (extract) the number of underlying factors or dimensions. Some of the most available extraction techniques are principal components; principal factor; image factoring; maximum likelihood factoring; alpha factoring; unweighted least squares; and generalised least squares.

The most used approach is principal components analysis. It is used to find a sample solution with as few factors as possible; and the need to explain as much of the variance in the data set as possible. Tabachnick et al. (2013) recommend that researchers adopt an exploratory approach, experimenting with different numbers of factors until a satisfactory solution is found. There are several techniques that can be used to help in the decision concerning the number of factors to retain: the eigenvalue rule, the Scree test, and the parallel analysis.

One of the most used techniques is known as Kaiser’s criterion or the eigenvalue rule. Using this rule, only factors with an eigenvalue of 1.0 or more are retained for further investigation.

The eigenvalue of a factor represents the amount of the total variance explained by the factor. Kaiser's criterion has been criticised, however, as resulting in the retention of too many factors.

Another approach that can be used is Cattell's scree test (Catell, 1966). This involves plotting each of the eigenvalues of factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal. Catell (1966) recommends retaining all factors above the elbow, or break in the plot, as these factors contribute the most to the explanation of the variance in the data set.

An additional technique that is gaining popularity, particularly in the social science literature (Choi et al., 2001), is **Horn's parallel analysis** (Horn 1965). The parallel analysis involves comparing the size of the eigenvalues with those obtained from a randomly generated data set of the same size. Only those eigenvalues that exceed the corresponding values from the random data set are retained. This approach to identifying the correct number of components to retain has been shown to be the most accurate, with both Kaiser's criterion and Cetell's scree test tending to overestimate the number of components (Hubbard and Allen, 1987).

**Step 3: Rotate and interpret the factors**

While deciding on the number of factors to extract, another concern is whether a variable might relate to more than one variable. Factor rotation presents a pattern of loadings in a way that is easier to interpret (Williams et al., 2010; Pallant, 2013). There are two basic rotation approaches of orthogonal rotation and oblique rotation. In line with Tabachnick and Fidell (2014), orthogonal rotation results in solutions that are easier to interpret and to report. However, it does require the researcher to assume that the underlying constructs are independent (not correlated). Within the orthogonal rotation approach, there are several different techniques like Varimax, Equimax and Quartimax (Costello and Osborne, 2005;

Thompson, 2007). The most used orthogonal approach is the Varimax method, which attempts to minimise the number of variables that have high loadings on each factor. The most used oblique technique is Direct Oblimin (Pallant, 2013).

Oblique approaches allow for the factors to be corrected, but they are more difficult to interpret, describe and report (Tabachnick and Fidell, 2013, p. 642). The orthogonal and oblique approaches often result in similar solutions, when the pattern of correlations among the items is clear (Tabachnick and Fidell, 2013). Pallant (2013) recommends that researchers should start with oblique rotation to check the degree of correlation between factors. In this study, factor analysis based on principal components analysis was used as the factor extraction approach to perform exploratory factor analysis. This technique allowed researcher to identify underlying factors that explain the patterns of correlation within constructs of the study.

## 4.18 Assess measurement quality

### 4.18.1 Reliability

The reliability of a scale indicates the extent to which it is without bias (error free) and hence ensures consistent measurement across various items in the instrument (Bougie and Sekaran, 2020; Pallant, 2020). In other words, the reliability of a measure is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the goodness of a measure (Bougie and Sekaran, 2020; De Vaus, 2013). There are two frequently used indicators of a scale's reliability namely stability of measures (or test-retest reliability), and internal consistency.

Stability of measures defined the ability of o measure to remain the same over time. This attests to its goodness because the concept is stably measured, no matter when it is done. Two tests of stability are test-retest reliability and parallel-form reliability (Bougie and Sekaran, 2020). The test-retest reliability of a scale is assessed by administering questionnaire to the same people on two different occasions and calculating the correlation between the two scores obtained (Pallant, 2020; Bougie and Sekaran, 2020). High test-retest correlations indicate a more reliable scale. When responses on two comparable sets of measures tapping the same construct are highly correlated is called parallel-form reliability (Bougie and Sekaran, 2020).

The second aspect of reliability that can be assessed is internal consistency of measures. The internal consistency of measures is indicative of the homogeneity of the items in the measure that taps the construct (Bougie and Sekaran, 2020). In other words, it is the degree to which the items that make up the scale measure the same underlying attribute, that is the extent to which the items 'hang together' (Pallant, 2020; Bougie and Sekaran, 2020). The most used indicators of internal consistency are Cronbach's alpha coefficient (Rungtusanatham et al., 2003; Stangor, 2006; Nunnally, 1978), the interitem consistency, and slit-half reliability tests (DeVellis, 2016).

Cronbach's alpha provides an indication of the average correlation among all the items that make up the scale (Pallant, 2020). Values range from 0 to 1, with higher values indicating greater reliability. While different levels of reliability are required, depending on the nature and purpose of the scale, DeVellis (2016) and Nunnally (1978) recommends a minimum level of 0.7. Cronbach's alpha values are dependent on the number of items in the scale.

The inter-item-correlation reliabilities were also examined. The inter-item correlation is an approach to determine the reliability of a single construct (DeVellis, 2016). It examines the degree to which scores on one item correlate with scores of all other items in the same construct (Swerdlik and Cohen, 2005). The most popular test of interitem consistency reliability is Cronbach's coefficient alpha (Cronbach, 1946), which is used for multipoint-scaled items, and the Kuder-Richardson formulas (Kuder and Richardson, 1937), used for dichotomous items. The higher the coefficients, the better the measuring instrument (Robinson et al., 2013; Briggs and Cheek, 1986).

Split-half reliability reflects the correlations between two halves of an instrument. Split-half reliabilities may be higher than Cronbach's alpha only in the circumstance of there being more than one underlying response dimension tapped by the measure and when certain other conditions are met as well (Campbell, 1976).

### 4.18.2 Validity analysis

This study conducted confirmatory factor analyses to ascertain the unidimensionality, convergent and discriminant validity, and composite reliability of the measurement scales. The validity of a scale refers to the degree to which it measures what it is supposed to measure (Bell et al., 2018). Writers distinguish between numerous ways of testing measurement validity, which reflect different ways of gauging the validity of a measure of a concept (De Vaus, 2014). There are three types of testing validity namely face or content validity, criterion validity and construct validity (Pallant, 2013; Bell et al., 2018; Bougie and Sekaran, 2020).

### 4.18.3 Content validity

Content validity refers to the adequacy with which a measure or scale has sampled from the intended universe or domain of content. That is, the measure reflects the content of the construct in question (Bell et al., 2018; Hair et al., 2014). Content validity, thus, is an initiative process. In this study, the researcher first reviewed extant literature on the main constructs such as sustainable supply chain practices and agile supply chain capabilities and confirmed that these variables were good predictors of operational and sustainability performance. In addition, validity was established by pretesting the questionnaire with colleagues, academics, supply chain managers, and target respondents who have a strong interest in agility and sustainability to determine whether, the measure seems to reflect the concept concerned (Nunnally and Bernstein, 1994). The role of the colleagues was to test if the questionnaire met the objectives of the research (Dillman et al., 2014). The role of industry experts was to prevent the inclusion of some obvious questions that might reveal avoidable ignorance of the investigator in some area. The role of target respondents was to provide feedback on aspect that could affect the responses of the target respondents. The feedback led to fewer changes in term of wordings of items as suggested by Pedhazur and Schmelkin (2013); Dillman (1978); and Nunnally and Bernstein (1994).

### 4.18.4 Criterion validity

Criterion validity relates to the relationship between scale scores and certain specified measurable criteria (Pallant, 2013). Criterion validity of a measuring instrument is evaluated by comparing the actual measurement with a criterion variable (Blunch, 2013). This can be done by establishing concurrent and predictive validity (Bell et al., 2018; Bougie and Sekaran, 2020). Here, concurrent validity is that in which the researcher uses a criterion on which cases are known to differ and that is relevant to the construct in question. In contrast, predictive validity is a situation whereby the researcher uses a measure of future criteria, and not a contemporary measure (Blunch, 2013).

### 4.18.5 Construct validity

Construct validity involves testing a scale not against a single criterion but in terms of theoretically derived hypotheses concerning the nature of the underlying variables or construct (Pallant, 2013). It embraces two modes of inquiry: (1) validation of a construct and (2) validation of a measuring instrument (Byrne, 2016). In validating a construct, the researcher seeks empirical evidence in support of hypothesised relationships amongst dimensions of the same construct, and the construct of interest and other dissimilar constructs (Byrne, 2016). Both theoretical linkages represent what Cronbach and Meehl (1955) referred to as the construct's nomological network. Validation of a measuring instrument, on the other hand, requires empirical evidence that the scale items do, measure the construct of interest and, in the case of a multidimensional construct, that the related subscales exhibit a well-defined factor structure that is consistent with the underlying theory (Byrne, 2016). Scholars often distinguish between convergent and discriminant validity, which reflect various techniques of gauging the validity of constructs.

### 4.18.6 Unidimensionality

Unidimensionality refers to the existence of a set of measured variables in a single latent construct. That is, one measured variable should load on only one construct. The criterion for evaluating construct unidimensionality in confirmatory factor analysis is the overall goodness-of-fit of the measurement model and components of the measurement model, such as CR, convergent, and discriminant validity (Garver and Mentzer, 1999). The constructs that show an acceptable reliability, convergent, and discriminant validity are likely to be unidimensional (Anderson and Gerbing, 1988).

### 4.18.7 Convergent validity

Convergent validity can be established when there is a high degree of correlation among different instruments measuring the same constructs (Bougie and Sekaran, 2020). Hair et al. (2014) described convergent validity as the extent to which indicators of a specific construct converge or share a high proportion of variance in common. Both exploratory and confirmatory factor analysis was used to establish convergent validity and discriminant validity of constructs (Byrne, 2016; Streiner et al., 2015). In the context of exploratory factor analysis, convergent validity can be determined if items loaded significantly on the same latent construct. A construct has convergent validity if its eigenvalue is greater than 1.0 and all the factor loadings are 0.5 or more (Hair et al., 2014).

By contrast, using confirmatory factor analysis, convergent validity can be assessed based on several factors: (i) factor loading, (ii) Average Variance Extracted, and (iii) composite reliability (Hair et al., 2014). As Fornell and Larcker (1981) suggested, the average variance extracted of each construct should be higher than 0.50 (Table 4. 10). It can be calculated as follows:

$$\text{AVE} = \frac{the\ sum\ of\ the\ square\ standardised\ factor\ loadings}{the\ number\ of\ indicators} \text{ -------------------------eq 5}$$

Composite reliability (CR) is a measure of internal consistency in scale items, much like Cronbach's alpha (Netemeyer et al., 2003, Hair et al., 2014). It is the ratio of item variance attributable to the true score of latent constructs (DeVellis, 2016). Following the rule of thumb, composite reliability must be more than 0.70 to suggest a convergent validity (Fornell and Larcker, 1981). Confirmatory factor analysis is the most used technique to measure composite reliability. It can also be gaged using the following formula:

$$Composit\ reliability = \frac{(\sum_{i=1}^{p} \lambda i)2}{(\sum_{i=1}^{p} \lambda i)2 + \sum_{i}^{p} V(\delta)} \text{ -------------------------------------eq 6}$$

Where:

- li = standardised factor loading for the ith indicator,
- V(di) = variance of the error term for the ith indicator,
- P = number of indicators

## 4.18.8 Discriminant validity

Discriminant validity was used to measure the extent to which the individual items of a construct are distinctive. It means that individual measured items should represent single latent constructs. A high discriminant validity implies that a construct is unique and captures some aspects that other measured items do not (Hair et al., 2014). Discriminant validity can be evaluated by subjecting the item to confirmatory factor analysis. This study compared the square root of the construct's average variance extracted with the constructs correlation to established discriminant validity as suggested by Fornell and Larcker (1981). The study also followed the procedure given in Campbell and Fiske (1959); Stratman and Roth (2002), which include performing a confirmatory factor analysis for the selected pair of scales, enabling correlation between constructs, and repeating the confirmatory analysis, setting the correlation of scales to a value 1. A significant difference in the $x^2$-value for the two models shows that the constructs considered are different. The $x^2$ difference was significant in all cases at ($p < 0.05$), indicating that the scales represented different constructs.

### 4.19 Hypothesis testing

A research hypothesis is a testable assumption or prediction about the outcome of a research study (Easterby-Smith et al., 2021). Other studies such as Black and Champion (1978, p. 126) described a hypothesis as a tentative, yet testable, statement, which predict what one expects to find in empirical data (Bougie and Sekaran, 2020). Kumar (2018) demonstrate how hypothesis could provide a focus for research, simplicity to research problem and enhancing objectivity in the research. Hypotheses are derived from the theory in which conceptual model is based and are relational in nature. Along these lines, hypotheses are logically conjectured relationships between two or more variables expressed in the form of testable statement. There are two categories of hypothesis: null hypotheses and alternative hypotheses (Kumar, 2011). Figure 4.6 illustrates two basic categories of hypothesis.

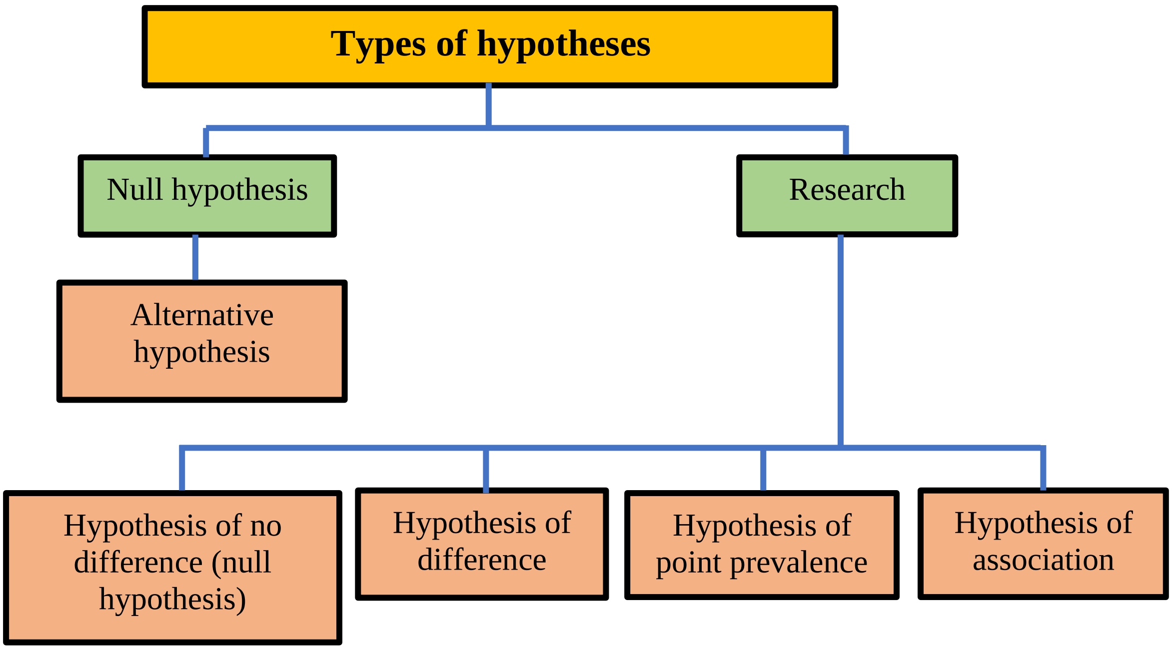



**Figure 4.6** Types of hypotheses (source: Kumar, 2018)

Bougie and Sekaran (2020) explained that the hypothetico-deductive method requires hypotheses to be falsifiable. For this reasons, null hypotheses are developed. These null hypotheses ($H_0$) are thus set up to be rejected to support the alternative hypothesis, termed ($H_a$). The null hypothesis is presumed true until statistical evidence, in the form of a hypothesis test, indicates otherwise. The required statistical evidence is provided by inferential statistics, such as regression analysis, structural equation modelling (SEM), or MANOVA. Inferential statistics help to draw conclusions or to make inferences about the population from a sample.

The purpose of hypothesis testing is to determine accurately if the null hypothesis can be rejected in favour of the alternative hypothesis. Based on the sample data the researcher can reject the null hypothesis and therefore accept the alternative hypothesis with a certain degree of confidence: there is a risk that the inference that is drawn about the population is incorrect. These are classified as type I and type II errors. A type I error, also referred to as alpha ($\alpha$), is the probability of rejecting the null hypothesis when it is true. The probability of type I error, also known as the significant level, is determined by the researcher. Significance levels are 5 percent ($<0.05$) and 1 percent ($<0.01$). a type II error, also referred to as beta ($\beta$), is the probability of failing to reject the null hypothesis given that the alternative hypothesis is true. The probability of type II error is inversely related to the probability of type I: the smaller the risk of these types of error, the higher the risk of the other type of error.

A third important concept in hypothesis testing is statistical power ($1-\beta$). Statistical power is the probability of correctly rejecting the null hypothesis. In other words, power is the probability that statistical significance will be indicated if it is present.

This thesis examines the relationships among sustainable supply chain practices, agile supply chain capabilities, various contingency variables, and organisational performance including operational/financial performance and sustainability performance. Hypothesis testing was accomplished via two statistical techniques: hierarchical regression; and structural equation modelling (SEM) technique via SPSS AMOS version 28. There are several other statistical techniques to test hypotheses, such as ANOVA and correlation statistics. This dual testing allows for a robust assessment of the hypotheses, within the different strengths and constraints of each technique (Shook et al., 2004). On the one hand, hierarchical regression allows the direct assessment of change in explanatory power between iterative steps, which cannot accomplish using SEM given that the step 1 equation is saturated. Further, as a traditional technique, it provides a baseline set of results for predictions. On the other hand, the more complex 'parsimonious latent-variable interaction technique' allows for the inclusion of measurement errors and indicators of the higher-order factors and can account for potential common method variables problems (Podsakoff et al., 2003; Netemeyer et al., 1999).

The regression analysis is the appropriate method of analysis when the research problem involves a single dependent variable presumed to be related to two or more independent variables, while structural equation modelling is a technique that allows separate relationships for each of a set of dependent variables. In its simplest sense, structural equation modelling provides the appropriate and most efficient estimation techniques for a series of separate multiple regression equation estimated simultaneously (Hair et al., 2014). Therefore, structural equation modelling was use as a complement technique. The advantage of using a structural equation modelling is that it could enables the examination of mediating and moderating effects on the relationship between independent variables and dependent variables. Because all constructs could be included in one model, the researcher could explore both direct and indirect effects of such relationships.

In the analysis chapter, the significance values of chi-square were 0.000 (i.e., <0.05), indicating that there was pact at 5% significant level. These results reject the null hypotheses, and alternative hypotheses ($H_a$) as follows were accepted:

Alternative hypotheses ($H_a$):

$Ha_1$: Sustainable supply chain practices have a positive effect on operational performance.

$Ha_2$: Sustainable supply chain practices have a positive effect on sustainability performance.

$Ha_3$: Agile supply chain capabilities have a positive effect on operational performance.

$Ha_4$: Agile supply chain capabilities have a positive effect on sustainability performance.

$Ha_{5a}$: The interaction between sustainable supply chain practices and agile supply chain capabilities positively affects operational performance

$Ha_{5b}$: The interaction between sustainable supply chain practices and agile supply chain capabilities positively affects sustainability performance.

$Ha_6$: Sustainability performance has a positive effect on operational performance

$Ha_7$: Agility capabilities mediate the relationship between sustainable supply chain practices and operational performance.

$Ha_8$: Agility capabilities mediate the relationship between sustainable supply chain practices and sustainability performance.

$Ha_{9a}$: Managerial experiences moderate the relationship between sustainable supply chain practices and operational performance.

$Ha_{10a}$: Managerial experiences moderate the relationship between sustainable supply chain practices and sustainability performance.

$Ha_{9b}$: Industry sectors moderate the relationship between sustainable supply chain practices and operational performance.

$Ha_{10b}$: Industry sector moderates the relationship between sustainable practices and sustainability performance.

## 4.20 Structural equation modelling

Hair et al. (2014, p. 551) defined structural equation modelling as a family of statistical models that seek to explain the relationships among multiple variables. The term structural equation modelling coveys two important aspects of the procedure: that the causal processes under study are represented by a series of structural equations, like a series of multiple regression equations; and that these structural relations can be modelled to enable a clearer conceptualisation of the theory under study (Byrne, 2016). Constructs are unobservable or latent factors represented by multiple variables. Structural equation modelling can be thought of as a unique combination of both types of techniques because its foundation lies in two familiar multivariate techniques: factor analysis and multiple regression analysis (Hair et al., 2014).

Structural equation models are distinguished by three characteristics: the estimation of multiple and interrelated dependent relationships; the ability to represent unobserved concepts in the relationships and account for measurement error in the estimation process; and the definition of a model to explain the entire relationships.

Several aspects of structural equation modelling set it apart from the other multivariate procedures. Structural equation modelling takes a confirmatory, rather than exploratory, approach to the data analysis. More so, by demanding that the pattern of intervariable relations be specified a priori, structural equation modelling lends itself well to the analysis of data for inferential purposes. By contrast, most other multivariate procedures are descriptive by nature (e.g., exploratory factor analysis), so that hypothesis testing is difficult, if not impossible.

Whereas traditional multivariate procedures are incapable of either assessing or correcting for measurement error, structural equation modelling provides explicit estimates of these error variance parameters. Indeed, regression methods assume that an error (s) in the explanatory (i.e., independent) variables vanish. Thus, applying those methods when there is error in the explanatory variables is tantamount to ignoring error, which may lead, to serious inaccuracies – especially when the errors are sizeable. Such mistakes are avoided when corresponding structural equation modelling are used (Byrne, 2016). Although data analyses using the regression methods are based on observed measurements only, using structural equation modelling procedures can incorporate both unobserved (or, latent) and observed variables (Byrne, 2016). There are not widely and easily applied alternative methods for modelling multivariate relations, or for estimating point and/or interval indirect effects; these important features are available using structural equation modelling methodology (Byrne, 2016).

Several academics are interested in structural equation modelling because it offers a conceptually appealing way to test theory. In this research, six stage decision procedures were followed in performing structural equation modelling. These are:

- Defining individual constructs
- Developing the overall measurement model
- Designing a study to produce empirical results
- Assessing the measurement model validity
- Specifying the structural model, and
- Assessing structural model validity.

### 4.20.1 Measurement model

This study employed confirmatory factor analysis to assess the measurement model of the first-order constructs. Measurement models capture complex constructs that it is not possible to measure directly using multiple indirect indicators (Easterby-Smith et al., 2021). The unobserved constructs are referred to as a latent variable, while its hypothesised observed indicators are called manifest variables. A measurement model is based in measurement theory that identifies how constructs are useful to measured sets of variables (Hair et al., 2014). In a measurement model, the number of factors and the variable loads on each factor come from the relevant theories known before the analysis can be performed. Before testing the hypotheses, the researcher must examine non-dimensionality by checking whether the measurement model is valid or not. Checking the validity of the measurement model is a critical step of the structural equation modelling.

### 4.20.2 Measurement model validation

The validity of the measurement model shows how measured variables represent logically and systematically a construct that is involved in a hypothetical model (Hair et al., 2010). Typically, a researcher needs to think about how each of the construct can come together to establish an overall measurement model. The measurement model of each construct will be validated by assessing the overall validity of the measurement model to check whether the validity of the model is acceptable or not. The validity of the measurement model depends on two main factors: establishing acceptable levels of goodness-of-fit for the measurement model and finding specific evidence of construct validity (Hair et al., 2014).

This study used SPSS AMOS 28 to generate and analyse the measurement model. The measurement models were categories into four sub-models: the model of SSCP, Agile capabilities, environmental dynamism, and sustainable supply chain performance. Sustainable supply chain practices involve sustainable design (SD), sustainable production (SProd), sustainable procurement (SPr), sustainable transportation (ST), investment recovery (IR), and social sustainable practices (SSP). Agile supply chain capabilities comprised five sub-constructs: market sensitivity (MS), technology integration (TI), process alignment (PA), network collaboration (NC), and people capabilities (PC). The sustainable supply chain performance includes two sub-constructs: operational (OPER_PERF)/ financial performance (FP), and sustainability performance (SUS_PERF) – social performance (SP) and environmental performance (EP).

The structural equation modelling was conducted to assess goodness-of-fit of the overall model. Goodness-of-fit (GOF) indicates how well the specified model reproduces the observed covariance matrix among the indicator items. Since the first GOF measure was developed, researchers have strived to refine and develop new measures that reflect various facets of the model's ability to represent the data. As such, several GOF measures are available to the researcher. The GOF measures are categorised into three groups: absolute measures, incremental measures, and parsimony fit measures. the following section explain some basic elements underlying GOF measures.

## 4.20.3 The basics of Goodness-of-fit (GOF)

### 4.20.3.1 CHI-SQUARE ($\chi^2$) GOF

**T**he difference in the observed and estimated covariance matrices (termed as S and $\Sigma_K$ respectively) is the key value in assessing the GOF of any SEM model. The chi square ($\chi^2$) test is the statistical test of the difference between matrices in SEM (Hair et al., 2010). The $\chi^2$ is represented using the following equation:

$\chi^2$ = (N-1) (observed sample covariance matrix – SEM estimated covariance matrix)

Or

$\chi^2 = (N - 1)(S - \Sigma_K)$ ----------------------------------------------------------------------eqn 7

Where:

N is the overall sample size; the $\chi^2$ value increases as sample size increases (Gerging and Anderson, 1985). Likewise, the estimated covariance matrix is influenced by how many parameters are specified in the model (the k in $\Sigma_K$), so the model degree of freedom also influence the $\chi^2$ GOF test. Thus, with some consensus in psychometric research, a model is said to represent reasonable fit if the $x^2$ adjusted by its df does not exceed 3.0 (Kline, 2015).

The ***degree of freedom (df)*** represents the amount of mathematical information available yo estimate model parameters. The df is calculated as follows:

$$df = \frac{1}{2}[(p)(p+1)] - k \text{ ----------------------------------------------------------eqn 8}$$

where p is the total number of observed variables and k is the number of estimated parameters.

The ***normed chi-square*** **(**$\chi^2$/df) is a simple ratio. In general, a ratio of 3:1 or less indicates better-fitting models. This value is less dependent on the sample size.

#### 4.20.3.2 Absolute fit indices

The ***goodness-of-fit index*** explains how well a researcher's theories fit the sample data. The GOF values range between 0 and 1; higher values indicate better fit. Values that are greater than 0.90 are considered acceptable (Hair et al., 2014). However, others argue that 0.95 should be used as the ideal value (Hu and Bentler, 1999).

The ***root mean square error of approximation (RMSEA)*** represents how well a model fits a population, and not just a sample used for estimation (Hair et al., 2014). It estimates the lack of fit in a model compared to a perfect model (Tabachnick and Fidell, 2013). The **RMSEA** values between 0.05 and 0.08 are considered acceptable (Gerver and Mentzer, 1999). Lower **RMSEA** values indicate better fit (Hair et al., 2014). The equation for the estimated RMSEA is given by

$$\text{Estimated RMSEA} = \sqrt{\frac{\mathcal{F}_0}{df_{model}}} \text{ ----------------------------------------------------eqn 9}$$

Where $\mathcal{F}_0 = \frac{\chi^2_{model} - df_{model}}{N}$ or 0 whichever is smaller but positive

When the model is perfect, $\mathcal{F}_0$ = 0. The greater the model misspecification, the larger $\mathcal{F}_0$. Values of 0.06 or less indicate a good-fitting model relative to the model degree of freedom (Hu and Bentler, 1999). Values larger than 0.10 are indication of poor-fitting models (Tabachnick and Fidell, 2013). Hu and Bentler (1999) found that in small sample, the RMSEA over rejected the true model, that is the value was too large. Because of this problem, this index may be less preferable with small samples (Tabachnick and Fidell, 2013).

#### 4.20.3.3 Incremental fit indices

Incremental fit indices differ from absolute fit indices in that, they assess how well the estimated model fits relative to some alternative baseline model (Hair et al., 2014).

##### *4.20.3.3.1 The normed fit index (NFI)*

The normed fit index is one of the original incremental fit indices (Hair et al., 2014). It evaluates the estimated model by comparing the $\chi^2$ value of the model to the $\chi^2$ value of the independence model (Tabachnick and Fidell, 2013). The NFI value ranges between 0 and 1, and a model with perfect fit would produce an NFI of 1. The NFI can be calculated by

$$\text{NFI} = \frac{\chi^2_{indep} - \chi^2_{model}}{\chi^2_{indep}} \text{ ---------------------------------------------------------eqn. 10}$$

According to Tabachnick and Fidell (2013), high values greater than 0.95 are indicative of a good-fitting model. Therefore, the NFI may underestimate the fit of the model in good-fitting models with small samples (Hair et al., 2018). An adjustment to NFI incorporating the degree of freedom in the model yields the non-normed fit index (NNFI), which can be evaluated by

$$\text{NNFI} = \frac{\chi^2_{indep} - \frac{df_{indep}}{df_{model}}\chi^2_{model}}{\chi^2_{indep} - df_{indep}} \text{ -----------------------------------------------eqn. 11}$$

The adjustment improves on the problem of understanding the fit in good-fitting models but can sometimes yield numbers outside of the 0 – 1 range. Anderson and Garbing (1984) observed that the NNFI may be too small in small sample samples, indicating a poor fit when other indices indicate an adequate fit. The incremental fit index (IFI) could help addressed the problem of the large variability in the NNFI (Bollen, 1989). The IFI is determined by

$$\text{IFI} = \frac{\chi^2_{indep} - \chi^2_{model}}{\chi^2_{indep-}\ df_{model}} \text{ ------------------------------------------------------------eqn. 12}$$

#### *4.20.3.3.2 The Tucker-Lewis Index (TLI)*

The Tucker-Lewis Index (TLI) is the same with the NFI but varies in that it is a comparison of the normed chi-square vales for the null and specified model, which to some degree considers model complexity (Hair et al., 2014). The TLI also is known as the non-normed fit index (NNFI) (Garver and Mentzer, 1999). The index measures parsimony by evaluating the df of the proposed model against the df of the null model. An acceptable value for TLI is 0.9 or higher (Marsh et al., 1988). The TLI value is like the CFI in most situations.

#### *4.20.3.3.3 The comparative fit index (CFI)*

The comparative fit index (CFI) is an extension of the normed fit index (NFI) (Hair et al., 2014). The CFI assesses fit relative to other models but uses a different approach. the CFI employs the noncentral $\chi^2$ distribution with non-centrality parameters, $\tau_i$. The larger the value of $\tau_i$, the greater the model misspecification: that is, if the estimated model is perfect, $\tau_i$ = 0. The CFI is defined as,

$$\text{CFI} = 1 - \frac{\tau_{est.model}}{\tau_{indep.model}} \text{ ----------------------------------------------------------- eqn. 13}$$

Unlike the SRMR and RMSEA, the CFI index ranges between 0 and 1; the acceptable threshold for CFI is 0.9 or higher (Hair et al., 2010).

#### 4.20.3.4 Indices of proportion of variance accounted

There are two fit indices could calculate a weighted proportion of variance in the sample covariance accounted for by the estimate population covariance matrix (Bentler, 1983; Tanaka and Huba, 1989). The goodness-of-fit index (GFI) can be defined by,

$$\text{GFI} = \frac{tr(\sigma' W \sigma)}{tr(s' W s)} \text{ ---------------------------------------------------------------- eqn. 14}$$

Where the numerator is the sum of the weighted variances from the estimated model covariance matrix and the denominator is the sum of the squared weighted variances from the sample covariance. W is the weight matrix that is selected by the choice of the estimation method. Tanaka and Huba (1989) suggested that the GFI is analogous to $R^2$ in multiple regression. This fit index can also be adjusted for the number of parameters estimated in the model. The adjusted fit index, labelled AGFI, is estimated by

$$\text{AGFI} = 1 - \frac{1 - GFI}{1 - \frac{Number\ of\ est.parameters}{Number\ of\ data\ points}} \text{ ------------------------------------------- eqn 15}$$

The fewer the number of estimated parameters relative to the number of data points, the closer the AGFI is to the GFI. In this way, the AGFI adjusts the GFI for the number of parameters estimated. The fit improves by estimating lots of parameters in SEM. While a second goal of modelling is to develop a parsimonious model with as few parameters as possible. Table 4.18 summaries some of the measurement model validity assessed in this study.

**Table 4.18** Model fit indices for the measurement model validity

| Types of models of fit indices | Model fit indices | Recommended value | References |
|---|---|---|---|
| Basics of Goodness-of-fit | Chi-square ($x^2$) | n/a | |
| | Degree of freedom (df) | n/a | |
| | Statistical significance of $x^2$ | Non-significance | Hair et al., 2010 |
| Absolute Fit Indices | Normed Chi-square or ($x^2/df$) or Chi-square ratio | ≤3.00 | Hair et al., 2010<br>Kline, 2015 |
| | Goodness-of-fit index (GFI) | ≥0.90 | Hair et al., 2010 |
| | Root Mean Square Error of Approximation (RMSEA) | ≤0.08<br><br><br>0.05 to 0.08 | Browne and Cudeck, 1993<br>Carter and Jennings, 2004<br>Garver and Mentzer, 1999 |
| | Standardised Root Mean Residual (SRMR) | ≤0.09 | Iacobucci, 2010 |
| Incremental fit indices | Normed Fit Index (NFI) | ≥0.90 | Hair et al., 2010 |
| | Turker-Lewis Index (TLI) | ≥0.90 | Garver and Mentzer, 1999 |
| | Comparative Fit Index (CFI) | ≥0.90<br><br><br>≥0.95 | Garver and Mentzer, 1999<br>Hair et al., 2010<br>Hu and Bentler, 1999<br>Iacobucci, 2010 |

Source: Hair et al. (2013)

Evaluating overall measurement model validity involves two strategies: selecting model fit indices that can show various groups of fit indices and specifying a rigorous criterion and choosing model fit indices that best illustrate the criteria (Garver and Mentzer, 1999). According to Marsh et al (1988) the criteria for the ideal model fit indices should be relative independence of sample size, accuracy, and consistency in evaluating various models, and easy interpretation by means of a well-defined on a pre-set range (e.g., 0 to1). Garver and Mentzer (1999) recommended three ideal GOF indices: TLI, CFI, and RMSEA. All these indices can be interpreted easily and are independent of sample size (Gerging and Anderson, 1992).

If the measurement model has an unacceptable model fit when assessing the model fit with the AMOS programme, Garver and Mentzer (1999) and Hair et al. (2010) suggest modifying the measurement model by employing three diagnostics measures from CFA. The diagnostics indicators should contain factor loadings of each measured items, standardised residuals (SRs), and modification index (MI). All the indicators can help a researcher examine why the measurement model is not fit or unacceptable (Joreskog and Sorbom, 1993). Theoretical considerations are still important for measurement model modification (Bollen, 1989).

Factor loadings or items with standardised loading values of 0.5 or greater were considered acceptable values. The items that had values lower than the threshold value should be dropped from the dataset. The researcher used SR when the measurement model was not fit. To examine SR value, the researcher considers a large residual value. A large residual value above 1.96 or 2.576, depending on the alpha level selected by the researchers. If researchers choose significant value at the 0.05, then they should consider SR value above 1.96).

The modification index (MI) was used examined how to adapt a measurement model. The MI value represents the expected change in the $\chi^2$ value and the expected parameter estimate. A substantial MI value is considered 7.88 and is more likely to be a significant model improvement. The greatest MI represents the largest scope for improvement in fit model. The items that have the largest MI should be considered for modification first (Garver and Mentzer, 1999). The measurement model should be recalculated after each re-specification.

### 4.20.4 Direct and indirect effect

A direct effect is the type of relationship that links two main constructs with single arrow that points from an independent variable to a dependent variable (Hair et al., 2010). The relationship between the independent variable and the dependent variable is called the total effect. The direct effect is the relationship between the independent variable and the dependent variable after ‘controlling for’ the mediator. For instance, the thesis indicates that the successful implementation of sustainable practices in supply chains would have positive effects on organisational performance in terms of operational and sustainability performance. That is, the overall sustainable performance would positively correct with the degree of SSCM practices implementation. Thus, the success of implementing SSCM practices is the independent variable, and organisational performance including finance measures/operational performance and the two-sustainability performance are the dependent variables. The degree of SSCM practices implementation will explain the variance in the overall sustainable performance of supply chains. This relationship and the labelling of the variables are shown in Figure 4.7. In this thesis, the direct relationships examined are SSCM practices – sustainable supply chain performance, agile capabilities – sustainable supply chain performance, and SSCM practices – agile capabilities relationships.

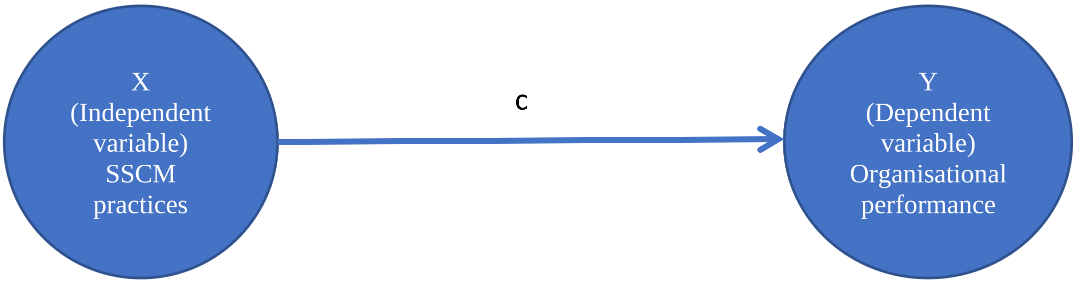



**Figure 4.7** The direct effect

An indirect effect, on the other hand, is a situation whereby there is not significant relationship between SSCM practices and sustainable supply chain performance, but there is a significant relationship with at least an intervening construct involved, such as a mediator or moderator variable (Hair et al., 2014).

### 4.20.5 Mediation and moderation analysis

A moderation analysis examines the causal effect of X and Y at different levels of a third variable called a moderator (Easterby-Smith et al., 2021; Hair et al., 2014). According to Baron and Kenny (1986), a moderator is a qualitative or quantitative variable that influences the direction or strength of the relationship between an independent and dependent variable. The moderating variable is one that has a contingent effect on the independent variable – dependent variable relationship (Bougie and Sekaran, 2020). That is the presence of third variable (moderating variable) modifies the original relationship between the independent and dependent variables. A prevalent theory is that the implementation of sustainable practices contributes more to the performance of supply chains because each members bring its own special expertise and skills to the chain. This synergy can be explored, only if managers have knowledge and experiences on how to harness the special talents of the diverse chain members; otherwise, they will remain unexploited. In this case, organisational effectiveness is the dependent variable, which is positively influenced by the implementation of sustainable practices – the independent variable. however, to harness the potential, managers must know how to encourage and coordinate the talents of the various supply chain members to implement sustainable practices. If not, the synergy will not be achieved. In other words, the effective implementation of sustainable supply chain practices and capabilities for enhanced organisational performance is contingent on the skill of the managers in acting as catalysts. This managerial expertise then becomes the moderating variable. These relationships can be depicted as in Figure 4.8.

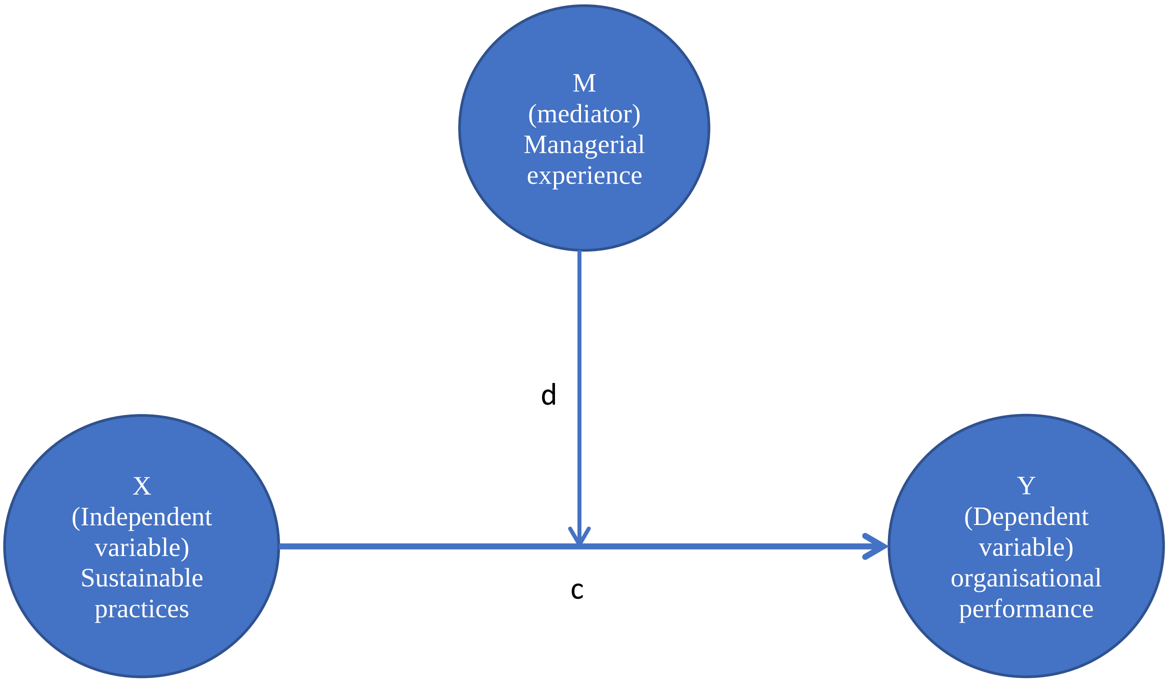



**Figure 4.8** The moderation effects

A mediation, on the other hand, is a causal method looking at the transmission of a causal effect from an independent variable to the performance outcome variable through a third variable called a mediator (Easterby-Smith et al., 2021; Hair et al., 2010). As Baron and Kenny (1986) noted, mediators can explain how or why the effects occur. The mediating variable is one that surfaces between the time the independent variables start operating to influence the dependent variable and the time their impact is felt on it (see figure 4.9). This research aimed to examine the mediating role of agility capabilities in the relationship between sustainable supply chain practices (as an independent variable) and organisational performance (as a dependent variable), in terms of operational/financial performance and two sustainability performance (i.e., social, and environmental performance).

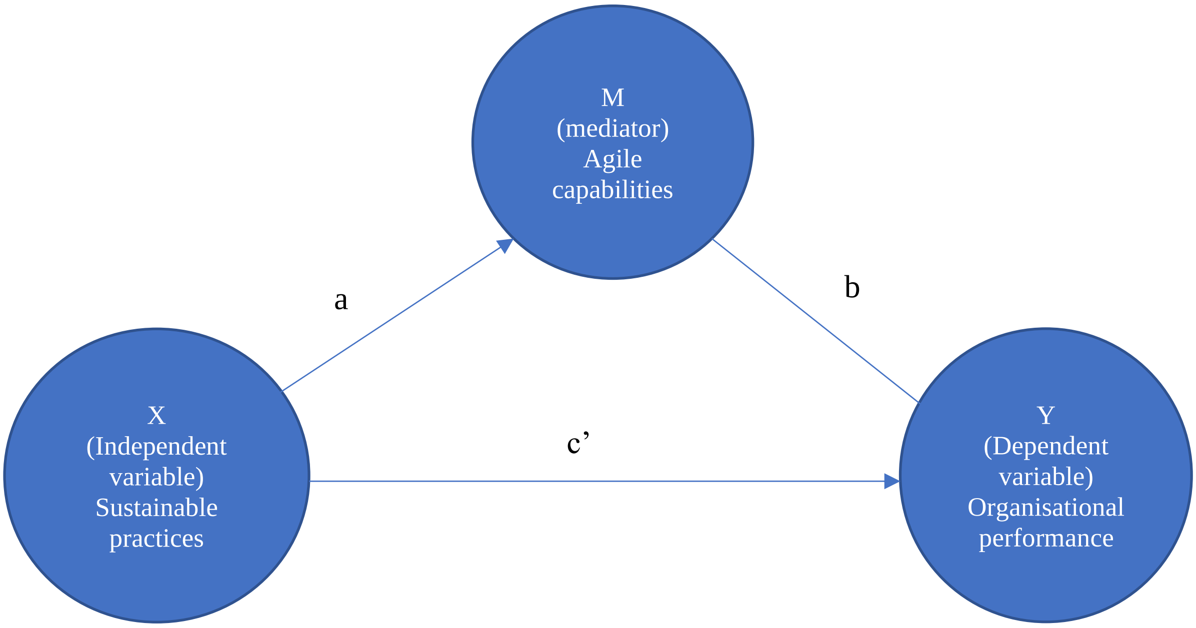



**Figure 4.9** The mediation effects

### 4.20.6 Testing mediation effect

In testing mediation, the relationships amongst the variables must satisfy all the following conditions as recommended by Baron and Kenny (1986).

i. The independent variable (in this case sustainable supply chain practices) must significantly influence the dependent variables (operational performance and sustainability performance), while not controlling for the mediator (agility capabilities),

ii. The independent variable (sustainable supply chain practices) must significantly affect the mediator (agility capabilities),

iii. The mediator (agility capabilities) must significantly affect influence the dependent variables (operational performance and sustainability performance) after the influence of the independent variable (sustainable supply chain practices) is controlled for.

iv. The effect of the independent variable on dependent variable must either increase or decrease after controlling for the effect of the moderator.

If all the conditions are satisfied and the influence of the independent variable becomes non-significance in the present of the mediator, the effects of the independent variable are said to be “completely” or “fully” mediated by the mediator. If all the conditions are satisfied, but the influence of the independent variables remains significant in the presence of the mediator, the effects of the independent variable are said to be “partially” mediated. If any of these conditions are not satisfied, there is no mediation (Baron and Kenny, 1986; Tepper et al., 1996).

Mediation testing may be conducted using correlation statistics and various methods of regression and hierarchical regression (e.g., da Silveira and Arkader, 2007). Using regression approaches for mediation may cause problems related to measurement error in mediator variable scores, resulting in difficulties in modelling causation and possible reverse causation (Hair et al., 2016; Hopwood, 2007). The use of structural equation modelling has also been recommended as a remedy to these problems. Structural equation modelling (SEM) attenuates this problem by reducing measurement error through the application of latent variables. These latent trails of SEM also attenuate concerns that method effects may be confused with actual substantive results when testing for mediation (Hair et al., 2016; `Hopwood, 2007).

# CHAPTER 5: Analysis of survey by questionnaire data and results

## 5.1 Introduction

This chapter focuses on the analysis of the questionnaire data and the interpretation of empirical results. The chapter was divided into two phases: preliminary data analysis and hypotheses testing. The preliminary analysis of data includes descriptive statistics that show the trends in the variables. Assess normality; check reliability; the validity of the measurement scales using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Then, the second phases used the technique of structural equation modelling to test the hypotheses.

## 5.2 Data analysis and results

### 5.2.1 Preliminary data analysis

In order to acquire knowledge of the characteristics and properties of the collected data several preliminary data analyses were carried out before performing measurement quality assessment or conducting tests of hypotheses. Carrying out such analyses before assessing measurement quality gives preliminary indications of how well the coding and entering of data have been done, how good the scales are, and if there is a suspicion of poor content validity or method bias. Before testing hypotheses, it is useful to check the assumptions underlying the tests and to get a feeling for the data to interpret the results of the tests better.

Preliminary analysis is performed through checking central tendencies, dispersions, frequency distributions, correlations. It is also good practices to calculate: the frequency distribution of the demographic variables; the mean, standard deviation, skewness and kurtosis, and variance of the other dependent and independent variables; and an inter-correlation matrix of the variables. These preliminary procedures and results obtained from them are described in the next sections.

#### 5.2.1.1 Descriptive statistics

Descriptive statistics were used to describe the characteristics of the sample. It is useful to check variables for any violation of the assumptions underlying the statistical techniques that will be used to address specific research questions. Testing of assumptions involves obtaining some central tendency on variables. These descriptive statistics includes the mean, standard deviation, range of scores, skewness, and kurtosis. It enables detailed comparison of the score on the various characteristics of the research sample (Bougie and Sekaran, 2020), thus it helps to identify if there is a significant difference among the respondents.

#### 5.2.1.2 Response rate

A total of nine hundred and forty-five (945) questionnaires were mailed out to potential respondents taken from financial analysis made easy (FAME) database and subsea oil and gas directory. A cover letter together with return stamped envelope were enclosed in the postal mail to encourage potential recipients to return the questionnaires. The survey tool was also uploaded onto the web based QuestionPro and made visible only to respondents chosen from the sample organisations. The online-based survey provides greater degrees of accuracy and minimises missing values (Creswell, 2014). Non-respondents were followed up two weeks after the initial mail with a reminder email and telephone calls and seven weeks later, extra questionnaires were resent to improve response rate as suggested by Frankfort-Nachmias and Nachmias (2007). In the end, 346 companies completed and returned the questionnaire, following Hair et al. (2010, p. 55) suggestions, 35 incomplete responses were removed from the analysis. A total of 311 usable responses were fully completed, yielding an effective response rate of 32.9% (346/945-35). The response rate was in line with similar studies in the literature (Hong et al., 2018; Sambasivan et al., 2013; Blome et al., 2013; Wamba et al., 2020; Gomes et al., 2019; Belhadi et al., 2020). In a related study on sustainable supply chain management, Sambasivan et al. (2013) achieved a response rate of 30%. Table 5.1 suggests that the response rate obtained in this study is consistent with those prior empirical works on agility and sustainable supply chain management practices.

**Table 5.1** Response rates reported by earlier works within operations and supply chain management

| **Authors** | **Response rate** |
|---|---|
| Wamba et al., 2020 | 41% |
| Hong et al., 2018 | 45.5% |
| Rialti et al., 2019 | 30.04 |
| Belhadi et al., 2020 | 31.81% |
| Tavani et al., 2014 | 31.3% |
| Swafford et al., 2008 | 25.2% |
| Esfahbodi et al., 2017 | 25% |

#### 5.2.1.3 Non-respondents bias

The non-response bias was investigated using the approach recommended by Armstrong and Overton (1977, p. 401), comparing early and late respondents as a proxy for non-respondents (Fullerton et al., 2014). The early respondents (n=136) were completed before the reminder email and telephone calls was made, and these were categorised as early wave, whilst those respondents (n=175) that returned the questionnaire after the email and telephone calls reminder formed the late wave. The independent-samples t-test was conducted to compare the scores for the early and late groups. As it can be seen in Table 5.2 the demographic characteristics of number of employees, turnover, and agility practices, result shows that there was no significant difference between the mean values of the two groups, showing the null hypothesis that there is no statistically significant difference between respondents and non-respondents cannot be rejected. In addition, based on the two-tailed significant level and Levene's t-test presented in Table 5.2 there was no non-response bias.

**Table 5.2** Independent-sample t-test external validity for non-response bias

| Control various and research Constructs | 1st Wave | 2nd Wave | 2 tail sig. | df | Levene's test |
|---|---|---|---|---|---|
| Business size | 2.87 | 2.88 | 0.961<br>0.961 | 309<br>292.121 | 0.820 |
| Age of business | 3.39 | 3.41 | 0.906<br>0.907 | 309<br>290.400 | 0.923 |
| Years of experience | 2.15 | 2.27 | 0.132<br>0.136 | 309<br>278.447 | 0.696 |
| Industry sector | 4.61 | 4.63 | 0.195<br>0.196 | 309<br>278.492 | 0.717 |
| Annual turnover | 3.49 | 3.53 | 0.916<br>0.916 | 309<br>290.848 | 0.984 |
| Market sensitivity | 3.75 | 3.77 | 0.875<br>0.875 | 309<br>286.805 | 0.662 |
| Process alignment | 3.75 | 3.80 | 0.679<br>0.678 | 309<br>290.785 | 0.943 |
| Technology integration | 3.92 | 3.97 | 0.658<br>0.660 | 309<br>283.962 | 0.350 |
| Network collaboration | 3.76 | 3.83 | 0.557<br>0.559 | 309<br>286.158 | 0.442 |
| Employee empowerment | 3.32 | 3.36 | 0.721<br>0.722 | 309<br>287.712 | 0.902 |
| Sustainable design | 3.12 | 3.17 | 0.464<br>0.465 | 309<br>291.896 | 0.414 |
| Sustainable procurement | 3.10 | 3.11 | 0.939<br>0.940 | 309<br>285.895 | 0.696 |
| Sustainable production | 3.90 | 3.98 | 0.605<br>0.607 | 309<br>283.543 | 0.381 |
| Sustainable transportation | 3.98 | 4.00 | 0.789<br>0.790 | 309<br>285.600 | 0.442 |
| Investment recovery | 3.58 | 3.59 | 0.863<br>0.864 | 309<br>280.948 | 0.525 |
| Social sustainable practices | 3.35 | 3.36 | 0.998<br>0.999 | 309<br>291.107 | 0.821 |

### 5.2.2 The respondents' demography

The table 5.3 shows the demography of the respondents, including business size, annual turnover, age of business, years of experience, and business sectors of responding organisations. The sample comprises of 311 oil and gas industry supply chains in the UK. The table shows that companies with less than £51 million annual turnovers constituted 52.4% of the entire respondents whilst those with less than 250 employees accounted for 68.8%, indicating a business structure dominated by small and medium-size enterprises.

The analysis of the respondents' business size shows that 41.5% of respondents are small size companies, 27.3% belong to medium size companies, and 31.2% for the large companies. The UK standard industry classification (SIC) was used in classifying the business size based on the number of employees. Small business denotes a business with 0 to 49 employees while medium-sized business signifies a business with 50 to 249 employees. Large business is a business with 250 or more employees (the UK SIC, 2007). Overall, the table shows better results for suppliers than for operators as noted by (Wood, 2014; Chima, 2007; Huque, 2004; Deloitte, 2019 Shuen et al., 2014). This confirms evidence that suppliers are adopting sustainable initiatives and developing agility capabilities for increasing their operations and sustainability performance.

More so, table 5.3 shows that 47.6% of turnovers belong to the large businesses, 15.9% of turnover to the medium businesses, and 26.5% of the turnover belong to small businesses. The respondents are well distributed across business sectors. There are three dominant groups – exploration and production companies, marine and subsea services, as well as marketing, retail and refined petroleum products – accounting for 51.4% of the total sample.

As shown in Table 5.3, supply chain managers account for 24.8% of the sample size, while operations managers constitute 19.3% of the total responding organisations. Plant managers, engineering managers and logistics managers constitute 35.5% while sale manager, procurement manager and industrial waste managers comprised of 20.5% of the total respondents. These respondents consisted of highly skilled and knowledgeable supply chain professionals who play important roles in their organisations. Thus, their responses have satisfied the researcher's requirements on target respondents.

**Table 5.3** Summary of respondents' demography

| **Criteria** | **Percent (%)** |
|---|---|
| **Size by number of employees** | |
| 0 – 49 employees | 41.5 |
| 50 – 249 employees | 27.3 |
| 250 or more employees | 31.2 |
| **Total** | **100** |
| | |
| **Company annual Turnover (£ Millions)** | |
| Less than 25 | 36.5 |
| 26 – 50 | 15.9 |
| 51 or more | 47.6 |
| **Total** | **100** |
| | |
| **Age of business** | |
| Up to 5 years | 4.8 |
| 6 to 10 years | 19.3 |
| 11 to 20 years | 32.2 |
| 21 to 30 years | 18.6 |
| 31 years or more | 25.1 |
| | |
| **Designation of Respondents** | |
| Plant managers | 10.9 |
| Engineering manager | 11.6 |
| Logistics manager | 12.9 |
| Operations manager | 19.3 |
| Sales manager | 7.4 |
| Supply chain manager | 24.8 |
| Industrial waste manager | 4.1 |
| Procurement manager | 9.0 |
| **Total** | **100** |
| | |
| **Industry classification (UK SIC – Standard industrial classification)** | |
| Exploration and production | 23.8 |
| Refining and facilities | 8.0 |
| Marketing, retail and refined petroleum products | 13.5 |
| Marine and subsea services | 14.1 |
| Energy consultancies | 2.9 |
| Wells and drillings services | 4.8 |
| Steel and metal products | 7.1 |
| Chemicals and chemical products | 3.2 |
| Cements | **4.5** |
| Transportation | 7.6 |
| Decommissioning | 1.8 |
| Other support services for oil and gas extraction | 8.7 |
| **Total** | **100** |

**Notes:**
Small business is a business with 0 to 49 employees
Medium-sized business is a business with 50 to 249 employees
Large business is a business with 250 or more employees
Small and medium-sized enterprises (SMEs) are businesses with 0 to 249 employees

#### 5.2.2.1 Years of professional experience

Figure 5.1 represent information on respondents' years of professional involvement and experience. From the figure, 18.30 percent of the respondents had less than five years of experiences, 22.60 percent had six to ten years of experiences with about 59.1 percent (i.e., 35.20 + 15.40 + 8.50) of the respondents had above eleven years of experiences. It reflects a good base of people experience in the oil and gas industry supply chain. This indicate that respondents have experience and knowledge of sustainability and agility, and their responses are reliable to some degree.

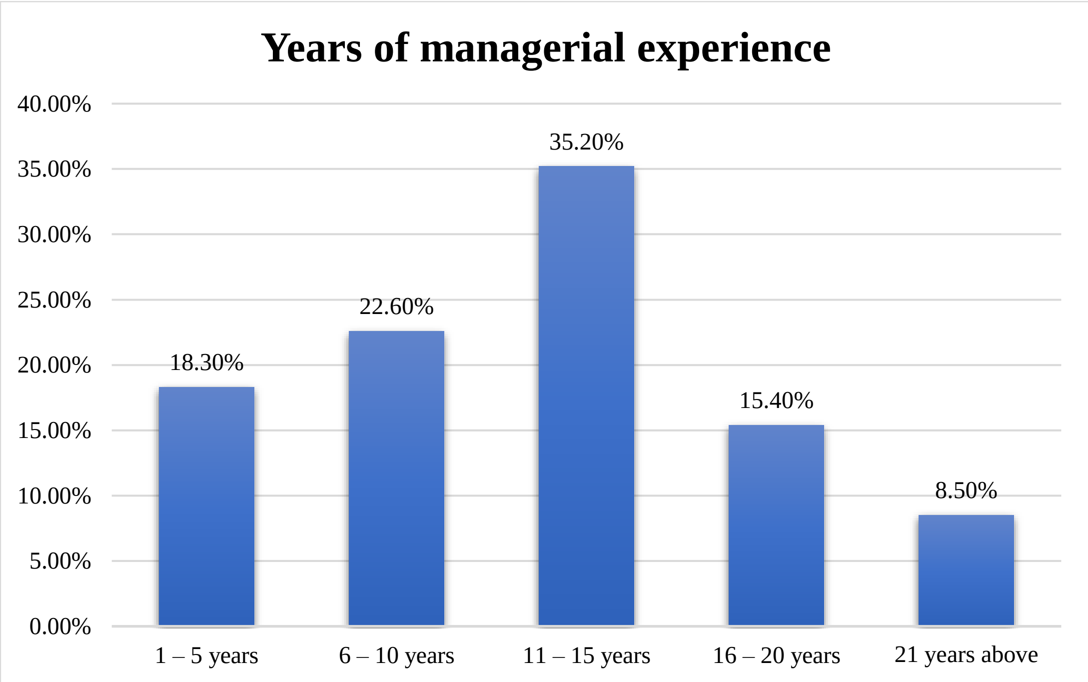



**Figure 5.1** Respondents' number of years of managerial experiences

#### 5.2.2.2 Respondents' company types

Figure 5.2 represent the major supply chain links in the oil and gas industry. The affiliations represent the interface between operators and contractors/suppliers where materials flow through the supply chain. From the figure, 31 percent belong to operators, while 64 percent belong to contractors/suppliers, and 5 percent of respondents did not indicate their company type.

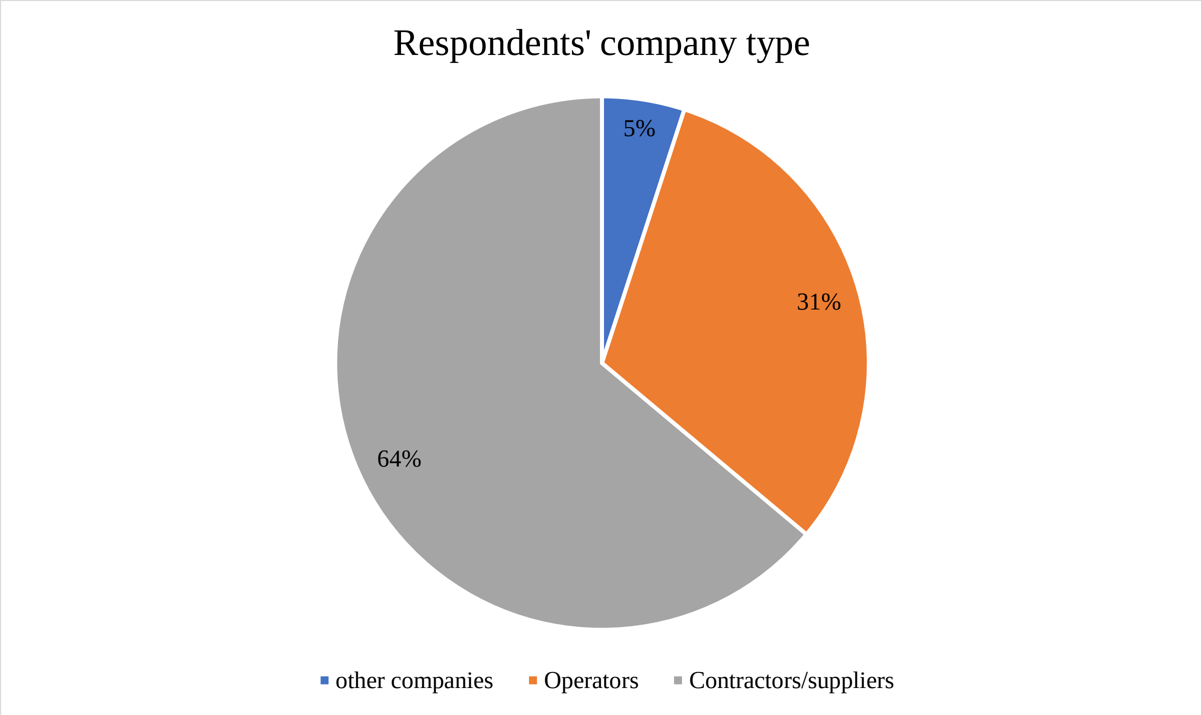



**Figure 5.2** Respondents' company type

#### 5.2.2.3 Respondents' job categories

Figure 5.3 shows the respondents' management levels. From the figure, 36.3 percent of respondents are senior management, 43.4 percent of the respondents belong to middle management, and 20.3 percent are supervisors. As could be expected, there are more middle managers than senior managers in the industry, and this is also reflected here. It shows that the questionnaires were well distributed among the professional level in the oil and gas industry supply chain.

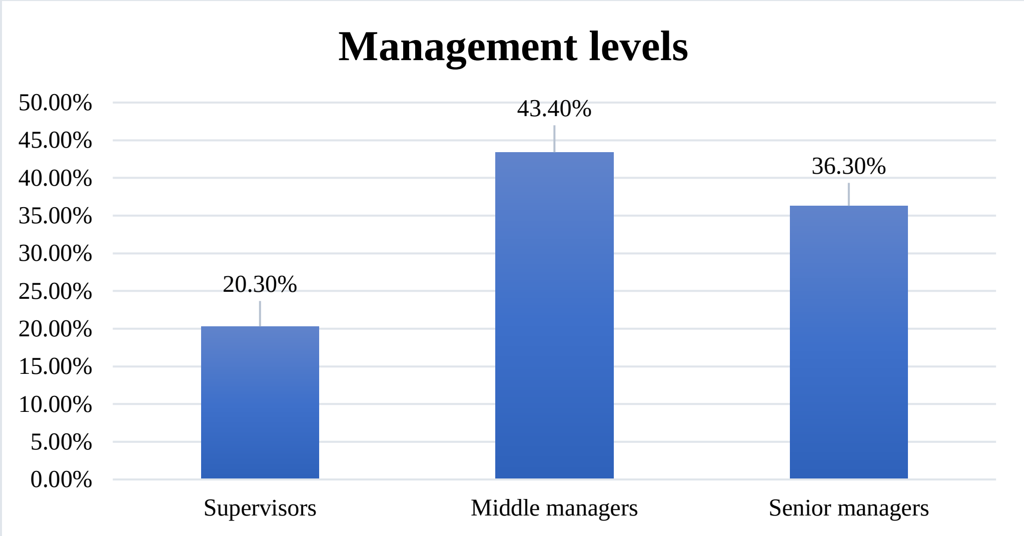



**Figure 5.3** Job levels

### 5.2.3 Descriptive statistics of the construct items

The respondents were asked to answer the survey regarding agility capabilities, sustainable supply chain practices, operations performance objectives and sustainability performance measures. Using the IBM-SPSS statistical package version 26. Table 5.4-6. presents the descriptive statistics including mean, standard deviation, skewness, kurtosis, maximum and minimum for variables.

The table also provides some information concerning the skewness and kurtosis. The skewness value indicates the symmetry of the distribution. The kurtosis, on the other hand, provides information about the 'peakedness' of the distribution. In line with Field (2013), the value of skewness and kurtosis that determine the normality of the data should range from -2.00 to +2.00. as can be seen from the table, none of the observed variables had a skewness greater than the recommended threshold value (Tabachnick and Fidell, 2013), indicating that the data was normally distributed.

Table 5.4 shows better results for sustainable supply chain practices. The mean values of sustainable supply chain practices were relatively high (4.18 to 2.37), and the standard deviation range ranged between 1.89 and 0.818. This confirms evidence that some oil and gas supply chain companies are implementing sustainable practices including sustainable product design, waste reduction initiatives, and socially responsible behaviours, while many companies struggle adopting investment recovery or decommissioning practices to increase sustainable competitive performance.

The results presented in Table 5.5, shows that the oil and gas sector understand to a large extent the important of agility capabilities for improving their sustainable supply chain performance. The most use agile capabilities are collaborative network, people empowerment, technological integration, and processes alignment, while some suppliers do not have strategy on how to sense and respond to changing market requirements (i.e., market sensitivity is the least used techniques). More so, the results (table 5.6) show that cost reduction and quality improvement are the most important benefit of agility and sustainable supply chain practices, while decreased greenhouse gas emission and reduced energy use were the least. These results are not sufficient for arriving at this conclusion; it is necessary to further analyse the data via other statistical techniques, such as factor analysis or structural equation modelling (SEM).

**Table 5.4** Descriptive statistics for independent sustainable supply chain practices

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| **Sustainable design (SD)** | | | | | | | |
| SD1 | 311 | 1 | 5 | 2.77 | .844 | .291 | -.460 |
| SD2 | 311 | 1 | 5 | 2.87 | .902 | .144 | -.715 |
| SD3 | 311 | 1 | 5 | 2.74 | .908 | .375 | -.364 |
| SD4 | 311 | 1 | 5 | 3.11 | .930 | -.219 | -.761 |
| SD5 | 311 | 1 | 5 | 3.05 | .932 | -.114 | -.957 |
| SD6 | 311 | 1 | 5 | 3.06 | .931 | -.128 | -1.000 |
| SD7 | 311 | 1 | 5 | 2.93 | .877 | .080 | -.641 |
| **Sustainable procurement (SPr)** | | | | | | | |
| SPr1 | 311 | 1 | 5 | 3.45 | .893 | -.037 | -.504 |
| SPr4 | 311 | 1 | 5 | 3.49 | .857 | -.042 | -.482 |
| SPr5 | 311 | 1 | 5 | 3.49 | .879 | -.104 | -.303 |
| SPr6 | 311 | 1 | 5 | 3.49 | .879 | -.162 | -.306 |
| SPr8 | 311 | 1 | 5 | 3.52 | .908 | -.206 | -.418 |
| SPr9 | 311 | 1 | 5 | 3.51 | .883 | -.148 | -.310 |

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| **Sustainable production (SPrd)** | | | | | | | |
| SPrd 1 | 311 | 1 | 5 | 3.10 | .805 | -.214 | -.012 |
| SPrd 2 | 311 | 1 | 5 | 3.11 | .822 | -.269 | .099 |
| SPrd 4 | 311 | 1 | 5 | 3.17 | .845 | -.455 | -.183 |
| SPrd 6 | 311 | 1 | 5 | 3.17 | .860 | -.329 | -.130 |
| SPrd 7 | 311 | 1 | 5 | 3.11 | .816 | -.383 | -.035 |
| **Sustainable transport (ST)** | | | | | | | |
| ST1 | 311 | 2 | 5 | 3.62 | .952 | .003 | -.975 |
| ST2 | 311 | 2 | 5 | 3.75 | .948 | -.121 | -1.007 |
| ST3 | 311 | 1 | 5 | 3.48 | .983 | .057 | -.835 |
| ST4 | 311 | 2 | 5 | 3.63 | .899 | .047 | -.846 |
| **Investment recovery (IR)** | | | | | | | |
| IR1 | 311 | 1 | 5 | 2.57 | .916 | .773 | -.066 |
| IR2 | 311 | 1 | 5 | 2.52 | .933 | .573 | -.279 |
| IR3 | 311 | 1 | 5 | 2.37 | .801 | .743 | .162 |
| IR4 | 311 | 1 | 5 | 2.41 | .849 | .619 | -.223 |
| IR5 | 311 | 1 | 5 | 2.43 | .836 | .711 | .139 |
| **Social sustainability practices (SSP)** | | | | | | | |
| SSP1 | 311 | 1 | 5 | 4.17 | 1.189 | -1.261 | .410 |
| SSP2 | 311 | 1 | 5 | 4.15 | 1.181 | -1.248 | .418 |
| SSP3 | 311 | 1 | 5 | 4.18 | 1.169 | -1.276 | .536 |
| SSP4 | 311 | 1 | 5 | 4.13 | 1.161 | -1.219 | .459 |
| SSP5 | 311 | 1 | 5 | 4.14 | 1.175 | -1.215 | .380 |
| SSP6 | 311 | 1 | 5 | 4.21 | .885 | -1.089 | .837 |
| SSP7 | 311 | 1 | 5 | 4.18 | 1.104 | -1.129 | .085 |
| SSP8 | 311 | 1 | 5 | 4.18 | 1.100 | -1.174 | .272 |

Note:
Item SPr1-SPr9, SPrd1-SPrd7, SSP1-SSP8, SD1-SD7, IR1-IR5, and ST1-ST4: 1 = 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent; n is the number of respondent oil and gas industry supply chain companies

**Table 5.5** Descriptive statistics for agile supply chain capabilities

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| **Process alignment (PA)** | | | | | | | |
| PA1 | 311 | 1 | 5 | 3.42 | 1.063 | -.053 | -.886 |
| PA2 | 311 | 1 | 5 | 3.42 | 1.075 | -.046 | -.931 |
| PA4 | 311 | 1 | 5 | 3.39 | 1.083 | -.048 | -.880 |
| PA6 | 311 | 1 | 5 | 3.41 | 1.088 | -.072 | -.892 |
| PA7 | 311 | 1 | 5 | 3.38 | 1.095 | -.032 | -.923 |
| **Employee empowerment (EE)** | | | | | | | |
| EE1 | 311 | 1 | 5 | 3.88 | .745 | -.565 | .662 |
| EE2 | 311 | 1 | 5 | 3.87 | .770 | -.539 | .439 |
| EE3 | 311 | 1 | 5 | 3.79 | .738 | -.477 | .496 |
| EE4 | 311 | 1 | 5 | 3.82 | .745 | -.498 | .506 |
| EE5 | 311 | 1 | 5 | 3.87 | .776 | -.480 | .282 |

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| EE6 | 311 | 1 | 5 | 3.83 | .748 | -.510 | .515 |
| **Market sensitivity (MS)** | | | | | | | |
| MS1 | 311 | 1 | 5 | 2.92 | .861 | -.326 | -.678 |
| MS2 | 311 | 1 | 5 | 2.95 | .873 | -.375 | -.703 |
| MS3 | 311 | 1 | 5 | 2.93 | .904 | -.276 | -.960 |
| MS5 | 311 | 1 | 5 | 2.92 | .893 | -.252 | -.948 |
| MS5 | 311 | 1 | 5 | 2.99 | .891 | -.416 | -.766 |
| **Technology integration (TI)** | | | | | | | |
| TI1 | 311 | 1 | 5 | 3.50 | .915 | -.154 | -.241 |
| TI2 | 311 | 1 | 5 | 3.52 | .960 | -.249 | -.366 |
| TI3 | 311 | 1 | 5 | 3.67 | .959 | -.413 | -.284 |
| TI4 | 311 | 1 | 5 | 3.54 | .939 | -.235 | -.437 |
| TI5 | 311 | 1 | 5 | 3.73 | 1.000 | -.444 | -.437 |
| TI6 | 311 | 1 | 5 | 3.52 | .986 | -.149 | -.671 |
| **Network collaboration (NC)** | | | | | | | |
| NC1 | 311 | 1 | 5 | 4.03 | .634 | -.634 | 1.052 |
| NC2 | 311 | 1 | 5 | 4.03 | .627 | -.657 | 1.257 |
| NC3 | 311 | 1 | 5 | 4.03 | .622 | -.666 | 1.358 |
| NC4 | 311 | 1 | 5 | 3.97 | .622 | -.551 | 1.889 |
| NC5 | 311 | 1 | 5 | 4.02 | .624 | -.656 | 1.275 |
| NC6 | 311 | 1 | 5 | 4.05 | .612 | -.620 | 1.390 |

Note:
Items PA1-PA7, EE1-EE6, MS1-MS5, TI1-TI6, and NC1-NC6: 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important; n is the number of respondents supply chains companies

**Table 5.6** Descriptive statistics for sustainable supply chain performance measurement

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| **Environmental performance (EP)** | | | | | | | |
| EP1 | 311 | 2 | 5 | 3.48 | .690 | -.962 | -.333 |
| EP2 | 311 | 2 | 5 | 3.47 | .694 | -.927 | -.402 |
| EP3 | 311 | 2 | 5 | 3.35 | .683 | -.576 | -.753 |
| EP4 | 311 | 2 | 5 | 3.29 | .673 | -.426 | -.793 |
| EP5 | 311 | 2 | 5 | 3.31 | .674 | -.468 | -.780 |
| EP6 | 311 | 2 | 5 | 3.27 | .667 | -.376 | -.781 |
| **Financial performance (FP)** | | | | | | | |
| FP6 | 311 | 3 | 5 | 3.33 | .473 | .705 | -1.512 |
| FP7 | 311 | 3 | 5 | 3.30 | .460 | .865 | -1.259 |
| FP8 | 311 | 3 | 5 | 3.31 | .464 | .816 | -1.343 |
| FP9 | 311 | 3 | 5 | 3.32 | .467 | .784 | -1.395 |
| FP10 | 311 | 3 | 5 | 3.32 | .468 | .768 | -1.420 |
| **Social performance (SP)** | | | | | | | |
| SP1 | 311 | 1 | 5 | 3.49 | .894 | -.225 | -.505 |
| SP2 | 311 | 1 | 5 | 3.52 | .886 | -.301 | -.435 |
| SP3 | 311 | 1 | 5 | 3.57 | .855 | -.378 | -.071 |
| SP4 | 311 | 2 | 5 | 3.75 | .763 | -.595 | .243 |
| SP5 | 311 | 1 | 5 | 3.42 | .890 | -.123 | -.674 |

| Constructs | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| SP6 | 311 | 2 | 5 | 3.74 | .807 | -.456 | -.125 |
| **Operational performance objectives (OPO)** | | | | | | | |
| OPO1 | 311 | 2 | 5 | 4.06 | .688 | -.682 | 1.111 |
| OPO2 | 311 | 1 | 5 | 4.02 | .693 | -.606 | 1.200 |
| OPO3 | 311 | 1 | 5 | 4.07 | .708 | -.985 | 1.523 |
| OPO4 | 311 | 2 | 5 | 4.11 | .680 | -.320 | -.168 |
| OPO5 | 311 | 1 | 5 | 3.88 | .755 | -.479 | .414 |
| OPO6 | 311 | 1 | 5 | 3.89 | .703 | -.514 | .864 |

Note:
Items EP1-EP5, FP1-FP10, SP1-SP6: 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant; Item OPO1-OP6: 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high

### 5.2.4 Assessing data normality and linearity

Prior to the analysis of the data, a test of normality was carried out using histograms, Kolmogorov-Smirnov and Shapiro-Wilk, and other statistical techniques. Normality is used to describe a symmetrical, bell-shaped curve, which has the greatest frequency of scores in the middle with smaller frequencies towards the extremes (Gravetter and Wallnau, 2004, p. 48). As described in the previous section, normality can also be assessed to some extent by obtaining skewness and kurtosis values. In this study, the test of normality related to the main construct of total agility practices, sustainable practices, operational performance objectives and sustainability performance.

The histogram is a statistical chart that assesses the distribution of a dataset. It provides information about the distribution of scores on each variable. In this study, the results show that the data was normally distributed (see Figure 5.4 below), with most of the scores occurring at the centre, tapering out towards the extremes. Other statistical tests of normality based on Kolmogorov-Smirnov and Shapiro-Wilk values. Table 5.7 presents the results of the Kolmogorov-Smirnov statistic, which test the normality of the distribution. As Coakes et al. (2006) and Pallant (2013) suggested, a non-significant result (Sig. value of more than 0.05), indicates normality. In this case, the significant of 0.200*, shows no violation of the assumption of normality (see table 5.7).

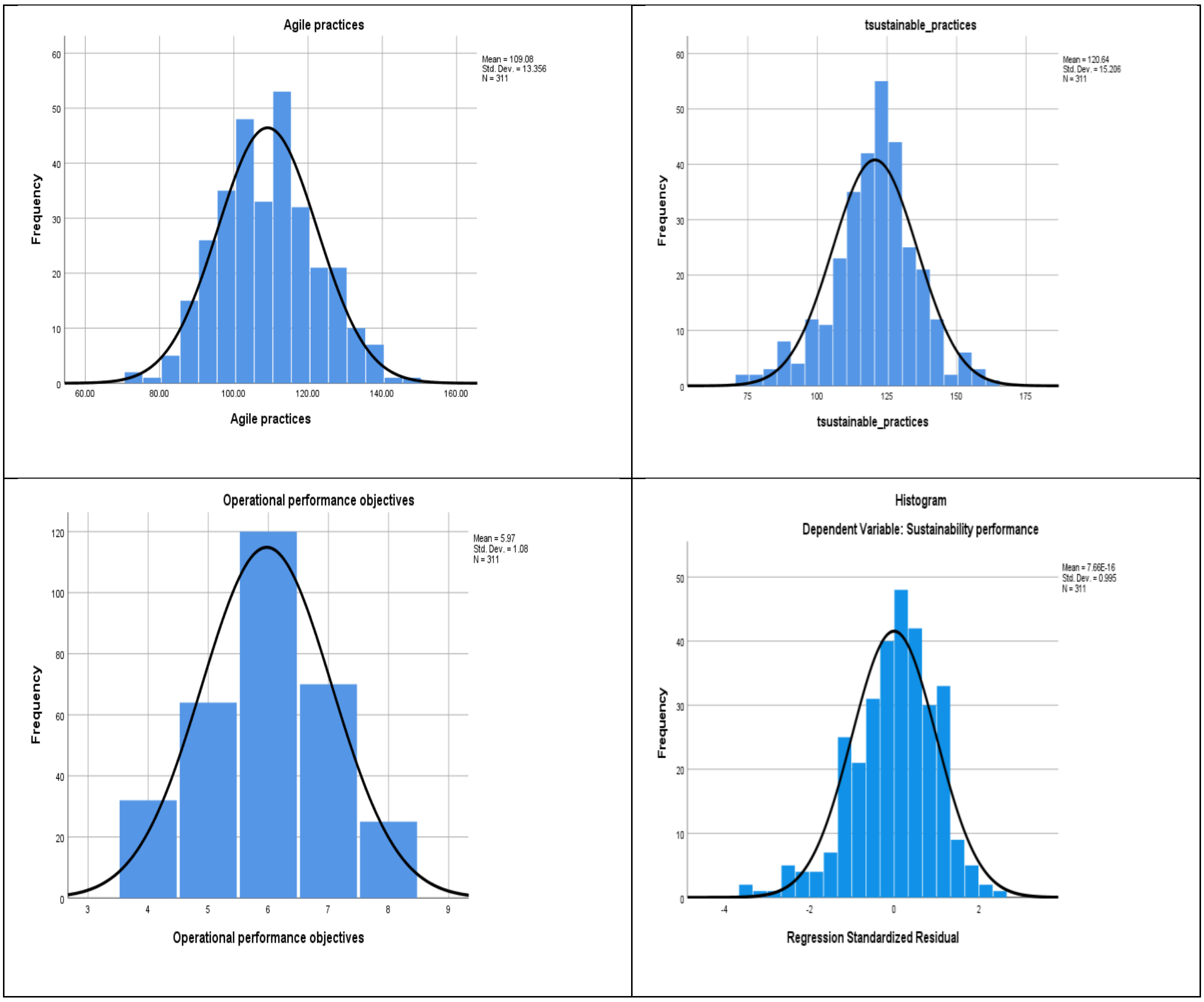



**Figure 5.4** Histogram of sustainable practices, agile capabilities, operational performance, and sustainability performance constructs for data distribution

**Table 5.7** Test of normality for sustainable practices, agile capability, and sustainable supply chain performance

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| Constructs | Statistics | df | Sig. | Statistics | df | Sig. |
| Agile practices | 0.044 | 311 | 0.200* | .992 | 311 | 0.199 |
| Sustainable supply chain practices | 0.047 | 311 | 0.200* | .992 | 311 | 0.088 |
| Operational performance | 0.049 | 311 | 0.170* | .992 | 311 | 0.177 |
| Sustainability performance | 0.045 | 311 | 0.200* | .993 | 311 | 0.171 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

### 5.2.5 Multicollinearity

When the dependent variables are highly correlated, this referred to as multicollinearity. It is the extent to which a variable can be explained by the other variables in the analysis (Hair, 2014). This survey assessed multicollinearity issue by inspecting the correlation matrix as Grewal et al. (2004) suggested. Table 5.8 indicates the correlation coefficient value ranging from ($r$ = 0.517 to 0.721, $p<0.01$), which is far below the limit of 0.80 or 0.90 (Pallant, 2013, p. 290). From the result, it can be confirmed that there was no evidence of multicollinearity and thus the data is normally distributed. Additional analysis was performed on variables as part of multiple regression procedure to pick up on problem of multicollinearity, which could not be evident in the correlation matrix. The results shown that tolerance value for each independent variable is 0.688, which was above the threshold of 0.10; so, we have not violated the multicollinearity assumption. This was also supported by the variance inflation factor (VIF) value, which is 1.454 well below the cut-up of 10, as recommended by Pallant, 2013, p. 158). These results are not surprising, given that correlation coefficient amongst constructs ranges from 0.52 to 0.67 (see Table 5.6).

**Table 5.8** Correlations among dependent variables

| **Secord order constructs** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| Operational performance | **1** | | | |
| Financial performance | 0.611** | **1** | | |
| Social performance | 0.521** | 0.721** | **1** | |
| Environmental performance | 0.581** | 0.679** | 0.517** | **1** |
| N | 311 | 311 | 311 | **311** |

**. Correlation is significant at the 0.01 level (2-tailed).

### 5.2.6 Test of homoscedasticity

Table 5.9 shows the results of Levene test for each of the dependent variables. From the analysis the significant level is above 0.355, as it was greater than 0.05, suggesting that the research have not violated the assumptions of homoscedasticity.

**Table 5.9** Test of homogeneity of variance for dependent variables

| Dependent variables | Levene statistic | df1 | df2 | Sig. |
|---|---|---|---|---|
| Operational performance | 0.838 | 1 | 309 | 0.361 |
| Financial performance | 0.858 | 1 | 309 | 0.355 |
| Social performance | 0.097 | 1 | 309 | 0.756 |
| Environmental performance | 0.031 | 1 | 309 | 0.861 |

# 5.3 Test of psychometric properties

## 5.3.1 Testing the reliability of first order and second-order constructs

The Cronbach's reliability test was used to test the reliability of the survey. It has been suggested that a good reliability should have a Cronbach's alpha coefficient of value above 0.70 and inter-item correlation should be 0.40 or more to be considered as a valid measure of the construct (DeVellis, 2014; Robinson et al., 2013). The results indicate Cronbach's values of 904 for entire study constructs (see table 5.10 for details reliability of sub-constructs). These suggest a very strong internal consistency and reliability as all alpha values are above 0.70 (DeVellis, 2014). Also, all correlated-item-total correlation value exceeded the limit of 0.50 (Nunnally and Bernstein, 1994).

**Table 5.10** Reliability of the study constructs: Cronbach's Alpha, correlated-item-total correlation, and Cronbach's Alpha if item deleted

| Constructs and sub-constructs | Item-total statistics | | | |
|---|---|---|---|---|
| | **Codes** | **Correlated Item-Total Correlation** | **Cronbach's Alpha if Item Deleted** | **Cronbach's Alpha (α)** |
| **Entire constructs** | | | | **0.904** |
| **Sustainable supply chain practices** | | | | **0.852** |
| Sustainable design (SD | | | | **0.924** |
| | SD1 | 0.691 | 0 .919 | |
| | SD2 | 0.842 | 0.904 | |
| | SD3 | 0.736 | 0.915 | |
| | SD4 | 0.766 | 0.912 | |
| | SD5 | 0.789 | 0.910 | |
| | SD6 | 0.811 | 0.907 | |
| | SD7 | 0.693 | 0.919 | |
| Sustainable procurement (SPr) | | | | **0.957** |

| Constructs and sub-constructs | Item-total statistics | | | |
|---|---|---|---|---|
| | Codes | Correlated Item-Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha (α) |
| | SPr1 | 0.868 | 0.949 | |
| | SPr4 | 0.855 | 0.950 | |
| | SPr5 | 0.879 | 0.947 | |
| | SPr6 | 0.870 | 0.948 | |
| | SPr8 | 0.876 | 0.948 | |
| | SPr9 | 0.841 | 0.952 | |
| Investment recovery (IR) | | | | **0.931** |
| | IR1 | 0.771 | 0.923 | |
| | IR2 | 0.817 | 0.914 | |
| | IR3 | 0.863 | 0.905 | |
| | IR4 | 0.836 | 0.910 | |
| | IR5 | 0.797 | 0.917 | |
| Social sustainable practices (SSP) | | | | **0.986** |
| | SSP1 | 0.972 | 0.982 | |
| | SSP2 | 0.973 | 0.982 | |
| | SSP3 | 0.974 | 0.982 | |
| | SSP4 | 0.962 | 0.983 | |
| | SSP5 | 0.960 | 0.983 | |
| | SSP6 | 0.799 | 0.990 | |
| | SSP7 | 0.943 | 0.984 | |
| | SSP8 | 0.939 | 0.984 | |
| Sustainable production (SPrd) | | | | **0.960** |
| | SPrd1 | 0.867 | 0.953 | |
| | SPrd2 | 0.884 | 0.950 | |
| | SPrd4 | 0.889 | 0.949 | |
| | SPrd6 | 0.899 | 0.948 | |
| | SPrd7 | 0.890 | 0.949 | |
| Sustainable transport (ST) | | | | **0.939** |
| | ST1 | 0.903 | 0.906 | |
| | ST2 | 0.865 | 0.918 | |
| | ST3 | 0.854 | 0.922 | |
| | ST4 | 0.804 | 0.937 | |
| **Agility capabilities** | | | | **0.884** |
| Market sensitivity (MS) | | | | **0.978** |
| | MS1 | 0.948 | 0.971 | |
| | MS2 | 0.925 | 0.975 | |
| | MS3 | 0.960 | 0.969 | |
| | MS5 | 0.955 | 0.970 | |
| | MS7 | 0.893 | 0.979 | |
| Employee empowerment (EE) | | | | **0.978** |
| | EE1 | 0.913 | 0.975 | |
| | EE2 | 0.939 | 0.973 | |
| | EE3 | 0.923 | 0.974 | |
| | EE4 | 0.945 | 0.972 | |
| | EE5 | 0.915 | 0.975 | |
| | EE6 | 0.928 | 0.974 | |
| Technology integration (TI) | | | | **0.950** |
| | TI1 | 0.813 | 0.943 | |

| Constructs and sub-constructs | Item-total statistics | | | |
|---|---|---|---|---|
| | Codes | Correlated Item-Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha (α) |
| | TI2 | 0.893 | 0.934 | |
| | TI3 | 0.828 | 0.942 | |
| | TI4 | 0.898 | 0.934 | |
| | TI5 | 0.828 | 0.942 | |
| | TI6 | 0.810 | 0.944 | |
| Process alignment (PA) | | | | **0994** |
| | PA1 | 0.980 | 0.993 | |
| | PA2 | 0.979 | 0.994 | |
| | PA4 | 0.984 | 0.993 | |
| | PA6 | 0.985 | 0.993 | |
| | PA7 | 0.986 | 0.993 | |
| Network collaboration (NC) | | | | **0.991** |
| | NC1 | 0.983 | 0.988 | |
| | NC2 | 0.986 | 0.987 | |
| | NC3 | 0.980 | 0.988 | |
| | NC4 | 0.905 | 0.994 | |
| | NC5 | 0.984 | 0.988 | |
| | NC6 | 0.970 | 0.989 | |
| Operational performance objectives (OPO) | | | | **0.909** |
| | OPO1 | 0.796 | 0.885 | |
| | OPO2 | 0.802 | 0.884 | |
| | OPO4 | 0.745 | 0.892 | |
| | OPO4 | 0.696 | 0.899 | |
| | OPO5 | 0.724 | 0.896 | |
| | OPO6 | 0.719 | 0.896 | |
| **Sustainability performance** | | | | **0.860** |
| Financial performance (FP) | | | | **0.932** |
| | FP6 | 0.726 | 0.934 | |
| | FP7 | 0.777 | 0.924 | |
| | FP8 | 0.890 | 0.903 | |
| | FP9 | 0.828 | 0.914 | |
| | FP10 | 0.878 | 0.905 | |
| Social performance (SP) | | | | **0.927** |
| | SP1 | 0.720 | 0.921 | |
| | SP2 | 0.819 | 0.907 | |
| | SP3 | 0.809 | 0.908 | |
| | SP4 | 0.826 | 0.907 | |
| | SP5 | 0.769 | 0.914 | |
| | SP5 | 0.777 | 0.913 | |
| Environmental performance (EP) | | | | **0.968** |
| | EP1 | 0.895 | 0.962 | |
| | EP2 | 0.904 | 0.961 | |
| | EP3 | 0.909 | 0.961 | |
| | EP4 | 0.900 | 0.962 | |
| | EP5 | 0.905 | 0.961 | |
| | EP6 | 0.868 | 0.965 | |

### 5.3.2 Factor analysis

It is suggested that in addition to estimating the Cronbach's Alpha, an exploratory factor should be conducted to ensure the internal reliability of the measurement (Hair et a., 2014). Prior to performing the exploratory factor analysis, the suitability of data for factor analysis was assessed. Table 5.11 shows that the Kaiser-Meyer-Olkin values was 0.872, exceeding the recommended value of 0.6 (Kaiser, 1974) and Bartlett's Test of Sphricity (Bartlett, 1954) reached statistical significance value of 0.000, supporting the factorability of the correlation matrix, as displayed in Table 5.11.

**Table 5.11** KMO and Bartlett's Test for the entire constructs

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.872 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 35885.440 |
| | df | 3321 |
| | Sig. | 0.000 |

Principal component analysis (PCA) was used as the factor extraction approach to performing exploratory factor analysis. Varimax technique of orthogonal rotation was then used (Fullerton et al., 2014), resulting to sixteen factors with eigenvalue greater than 1, explaining (see table 5.10 for details) of the variance respectively (Hair et al., 2014). All components show strong loadings, and each item loads substantially on one component (see detail in table 5.10). loadings under 0.50 were removed as suggested by (Marshall et al., 2007). The initial 110 items were reduced to 86 items.

In sum, inspection of the factor items in Table 5.12 shows the components of agile supply chain capabilities. For example, component 1 represent processes alignment (PA), component 7 was labelled as market sensitivity (MS), component 8 relates to employee empowerment (EE), component 11 reflected technology integration (TI), and component 14 represent network collaboration (NC). The components on sustainable supply chain practices include component

2: sustainable procurement (SPr); component 3 social sustainability practices (SSP); component 5 sustainable design (SD); component 9: sustainable production (SPrd), component 13 investment recovery (IR), and component 15 sustainable transport (ST). The factors on the dependent variable are component 4; environmental performance (EP); component 6 operational performance objectives (OPO); component 10 social performance (SP) and component 12 financial performance (FP).

**Table 5.12** Exploratory factor analysis: factor loading for explanatory variables.

| Item # | **Factor loadings** | | | | | | | | | | | | | | | **Comlities.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Extraction |
| | SSP | NC | EE | EP | SPr | SD | PA | TI | MS | SP | SPrd | OPO | FP | IR | ST | CE |
| spr1 | | | | | 0.892 | | | | | | | | | | | 0.838 |
| spr4 | | | | | 0.893 | | | | | | | | | | | 0.828 |
| spr5 | | | | | 0.893 | | | | | | | | | | | 0.844 |
| spr6 | | | | | 0.899 | | | | | | | | | | | 0.840 |
| spr8 | | | | | 0.899 | | | | | | | | | | | 0.848 |
| spr9 | | | | | 0.857 | | | | | | | | | | | 0.799 |
| ep1 | | | | 0.917 | | | | | | | | | | | | 0.872 |
| ep2 | | | | 0.924 | | | | | | | | | | | | 0.885 |
| ep3 | | | | 0.909 | | | | | | | | | | | | 0.883 |
| ep4 | | | | 0.896 | | | | | | | | | | | | 0.872 |
| ep5 | | | | 0.909 | | | | | | | | | | | | 0.879 |
| ep6 | | | | 0.884 | | | | | | | | | | | | 0.834 |
| fp6 | | | | | | | | | | | | | 0.799 | | | 0.690 |
| fp7 | | | | | | | | | | | | | 0.838 | | | 0.742 |
| fp8 | | | | | | | | | | | | | 0.931 | | | 0.883 |
| fp9 | | | | | | | | | | | | | 0.891 | | | 0.820 |
| fp10 | | | | | | | | | | | | | 0.916 | | | 0.875 |
| SPrd 1 | | | | | | | | | | | 0.885 | | | | | 0.842 |
| SPrd 2 | | | | | | | | | | | 0.898 | | | | | 0.865 |
| SPrd 4 | | | | | | | | | | | 0.916 | | | | | 0.873 |
| SPrd 6 | | | | | | | | | | | 0.929 | | | | | 0.884 |
| SPrd 7 | | | | | | | | | | | 0.922 | | | | | 0.872 |
| pa1 | | | | | | | 0.977 | | | | | | | | | 0.976 |
| pa2 | | | | | | | 0.978 | | | | | | | | | 0.972 |
| pa4 | | | | | | | 0.978 | | | | | | | | | 0.979 |
| pa6 | | | | | | | 0.982 | | | | | | | | | 0.981 |
| pa7 | | | | | | | 0.981 | | | | | | | | | 0.981 |
| ee1 | | | 0.877 | | | | | | | | | | | | | 0.886 |
| ee2 | | | 0.902 | | | | | | | | | | | | | 0.920 |
| ee3 | | | 0.895 | | | | | | | | | | | | | 0.901 |
| ee4 | | | 0.901 | | | | | | | | | | | | | 0.929 |
| ee5 | | | 0.877 | | | | | | | | | | | | | 0.887 |
| ee6 | | | 0.894 | | | | | | | | | | | | | 0.907 |
| ms1 | | | | | | | | | 0.961 | | | | | | | 0.939 |
| ms2 | | | | | | | | | 0.949 | | | | | | | 0.910 |

| Item # | Factor loadings | | | | | | | | | | | | | | | Comlities. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Extraction |
| | SSP | NC | EE | EP | SPr | SD | PA | TI | MS | SP | SPrd | OPO | FP | IR | ST | CE |
| ms3 | | | | | | | | | 0.966 | | | | | | | 0.952 |
| ms5 | | | | | | | | | 0.962 | | | | | | | 0.944 |
| ms7 | | | | | | | | | 0.926 | | | | | | | 0.871 |
| ssp1 | 0.958 | | | | | | | | | | | | | | | 0.960 |
| ssp2 | 0.960 | | | | | | | | | | | | | | | 0.960 |
| ssp3 | 0.962 | | | | | | | | | | | | | | | 0.963 |
| ssp4 | 0.949 | | | | | | | | | | | | | | | 0.946 |
| ssp5 | 0.952 | | | | | | | | | | | | | | | 0.942 |
| ssp6 | 0.843 | | | | | | | | | | | | | | | 0.723 |
| ssp7 | 0.943 | | | | | | | | | | | | | | | 0.922 |
| ssp8 | 0.941 | | | | | | | | | | | | | | | 0.915 |
| sd1 | | | | | | 0.746 | | | | | | | | | | 0.626 |
| sd2 | | | | | | 0.857 | | | | | | | | | | 0.804 |
| sd3 | | | | | | 0.769 | | | | | | | | | | 0.675 |
| sd4 | | | | | | 0.779 | | | | | | | | | | 0.715 |
| sd5 | | | | | | 0.820 | | | | | | | | | | 0.741 |
| sd6 | | | | | | 0.831 | | | | | | | | | | 0.770 |
| sd7 | | | | | | 0.738 | | | | | | | | | | 0.616 |
| ti1 | | | | | | | | 0.864 | | | | | | | | 0.772 |
| ti2 | | | | | | | | 0.923 | | | | | | | | 0.873 |
| ti3 | | | | | | | | 0.864 | | | | | | | | 0.787 |
| ti4 | | | | | | | | 0.928 | | | | | | | | 0.870 |
| ti5 | | | | | | | | 0.878 | | | | | | | | 0.793 |
| ti6 | | | | | | | | 0.865 | | | | | | | | 0.772 |
| sp1 | | | | | | | | | | 0.732 | | | | | | 0.656 |
| sp2 | | | | | | | | | | 0.841 | | | | | | 0.790 |
| sp3 | | | | | | | | | | 0.807 | | | | | | 0.776 |
| sp4 | | | | | | | | | | 0.825 | | | | | | 0.791 |
| sp5 | | | | | | | | | | 0.803 | | | | | | 0.733 |
| sp6 | | | | | | | | | | 0.789 | | | | | | 0.740 |
| ir1 | | | | | | | | | | | | | | 0.808 | | 0.731 |
| ir2 | | | | | | | | | | | | | | 0.862 | | 0.801 |
| ir3 | | | | | | | | | | | | | | 0.903 | | 0.852 |
| ir4 | | | | | | | | | | | | | | 0.877 | | 0.819 |
| ir5 | | | | | | | | | | | | | | 0.851 | | 0.772 |
| nc1 | | 0.920 | | | | | | | | | | | | | | 0.977 |
| nc2 | | 0.927 | | | | | | | | | | | | | | 0.981 |
| nc3 | | 0.914 | | | | | | | | | | | | | | 0.974 |
| nc4 | | 0.868 | | | | | | | | | | | | | | 0.873 |
| nc5 | | 0.921 | | | | | | | | | | | | | | 0.978 |
| nc6 | | 0.916 | | | | | | | | | | | | | | 0.963 |
| opo1 | | | | | | | | | | | | 0.817 | | | | 0.769 |
| opo2 | | | | | | | | | | | | 0.773 | | | | 0.779 |
| opo4 | | | | | | | | | | | | 0.774 | | | | 0.697 |
| opo4 | | | | | | | | | | | | 0.723 | | | | 0.642 |
| opo5 | | | | | | | | | | | | 0.802 | | | | 0.724 |
| opo6 | | | | | | | | | | | | 0.750 | | | | 0.670 |
| st1 | | | | | | | | | | | | | | | 0.937 | 0.903 |
| st2 | | | | | | | | | | | | | | | 0.916 | 0.864 |
| st3 | | | | | | | | | | | | | | | 0.904 | 0.852 |
| st4 | | | | | | | | | | | | | | | 0.871 | 0.803 |

| Item # | Factor loadings | | | | | | | | | | | | | | | Comlities. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Extraction |
| | SSP | NC | EE | EP | SPr | SD | PA | TI | MS | SP | SPrd | OPO | FP | IR | ST | CE |
| **% Of Variance** | **15.07 %** | **11.52 %** | **6.84 %** | **6.43 %** | **5.85 %** | **5.68 %** | **5.02 %** | **4.83 %** | **4.14 %** | **3.97 %** | **3.55 %** | **3.13%** | **2.97%** | **2.88%** | **2.57%** | |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

CE. Communalities extraction

### 5.3.3 Assessing validation of constructs

The confirmatory factor analysis was performed separately for independent and dependent variables. Confirmatory factor analysis was used to evaluate the research constructs. It enables a series of observable items to be directly or indirectly related to the laten variables or factors (Hays et al., 1994). Maximum likelihood (ML) is the method of estimation employed. This procedure allows for a global adjustment of the proposed models over diverse statistics that were corrected for non-normality assumptions. The results show a good model fit for the independent and dependent variables as follows: independent variables normed chi-square (chi-square/degree of freedom) value of 1.336; a root means square error of approximation (RMSEA) = 0.033; a goodness of fit index (GFI) value of 0.829; and a comparative fit index (CFI) value of 0.982. Whilst dependent variables include normed chi-square (chi-square/degree of freedom) value of 1.886; a root mean square error of approximation (RMSEA) = 0.053; a goodness of fit index (GFI) value of 0.906; and a comparative fit index (CFI) value of 0.985 were found to be adequate. The fit indices equal to or exceeded the minimum threshold value of 0.9 as recommended by (Koufteros, 1999). In addition, standardised items loadings were in all cases above 0.70 (see table 5.10). Thus, support was found for the convergent validity (Tabachnick and Fidell, 2014; Byrne, 2016).

More so, the average variance extracted (AVE) was used to assess the amount of variance that is captured by a construct to the amount of variance due to measurement error. As depicted in

Table 5.13 and 5.14, both the average variance extracted and composite reliability of all the latent constructs was higher than the threshold level of 0.50 and 0.70, respectively. Thus, in all cases, these measurement models provided enough evidence of the convergent validity and composite reliability as recommended by Fornell and Larcker (1981).

**Table 5.13** The average variance extracted (AVE) and composite reliability of constructs

| Second-order constructs | First-order constructs | AVE | Composite reliability |
|---|---|---|---|
| Sustainable supply chain practices | | 0.781 | 0.992 |
| | Sustainable design | 0.628 | 0.922 |
| | Sustainable procurement | 0.790 | 0.958 |
| | Investment recovery | 0.741 | 0.935 |
| | Social sustainability practices | 0.882 | 0.984 |
| | Sustainable transport | 0.823 | 0.949 |
| | Environmental management practices | 0.829 | 0.960 |
| Agile capabilities | | 0.850 | 0.994 |
| | Market sensitivity | 0.908 | 0.980 |
| | Technology integration | 0.787 | 0.957 |
| | Process alignment | 0.959 | 0.991 |
| | Network collaboration | 0.830 | 0.967 |
| | Employee empowerment | 0.794 | 0.958 |
| Operational performance objectives | | 0.599 | 0.899 |
| Sustainability performance | | 0.742 | 0.980 |
| | Financial performance | 0.768 | 0.943 |
| | Social performance | 0.640 | 0.914 |
| | Environmental performance | 0.822 | 0.965 |

#### 5.3.3.1 Assessing discriminant validity

Discriminant validity was also indicated at the construct level, as none of the construct correlations has a confidence interval that included the value of 1 or none of the variables were theorised to be uncorrelated (Bougie and Sekaran, 2020). Discriminant validity was also assessed using the average extracted variance (AVE). This study compared the square root of the construct’s average variance extracted with the constructs correlation to established discriminant validity as suggested by Fornell and Larcker (1981). Table 5.14 and Table 5.15 indicates the square root of the average variance extracted as bold in the diagonal. As can be seen, the entire construct’s correlations were found to be less than the square root of the average variance extracted for individual construct. As such, there is support for discriminant validity.

The study also followed the procedure given in Campbell and Fiske (1959); Stratman and Roth (2002), which include performing a confirmatory factor analysis for the selected pair of scales, enabling correlation between constructs, and repeating the confirmatory analysis, setting the correlation of scales to a value 1. A significant difference in the $X^2$-value for the two models shows that the constructs considered are different. The $X^2$ difference was significant in all cases at ($p < 0.05$), indicating that the scales represented different constructs.

**Table 5.14** Correlation matric, convergent and discriminant validity test of the constructs (second-order model)

| | **α** | **CR** | **AVE** | **AC** | **SSCP** | OperPerf | SusPerf |
|---|---|---|---|---|---|---|---|
| Agile capabilities (AC) | 0.884 | 0.994 | 0.850 | **0.922** | | | |
| Sustainable supply chain practices (SSCP) | 0.864 | 0.991 | 0.776 | .559** | **0.881** | | |
| Operational performance (OperPerf) | 0.909 | 0.899 | 0.598 | .639** | .517** | **0.773** | |
| Sustainability performance (SusPerf) | 0.860 | 0.979 | 0.742 | .683** | .685** | .653** | **0.861** |

**. Correlation is significant at the 0.01 level (2-tailed).
A construct reliabilities
Square root of Average Variance Extracted (AVE) shown as bold in diagonal

**Table 5.15** Correlation matric, convergent and discriminant validity test of the constructs (first-order model)

| **Sub-constructs** | **CR** | **AVE** | **EE** | **MS** | **PA** | **TI** | **NC** | **EMP** | **SPr** | **SD** | **IR** | **SSP** | **ST** | **OPO** | **EP** | **SP** | **FP** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Employee empowerment (EE) | .958 | .794 | ***.891*** | | | | | | | | | | | | | | |
| Market sensitivity (MS) | .980 | .908 | .231** | ***.953*** | | | | | | | | | | | | | |
| Process alignment (PA) | .991 | .959 | .543** | .314** | ***.979*** | | | | | | | | | | | | |
| Technology integration (TI) | .957 | .787 | .455** | .354** | .557** | ***.887*** | | | | | | | | | | | |
| Network collaboration (NC) | .967 | .830 | .395** | .265** | .555** | .528** | ***.911*** | | | | | | | | | | |
| Sustainable production (SPrd) | .960 | .829 | .127* | .118* | .109 | .154** | .161** | ***.910*** | | | | | | | | | |
| Sustainable procurement (SPr) | .958 | .790 | .398** | .372** | .466** | .522** | .344** | .424** | ***.889*** | | | | | | | | |
| Sustainable Design (SD) | .922 | .628 | .328** | .370** | .323** | .430** | .313** | .651** | .680** | ***.792*** | | | | | | | |
| Investment recovery (IR) | .935 | .741 | .266** | .213** | .313** | .317** | .105 | .165** | .432** | .398** | ***.861*** | | | | | | |
| Social sustainability practices (SSP) | .984 | .882 | .338** | .268** | .441** | .443** | .269** | .132* | .681** | .392** | .334** | ***.939*** | | | | | |
| Sustainable transportation (ST) | .949 | .823 | .244** | .261** | .209** | .279** | .262** | .114* | .569** | .720** | .104 | .294** | ***.907*** | | | | |
| Operational performance objectives (OPO) | .899 | .599 | .457** | .430** | .558** | .490** | .457** | .187** | .517** | .515** | .372** | .371** | .465** | ***.774*** | | | |
| Environmental performance (EP) | .965 | .822 | .446** | .387** | .481** | .561** | .425** | .178** | .684** | .483** | .323** | .641** | .399** | .581** | ***.907*** | | |
| Social performance (SP) | .914 | .640 | .327** | .380** | .568** | .399** | .359** | .162** | .500** | .393** | .235** | .438** | .278** | .521** | .517** | ***.800*** | |
| Financial performance (FP) | .943 | .768 | .384** | .559** | .511** | .449** | .376** | .275** | .626** | .517** | .313** | .530** | .372** | .611** | .679** | .721** | ***.876*** |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Square root of Average Variance Extracted (AVE) shown as bold in diagonal

#### 5.3.3.2 Assessing common method bias

Since the data were gathered from single respondents, there exists the possibility of common methods bias. This study used procedural approach to reduce the potential for common method bias (Podsakoff et al., 2003; Jajja et al., 2018; Fawcett et al., 2014). The respondents to the questionnaire survey were mostly supply chain professionals with high level of skills, knowledge, and experience about agility and sustainability, which tends to minimise common method bias. In the same way, Harman's one-factor test was carried out (Harman, 1967; Podsakoff et al., 2003). As mentioned earlier, an exploratory factor analysis was conducted on the variables and it did not yield a single-factor solution, suggesting that common method bias is not a problem in this study. This is because several factors were identified; the first factor did not account for the majority of variance; and there is no general factor in the unrotated factor structure. In addition, the validity and reliability test (Table 5.12 and Table 5.13) plus whole model fit (Table 5.13) show strong support for the suitability of the model constructs.

#### 5.3.3.3 Assessing the fit of the measurement model

A measurement model is the relationship between a set of observed variables and the construct that they are intended to measure (Easterby-Smith et al., 2018). After the model has been specified and then estimated, there is the need to determine whether it is a good model fit to run structural equation modelling. The key factor of a good model is the fit among the covariance matrices. One very rough rule of thumb, however, directly related to the $\chi^2$ value is that a good-fitting model may be indicated when the ratio of the chi-squared test $\chi^2$ to the degree of freedom is less than 2. Broadly, the following type of fit indexes was assessed (Hair et al., 2014; Tabachnick and Fidell, 2014). The normed fit index (NFI), which compares the $\chi^2$ value of the estimated model to the $\chi^2$ value of the independent model. The non-normed fit index (NNFI) which is an adjustment to the NFI integrating the degree of freedom in the model, the incremental fit index (IFI) which addresses the problem of the large variability in the NNFI and the comparative fit index (CFI) that assesses fit relative to other models. Other fit indexes include the root mean square error of approximation (RMSEA); the goodness-of-fit index (GFI), and many others (Hair et al., 2014; Tabachnick and Fidell, 2014). The suggested values for CFI, NFI, IFI and TLI must be above 0.90 or close to 1.00 (Byrne, 2016). Whereas RMSEA values for a good model should be less than or equal to 0.06 (Hu and Bentler, 1999).

In this study, the assessment of distinct measurement models was done: (1) to test the hypothesised structure of the agile capability constructs using the second-order confirmatory analysis, and (2) to test the first-order measurement model including agile practices, sustainable practices, operational performance, and sustainability performance constructs (Thornton et al., 2015; Byrne, 2016). The section below describes the results of the second order and first-order measurement models.

#### 5.3.3.4 Sustainable practices and agile capabilities as a higher-order model

In line with the current works on agility capabilities (Eckstein et al., 2015; Aslam et al., 2018; Blome et al., 2013), the agile capability was operationalised as a higher-order construct, which reflects market sensitivity, technology integration, process alignment, network collaboration and employee empowerment. The second-order factor model was examined to confirm that agility capability is a second-order reflective measurement model. The results show a good model fit for the agile capability variables as follows: a normed chi-square (chi-square/degree of freedom) value of ($X^2 = 1.68$, $P < 0.001$); CFI value of 0.986; TLI value of 0.984; IFI value of 0.986; NFI value of 0.965 and RMSEA value of 0.047. The fit indices were equal to or exceeded the minimum threshold value of 0.90 as recommended by Koufteros, (1999); Dangelico et al. (2017). Also, standardised loadings were in all cases above 0.70.

As can be seen in figure 5.5 the standardised loadings between the second order and first-order constructs are statistically significant at $p < 0.001$ with technology integration: 0.820, network collaboration: 0.885, process alignment: 0.937, market sensitivity: 0.968, and employee empowerment: 0.953. The figure also depicted the standardised loadings for sustainable supply chain practices and performance objectives.

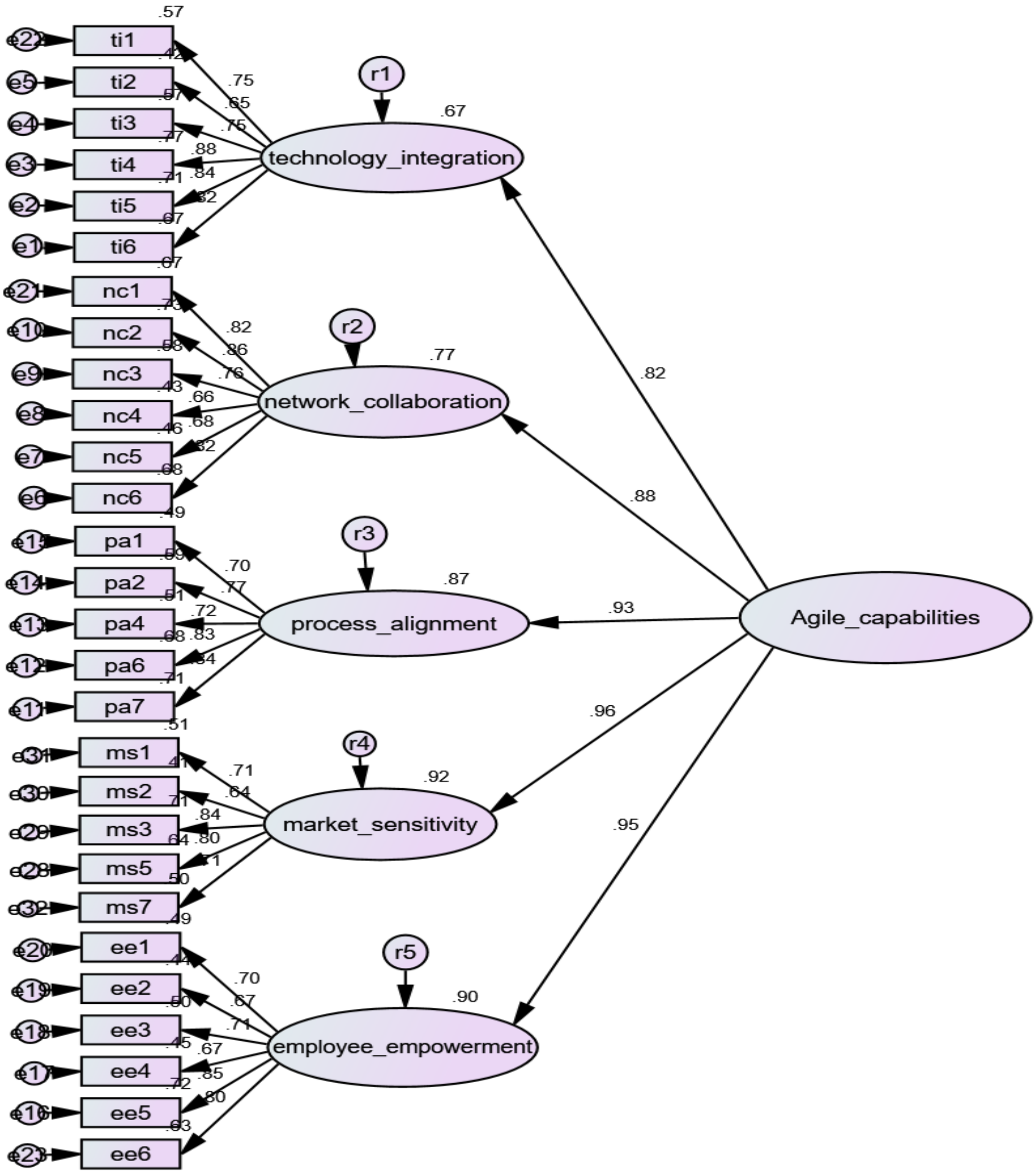



**Figure 5.5** Measurement model of agile supply chain capabilities

Figure 5.6 the shows the measurement model of sustainable supply chain practice. The standardised loadings between the second order and first-order constructs are statistically significant at $p < 0.001$ with sustainable design: 0.885, sustainable procurement: 0.854, sustainable transportation: 0.779, investment recovery: 0.884, and social sustainable practices: 0.728. The figure also depicted the standardised loadings for sustainable supply chain practices and performance objectives.

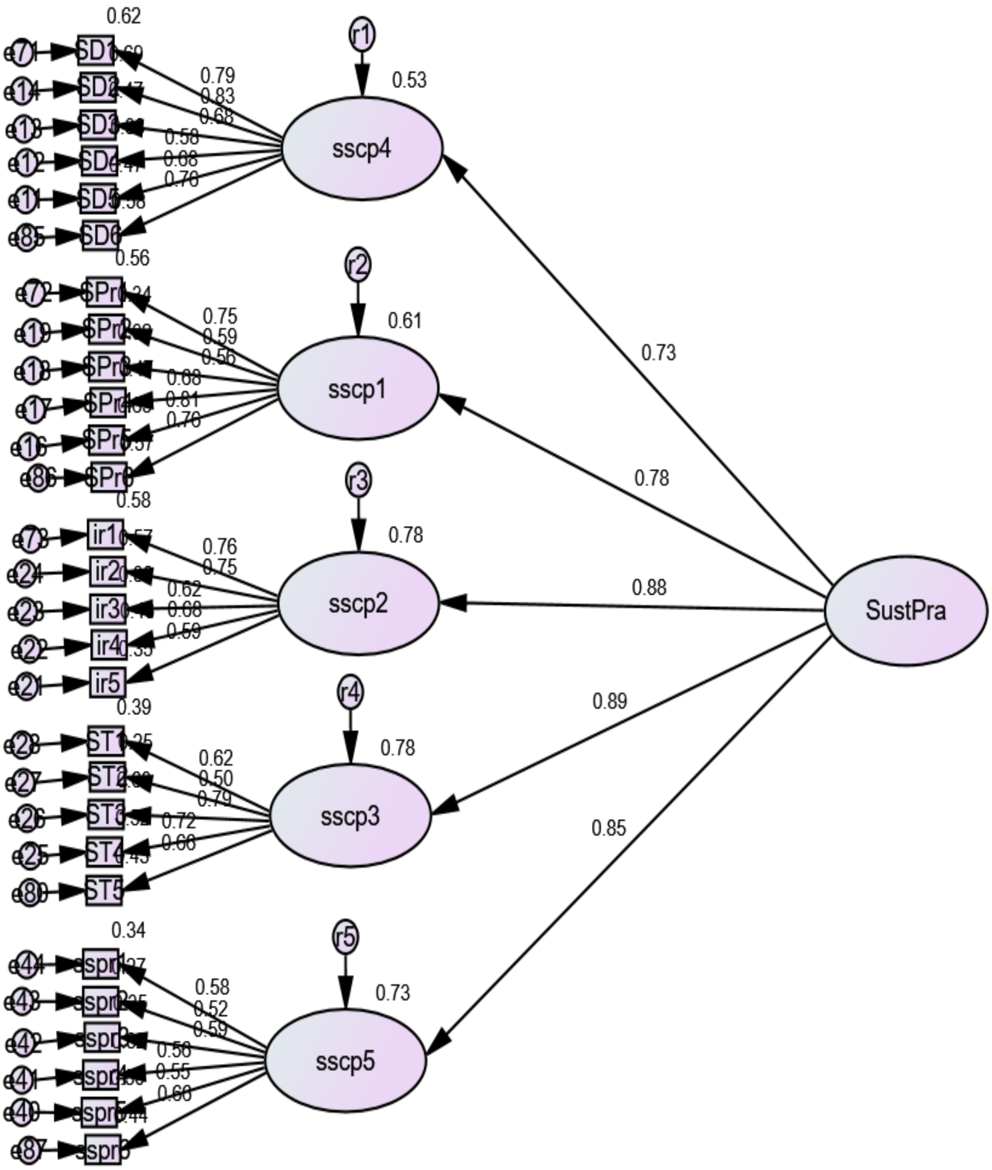



**Figure 5.6** Measurement model of sustainable supply chain practices

#### 5.3.3.5 The measurement models fit for the entire first-order constructs

Based on the above second-order measurement model, a separate first-order measurement model was carried out. In this study, the assessment of model fit shows a normed chi-square (chi-square/degree of freedom) value of ($X^2$ = 1.735, $P < 0.001$); CFI value of 0.932; TLI value of 0.928; IFI value of 0.932; NFI value of 0.853 and RMSEA value of 0.049. This indicates that the model provides a good model fit. As well, the fifteen components give a good structure in which to continue the structural equation modelling. The standardised values for the item loadings and the t-values for all the scale items are shown in Table 5.16.

**Table 5.16** Results of confirmatory factor analysis

| Items # | Scale items | Standardised item loadings | $R^2$ | t-value |
|---|---|---|---|---|
| **Entire constructs Cronbach's α = .906** | | | | |
| Agile capabilities/practices | Second-order construct consisting of five main dimensions; Cronbach's α = (.884) | | | |
| Process alignment (PA) | Cronbach's α = (.994), CR = (0.991), AVE = (0.959) | | | |
| PA1 | Decentralised decision making | .983 | .966 | 9.043 |
| PA2 | Cross functional teams | .982 | .964 | 9.105 |
| PA4 | Information accessible to employees | .990 | .981 | 7.040 |
| PA6 | Concurrent execution of activities | .984 | .969 | 9.254 |
| PA7 | Quality over product life | .984 | .969 | _a |
| Technology integration (TI) | Cronbach's α = (.950), CR = (0.957), AVE = (0.787) | | | |
| TI1 | Flexible production technology | .836 | .699 | _a |
| TI2 | Leadership in the use of current technology | .928 | .861 | 8.885 |
| TI3 | Skill and knowledge enhancing technologies | .848 | .720 | 10.997 |
| TI4 | Technology awareness | .931 | .867 | 8.706 |
| TI5 | First time right design | .843 | .710 | 11.064 |
| TI6 | Virtual enterprise | .841 | .706 | 11.089 |
| Network collaboration (NC) | Cronbach's α = (.991), CR = (0.967), AVE = (0.830) | | | |
| NC1 | Close relationship with customer | .991 | .983 | _a |
| NC2 | Trust-based relationship with customers/suppliers | .994 | .989 | 7.586 |
| NC3 | Multi-venturing capabilities | .982 | .964 | 10.972 |
| NC4 | Rapid partnership formation | .906 | .821 | 12.205 |
| NC5 | Teams across company borders | .986 | .973 | 10.495 |
| NC6 | Enterprise integration | .977 | .956 | 11.285 |
| Employee empowerment (EE) | Cronbach's α = (.978), CR = (0.958), AVE = (0.794) | | | |
| EE1 | Employee satisfaction | .910 | .828 | 9.989 |
| EE2 | Learning organisation | .936 | .876 | 10.388 |
| EE3 | Workforce skill upgrade | .934 | .872 | 8.707 |
| EE4 | Multi-skilled and flexible people | .962 | .926 | 10.436 |
| EE5 | Continuous training and development | .935 | .875 | 10.313 |
| EE6 | Culture of change | .945 | .892 | _a |
| Market sensitivity (MS) | Cronbach's α = (.978), CR = (0.980), AVE = (0.908) | | | |
| MS1 | Customer driven innovation | .944 | .892 | 11.544 |
| MS2 | Response to changing market requirements | .918 | .842 | 7.712 |

| Items # | Scale items | Standardised item loadings | $R^2$ | t-value |
|---|---|---|---|---|
| MS3 | New product introduction | .983 | .967 | 6.063 |
| MS5 | Customer satisfaction | .976 | .953 | 11.274 |
| MS7 | Strategic relationship with customers and stakeholders | .904 | .816 | _a |
| Sustainable supply chain practices | Second-order construct consisting of five main dimensions; Cronbach's α = (.864) | | | |
| Sustainable procurement (SPr) | Cronbach's α = (.957), CR = (0.958), AVE = (0.790) | | | |
| SPr1 | Sustainability audit for suppliers' internal management | .891 | .795 | 10.286 |
| SPr4 | Cooperation with customer for sustainable packaging | .877 | .770 | 10.584 |
| SPr5 | Cooperation with suppliers for sustainability objectives | .901 | .813 | 10.022 |
| SPr6 | Providing design specification to suppliers that include sustainability requirements for their process | .893 | .798 | 10.247 |
| SPr8 | Supplier' ISO 14000 certification | .899 | .809 | 10.087 |
| SPr9 | Multi-tiers suppliers' sustainability practices evaluation | .864 | .747 | _a |
| Sustainable design (SD) | Cronbach's α = (.924), CR = (0.922), AVE = (0.628) | | | |
| SD1 | Cooperation with customers for eco design | .717 | .515 | 11.497 |
| SD2 | Design of products for reduced consumption of materials | .869 | .755 | 9.650 |
| SD3 | Design of products for reuse, recycle, remanufacturing, and/or recovery of materials and component parts | .769 | .591 | 11.146 |
| SD4 | Design of products for easy disassembly | .808 | .654 | 10.744 |
| SD5 | Design of products to avoid or reduce use of hazardous materials | .835 | .698 | 10.359 |
| SD6 | Cooperation with customers for cleaner production | .723 | .523 | 11.467 |
| SD7 | Design of products for reduced consumption of energy | .855 | .730 | _a |
| Investment recovery (IR) | Cronbach's α = (.931), CR = (0.935), AVE = (0.741) | | | |
| IR1 | We used a product's materials for a basic, low value purpose | .801 | .641 | _a |
| IR2 | We are extracting a product's raw materials and using them for new products | .853 | .728 | 10.143 |
| IR3 | We returned products to the performance specification of the original equipment manufacturer | .907 | .823 | 8.414 |
| IR4 | We are redeploying products without the need for refurbishment | .879 | .772 | 9.514 |
| IR5 | We sale excess capital equipment | .834 | .695 | 10.499 |
| Social sustainability practices (SSP) | Cronbach's α = (.986), CR = (0.984), AVE = (0.882) | | | |
| SSP1 | We established health and safety management system | .988 | .978 | 8.995 |
| SSP2 | We support community involvement and development | .985 | .979 | 8.923 |
| SSP3 | Worker's Skills and capabilities development | .989 | .978 | 9.147 |
| SSP4 | Respect for people rights | .968 | .936 | 11.361 |
| SSP5 | Provide training for emergency preparedness program to employees, suppliers and community | .963 | .928 | 11.500 |
| SSP6 | We guarantee worker's health and safety at work | .792 | .627 | 12.327 |
| SSP7 | We make products that protect consumers' health and safety | .924 | .854 | 12.021 |
| SSP8 | We support and promote health situation in the community | .920 | .847 | _a |
| Sustainable production practices (SPrd) | Cronbach's α = (.960), CR = (0.960), AVE = (0.829) | | | |
| SPrd1 | We monitor our suppliers' commitment to sustainability improvement | .883 | .780 | 10.607 |
| SPrd 2 | Commitment of sustainability practices from senior manager | .901 | .811 | 10.199 |
| SPrd 4 | We helped our suppliers obtain ISO 14001 certification | .916 | .838 | 9.725 |
| SPrd 6 | Support for sustainability practices from mid-level managers | .928 | .861 | 9.187 |
| SPrd7 | We frequently visit our suppliers' premises to help improve their eco innovation | .916 | .838 | _a |

| Items # | Scale items | Standardised item loadings | $R^2$ | t-value |
|---|---|---|---|---|
| Sustainable transportation | | | | |
| ST1 | We use renewable energy in any model of product transportation | .953 | .909 | _a |
| ST2 | We track and monitor carbon footprint caused during product delivery | .900 | .809 | 9.460 |
| ST3 | We frequently upgrade freight logistics and transportation systems | .892 | .795 | 9.782 |
| ST4 | We work together with our customers for using less energy during product delivery | .820 | .673 | 11.104 |
| Operational performance objectives (OPO) | Cronbach's α = (.909), CR = (0.899), AVE = (0.598) | | | |
| OPO1 | Costs | .843 | .711 | _a |
| OPO2 | Flexibility | .862 | .743 | 9.189 |
| OPO4 | Quality | .782 | .611 | 10.686 |
| OPO4 | Innovation | .742 | .550 | 11.083 |
| OPO5 | Reliability | .763 | .582 | 10.892 |
| OPO6 | Speed | .750 | .562 | 11.012 |
| Sustainability performance | Second-order construct consisting of three main dimensions, Cronbach's α = (.860) | | | |
| Financial performance (FP) | Cronbach's α = (.932), CR = (0.943), AVE = (0.768) | | | |
| FP6 | Increase in rate of return on investment | .724 | .524 | _a |
| FP7 | Growth in market share | .773 | .597 | 11.531 |
| FP8 | Increase in sale turnover | .928 | .860 | 8.415 |
| FP9 | Increase in profitability | .905 | .818 | 9.552 |
| FP10 | Increase in customers' satisfaction | .937 | .878 | 7.784 |
| Social performance (SP) | Cronbach's α = (.927), CR = (0.914), AVE = (0.640) | | | |
| SP1 | Improved overall stakeholders' welfare | .755 | .569 | _a |
| SP2 | Improved health and safety of the community | .857 | .735 | 9.936 |
| SP3 | Improved health and safety of workers | .852 | .725 | 10.051 |
| SP4 | Improved community involvement and development | .873 | .762 | 9.539 |
| SP5 | Improved awareness or protection of human rights | .801 | .641 | 10.839 |
| SP5 | Improved product responsibility | .805 | .647 | 10.792 |
| Environmental performance (EP) | Cronbach's α = (.968), CR = (0.965), AVE = (0.822) | | | |
| EP1 | Reduction in solid waste and wastewater | .981 | .963 | _a |
| EP2 | Reduction of air emission | .988 | .976 | 4.289 |
| EP3 | Decrease in use of natural resources | .880 | .775 | 11.857 |
| EP4 | Decrease in consumption for hazardous/harmful/toxic materials | .835 | .697 | 12.059 |
| EP5 | Decrease in frequency for environmental accidents | .817 | .668 | 12.108 |
| EP6 | Improvement of an enterprise's environmental situation | .786 | .619 | 12.174 |

*** all significant to $P < 0.000$

_a indicates a parameter that was fixed at 1.000

n = 311, Estimation Method = Maximum Likelihood.

Model fit indexes: CMIN/DF = 1.735; CFI = 0.932; TLI = 0.928; IFI = 0.932; and RMSEA = 0.049

## 5.4 Structural model

Having validated the measurement model and attained construct validity like convergent, discriminant and face validity as well as assuring the absence of the common method bias and multi-collinearity issues, it was now possible to examine the causal relationships in the theorised model using structural equation modelling techniques. This section thus ascertains if the suggested research hypotheses are supported by the data, reporting the results of the hypothesis testing with the full-scale structural equation modelling.

### 5.4.1 Assessing the fit of the structural model

Before hypotheses testing, it was essential to validate the structural model (Hair et al., 2014). The structural model is a conceptual representation of structural correlations amongst hypothesised constructs via path estimates (Schreiber et al., 2006). It was described in AMOS, as shown in Figure 5.7 -10 below.

Even though we have found some support for the hypothesised model, post hoc model modifications were carried out to develop a better fitting model. Based on the theoretical importance, seven residual covariances were estimated (residual covariance among: information accessible to employees and team across company borders; concurrent execution of activities and quality over product life; monitor supplier operations and leadership commitment; provision of design specification to supplier and ISO 14000 certification; and increase in profitability and increase in customer satisfaction). The model was significantly improved with the addition of these paths. The assessment of model fit shows a normed chi-square (chi-square/degree of freedom) value of ($X^2$ = 1.389, $P$ < 0.001); CFI value of 0.963; TLI value of 0.962; IFI value of 0.963 and RMSEA value of 0.035. These indicate adequate fit (see details in Table 4.14).

As depicted in Figure 5.5, the conceptual model of this empirical study integrates agile supply chains capabilities, sustainable supply chain practices with operational performance objectives and sustainability performance. The proposed hypotheses were established in chapter 3 for a specific relationship amongst the four constructs. In line with Milanov and Shepherd (2013), three ratios of significance were used to test hypotheses: ≤0.05, ≤0.01, and ≤0.001. The lesser the significant value, the greater the data deviates from the null hypothesis. Thus, ≤0.001 is regarded as a high significance value, while ≤0.05 was considered as a marginal significance value. Previous works used these significance levels to test hypotheses (Eckstein et al., 2015; Aslam et al., 2018; Blome et al., 2013, 2014). In the following sections, we will present the results of the hypotheses testing.

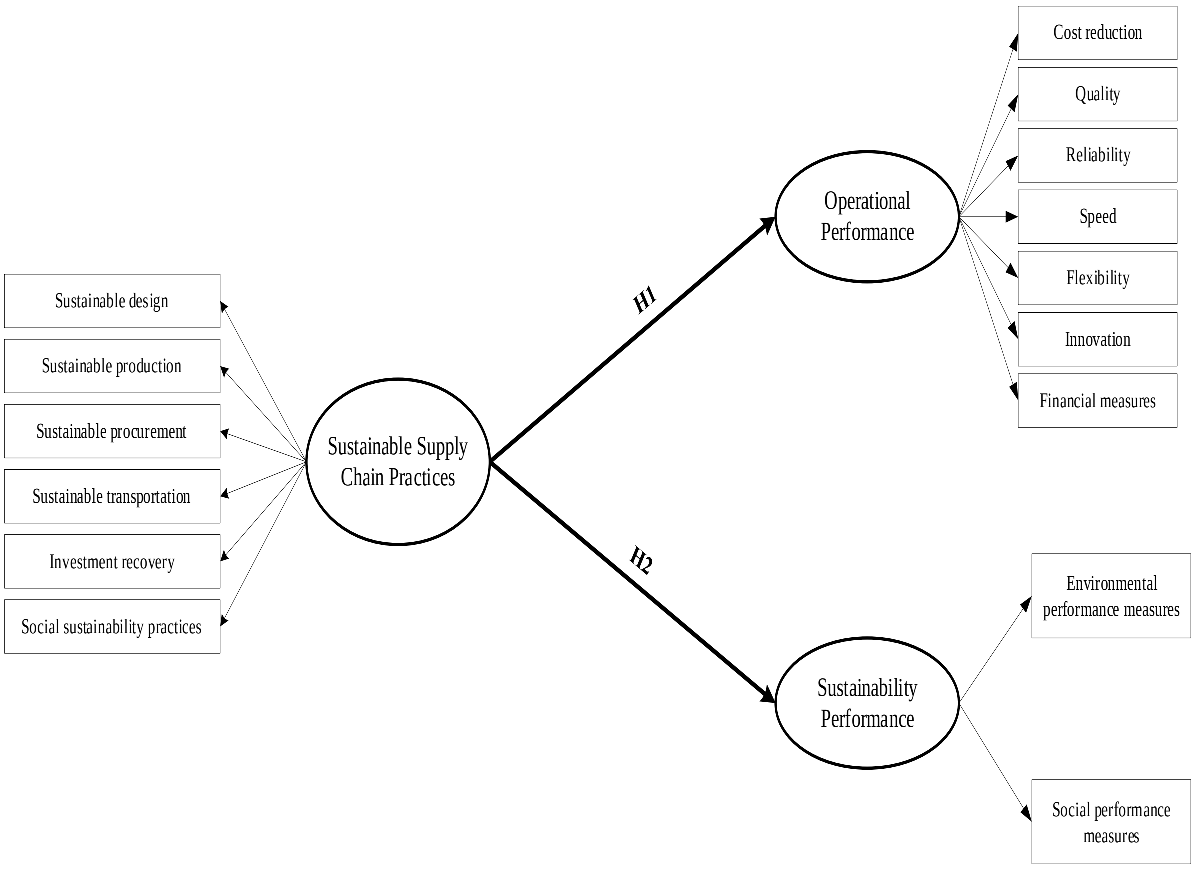



**Figure 5.7** Structure equation model for the direct effects of sustainable supply chain practices on operational performance and sustainability performance

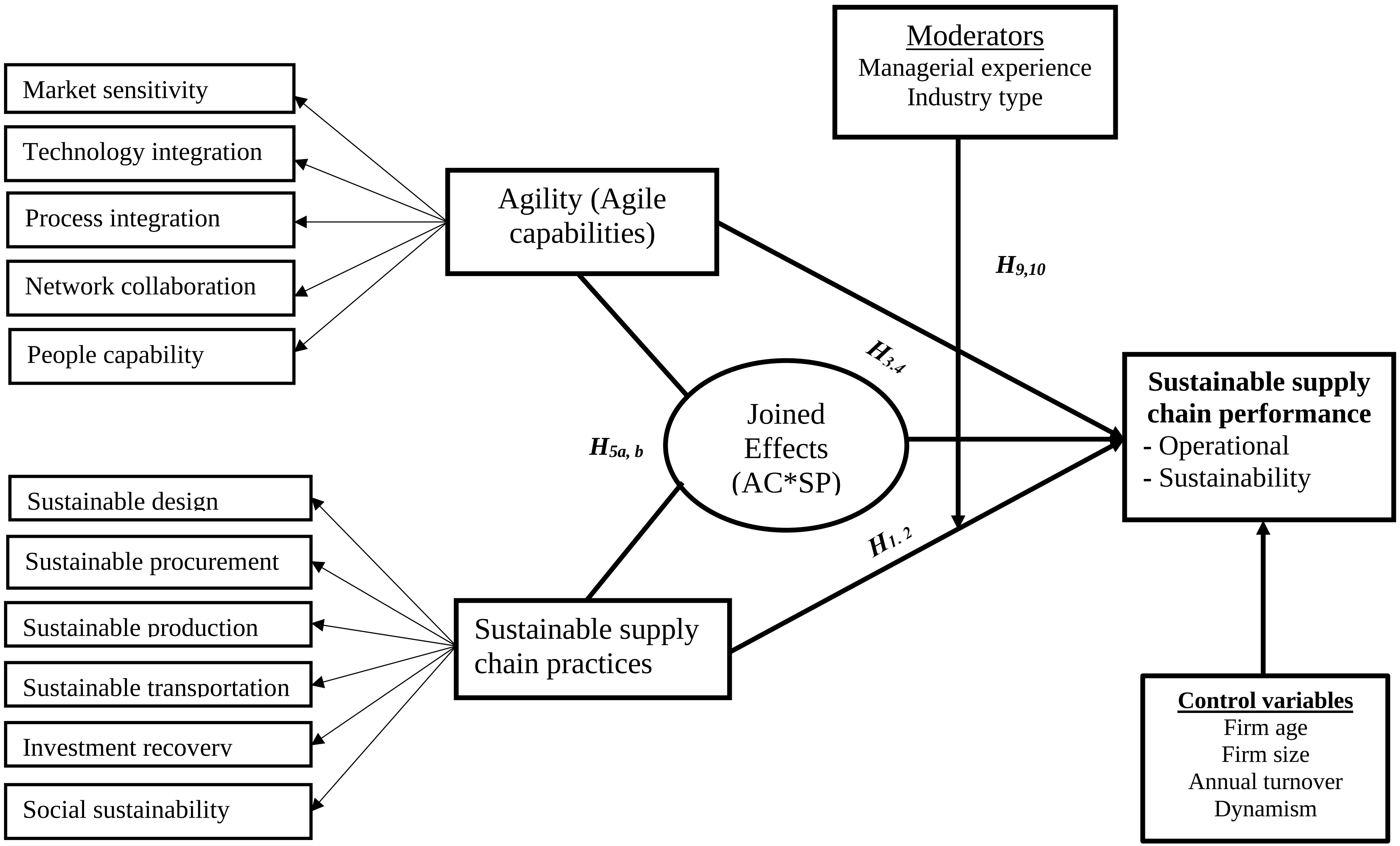



**Figure 5.8** Structural equation model for interaction effects between sustainable supply chain practices and agility capabilities

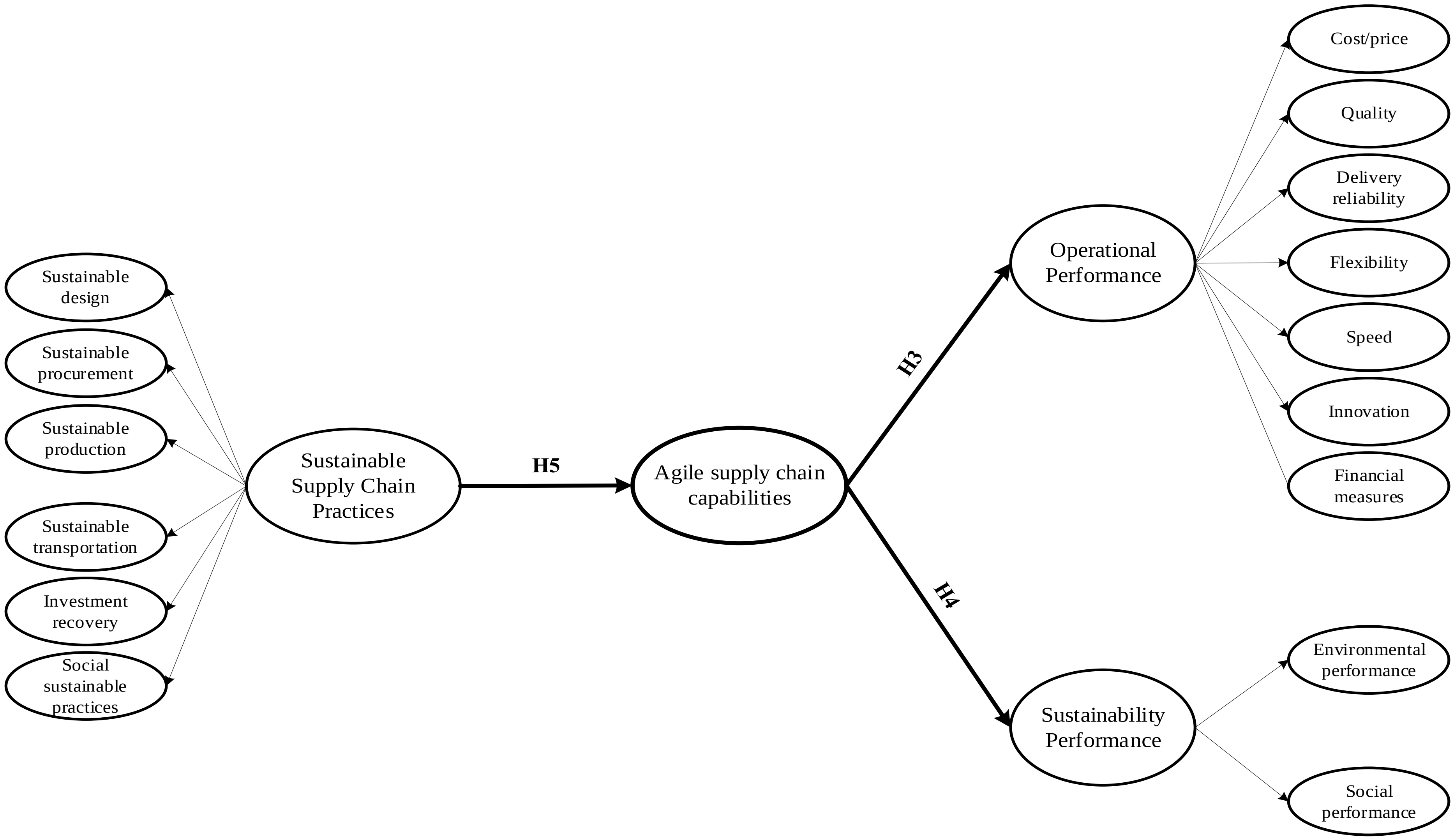



**Figure 5.9** Structural equation model for mediating effects

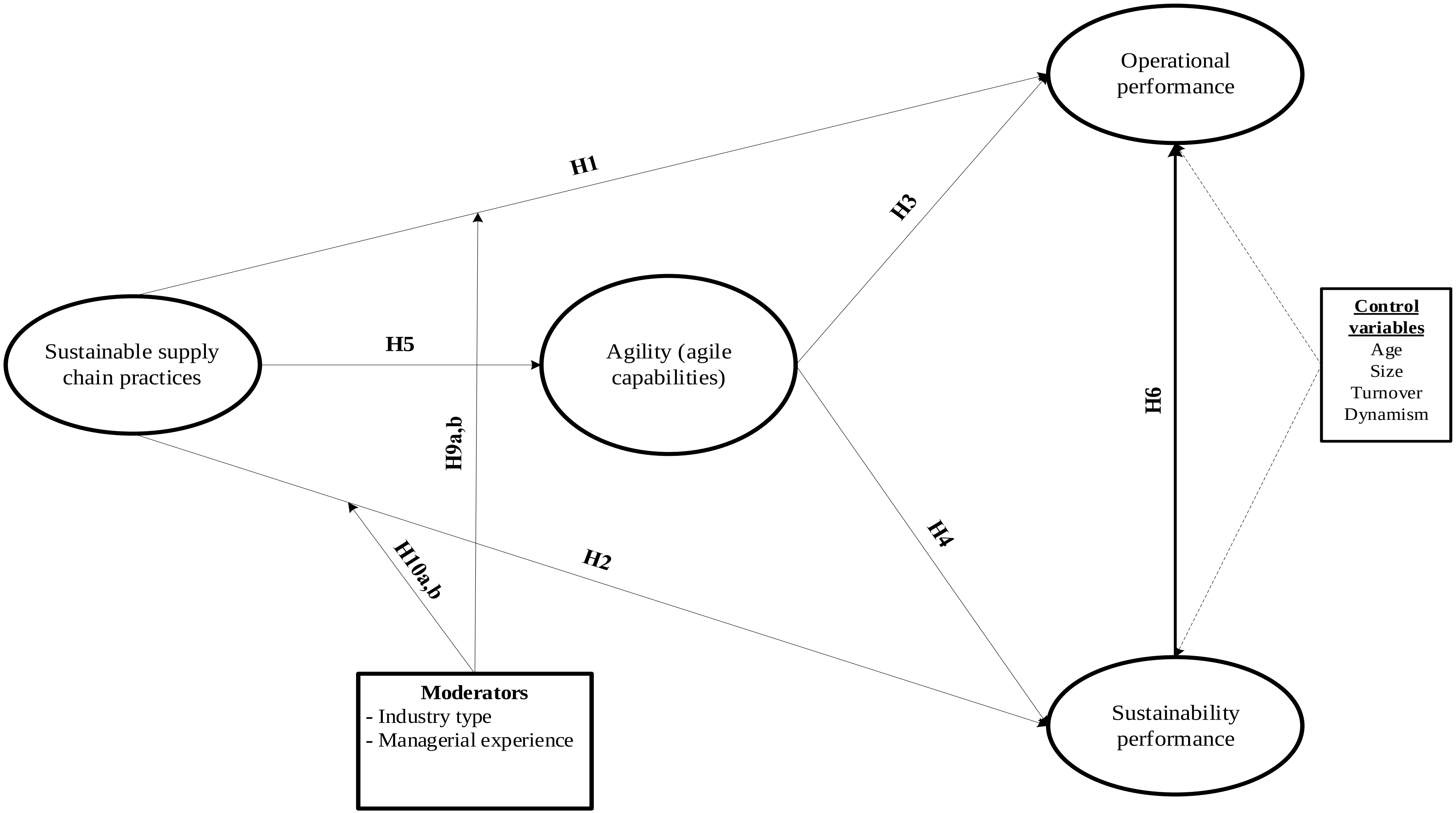



**Figure 5.10** Final structural model of the study

## 5.5 Hypotheses testing

Following the approaches suggested by Hult et al. (2007), Wamba et al. (2020), and Schilke and Goerzen (2010), hypotheses testing was analysed with SPSS AMOS 28 version software using the two statistical techniques: hierarchical regression and structural equation modelling (SEM) technique. This dual testing allows for a robust assessment of hypotheses, within the different strengths and constraints of each technique (Shook et al., 2004). Hierarchical regression, on the one hand, permits the direct assessment of change in explanatory power between iterative steps, which cannot achieve using SEM given that the step 1 equation is saturated. Further, as a traditional technique, it provides a baseline set of results for predictions. The more complex 'parsimonious latent-variable interaction technique', on the other hand, enables for the inclusion of measurement errors and indicators of the higher-order factors and can account for potential common method variables problems (Podsakoff et al., 2003).

### 5.5.1 Assessing direct effect and interaction (moderation) effects

The result (table:5.15 and 5,16) show the synergies between sustainable practices (SusPra), agile capabilities (AgilCaps), managerial experience (ME), industry type (IT) and both performance outcomes. Model 1 include the control variables (such as firm age, size, turnover, and dynamism). In model 2, the direct effects of sustainable practices, agile capabilities, and the two contingency variables were added to model 1, which increase $R^2$ by 46.7% and 60.2%. Finally, the interaction term between SusPra X AGCaps; SusPra X ME; and SusPra X IT was placed in model 4. This study adopts the procedure as suggested by Aiken and West (1991). The table 5.17 shows the results of the tests for operational performance as dependent variable. Table 5.18 illustrates the same results for sustainability performance as dependent variables.

The results in model 2 show that the rate of adopting sustainable practices in supply chain positively related to increase operational performance and sustainability performance (H1: $\beta$ = 0.234, p < 0.001) and sustainability performance (H2: $\beta$ = 0.352, p < 0.001). H1 and H2 are supported. More so, agility capabilities in supply chain have a positive effect on operational performance (H3: $\beta$ = 0.538, p < 0.001) and on sustainability performance (H4: $\beta$ = 0.536, p < 0.001). H3 and H4 are supported.

The hypothesized interaction term of SusPra X AGCaps had a positive effect on operational performance (H5a: $\beta$ = 0.160, p < 0.001) and on sustainability performance (H5b: $\beta$ = 0.227, p. 0.001). Managerial experience shows no significant moderating effects on the linkages between sustainable supply chain practices and operational performance (H9a: $\beta$ = -0.62, p > 0.143) and on sustainability performance (H10a: $\beta$ = 0.002, p > 0.953). H9a and 10a are not supported. However, for sustainable supply chain practices, industry sector SusPra X IS positively moderates the operational performance (H9b: $\beta$ 0.067, p > 0.209) and the sustainability performance relationship (H10b: $\beta$ = 0.236, p < 0.001). H9b and H10b are supported.

**Table 5.17** Standardised results of the hypothesis testing with operational performance as the criterion variable

| **Variables** | **Determinant of operational performance** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Model 1** | | **Model2** | | **Model3** | | **Model4** | | **VIF** |
| | $\beta$ | *Std Error* | $\beta$ | *Std Error* | $\beta$ | *Std Error* | $\beta$ | *Std Error* | 1.005 |
| Age | -0.029 | (0.159) | -0.051 | (0.120) | -0.068 | (0.121) | -0.050 | (0.118) | 1.007 |
| Size | 0.055 | (0.228) | 0.007 | (0.169) | 0.013 | (0.168) | 0.016 | (0.164) | 1.005 |
| Turnover | 0.011 | (0.212) | 0.002 | (0.157) | 0.003 | (0.159) | 0.016 | (0.155) | 1.003 |
| Managerial experience (ME) | | | -0.062 | (0.194) | 0.184 | (2.099) | -0.424 | (2.073) | 1.013 |
| Industry sector (IS) | | | 0.164 | (0.085) | -0.975 | (1.613) | -1.425 | (1.633) | 1.016 |
| Agility capabilities (AGCaps) | | | 0.538** | (0.053) | 0.466** | (0.803) | 0.427** | (0.787) | 1.011 |
| Sustainable practices (SusPra) | | | 0.234** | (0.142) | 0.221** | (0.143) | 0.204** | (2.073) | 1.044 |
| $ME^2$ | | | | | 0.013 | (0.443) | 0.018 | (0.430) | 1.011 |
| $IS^2$ | | | | | 0.027 | (5.872) | 0.395 | (5.819) | 1.027 |
| $AGCaps^2$ | | | | | 1.050 | (11.184) | 1.509 | (1.368) | 1.343 |
| $SusPra^2$ | | | | | -1.935 | (6.109) | -1.528 | (5.972) | 1.529 |
| SusPra X AGCaps | | | | | | | 0.160** | (0.158) | 1.064 |
| SusPra X ME | | | | | | | 0.067 | (0.172) | 1.098 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SusPra X IS | | | | -0.062 | (0.137) | 1.062 |
| $R^2$ | 0.004 | 0.471 | 0.486 | 0.524 | | |
| Adjusted $R^2$ | -0.006 | 0.459 | 0.467 | 0.499 | | |
| *F*-value | 0.370ns | 38.558** | 25.655** | 21.607** | | |

Note: significant at *p < 0.05, **p < 0.01, and ***p < 0.001

**Table 5.18** Standardised results of the hypothesis testing with sustainability performance

| Variables | Determinant of sustainability performance | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model2 | | Model3 | | Model4 | | VIF |
| | *β* | *Std Error* | *β* | *Std Error* | *β* | *Std Error* | *β* | *Std Error* | 1.005 |
| Control variables | | | | | | | | | |
| Age | -0.044 | (0.949) | -0.055 | (0.620) | -0.042 | (0.621) | -0.009 | (-0.273) | 1.007 |
| Size | 0.062 | (1.364) | -0.004 | (0.869) | -0.007 | (0.861) | 0.011 | (0.344) | 1.005 |
| Turnover | -0.032 | (1.269) | -0.040 | (0.809) | -0.030 | (0.817) | -0.020 | (-0.594) | 1.003 |
| Direct effects | | | | | | | | | |
| Managerial experience (ME) | | | -0.007 | (0.999) | 0.764 | (0.780) | 0.476 | (1.368) | 1.013 |
| Industry sector (IS) | | | 0.352** | (0.729) | 0.374** | (0.734) | 0.368** | (0.764) | 1.016 |
| Agility capabilities (AGCaps) | | | 0.536** | (0.273) | 0.486** | (4.125) | 0.408** | (1.276) | 1.011 |
| Sustainable practices (SusPra) | | | 0.221** | (0.435) | 0.219** | (8.283) | 0.153** | (2.751) | 1.044 |
| $ME^2$ | | | | | 0.007 | (2.276) | 0.011 | (0.355) | 1.011 |
| $IS^2$ | | | | | -0.780 | (0.159) | -0.472 | (-1.350) | 1.027 |
| $AGCaps^2$ | | | | | -1.811 | (7.446) | -1.868 | (-2.619) | 1.343 |
| $SusPra^2$ | | | | | 0.619 | (0.780) | 1.085 | (1.960) | 1.529 |
| Interaction (Moderation) effects | | | | | | | | | |
| SusPra X AGCaps | | | | | | | .227** | (6.065) | 1.064 |
| SusPra X ME | | | | | | | 0.002 | (0.059) | 1.098 |
| SusPra X IS | | | | | | | 0.236 | (5.767) | 1.062 |
| $R^2$ | 0.005 | | 0.607 | | 0.620 | | 0.721 | | |
| Adjusted $R^2$ | -0.005 | | 0.598 | | 0.606 | | 0.707 | | |
| *F*-value | 0. 537ns | | 66.993** | | 44.415** | | 50.778** | | |

Note: significant at *p < 0.05, **p < 0.01, and ***p < 0.001

### 5.5.2 Assessing interaction and moderation effects using structural equation modelling

As a second step in testing the interaction/moderation hypotheses, this research used structural equation modelling technique via SPSS AMOS software 28 to create an interaction variable to assess the interaction term (SusPra X AGCaps; SusPra X ME, and SusPra X IS). This technique is a more parsimonious estimation technique for latent interaction and quadratic variables than its predecessors by Kenny and Judd (1984) and Hayduk (1987). The use of this technique to examine the hypotheses adds to the hierarchical regression analysis in two ways:

i. the latent-variable technique allows us to incorporate measurement errors for the main and interaction effects (Ping, 1995, 1998) to assess whether such errors under- mine any statistically significant links within the results (Busemeyer and Jones, 1983).

ii. It allows to incorporate a test of potential CMV issues at the hypothesis-testing level to determine whether CMV inflates or curtails the magnitude of the obtained effects (e.g., Netermeyer et al., 1997; Podsakoff et al., 2003).

Table 5.19 indicate that the structural model had a good fit (CMIN/DF = 2.620, CFI = 0.985, TLI = 0.895, IFI = 0.986, NFI = 0.978, GFI = 9.82, RMSEA = 0.042). The CMIN/DF was well within the accepted range (less than 3.0) and the CFI and TLI value were both greater than the acceptable threshold of 0.90, and RMSEA index was 0.042. While TFI and RFI were acceptable – the values were lower than the recommended 0.9, above 0.80, as suggested by (Vachon, 2003). The structural model fit indices were all acceptable. Figure 5.11 contains details on this analysis.

**Table 5.19** Standardised regression weight for the interaction model

| Variables | | | Standardised estimates | S. E | C.R | P | Note |
|---|---|---|---|---|---|---|---|
| **Operational performance (OperPerf)** | | | | | | | |
| AgilCaps | <--- | SusPra | 0.564 | 0.076 | 9.675 | *** | Sig. |
| OperPerf | <--- | SusPra | 0.244 | 0.086 | 2.530 | 0.011 | Sig. |
| OperPerf | <--- | AgilCaps | 0.409 | 0.044 | 6.441 | *** | Sig. |
| OperPerf | <--- | IT | -0.024 | 0.294 | -0.419 | 0.675 | ns |
| OperPerf | <--- | ME | -0.017 | 0.232 | -0.307 | 0.759 | ns |
| OperPerf | <--- | SusPra_X_AgilCaps | 0.152 | 0.287 | 1.737 | 0.082 | ns |
| OperPerf | <--- | SusPra_X_ME | -0.065 | 0.162 | -1.186 | 0.236 | ns |
| OperPerf | <--- | SusPra_X_IT | -0.128 | 0.209 | -2.335 | 0.020 | Sig. |
| **Sustainability performance (SusPerf)** | | | | | | | |
| SusPerf | <--- | SusPra | 0.226 | 0.215 | 2.491 | 0.013 | Sig. |
| SusPerf | <--- | AgilCaps | 0.438 | 0.109 | 7.311 | *** | Sig. |
| SusPerf | <--- | IT | 0.015 | 0.733 | 0.265 | 0.791 | ns |
| SusPerf | <--- | ME | -0.040 | 0.578 | -0.793 | 0.428 | ns |
| SusPerf | <--- | SusPra_X_AgilCaps | 0.155 | 0.717 | 1.878 | 0.060 | ns |
| SusPerf | <--- | SusPra_X_ME | -0.081 | 0.404 | -1.563 | 0.118 | ns |
| SusPerf | <--- | SusPra_X_IT | 0.012 | 0.522 | 0.238 | 0.812 | ns |

Note: *p < 0.05, **p < 0.01, ***p < 0.001, ns = no significant, Sig. = significant
SusPra = sustainability performance, SusPra = sustainable supply chain practices, AgilCaps = agile supply chain capabilities, OperPerf = operational performance, ME = managerial experience, IT = industry type
n = 311, Estimation Method = Maximum Likelihood.
Model fit indexes: CMIN/DF = 1.599; CFI = 0.960; TLI = 0.958; IFI = 0.899; and RMSEA = 0.044

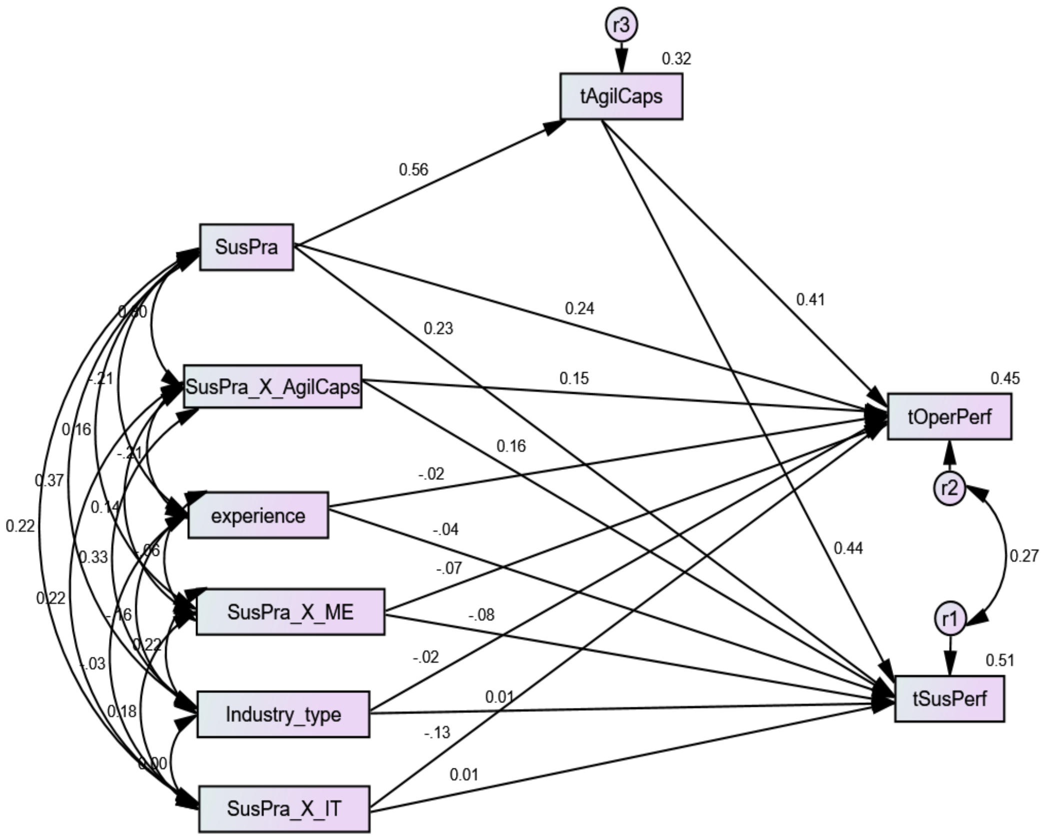



**Figure 5.10** Interaction/moderation structural model

The results of the parsimonious latent-variable interaction analyses mirror those in the hierarchical regression analysis, with the exception that all the moderation variables have not significant association. The research followed Ganzach' s (1997) hierarchical procedure to structural equation modelling testing to estimate whether the inclusion of main and interaction effects is meaningful (the results are shown in Table 5.19 and figure 5.11).

The results (Table 5.19) indicate that the degree of implementing sustainable practices was positively correlated with operational performance (H1: $\beta = 0.244$, p < 0.011) and sustainability performance (H1: $\beta = 0.226$, P < 0.001). Also, the degree of agile capabilities-building in the supply chain is positively linked with operational performance (H3: $\beta = 0.409$ p < 0.001) and sustainability performance (H4: $\beta = 0.438$, P < 0.001). As predicted in H1, 2, 3, and 4, these results suggest that the increase in level of implementing sustainable supply chain practices and the greater agile capabilities, which are both correlated to amplified operational and sustainability performance of supply chains.

The interaction term (SusPra × AgilCaps) is positive, which supports (H5a: $\beta = 0.152$, p > 0.082) and (H5b: $\beta = 0.155$ p > 0.060). In other words, the combined value of sustainable practices and agile capabilities will be higher than the cost of developing or deploying each capability individually. The interaction effects between, SusPra × ME (H9a: $\beta$ = -.028, p >0.566) and SusPra × IT (H10b: $\beta$ = 0.022, p < 0.01) did not attain the statistical significance level and are not consistent with the hypothesis, so, hypotheses (H9a and 10b) are rejected.

The $\beta$ coefficient for interaction term between SusPra and IT is negative and significant SusPra × IT (H9b: $\beta$ = -0.128, p < 0.020) while the moderation effect of SusPra × ME (H10a: $\beta$ = -0.065, p > 0.236) on operational performance and SusPra x ME (H10b: $\beta = -0.081, p > 0.118$) have negative and no significant effect, hence no support is found for the hypotheses (H9a and H10a, and H10b). more so, the β coefficient for interaction term between SusPra x IT was positive but no significant (β = 0.012, p > 0.812). As significant associations were found between SusPra X IT and sustainability performance, more in depth analysis was undertaken to shed more light on the nature of this relationship. In short, these results verify that the strengths of the hypotheses 1, 2, 3, 4, and 5ab paths were consistent and supported across the hierarchical regression and SEM interaction analyses. Also control variables such as age, size, and turnover had no direct association with operational performance and sustainability performance. Besides, the relationship between sustainable practices and agile capabilities were positively significant. Also, the relationship between sustainability performance and operational performance was found to be positive and significant, supporting hypothesis (H6).

To gain an intuitive understanding of the nature of these interaction or moderation effects, the research used the common procedure introduced by Schoenher and Swink (2012) and Aiken and West (1991), which assesses the significance of the regression coefficient for the independent variable at one standard deviation above and below the mean (labelled as a high level, and low level, respectively). A dichotomous variable was generated dividing the sample into groups with low sustainable practices and highly sustainable practices, and in a similar ways into groups with low agile capabilities and high agile capabilities. Dependent variable axes indicate the lower and upper end of standardised regression values. The procedure was used to managerial experience and industry sector as the moderators. Moderator values reflect the sample mean a plus/minus one standard deviation from the sample mean.

The figure 5.12 depicted the interactions graphically, when sustainable practices is high, agile capabilities has a stronger positive effect on both operational performance and sustainability performance than when sustainable practices is low.

**Chart 1**

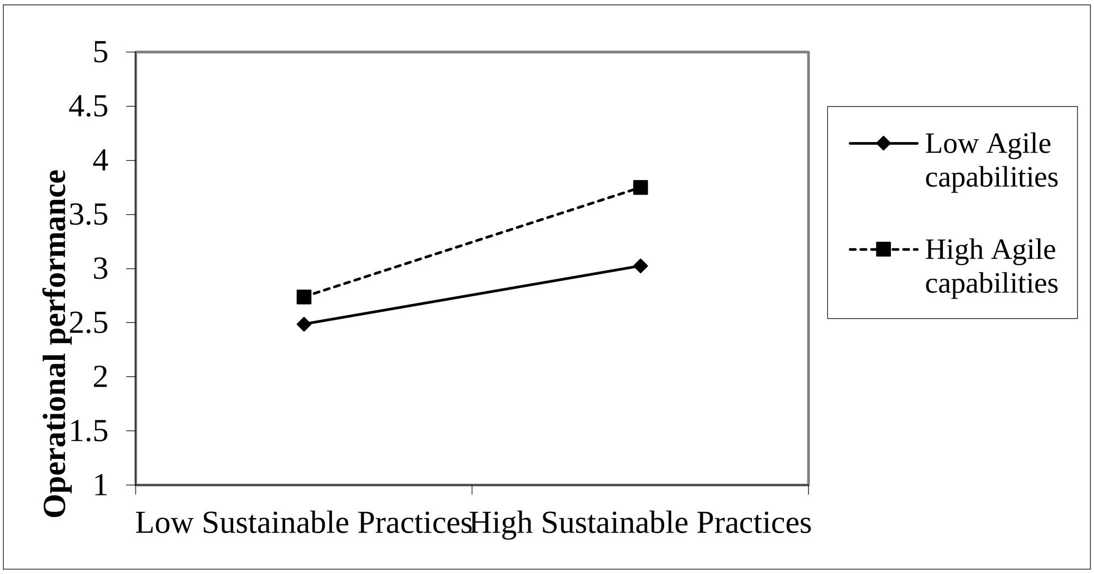



**Chart 2**

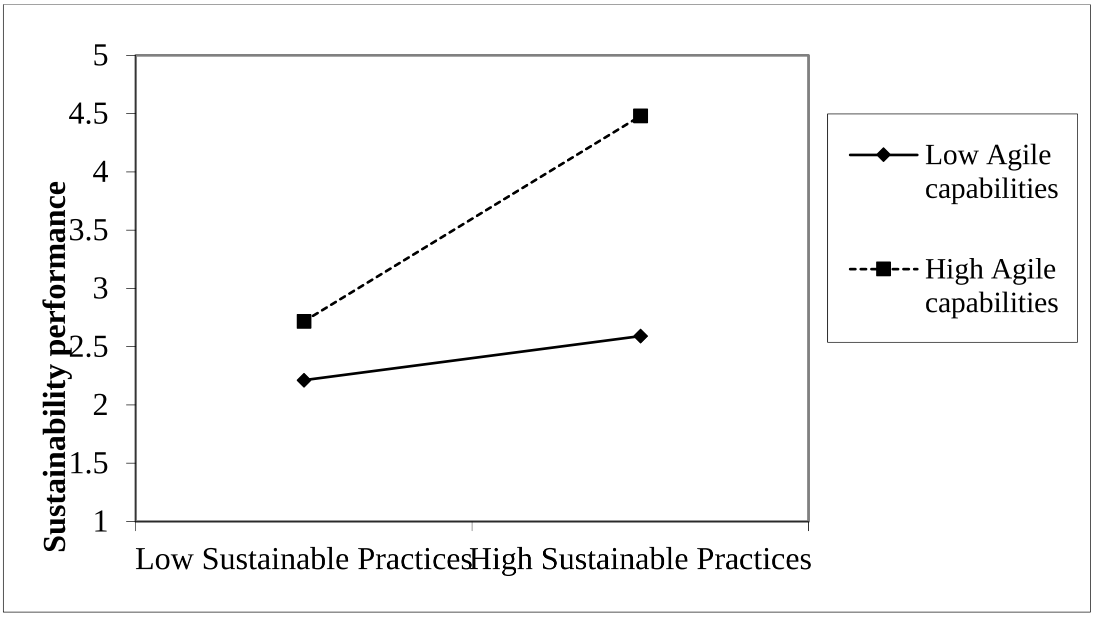



**Figure 5.12** Interaction effect

Figure 5.13 shows the mean plots for significant interaction and moderating effects and confirms the regression results. Chart 3 shows the operational performance relationship of low sustainable supply chain practices to high sustainable supply chain practices, yet the performance difference between low and high industry sector is little. Chart 4 illustrate the significant moderating effect of industry sector on the link between sustainable supply chain practices and sustainability performance. the higher the industry sector, the higher the performance effect that can be derived from increasing sustainable practices. when sustainable supply chain practices are low, low industry sector outperforms high industry sector. Chart 5 reflects the non-significant finding of the performance effect of managerial experience in moderating the association between sustainable supply chain practices and operational performance. Chart 6 shows the sustainability performance relationship of low sustainable supply chain practices and high sustainable supply chain practices. the performance effect increases from low managerial experience to high managerial experience. Thereby, high managerial experience outperforms low managerial experience with increasing sustainable supply chain performance. When sustainable supply chain practices are low, low managerial experience outperforms high managerial experience. Chart 4 shows major results, shows major results, as such, industry sector promotes operational performance and sustainability performance with increasing implementation of sustainable supply chain practices. supply chain companies in static industries invest a higher amount, more productively, in sustainable supply chain practices than companies in dynamic ones. Because standards may be less effective when there are significant technological changes within the supply networks (Pibeam et al., 2012). When firms operate in high carbon and energy intensive industries (high-pollution industry like oil and gas, stakeholder's pressure for sustainability performance improvement is often more intense, so these firms tend to develop agile capabilities and adopt a more sustainable approach. companies that operate in low carbon and energy intensive (low pollution) sectors faces less intense stakeholders' pressure and tend to wait longer to adopt new sustainability practices.

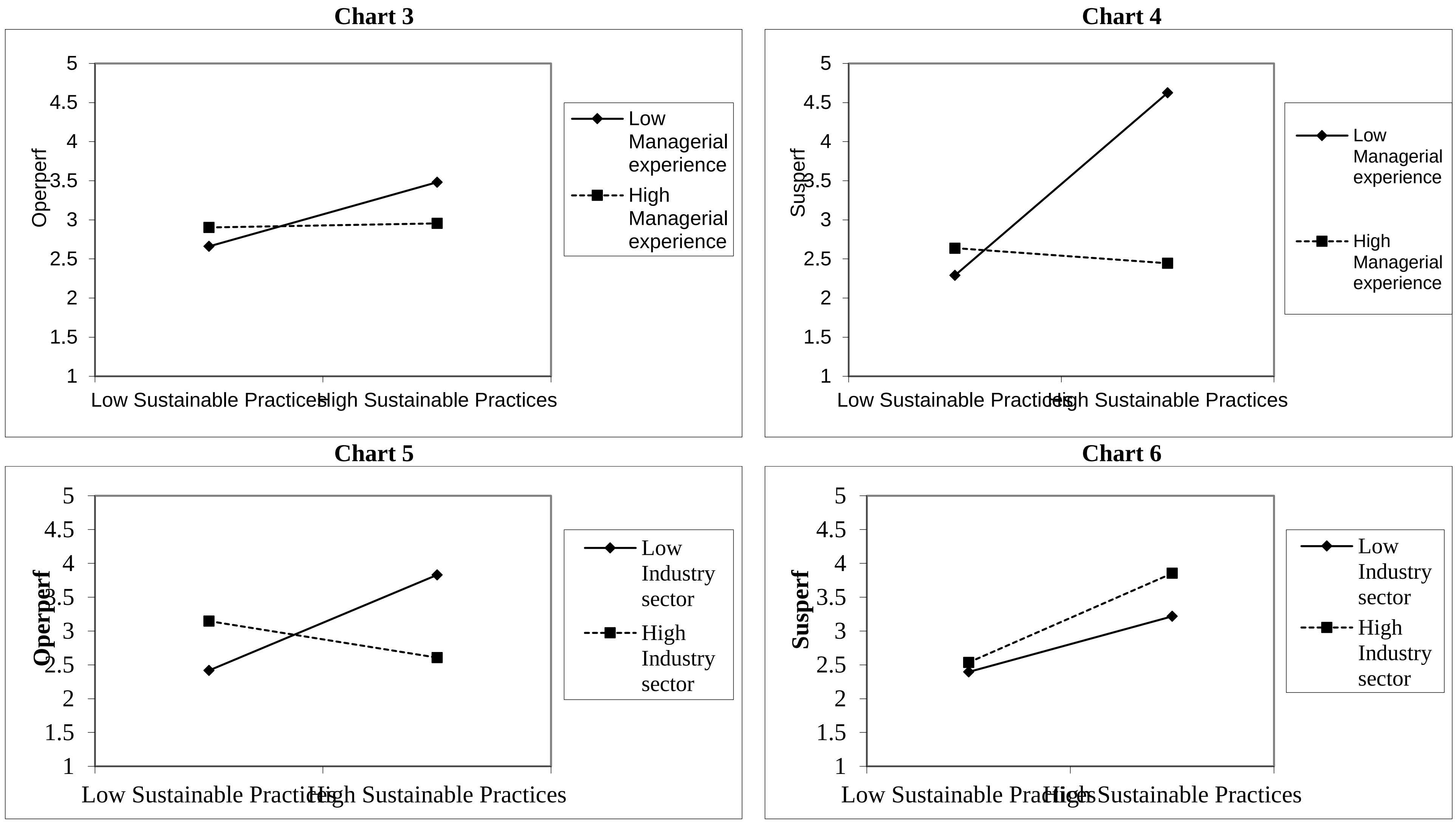



Figure 5.13: The moderating effect of managerial experience and industry sector

### 5.5.3 Assessing the mediation effects

As can be seen in Figure 5.15 below, the correlation between independent variables and dependent variables is called the total effect. The direct effect is the relationship between independent variables and dependent variables after controlling for the mediator. In line with Baron and Kenny (1986) a variable could be confirmed as a mediator if: (1) there is a significant relationship between the independent variable and the dependent variable, (2) there is a significant relationship between the independent variable and mediator, (3) the mediator still predicts the dependent variable after controlling for the independent variable, and (4) the relationship between the independent variable and dependent variable is increased when the mediator is in the equation. These criteria can be used to judge whether mediation is occurring, but MacKinnon et al. (2004) have popularised statistically based methods in which mediation may be assessed.

Following from above, the first step to assessing mediation must show that the independent variable (sustainable supply chain practices) influences the dependent variable (operational performance and sustainability performance). This can be seen in figure 5.14, which show a significant positive relationship between sustainable supply chain practices and each of the performance measures (*β = 0*.402, *p* < 0.001; *β* = 0. .810, *p* < 0.001) respectively.

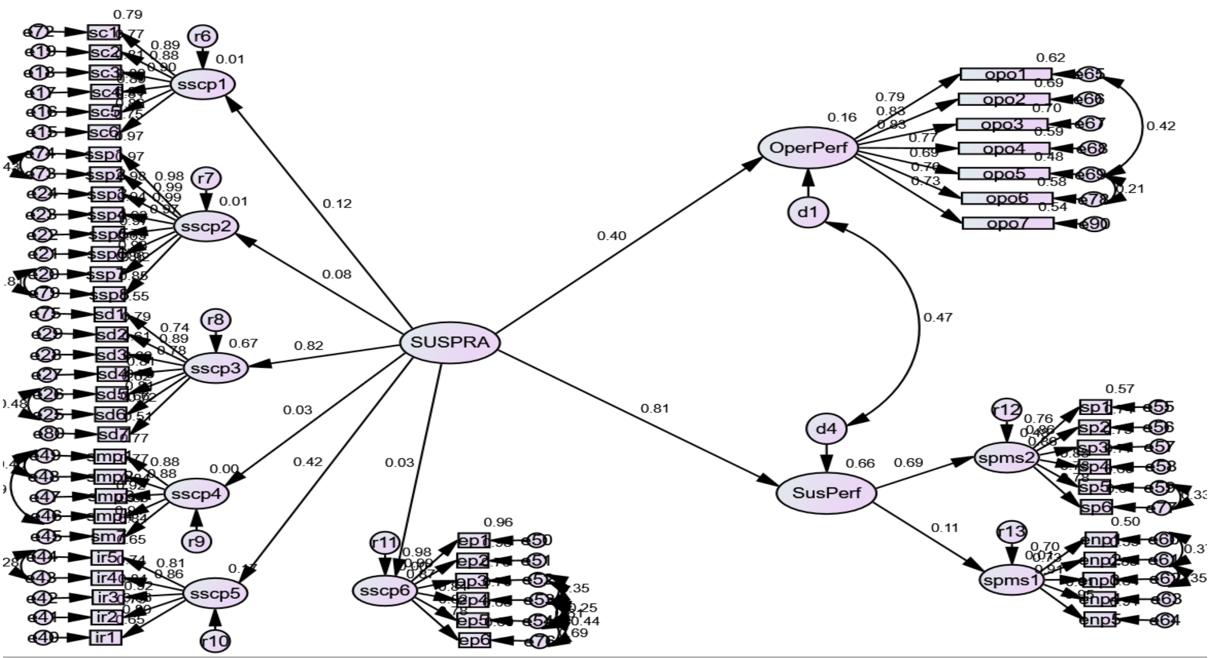



**Figure 5.14** Results of the direct relationship model (*p<0.05; **p< 0.01; ***p<0.001).

The second step for mediation assessment is that the direct relationship between the independent variable and the mediator is significant. The result in figure 5.15 indicate that sustainable supply chain practices is significantly corrected with agility capabilities at the $p < 0.001$ level. The third step is to show that mediator variable (agility capabilities) influences the sustainable supply chain performance variables (operational performance and sustainability performance). Again, Figure 5.9 show that the mediator variable is strongly correlated with each of the sustainable performance measure at the $p < 0.001$ level. The final step in testing for mediation needs to evaluate original direct relationships between the independent (sustainable practices) and dependent (sustainable performance) variables. These results (figure 5.15) show that all these relationships are statistically insignificant. These results indicate strong evidence of full mediation of the relationship between sustainable supply chain practices and performance, through the mediator variable agile capabilities. Therefore, hypotheses (H7 and H8) are all strongly supported. As mediating role of agility capabilities was established, more in-depth analysis was undertaken to shed more light on the nature of the mediation. To gain insights whether the mediation effects are statistically significant, the Sobel test techniques (Sobel, 1982 quoted in Tabachnick and Fidell, 2014) was carried out.

The results (table 5.20) show that sustainable supply chain initiatives, when mediated through agile capabilities, lead to a much better sustainability performance ($\beta = 0.235$, t-value = 1.551, $P > 0.121$), and higher level of operational performance ($\beta = 0.180$, t-value = 2.44, $P > 0.084$). The $P$-values in both cases ($P > 0.121$; $P > 0.084$) are greater than 0.05 indicating there are full mediation. In addition, CFI and NFI exceeded 0.90 as recommended by Byrne (2016), RMSEA is below 0.06 (Hu and Bentler, 1999), and the normed chi-square (chi-square/degree of freedom) value of $X^2$ is less than 2 (Tabachnick and Fidell, 2014) all indicating a strong case of mediation. The totality of these statistics suggests the amplification effects of agile practices on the transformation of sustainable supply chain implementation initiatives into sustainability performance of industries. In other words, sustainable supply chain practices on their own contribute to enterprises' sustainability, but the contributions are significantly better if agile capabilities facilitate sustainable supply chain practices. Based on the suggestion by Esfahbodi et al. (2016), this research checked whether the model had greater explanatory value than a simpler model wherein all first-order factors were allowed to affect organisational performance directly. The next section looks at the effects of individual practices on operational and sustainability performance.

**Table 5.20** Hypotheses testing results with mediating

| **Corrections** | **Direct effect** | **Indirect effects** | **Total effect** | **P** | **Note** |
|---|---|---|---|---|---|
| $H_1$: Sustainable SCM practices → Operational performance | 0.195 | 0.000 | 0.195 | 0.055 | Supported |
| $H_2$: Sustainable SCM practices → sustainability performance | 0.738 | 0.000 | 0.738 | *** | Supported |
| $H_3$: Agile capabilities → operational performance | 0.567 | 0.000 | 0.567 | *** | Supported |
| $H_4$: Agile capabilities → sustainability performance | 0.420 | 0.000 | 0.420 | *** | Supported |
| $H_5$: Sustainable SCM practices → agile capabilities | 0.318 | 0.000 | 0.318 | *** | Supported |
| $H_5$: Sustainability performance → operational performance | 0.494 | 0.000 | 0.494 | *** | Supported |
| $H_7$: Sustainable SCM practices → agile capabilities → operational performance | 0.195 | 0.180 | 0.375 | 0.084 | Full mediation |
| $H_8$: sustainable SCM practices → agile capabilities → sustainability performance | 0.738 | 0.235 | 0.973 | 0.121 | Full mediation |
| Note: *p < 0.05, **p < 0.01, ***p < 0.001 | | | | | |
| n = 311, Estimation Method = Maximum Likelihood. | | | | | |
| Model fit indexes: CMIN/DF = 1.472; CFI = 0.956; TLI = 0.954; IFI = 0.956; and RMSEA = 0.039 | | | | | |

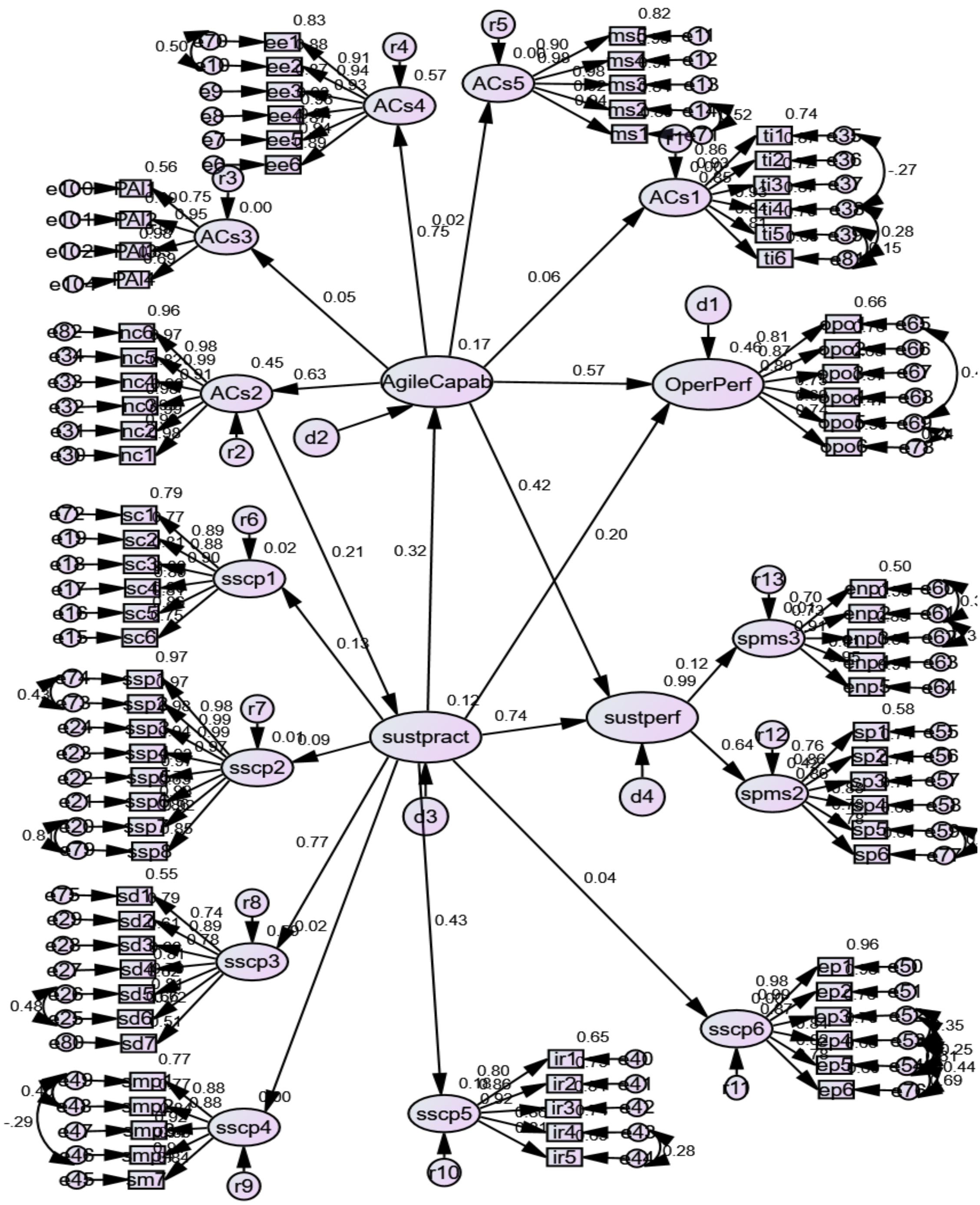


**Figure 5.15** Results of the mediation effects

## 5.6 Assessing the impact of individual practices on sustainability and operational performance

Based on the above, we confirm the findings of the primary structural model, the impact of individual agility and sustainable initiatives on operational and sustainability performance objectives were tested. The aim was to explore which specific practices has the greatest impact on organisational performance.

The results from the assessment of the structural model for the individual agility and sustainable variables are reported in Figure 5.16 and Table 5.21 the individual agile constructs have a normed chi-square (chi-square/degree of freedom) value of 1.582; RMSEA = 0.043; IFI value of 0.970; TLI value of 0.968 and CFI value of 0.970. Whilst the individual sustainable variables include normed chi-square (chi-square/degree of freedom) value of 1.451; RMSEA = 0.038; IFI value of 0.966; TLI value of 0.964 and CFI value of 0.966 were found to be adequate. These model fit indices equal to or exceeded the minimum threshold value of 0.9. Having established the validity of the structural model, the standardised regression weights were estimated. A summary of the alternative hypotheses testing, and directions are illustrated in Table 5.21 below.

All the hypothesised impacts of each agile constructs on performance outcomes were positive and significant. In, Figure 5.15, the standardised coefficient from market sensitivity to operational performance objectives is significant ($\beta = 0.401$, $p < 0.001$). Hence agile organisation with strong market sensitivity is found to exhibit a high level of operational performance objectives. In the same vein, the standardised coefficient from market sensitivity to sustainability performance is also significant ($\beta = 0.481$, $p < 0.001$), supporting the idea that the market sensing capability of an agile organisation can help in understanding the expectation of stakeholders whilst a lack of sensing capability could render sustainability objectives unsuccessful.

The standardised coefficient from technology integration to operational performance objectives is appeared to be highly significant (β = 0.605, $p < 0.001$). Likewise, the standardised path from technology integration to sustainability performance is found to be significant (β = 0.299, $p < 0.001$). Besides, rising sustainability performance was predicted via process alignment practices (β = 0.256, $p < 0.001$), also operational performance objectives improved as process alignment improved (β = 0.183, $p < 0.01$).

More so, the greater the network collaboration predict positive relationships with sustainability performance (β = 0.477, $p < 0.001$). While increasing operational performance was predicted also by network collaboration (β = 0.199, $p < 0.01$). The path coefficient from employee empowerment to operational performance seem to be positive and significant (β = 0.195, $p < 0.01$). Given the strong influence of worker's education and empowerment on operational performance objectives, it is apparent that employee empowerment only has a weak positive and significant effect on sustainability performance (β = 0.128, $p < 0.05$).

Of the five agile capabilities examined, technology integration had the largest and significant impact on operational performance (β = 0.605, $p < 0.001$). Supporting existing work in which technology capability is an essential factor to improve organisational performance (Partanen et al., 2020). Other agile practices that have the highest impacts on sustainability performance include market sensitivity, network collaboration and process alignment. However, the relationship between employee empowerment and organisational performance was weak and significant. Despite the importance of education and training to support organisations' sustainability performance (Seuring and Muller, 2008).

As regards the sustainable supply chain practices, this study discovered that all the standardised coefficients are positive and significant except the influence of environmental management practices on operational performance objectives. From Figure 5.16 and Table 5.21, it indicates that the higher the level of sustainable design practices predict sustainability performance ($\beta = 0.436$, $p < 0.001$). Similarly, sustainable design also predicts positive and significant impact on operational performance objectives ($\beta = 0.350$, $p < 0.001$). These results show that sustainable design is an important precursor to improved organisational performance. More so, increases in sustainable procurement predict both operational performance objectives and sustainability performance ($\beta = 0.339$, $p < 0.001$; $\beta = 0.267$, $p < 0.001$), respectively.

Furthermore, the impacts of sustainable transport, investment recovery and social sustainability practices on operational and sustainability performance objectives are positive and significant (see Table 5.21 for details). However, the environmental management practices do not significantly impact on operational performance objectives ($\beta = 0.086$, $p > 0.211$), rather it can have influence on sustainability performance ($\beta = 0.237$, $p < 0.001$). Figure 5.16 shows the hypothetical model, including the results associated with the individual agility and sustainable initiatives effects on performance outcomes of the supply chain.

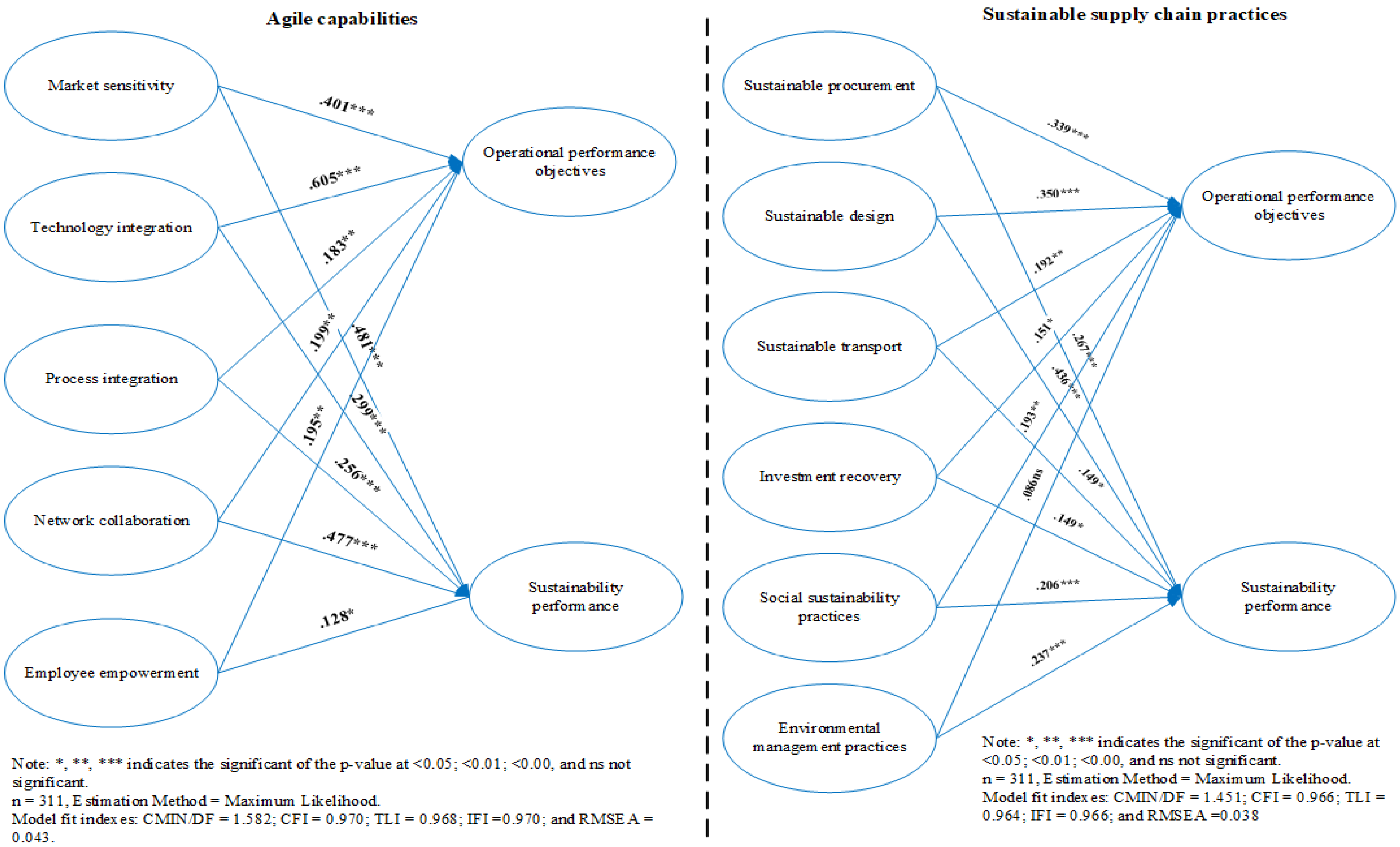



**Figure 5.16** Structural model: the impact of individual agility and sustainable initiatives on performance outcomes of supply chain

These findings allow this study to answer the research question five. The findings show significant impacts of sustainable implementation on both operational and sustainability performance objectives. But the finding associated with the link between environmental performance practices and operational performance is no significant. From these results, it is apparent that environmental management systems and operational performance objectives are unrelated.

Overall, the results provide empirical evidence that all individual agile practices do affect operational and sustainability performance objectives, with technology capability, market sensing and network collaboration capabilities have the greatest impact on both performance outcomes. The result also revealed that sustainable supply chain practices do affect both operational and sustainable performance objectives, while the environmental management practices only have a strong impact on sustainability performance and no significant influence on operational performance objectives. All the individual practices examined are found to have a direct and significant impact on the supply chain performance objectives.

**Table 5.21** Standardised path coefficients, t-value and significant of the individual agility and sustainable supply chain practices

| Code | First order constructs | Standardised estimates | t-value | Sig. |
|---|---|---|---|---|
| Un-hypothesised | Market sensitivity → operational performance objectives | 0.401 | 4.857 | 0.000 |
| Un-hypothesised | Market sensitivity → sustainability performance | 0.481 | 6.729 | 0.000 |
| Un-hypothesised | Technology integration → operational performance objectives | 0.605 | 5.882 | 0.000 |
| Un-hypothesised | Technology integration → sustainability performance | 0.299 | 4.796 | 0.000 |
| Un-hypothesised | Process integration → operational performance objectives | 0.183 | 2.735 | 0.006 |
| Un-hypothesised | Process integration → sustainability performance | 0.256 | 4.233 | 0.000 |
| Un-hypothesised | Network collaboration → operational performance objectives | 0.199 | 2.936 | 0.003 |
| Un-hypothesised | Network collaboration → sustainability performance | 0.477 | 6.698 | 0.000 |
| Un-hypothesised | Employee empowerment → operational performance objectives | 0.195 | 2.856 | 0..004 |
| Un-hypothesised | Employee empowerment → sustainability performance | 0.328 | 2.254 | 0..024 |
| Un-hypothesised | Sustainable procurement → operational performance objectives | 0.339 | 4.150 | 0.000 |
| Un-hypothesised | Sustainable procurement → sustainability performance | 0.267 | 4.399 | 0.000 |
| Un-hypothesised | Sustainable design → operational performance objectives | 0.350 | 4.243 | 0.000 |
| Un-hypothesised | Sustainable design → sustainability performance | 0.436 | 6.643 | 0.000 |
| Un-hypothesised | Sustainable transport → operational performance objectives | 0.192 | 2.642 | 0.008 |
| Un-hypothesised | Sustainable transport → sustainability performance | 0.149 | 2.548 | 0.011 |

| Code | First order constructs | Standardised estimates | t-value | Sig. |
|---|---|---|---|---|
| Un-hypothesised | Investment recovery → operational performance objectives | 0.151 | 2.126 | 0.034 |
| Un-hypothesised | Investment recovery → sustainability performance | 0.149 | 2.546 | 0.011 |
| Un-hypothesised | Social sustainability practices → operational performance objectives | 0.193 | 2.653 | 0.008 |
| Un-hypothesised | Social sustainability performance → sustainability performance | 0.206 | 3.467 | 0.000 |
| Un-hypothesised | Environmental management practices → operational performance objectives | 0.086 | 1.250 | 0.211 |
| Un-hypothesised | Environmental management practices → sustainability performance | 0.237 | 3.940 | 0.000 |

## 5.7 Assessing the individual practices or groups of practices that have the greatest impacts on specific performance

Another key objective of this study was to determine if there are specific differences between groups of agile companies. So, more analysis was performed for further clarifications and insights to seek validation of the above results. Differences amongst agile organisations were assessed in terms of organisational performance such as cost, quality, speed, reliability, flexibility, innovation, financial measure, social and environmental sustainability objectives.

A cluster analysis was, therefore, used to identify agile classifications from organisations attributes. Cluster analysis includes several stages: (1) established and validated different sub-groups (clusters); (2) examined different clustering variables across groups; (3) created a cluster profile via examining differences in other constructs across groups (Hair et al., 2014).

The main issue with cluster analysis is how to determine the most appropriate number of clusters. This thesis used a combination of approaches employed by (Zhang and Sharifi, 2007; Narasimhan et al., 2006; Bottani, 2010). Firstly, hierarchical clustering was done using Ward approach and the squared-Euclidian distance metric to help determine the appropriate number of clusters. The results show that three clusters of agile companies appeared to be most appropriate (Narasimhan et al., 2006; Zhang and Sharifi, 2007). This result was further confirmed using K-means clustering technique. The use of a hierarchical approach to ascertain the number of clusters and subsequent refinement via the K-means method makes the best use of the strengths of both approaches (Narasimhan et al., 2006; Bottani, 2010). This procedure resulted in the final cluster solution.

As a validity check on the clustering approach, we recomputed the clusters using factor loadings from the outer model of the SPSS output. Employing a factor score in this way creates a more accurate measure, which assigns equal weights (Lastovicka and Thamodaran, 1991). The companies in our sample were groups based on highly agile companies (n=121), moderately agile companies (n=131) and less agile companies (n=59).

Unlike analysis of variance (ANOVA) technique, which allows researcher to look at the individual and joint effect of two independent variables on one dependent variable. However, this study is interested in comparing individual practices or groups of practices on more than one dependent variable. So, multivariate analysis of variance (MANOVA) enables researcher to compare the groups and tells if the mean differences between the groups on the combination of dependent variables are likely to occurred. That is, it helps to compares groups of agile organisations in term of the mean differences in each of the nine subdimensions of performance objectives such as cost, quality, speed, reliability, flexibility, innovation, financial, social and environmental sustainability objectives. This tests the null hypothesis that the sample means on a set of dependent variables do not vary across different levels of groups variables. The MANOVA tell if there are significant differences on agile clusters means of the organisational performance variables at 0.05 level or less; relative importance of performance objectives in the clusters and, provides the univariate results for each performance variable separately. The advantage of using MANOVA is that it controls or adjusts for the increased risk of a type 1 error.

This study follows the MANOVA assumptions, as suggested by Stevens (2009); Tabachnick and Fidell (2013) and Hair et al. (2009) to perform the analyses. The observations in this study are detached because they represent responses from supply chain professionals in different organisations. Regarding normality, the Kolmogorov-Smirnov test was carried out as recommended by George and Mallery (2003). Other assumptions considered are linearity, homogeneity of variance and multicollinearity. The results of these tests are explained in more detail in sections 5.3.7. It was therefore established that this data is suitable for the MANOVA analysis.

Table 5.22 show the results of mean scores and standard deviation of each agile cluster based on scale (such as 1 = not at all, 5 = very significant). From the table, highly agile organisation appears to have the greatest impacts on all performance objectives. Compared with other two agile clusters, they indicate significantly highest mean values on flexibility, quality, reliability, financial, speed, social, innovation, and environmental sustainability objectives. This suggest that to be sustainable and agile, organisations must be flexible, quick, and innovative. While moderately agile organisations give significantly higher mean values to reliability and flexibility. The score for quality, costs, and sustainability measures were modest, while the score for innovation is significantly lowest. The less agile organisations, on the other hand, gives significantly lowest mean values on all performance objectives. From this result, we could suggest that organisations with high level of agile capabilities would perform better than less agile organisations. To confirm this, we further performed a post hoc test. These tests compare each of pairs agile groups and indicate if there is a significant difference in the means of each.

**Table 5.22** MANOVA mean value and standard deviation of organisational performance by agile strategy groups

| Performance | Groups of agility strategy | | | *F* = value (significance) |
|---|---|---|---|---|
| | Less agile companies (n=59) Group 1 | Moderately agile companies (n=131) Group 2 | Highly agile companies (n=121) Group 3 | |
| Cost | | | | |
| Cluster mean* | 3.85 | 3.92 | **4.46** | 30.175 (0.000) |
| Rank** | 1 | 4 | 4 | |
| Standard Error*** | 0.077 | 0.059 | 0.065 | |
| Quality | | | | |
| Cluster mean* | 3.76 | 3.96 | **4.51** | 31.443 (0.000) |
| Rank** | 2 | 3 | 2 | |
| Standard Error*** | 0.083 | 0.069 | 0.059 | |
| Speed | | | | |
| Cluster mean* | 3.51 | 3.87 | **4.36** | 37.782 (0.000) |
| Rank** | 5 | 5 | 6 | |
| Standard Error*** | 0.074 | 0.058 | 0.061 | |
| Reliability | | | | |
| Cluster mean* | 3.76 | 4.11 | **4.50** | 26.495 (0.000) |
| Rank** | 2 | 2 | 3 | |
| Standard Error*** | 0.081 | 0.060 | 0.060 | |
| Flexibility | | | | |
| Cluster mean* | 3.71 | 4.24 | **4.57** | 24.976 (0.000) |
| Rank** | 4 | 1 | 1 | |
| Standard Error*** | 0.081 | 0.064 | 0.051 | |
| Innovation | | | | |
| Cluster mean* | 2.63 | 3.18 | **4.33** | 80.579 (0.000) |
| Rank** | 9 | 9 | 8 | |
| Standard Error*** | 0.063 | 0.085 | 0.096 | |
| Environmental sustainability | | | | |
| Cluster mean* | 2.95 | 3.46 | **4.05** | 80.674 (0.000) |
| Rank** | 6 | 6 | 9 | |
| Standard Error*** | 0.084 | 0.057 | 0.036 | |
| Social sustainability | | | | |
| Cluster mean* | 2.84 | 3.33 | **4.36** | 78.055 (0.000) |
| Rank** | 8 | 8 | 6 | |
| Standard Error*** | 0.106 | 0.076 | 0.077 | |
| Financial sustainability | | | | |
| Cluster mean* | 2.94 | 3.34 | **4.37** | 96.070 (0.000) |
| Rank** | 7 | 7 | 5 | |
| Standard Error*** | 0.093 | 0.071 | 0.060 | |

* Represents the average degree of importance attached to each performance criteria by cluster. Importance is measured on a five-point Likert scale (1 = very low, 5 = very high; 1 = not at all, 5 = very significant).
** The rank order of importance of this performance criteria within the group.
*** the standard error of the estimate of the mean for the group.
Note: the numbers in parentheses indicate the group numbers from which this group was significantly different at the 0.05 level as indicated by the Scheffe pairwise comparison procedure. Numbers in **bold** indicate the highest group centroid for that measure. Group 1 = Less agile companies, group 2 = Moderately agile companies, group 3 = Highly agile companies. The observed F-statistics were derived from one-way ANOVAs and *p*-values are associated with the observed *F*-statistics.

Notwithstanding the above results, it does not disclose the degree to which the agile strategy stroups differ in each dimension. So, it is vital to determine the effect size for specific organisational performance. The effect size is a set of statistics that indicate the relative magnitude of the difference between the amount of the total variance in the dependent variable

(Tabachnick and Fidell, 2013, p. 54). There are numerous ways to calculate the effect size in the literature. Pallant (2020) suggested partial eta squared as the most used approach.

Table 5.23 shows the post-hoc test results for each organisational performance. This table disclose where the differences among the agile groups occur. Looking at the mean difference, there are asterisks (*) next to the values listed. This suggests that there is a difference between the groups at the $p < 0.05$ level. In the table, all agile companies differ significantly in terms of their relative performance objectives. 59 companies in our sample were describe as less agile organisations. These less agile companies have poor organisational performance: in fact, they had the lowest average scores in each of the organisational performance among the three groups. At best, the less agile companies focus more on performance outcomes such as cost reduction quality and reliability improvements.

In contrast, 42 percent of companies stood out as being moderately agile. These organisations had performed above average in term of flexibility, reliability, quality, cost, speed, innovation, and sustainability performance objectives. Their mean differences are significantly higher than that of less agile companies, but it is also significantly lower than that of highly agile companies. Though these values are closer to highly agile organisations than they are to less agile organisations (see Figure 5.17). But the least performance objectives of moderately agile organisations seem to be in innovation objectives.

In addition, 39 percent of the companies in our sample were highly agile. From Table 5.23, it can be established that all the highly agile companies had better mean difference scores in each of the organisational performance criterion than the other 61 percent did. Highly agile companies, however, enjoyed a wide range of specific benefits arising from their agile transformations that include, but go well beyond operational performance objectives. Some of these benefits such as, improved innovation, speed, and flexibility, contribute to better financial performance. Other benefits like eliminating environmental impact and increasing social responsibilities are part of supply chain broader sustainability performance, which statistically dominate that of nonagile clusters. Most importantly, the greatest differences in mean values between highly agile and less agile companies are in innovation, speed, and sustainability performance objectives.

To reap the overall organisational performance such as these, businesses must do far more than implementing sustainable practices. Successful sustainability transformation requires the integration of agility-related capabilities across the entire supply chain. Recent Deloitte survey on digital transformation demonstrated that using new technology capabilities combined tend to perform better sustainably. The current survey confirms this finding: most agile organisations were far more likely than nonagile companies to significantly outperform their industry average on key organisational performance metrics.

Notwithstanding the above results, it does not disclose the degree to which the agile groups differ in each dimension. So, it is vital to determine the effect size for specific organisational performance. The effect size is a set of statistics that indicates the relative magnitude of the difference between the amount of the total variance in the dependent variable (Tabachnick and Fidell, 2013, p. 54). There are numerous ways to calculate the effect size in the literature. Pallant (2013) suggested partial eta squared as the most used approach.

**Table 5.23** Post-hoc results: Organisational performance by agile strategy groups

| Organisational performance criteria | Less agile companies (n = 59) Group 1 | Moderately agile companies (n = 131) Group 2 | Highly agile companies (n = 121) Group 3 | F-value (significant) |
|---|---|---|---|---|
| Cost | -0.20ns | 1.16* | 0.75* | 30.175 (0.000) |
| Quality | -0.21ns | 0.92* | 0.75* | 31.443 (0.000) |
| Speed | -0.36* | 0.49* | 0.85* | 37.782 (0.000) |
| Reliability | -0.35* | 0.90* | 0.74* | 26.495 (0.000) |
| Flexibility | -0.40* | 0.33* | 0.72* | 24.976 (0.000) |
| Innovation | -0.55* | 0.39* | 1.70* | 80.579 (0.000) |
| Environmental sustainability | -0.45* | 0.55* | 0.99* | 80.674 (0.000) |
| Social sustainability | -0.42* | 0.53* | 1.33* | 78.055 (0.000) |

*. The group means difference are significance at the 0.05 level, Scheffe multiple comparison test

Ns = no significant value


**Figure 5.17** Comparison of mean difference – organisational performance

An inspection of the results of the 'between-subjects' effects (Table 5.23), showed that there are significant differences amongst agile companies on all sub-indicators of the organisational performance under consideration. Figure 5.17 illustrates the relative importance of performance objectives for each group of agile organisations. A line describes the relative importance of each performance objectives. The closer the line to the common origin, the less important is the performance objective to the operations. Each agile organisation provides the same service but with different objectives. The differences among the three agile groups are shown by the diagram. The effect size for the variables of the agile groups can be found in the "Partial Eta Squared" column Table 5.24 and table 5.25). Using Cohen's criterion (1988, p. 284-7), the largest effect size appears to be in speed, innovation, and sustainability performance objectives. These results provide additional support for the results obtained from the structural model discussed above.

**Table 5.24** Multivariate tests

| Effect | | Value | F | Hypothesis df | Error df | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| Intercept | Pillai's Trace | .991 | 3517.511[b] | 9.000 | 300.000 | .000 | .991 |
| | Wilks' Lambda | .009 | 3517.511[b] | 9.000 | 300.000 | .000 | .991 |
| | Hotelling's Trace | 105.525 | 3517.511[b] | 9.000 | 300.000 | .000 | .991 |
| | Roy's Largest Root | 105.525 | 3517.511[b] | 9.000 | 300.000 | .000 | .991 |
| Agile groups | Pillai's Trace | .606 | 14.539 | 18.000 | 602.000 | .000 | .303 |
| | Wilks' Lambda | .420 | 18.091[b] | 18.000 | 600.000 | .000 | .352 |
| | Hotelling's Trace | 1.318 | 21.889 | 18.000 | 598.000 | .000 | .397 |
| | Roy's Largest Root | 1.269 | 42.429[c] | 9.000 | 301.000 | .000 | .559 |

a. Design: Intercept + Agile groups

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

**Table 5.25** Test of Between-subjects' effects: MANOVA results

| Source | Dependent Variable | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| Corrected Model | Speed | 31.712[a] | 2 | 15.856 | 37.782 | .000 | .197 |
| | Flexibility | 21.321[b] | 2 | 10.661 | 24.976 | .000 | .140 |
| | Cost | 29.336[c] | 2 | 14.668 | 30.175 | .000 | .164 |
| | Reliability | 23.432[d] | 2 | 11.716 | 26.492 | .000 | .147 |
| | Quality | 28.875[e] | 2 | 14.437 | 31.443 | .000 | .170 |
| | Innovation | 142.079[f] | 2 | 71.039 | 80.579 | .000 | .344 |
| | environmental performance | 51.711[g] | 2 | 25.856 | 80.674 | .000 | .344 |
| | social performance | 112.957[h] | 2 | 56.479 | 78.055 | .000 | .336 |
| Intercept | Speed | 4191.788 | 1 | 4191.788 | 9988.273 | .000 | .970 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Flexibility | 4880.956 | 1 | 4880.956 | 11435.399 | .000 | .974 |
| | Cost | 4558.766 | 1 | 4558.766 | 9378.264 | .000 | .968 |
| | Reliability | 4666.996 | 1 | 4666.996 | 10553.207 | .000 | .972 |
| | Quality | 4456.081 | 1 | 4456.081 | 9704.875 | .000 | .969 |
| | Innovation | 3126.085 | 1 | 3126.085 | 3545.890 | .000 | .920 |
| | environmental performance | 3326.685 | 1 | 3326.685 | 10379.772 | .000 | .971 |
| | social performance | 3374.114 | 1 | 3374.114 | 4663.125 | .000 | .938 |
| Agile groups | Speed | 31.712 | 2 | 15.856 | 37.782 | .000 | .197 |
| | Flexibility | 21.321 | 2 | 10.661 | 24.976 | .000 | .140 |
| | Cost | 29.336 | 2 | 14.668 | 30.175 | .000 | .164 |
| | Reliability | 23.432 | 2 | 11.716 | 26.492 | .000 | .147 |
| | Quality | 28.875 | 2 | 14.437 | 31.443 | .000 | .170 |
| | Innovation | 142.079 | 2 | 71.039 | 80.579 | .000 | .344 |
| | environmental performance | 51.711 | 2 | 25.856 | 80.674 | .000 | .344 |
| | social performance | 112.957 | 2 | 56.479 | 78.055 | .000 | .336 |

a. R Squared = .197 (Adjusted R Squared = .192); b. R Squared = .140 (Adjusted R Squared = .134); c. R Squared = .164 (Adjusted R Squared = .158); d. R Squared = .147 (Adjusted R Squared = .141); e. R Squared = .170 (Adjusted R Squared = .164); f. R Squared = .344 (Adjusted R Squared = .339); g. R Squared = .344 (Adjusted R Squared = .340); h. R Squared = .336 (Adjusted R Squared = .332); i. R Squared = .384 (Adjusted R Squared = .380).

In furtherance to the above, while factor and cluster analysis help to understand underlying data structures. A discriminant analysis was carried out to help identify underlying variables that separate the groups from each other. In line with Narasimhan et al. (2006); Zhang and Sharifi (2007), a canonical discriminant analysis was done, with each agile group. Table 5.26 and Table 5.27 contain the standardised canonical and structure matrix discriminant function coefficients. Figure 5.18 shows a graphical representation of the discriminant function values. As can be seen from tables, two discriminant functions were identified. Almost 96.3% of the variance in the cluster memberships was explained by the first discriminant function. The coefficients for this function indicate heavyweights for indicators of sustainability, innovation, speed, and flexibility. Whilst 3.7% of the variance was explained by the second discriminant function. In this function, cost, environmental performance, quality, and reliability showed to receive the highest positive weights. Both functions are statistically significant, as stated in the Wilk's $\lambda$ test. The structure matrix (Table 5.26) shows the correlations between the discriminant functions. Values marked with (*) indicate the highest correlation between variables and discriminant functions. The diagram of the discriminant functions (Figure 5.18) illustrates these results and suggests a close and distinct grouping of the agile companies.

Overall, the findings identify groups with performance objectives that are in line with expected differences in high, moderate, and less level of agility capabilities. The moderate or less agile companies seem to show a positive and significant impact in cost, quality, reliability, and environmental performance objectives, while their impact on innovation, speed, flexibility financial and social sustainability objectives was low.

By way of contrast, the highly agile companies have performed beyond the less agile companies in areas of innovation, speed, flexibility, and sustainability performance objectives. Most importantly, the greatest performance of highly agile companies appears to be in speed, innovation, and sustainability objectives. This result concurred with existing work (Bottani, 2010, Narasimhan et al., 2006, and Braunscheidel and Suresh, 2009), who found that the most agile companies exhibit significant higher performance than moderate and low agile organisations against speed and flexibility. The current result further shows that highly agile organisations performed most in innovation, speed, and sustainability performance objectives. This suggests that supply chain agility capabilities are significant catalysts for organisational sustainability and performance.

**Table 5.26** Structure Matrix discriminant function coefficients

| | Function | |
|---|---|---|
| Indicators | 1 | 2 |
| Innovation | .642* | -.125 |
| Environmental performance | .637* | .416* |
| Social performance | .632* | -.134 |
| Reliability | .438* | .192* |
| speed | .400* | -.167 |
| Flexibility | .391* | -.198 |
| Quality | .364* | .272* |
| Cost | .347 | .439* |
| Eigenvalue | 3.269 | .049 |
| % Of variance | 96.3 | 3.7 |
| Canonical correlation | .748 | .216 |
| Wilks' λ | .420 | .953 |
| Sig. | .000 | .048 |

*. Largest absolute correlation between each variable and any discriminant function

**Table 5.27** Standardized Canonical Discriminant Function Coefficients

| | Function | |
|---|---|---|
| | 1 | 2 |
| Reliability | 0.190 | 0.188 |
| Cost | 0.039 | 0.465 |
| Flexibility | 0.151 | -0.472 |
| Quality | 0.085 | 0.408 |
| Speed | 0.079 | -0.125 |
| Innovation | 0.405 | -0.122 |
| Environmental performance | 0.285 | 0.720 |
| Social performance | 0.321 | -0.070 |

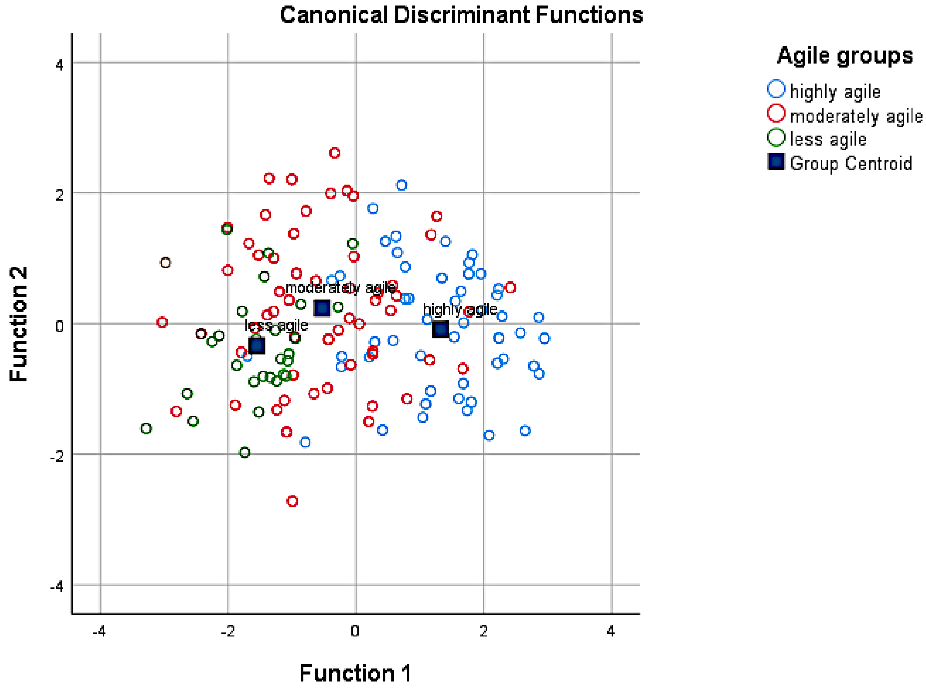



**Figure 5.18** Discriminant function plot

Following the above results, the question remains, however, why is highly agile organisations associated with better innovation, financial growth, and sustainability performance? The next analysis digs deeper into the factors that could link higher agile organisations with superior sustainability performance. As such, academics and practitioners may be curious which agile practices deliver the greatest return on investment, in terms of the performance objectives outlined above.

Figure 5.19 show that four of the five agile practices – market sensing, technology integration, network collaboration, and process alignment – appears to have the strongest measurable impact on the nine specific organisational performance objectives of cost efficiency, quality, speed, reliability, flexibility, innovation, financial, social, and environmental sustainability outcomes. The analysis suggests that these four practices combined account for two-third the impact seen on these performance outcomes, the employee empowerment play a smaller role.

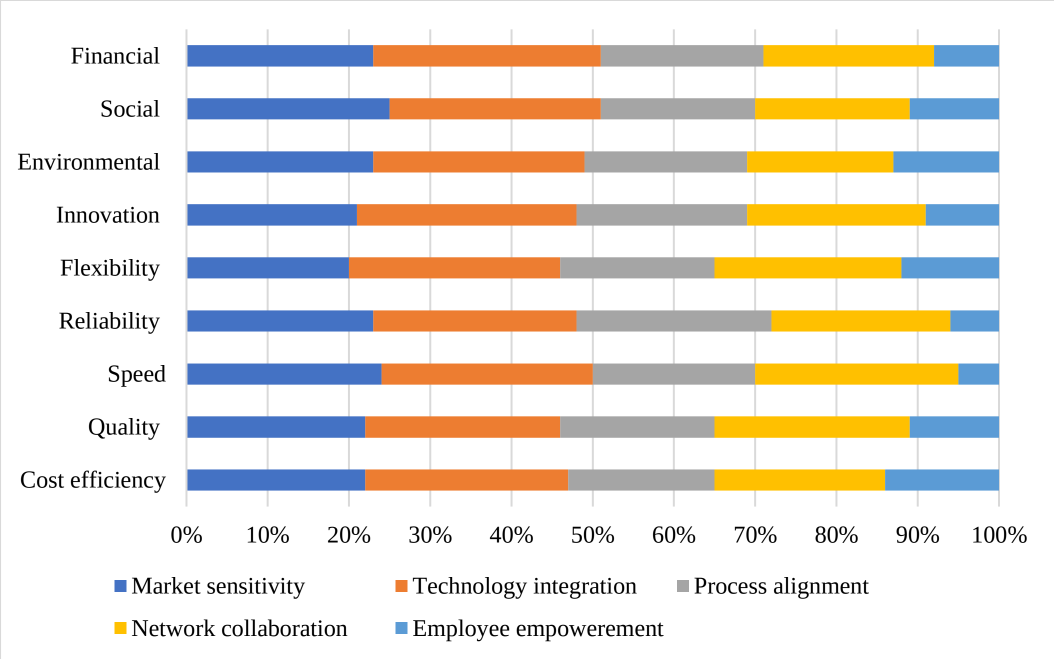



**Figure 5.19** Relative importance of individual agile practices in driving organisational performance outcomes

The thesis, therefore, should not be that organisations can gain the most benefit by pursuing these four practices at the expense of employee education. Because, as mentioned earlier, organisations that execute sustainability and agility concurrently across their supply chains tend to achieve a higher level of sustainability performance.

## 5.7 Assessing differences in agility strategy groups

Given the strike outperformance of the highly agile companies, this study conducted additional analyses to understand the characteristics and benefits of agility. We identified eleven supply chain practices that differentiated our sample's most agile companies from the moderate and least agile companies. The clusters varied in eleven agile practices indicated in table 5.28. Less agile companies have the lowest mean values on all 11 attributes, while moderately agile companies have higher mean value than less agile companies. It may be because of the increasing demands for innovative and sustainable products; environmental and ethical standards compliance. These forces perhaps pushed them to be more flexible and reliable, improved quality, reduced costs, increased market access and reputation, as well as enhance the level of investment in sustainability. Low pressures gave less agile companies little motivation to do so. Less agile companies, with a poor implementation on all eleven practices, have elected to compete by improving quality and efficiency improvement. Highly agile companies, on the other hand, gave the highest mean values on all eleven practices. Their adaptation to sustainability was significantly higher than those of nonagile groups combined, which justified why they implement all attributes. Being agile and sustainable are capabilities for heightening flexibility, quality, cost-efficiency, speed, innovation and amplifying sustainability performance outcomes.

**Table 5.28** Agility and sustainable practices by agile company groups

| Agile and sustainable practices | Groups of agile strategy | | | *F* = value (significance) |
|---|---|---|---|---|
| | Less agile companies (n=59) Group 1 | Moderately agile companies (n=131) Group 2 | Highly agile companies (n=121) Group 3 | |
| Market sensitivity | | | | |
| Cluster mean* | 2.97 | 3.44 | **4.33** | 52.247(0.000) |
| Rank** | 4 | 7 | 5 | |
| Standard Error*** | 0.135 | 0.074 | 0.086 | |
| Employee empowerment | | | | |
| Cluster mean* | 2.92 | 3.66 | **4.28** | 74.151(0.00) |
| Rank** | 5 | 4 | 6 | |
| Standard Error*** | 0.091 | 0.069 | 0.058 | |
| Process alignment | | | | |
| Cluster mean* | 2.42 | 3.56 | **4.68** | 62.388(0.000) |
| Rank** | 11 | 6 | 2 | |
| Standard Error*** | 0.073 | 0.064 | 0.054 | |
| Technology integration | | | | |
| Cluster mean* | 2.90 | 3.73 | **4.69** | 168.601(0.00) |
| Rank** | 6 | 3 | 1 | |
| Standard Error*** | 0.096 | 0.060 | 0.047 | |
| Network collaboration | | | | |
| Cluster mean* | 2.51 | 3.60 | **4.64** | 30.896(0.000) |
| Rank** | 10 | 5 | 3 | |
| Standard Error*** | 0.074 | 0.072 | 0.060 | |
| Environmental management practices | | | | |
| Cluster mean* | 3.34 | 3.35 | **3.59** | 5.341(0.005) |
| Rank** | 2 | 8 | 8 | |
| Standard Error*** | 0.086 | 0.063 | 0.053 | |
| Sustainable procurement | | | | |
| Cluster mean* | 2.75 | 3.07 | **3.28** | 32.095(0.000) |
| Rank** | 9 | 9 | 9 | |
| Standard Error*** | 0.054 | 0.042 | 0.031 | |
| Sustainable transport | | | | |
| Cluster mean* | 2.87 | 3.06 | **3.27** | 21.383(0.000) |

| | | | | |
|---|---|---|---|---|
| Rank** | 7 | 10 | 10 | |
| Standard Error*** | 0.047 | 0.035 | 0.038 | |
| Investment recovery | | | | |
| Cluster mean* | 2.85 | 2.86 | **3.20** | 15.969(0.000) |
| Rank** | 8 | 11 | 11 | |
| Standard Error*** | 0.078 | 0.041 | 0.047 | |
| Social sustainability practices | | | | |
| Cluster mean* | 3.18 | 3.87 | **4.48** | 36.526(0.000) |
| Rank** | 3 | 2 | 4 | |
| Standard Error*** | 0.169 | 0.087 | 0.069 | |
| Sustainable design | | | | |
| Cluster mean* | 3.70 | 3.89 | **4.19** | 40.074(0.000) |
| Rank** | 1 | 1 | 7 | |
| Standard Error*** | 0.060 | 0.073 | 0.048 | |

* Represents the average degree of importance attached to each practice by cluster. Importance is measured on a five-point Likert scale (1 = not important, 5 = extremely important; 1 = not at all, 5 = to a great extent).
** The rank order of importance of these practices within the group.
*** the standard error of the estimate of the mean for the group.
Note: the numbers in parentheses indicate the group numbers from which this group was significantly different at the 0.05 level as indicated by the Scheffe pairwise comparison procedure. Numbers in **bold** indicate the highest group centroid for that measure. Group 1 = Less agile companies, group 2 = Moderately agile companies, group 3 = Highly agile companies. The observed F-statistics were derived from one-way ANOVAs and *p*-values are associated with the observed *F*-statistics.

More so, responses from the three agile clusters compared using ANOVA and Scheffer pairwise comparison of mean difference to determine if and how well they implement these practices. Table 5.29 shows the results of the Post Hoc test and multiple comparison tests on the cluster mean values for each attribute. In the table, less agile organisations do not exceed the other two agile groups in the extent to which they implement these practices. The mean practices implementation values for fewer agility groups and moderately agile groups do not significantly vary for environmental management practices and investment recovery practices. Moderate agile organisations significantly dominate the least agile companies with the implementation of sustainable design, sustainable procurement, sustainable transport, and social sustainability practices. Moderately agile organisations also have higher executions of market sensitivity, employee empowerment practices, technology integration, these differences are slightly significant. By contrast, highly agile organisations statistically dominate the other two agile groups in the implementation of all attributes. What makes them different is the ability to balance fast action and rapid change.

In short, highly agile organisations appear to be strongest at the implementation of all practices (Figure 5.20). These companies excel at social sustainability practices, sustainable design, technology integration, market sensitivity, network collaboration, employee education and empowerment, amongst others. The results indicate that moderately agile and highly agile companies share several practices. Since highly agile companies seem to outperform moderate agile companies, this study accepts the view that medium agile companies are precursors to highly agile organisations (Narasimhan et al., 2006; Bottani, 2010).

**Table 5.29** Agile and sustainable practices mean difference by agile companies' groups

| Practices | Group 1: less agile organisations (n = 59) | Group 2: moderately agile organisations (n = 131) | Group 3: highly agile organisations (n = 121) | F-value (significant) |
|---|---|---|---|---|
| Market sensitivity | -1.36* | .48* | .89* | 52.247(0.000) |
| Employee empowerment | -1.37* | .62* | .74* | 74.151(0.00) |
| Process alignment | -.28* | -.28* | .66* | 62.388(0.000) |
| Technology integration | -1.79* | .83* | .95* | 168.601(0.00) |
| Network collaboration | -.18* | .18* | .76* | 30.896(0.000) |
| Environmental management practices | -.03ns | .26 | .35* | 5.341(0.005) |
| Sustainable procurement | -.32* | .21* | .65* | 32.095(0.000) |
| Sustainable transport | -.19* | .21* | .64* | 21.383(0.000) |
| Investment recovery | -.02ns | .22* | .63* | 15.969(0.000) |
| Social sustainability practices | -.69 | .62* | 1.31* | 36.526(0.000) |
| Sustainable design | -.45* | .71* | 1.16* | 40.074(0.000) |

*. The group means difference are significance at the 0.05 level, Scheffe multiple comparison test

ns = no significant value

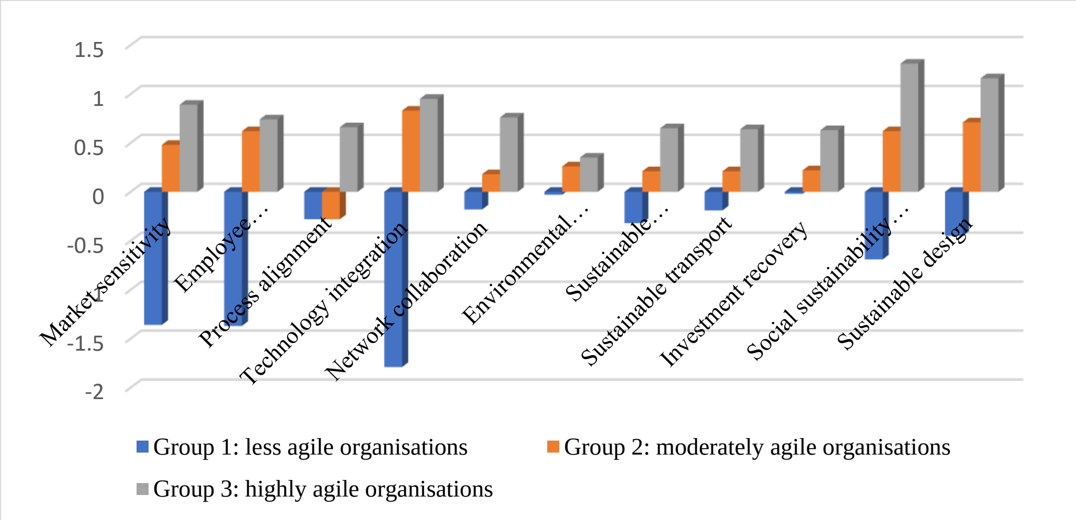



**Figure 5.20** Practices distinguishing highly agile companies from nonagile companies

## 5.8 Assessing the control variable effect: business size

This section looks at the role of control variables for the hypothesised model. The multiple-group analysis was used to compare the different business size. The relationship between agility, sustainable supply chain practices and organisational performance can also depend on the business size. As such, this study considered the total number of employees as a control variable. Small businesses are business with 0 to 49 employees while medium-sized businesses are business with 50 to 249 employees. Besides, large businesses are business with 250 or more employees.

As the focus of the research was on supply chains, three groups were identified: small-size companies (n = 129), medium size companies (n = 85) and large size companies (n = 97). Using multiple group analysis, the results show a significant chi-square difference ($\Delta\chi^2_{(\Delta df = 1)} = 5.458$ $p < 0.025$) between the constrained model ($X^2_{(\Delta df = 4)} = 39.992$) and unconstrained model ($X^2_{(\Delta df = 3)} = 34.534$), as indicated in Table 5.30 This effect suggests that small, medium, and large-sized enterprises are different at group level (Figure 5.21).

To estimate the difference at path level, several structural paths were individually constrained and compared with the unconstrained model. There was a significant difference between different-sized businesses, signifying that company sizes have a significant impact on operational performance and sustainability performance measures. It was also found that large enterprises have higher impacts on sustainability performance than the other two firms (see Figure 5.21 for details). This demonstrates that large firms invest a high amount, more productively, in agility and sustainable supply chain practices than small and medium-sized enterprises with poor resources. This is important when considering small suppliers, who less impact on their sustainable practices. In line with Simpson et al. (2012), when firms operate in asset-heavy industries, stakeholder pressure for performance enhancement is often more intense, so they tend to develop sustainable and agility capabilities and adopt a more proactive approach. In contrast, small and medium-sized enterprises face fewer intense stakeholder pressures and tend to wait longer to adopt sustainability initiatives.

**Table 5.30** Comparison between small, medium, and large-sized businesses

| Structural Path | Standardised loading | Groups (company size) | | | Path constrained model | $X^2$ | $\Delta X^2$ |
|---|---|---|---|---|---|---|---|
| | | Small | Medium | Large | | | |
| Agile capabilities → operational performance objectives | .509*** | .329** | .338*** | .388*** | B1 | 36.320 | $\Delta X^2$ = *1.786* |
| Agile capabilities → sustainability performance | .436*** | .278** | .546*** | .520*** | B2 | 39.992 | $\Delta X^2$ =*5.458* |
| Sustainable practices → agile capabilities | .559*** | .499*** | .548*** | .614*** | B3 | 36.008 | $\Delta X^2$ = *1.474* |
| Sustainable practices → operational performance objectives | .442*** | .333*** | .340*** | .576*** | B4 | 34.551 | $\Delta X^2$ = *0.017* |
| Sustainable practices → sustainability performance | .433*** | .087ns | .079ns | .442*** | B5 | 37.543 | $\Delta X^2$ = *3.009* |
| Sustainability performance → operational performance | .367*** | .269* | .338** | .466*** | B6 | 38.624 | $\Delta X^2$ = *4.090* |

*, **, *** indicates the significance of the p value at < 0.05; < 0.01, < 0.001, ns = no significant
n = 311, Estimation Method = Maximum Likelihood.
Path Constrained Model fit indexes B1: CMIN/DF = 9.080; CFI = 0.945; NFI = 0.940; IFI = 0.946; and RMSEA = 0.062
Path Constrained Model fit indexes B2: CMIN/DF = 9.998; CFI = 0.939; NFI = 0.934; IFI = 0.940; and RMSEA = 0.071
Path Constrained Model fit indexes B3: CMIN/DF = 9.002; CFI = 0.946; NFI = 0.941; IFI = 0.947; and RMSEA = 0.061
Path Constrained Model fit indexes B4: CMIN/DF = 8.638; CFI = 0.948; NFI = 0.943; IFI = 0.949; and RMSEA = 0.057
Path Constrained Model fit indexes B5: CMIN/DF = 9.386; CFI = 0.943; NFI = 0.938; IFI = 0.944; and RMSEA = 0.065
Path Constrained Model fit indexes B6: CMIN/DF = 9.656; CFI = 0.941; NFI = 0.936; IFI = 0.943; and RMSEA = 0.068

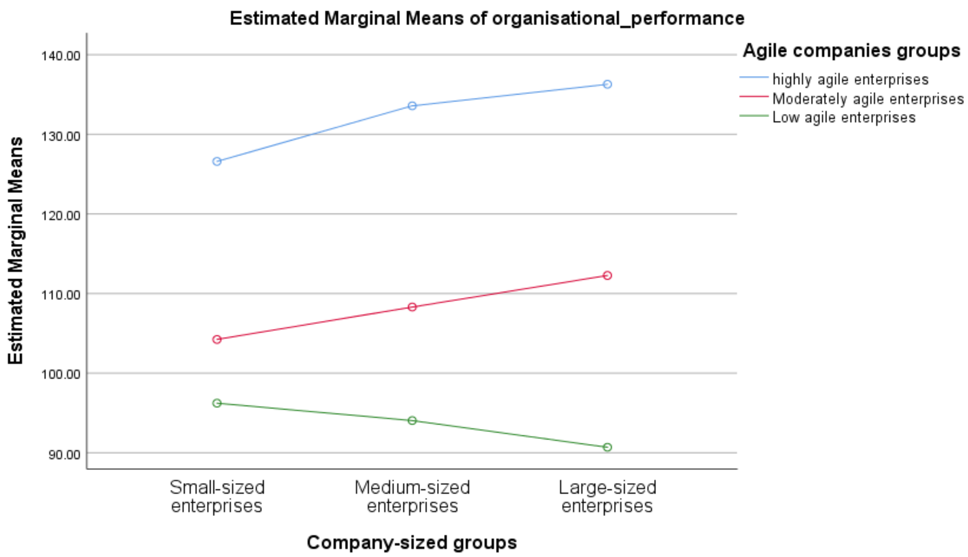



**Figure 5.21** Profile plot: comparison among business sized

## 5.9 Summary

This chapter focus on a wide range of statistical analysis and results of several hypotheses that were generated in chapter 3. The chapter began with a preliminary analysis, which revealed the consistent pattern of respondents' attributes and frequency of the study variables. Following this, a series of statistical tests were carried out to validate the measurement scales. This technique led to removing some items from the initial study constructs. The combination of exploratory factor analysis and confirmatory factor analysis was performed to assess the measurement model and inspect the reliability and validity of constructs.

The conceptual model was tested after the assumption of structural equation modelling had been fulfilled, and the structural model fit had been determined. The results of this study advance the knowledge of sustainability practices and confirm the role of agile practices as enablers of sustainability performance. We adopt the dynamic capability view to examine the interactive effects between agile practices, sustainable practices, operational performance, and sustainability performance of the supply chain. We provide empirical evidence of sustainability approaches as a strong driver for the development of agile capabilities. More so, there is a clear indication of a strong positive and significant effect of agile practices on sustainability performance. The research findings also demonstrate that sustainability practices are direct sources of sustainable competitiveness, but their performance impacts are improved when facilitated through agile practices. This suggests that agile capabilities are necessary conditions for maximising the impacts of implementation of sustainability practices on enterprise performance. The research offers insights into the outcome of agility and the degree to which the performance of sustainable product design, investment recovery, health and safety, and a broader socially responsible behaviour collectively can be achieved.

In addition, the effects of individual practices on operational performance objectives and sustainability performance were tested. The results show that all different agile practices have a significant impact on both operational performance objectives and sustainability performance. However, all sustainable supply chain practices have a positive and significant effect, except for environmental management practices, which have no significant impact on operational performance.

This study further obtained clarification and empirical support of agile supply chains paradigms. The study identified agile companies groups whose characteristics accord well with the descriptions found in agility literature. The data distinguish moderately agile companies from less agile companies on performance and practice dimensions that are in line with concepts put forward in the literature. In the same vein, the data distinguish highly agile organisations from the others in expected dimensions. Moreover, agility appears to represent a higher state of organisational performance and practices, as highly agile companies exceed the other two companies in all the performance and practice dimensions that we measured. The results give charity on which individual practices and groups of agile companies have the greatest impacts on specific performance objectives and practices. Finally, the effect of the control variable was evaluated, which gave some interesting results. The results showed that company size influenced the study's relationship.

# CHAPTER 6: Discussions and implications

## 6.1 Introduction

This chapter presents the discussion of results, carried out in the previous chapter, to clarify the impacts of agility and sustainable practices on organisational performance in the UK oil and gas industry. The chapter then examines important research findings. The chapter concludes by outlining a range of research contributions and implications for policymakers and managers, and the relevant suggestion that could need to be addressed as industrial supply chains becomes more agile and sustainable.

## 6.2 Overview of the research

Several studies have explored agility and sustainability practices separately (Blome et al., 2013; Marshall et al., 2015). But these practices have rarely been looked at together. Therefore, this study aims to investigate the relationships between agility and sustainability and their individual and combined impacts on sustainability performance of industries. This is predicated upon the fact that whilst agility or sustainability has been correlated with financial measures and operational performance objectives, there is no empirical study currently that examines the influence of agile practices on the extent to which organisations could translate sustainability practices into sustainability performance (Ciccullo et al., 2018; Chen et al., 2017). It is not clear if agility serves as an effective mediator of sustainability.

Sustainable supply chain, according to Roy et al (2018), involves 'the management of economic and non-economic measures within the supply chains.' Similarly, Marshall et al (2015) contend, it is a set of practices aimed at minimising the environmental impacts and enhancing the social welfare of different stakeholders while contributing to the long-term financial growth of the entities within the supply chain. Azevedo et al. (2012) and Dües et al. (2013) distinguish between green and sustainable supply chain paradigms and contend that green supply chain paradigm involves practices aimed at minimising the environmental impacts of the supply chain whilst sustainable supply chain encompasses the triple-bottom line of environmental, social, and economic objectives. In furtherance of this, several works have examined the relationship between adoption of sustainable supply chain practices and organisational performance. Such work includes (Golicic and Smith, 2013; Rao and Holt, 2005; Paulraj et al., 2017) who have demonstrated a positive correlation between sustainability and organisational performance. However, there are contrasting reports (Esfahbodi et al., 2017; Winn et al., 2012; Green et al., 2012b; Hahn et al., 2010) of sustainability having a negative impact on firms' profitability indicating a need to find ways to maximise the performance advantage of implementation of sustainability practices. The challenge for organisations, thus, is how to integrate social and environmental sustainability practices with agile supply chain capabilities to develop unique capabilities to improve their sustainability competitiveness (Ciccullo et al., 2018; Chen et al., 2017), which is the subject of investigation of work reported here.

Agile approaches focus on a network of teams within a people-centred mindset that operates in rapid learning and fast decision cycles, which are enable by technology, and that is guided by a powerful common purpose to co-create value for all stakeholders (Ebrahim et al., 2018, p. 2). Such an agile operating model can quickly and efficiently reconfigure strategy, people, technology, and processes while collaborating with customers and adapting to change (Serrador and Pinto, 2015) to take advantage of windows of opportunities. It is a business model that allows companies to use market knowledge and teamwork to exploit profitable opportunities in a volatile marketplace (Naylor et al., 1999, p.108). This idea has been extended beyond organisation's boundaries to include the activities of the supply chain, emphasising the need for strategic alliances, knowledge transfer, information sharing, aligning resource capabilities and effective leadership practices across supply chain (Dyer et al., 2018).

According to Lee (2004), agile supply chains is about being responsible and adaptable to the customer requirements while avoid the risk of supply chain disruptions. Supply chain agility is the ability of the firm to sense short-term, temporary changes in supply chain and market environment as well as to quickly adjust to those changes (Aslam et al., 2018; Eckstein et al., 2015). Agile supply chain capabilities have extensively researched and linked to superior organisational performance. However, whilst it established that agility, on the one hand, induces better operational performance and sustainability, on the other hand, could potentially induce enhanced indicators of environmental and social sustainability, the cumulative impacts of both agility and sustainability has not been clarified. Ciccullo et al. (2018) called for the development of a model that integrates agility practices with sustainability practices and advocated for empirical studies of the relationships between the set of constructs. Therefore, in this study, we explored agility as a mediator of sustainability and examined the roles of agile capabilities in maximising the transformation of sustainability practices into environmental and social sustainability performance. The relationships amongst agile practices, sustainable practices, and organisational performance criteria (operational performance objectives and sustainability performance) depicted in Figure 6.1. So, the thesis proposed the following nine hypotheses to answer the research questions:

$H_1$: Sustainable supply chain practices have a positive effect on operational performance.

$H_2$: Sustainable supply chain practices have a positive effect on sustainability performance.

$H_3$: Agile supply chain capabilities have a positive effect on operational performance.

$H_4$: Agile supply chain capabilities have a positive effect on sustainability performance.

$H_{5a}$: The interaction between sustainable supply chain practices and agile supply chain capabilities positively affects operational performance

$H_{5b}$: The interaction between sustainable supply chain practices and agile supply chain capabilities positively affects sustainability performance.

$H_6$: Sustainability performance has a positive effect on operational performance

$H_7$: Agility capabilities mediate the relationship between sustainable supply chain practices and operational performance.

$H_8$: Agility capabilities mediate the relationship between sustainable supply chain practices and sustainability performance.

$H_{9a}$: Managerial experience moderates the relationship between sustainable supply chain practices and operational performance.

$H_{10a}$: Managerial experience moderates the relationship between sustainable supply chain practices and sustainability performance.

$H_{9b}$: Industry sector moderates the relationship between sustainable supply chain practices and operational performance.

$H_{10b}$: Industry sector moderates the relationship between sustainable practices and sustainability performance.

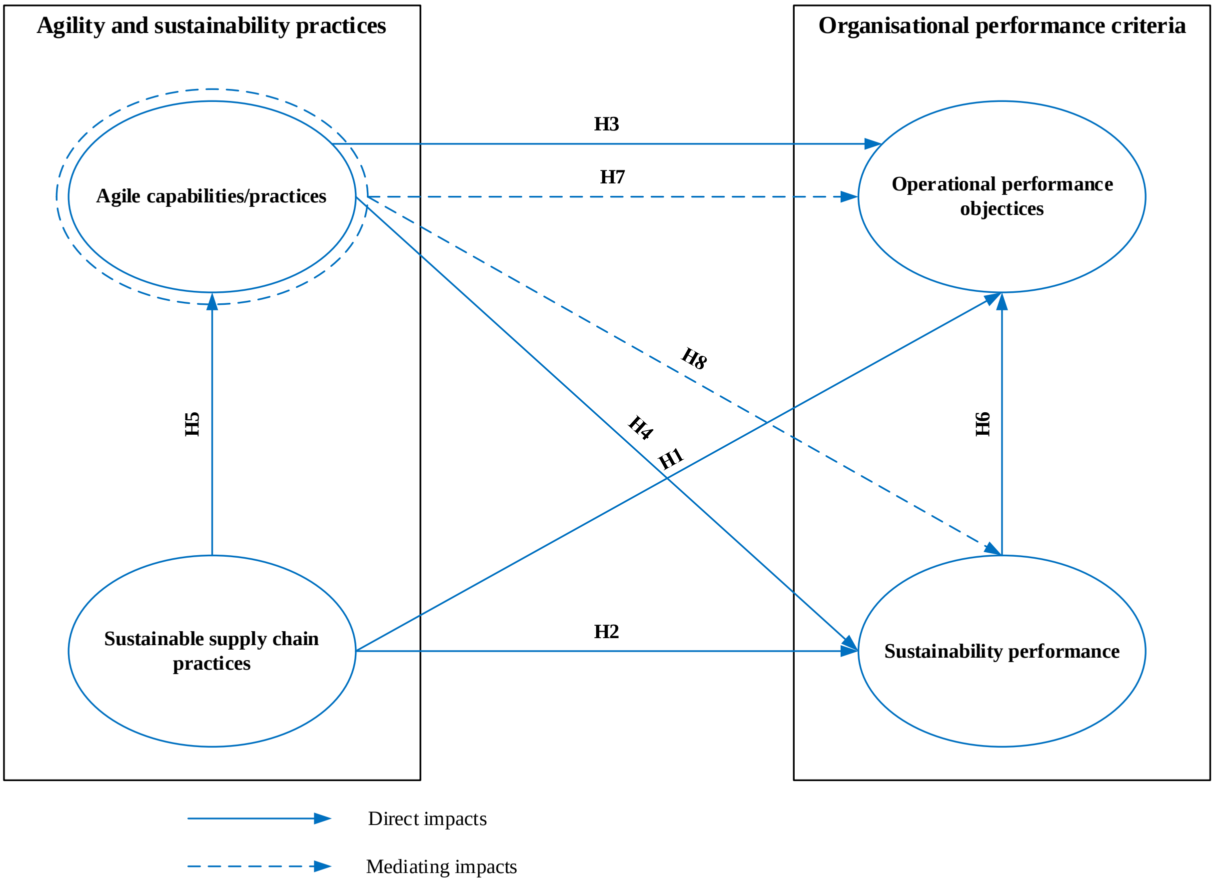



**Figure 6.1** Final conceptual model

## 6.3 The effect of sustainable SCM practices on operational performance and sustainability performance

We found that sustainable supply chain practices have a positive and significant effect on both sustainability and operational performance. These results point out that sustainable supply chain practices are essential for differentiating products in the marketplace, and for additional and innovative value-creation. Through sustainable practices, the UK oil and gas sectors can realise significant savings, resulting in a cost advantage relative to their competitors. In fact, sustainable supply chain practices can save not only the cost of operations, but it can also boost productivity and increased energy efficiency. Less waste means better use of material inputs, resulting in lower cost for raw materials and waste disposal. For the same reason, sustainable practices may reduce cycle time by removing non-value adding activities. More so, a shift towards a circular flow of product, sustainable product design and socially responsible behaviours could provide UK manufacturing firms with the potential to cut emissions well below required levels, lessening the organisation's compliance costs, which, ultimately result in enhanced cash flow and profitability or new revenue streams for the supply chain. Investment in sustainable practices can help reduce reputation risks, increased market access and enhance employee engagement and diversity. Whilst other studies appeared to suggest that SSCM practices have damaging effects on operational and financial performance (Esfahbodi et al., 2017; Zhu et al., 2007, 2013), our findings provide strong empirical evidence that the implementation of SSCM practices will lead to better sustainability performance as well as better organisational performance in terms of cost, quality, speed, flexibility, and innovation.

## 6.4 The effect of agility capabilities on operational performance and sustainability performance

The results also show that agile practices have strong positive and significant effect on sustainability performance and operational performance. These findings are consistent with prior studies, which noted that the higher the level of agility approaches, indeed the greater the increase in overall organisational performance (Tse et al., 2016; Eckstein et al., 2015; Yusuf et al., 2014; de Groote and Marx, 2013; Blome et al., 2013). Suffices to state that whilst the link between agility and operational performance is not new, what is new here is the connection between agile practices and sustainability performance. The agile practices seem to account for more than 69 and 46 per cent of the variance in sustainability performance and operational performance respectively. As changing climate will make resources becoming scarce, using market-sensing capability and advanced technology can facilitate the reduction of social and environmental impacts. Further, they can help identify ways to eliminate waste, minimise materials input, water, and energy consumption in manufacturing, which, in turn, can help reduce operating costs. Additionally, joint effort with suppliers for sustainable procurement and process development will reduce toxic chemicals during production and can help prevent corporate reputations from damage and remove unwanted pressures from regulators and civil society groups. Since these capabilities are socially created with suppliers, customers, and other stakeholders, they can be a source of operational performance while also leading to improved sustainable supply chain performance.

## 6.5 The interaction between sustainable SCM practice and agility capabilities

The outcome of this study shows that there is a significant correlation between sustainable supply chain practices and agile practices in the UK oil and gas industry. Thus, it can be argued that the higher the implementation of sustainable supply chain practices, the greater the likelihood that agile capabilities will develop. The ability of organisations to design and create new sustainable products may lead to the development of agile practices. This seems to indicate that the constraints and challenges posed by social and natural environment are drivers of new capability development for firms. Further inspection of the hypothesised tests indicate that sustainable practices explained more than 17 per cent of the variance in agile practices. This suggests that agility capabilities are likely to emerge during a period of greater social and environmental changes. In this regard, the research assume that agile capabilities evolve because of organisations’ responses to consumer demand for sustainable products.

Furthermore, the research provides novel findings regarding the interactive effects of both sustainable supply chain practices and agile supply chain capabilities in influencing performance outcomes. Results indicate that agile capabilities and sustainable practices interaction explains a significant amount of variance in performance beyond individual effects. That is agility and sustainable practices act as complements in enhancing sustainable supply chain performance. With the marginal benefits of each of the capabilities increases in the presence of the other (Rothaermel and Hess, 2007; Makadok, 2001). This finding show that sustainable practices are both antecedent and complements of agile capabilities in supply chains.

## 6.6 The effect of sustainability performance on operational performance

In addition to the above results, this research reveals that sustainability performance also has a positive impact on operational performance objectives. This impact seems to make logical sense, as operational performance reflect savings that result from improved social and environmental performance (Zhu and Sarkis, 2006). Indeed, literature point to a positive connection between social performance and economic performance. At the highest levels of abstraction, social responsibility is linked to positive organisational outcomes (Orliztky et al., 2003; Bauer et al., 2005). Investment in human development is linked to positive organisational performance (Collins and Clark, 2003; Hitt et al., 2001). According to Das et al. (2008) and Brown et al. (2000), protecting and promoting workers' wellbeing via improved health and safety can help intensified operational performance objectives. In line with Pagell and Gobleli (2009), environmental and social performance interact significantly with operational performance. That is, overall performance on all three dimension of sustainability is possible. While the influence of implementing sustainable practices on operational performance can be further be explained through the correlations between sustainability performance and operational performance objectives. In this view, environmental management practices that do not have a significant impact on operational performance can indirectly influence sustainability performance.

## 6.7 The mediating role of agility capabilities

While the impact of sustainable practices and agile capabilities is positive and significant ($\beta$ = 0.327, $p < 0.001$). Thus, factors other than sustainable practices must help to develop agile capabilities. This study further confirms the mediating role of agile capabilities in the relationship between sustainable supply chain practices and organisational performance. This research contradicts Hong et al. (2018) findings, which predicted that supply chain capabilities do not affect both economic and social performance. As already mentioned, the successful implementation of sustainability practices depends on the knowledge of customers and other stakeholders. The market sensing capability of an agile organisation can help in understanding the expectations of customers whilst the lack of a sensing capability could render sustainability initiatives unsuccessful (Wu et al., 2016). As insights from customers can help shape platforms that create a maximum return for organisations, agile organisations with market sensing capabilities can quickly leverage the understanding of customers and information technology to improve sustainability. Several organisations have improved sustainability performance through the level of involvement with suppliers or collaborative effort with network members on reducing their negative sustainability impacts. The greater the level of collaboration practices, the more likely it is that organisations could bolster sustainability outcomes.

Strong governments support has also identified as a critical factor in simplifying sustainable supply chain management implementation. It involves the willingness of governments to invest resources in social and environmental initiatives. With governments and regulatory support, contractors and sub-suppliers tend to be more interested in sustainable supply chains and be motivated to join and offer complimentary resources to help the supply base. In line with Yu and Cruz (2019) and Chen and Chen (2019), a lack of strong government support could affect the sustainability and competitiveness of supply networks. The more third-party involvement, the higher businesses are committed to sustainability. Besides, regulatory policies can affect many stages of the supply chain, without governments intervention, aspects of the energy-intensive industry in the UK will not be sustainable (Vallack et al., 2011; TUC, 2012). In this case, sustainable regulatory policies focus on lower carbon and energy taxes can not only increasing businesses' ability to invest in sustainable technologies but also lessening their overall carbon footprint. Government's support can facilitate the oil and gas sectors to become more sustainable. This approach can result in better jobs, increased public health and safety, enhanced profitability, better waste management, increased energy efficiency, and reduced water use.

Furthermore, both governments and operators have a constructive role to play in reducing carbon emissions of oil and gas supply chains. The move towards net-zero carbon emissions will require concerted efforts and actions in resources and energy efficiencies such as less energy demand, changes to society choices in diet and travel, the electrification of industry, heat and transport, increased use of hydrogen, and changes in land use. As part of this, some oil and gas industry focused on environmental protection system and the reduction of operational emissions. The ability of governments to undertake a strategic environmental assessment before licensing an area for oil and gas activities can help the sectors in adopting environmental, social, and health impact assessment. Likewise, Governments need to institute an oil spill contingency strategy before the oil and gas sectors make their contingency policies. According to (Rajesh and Ravi, 2015; Yang et al., 2011), governments initiatives such as environmental impact assessment, environmental management plans, social management strategies, health management plan, as well as compliance inspection and audit are all essential practices to maintain sustainable competitiveness in the oil and gas industry.

There are several approaches, parties in the oil and gas sectors are embracing in respond to the changing environment. These include improved operational management systems; the decommissioning of older assets; more emission-intensive installations, lower emissions from new fields and the use of more efficient technologies; energy-efficient technologies for power generation offshore. Other methods include reduced routine flaring in greenfield projects; evaluating the opportunities to use renewable energy sources or connection to onshore power generation; the use of offshore wind developments; reducing system leakages; upgrading and altering equipment to maximise operational and energy efficiency; and participation in the emissions trading scheme. The industry also involved in workshops, where members share emissions reduction projects and ideas to familiarise with sustainability policy improvement.

The industry must also consider the development and use of new technological capabilities. Some oil and gas sectors have started to develop capacities in sustainable technology, electric vehicle technology, process modelling, asset recovery, renewable services and carbon capture and storage technology. Additional investments in agile technology-related capabilities (such as cloud and mobile devices, big data analytics, automotive robotics, and artificial intelligence, blockchain, and the internet of things) would help the industry intensify sustainability objectives. These capabilities offer the capacity for traceability and transparency of operations throughout the oil and gas industry. Recent falling in oil price has highlighted the role of new technologies in driving operations efficiencies - albeit at the cost of limited investment. Both operators and governments must show commitment to the adoption of game-changing technologies to support their sustainability accomplishment. Besides, the integration of these new technologies will speed up oilfield service transactions, increased resources efficiency, and improved safety by removing people from harm, which, in turn, can reduce costs, enhance business reputation, increased customer satisfaction, and employee engagement.

There are several dynamic capabilities that oil and gas industries need to consider to be competitive in the current climate as well as in the future. This study highlighted some of the dynamic capabilities that are critical for oil and gas leaders to create and capture sustainability values. These include scanning/sensing capabilities; coordinating/learning capabilities; transformation or integration capabilities; alliancing and innovative capabilities. The oil and gas industry needs to align and realign its operations and business models to enable new innovative and sustainable products and technologies to remain competitive as conditions changes.

The education or training of workers is another important dynamic capability that needs to consider. Most oil and gas supply chain companies are likely to be SMEs, and they often face the challenge of insufficient resources and expertise, especially at the start of a sustainable programme. Manufacturers and governments provision of the necessary human resources support and expertise, such as education and training, can provide further supplier implementation support for sustainability. This process can help to build capabilities and competencies through workers and supplier development programmes. As such, the engineering expertise skills and knowledge to deliver operational emission reduction, sustainable development in production efficiency and supporting the advancement in low carbon technologies can aid the diffusion of sustainability throughout the entire supply networks.

## 6.8 Moderating effects of managerial experience and industry sector

The research showed that industry sector can serve as a significant moderate of the relationship between sustainable practices and sustainability success. on the other hand, managerial experience is not found to moderate the relationship between sustainable practices and organisational performance success. It is interesting to note that the regression analysis showed statistical significance but low values for percentage of variance explained ($R^2$). When the moderator variables were included in the regression, the overall $R^2$ rose significantly. This suggest that firms in the high energy intensive incline to adopts a proactive sustainable initiative, then those in low carbon intensive once. As Simpson et al. (2012) pointed out that when firms operate in high-pollution industry like oil and gas, institutional pressure for sustainability performance enhancement is often more intense, so they tend to develop superior agility capabilities and adopt proactive sustainable strategies. While firms that operate in low-pollution sectors face less intense stakeholder pressure and tend to wait longer to adopt new sustainability practices.

While the research predicted that the positive impacts of sustainable practices on performance will be increasingly manifested as the managerial experience increases, the result fails to support this hypothesis (H10a and H10b). The analysis shows that there is a negative interplay, managerial experience negatively moderates the link between sustainable practices and organisational success. This is an intriguing finding because it suggests that one of the benefits of implementing sustainable practices is that they enable for superior success regardless of the use of staff experience. Using the technique suggested by Aiken and West (1991), the research indicate that at a high level of managerial experience, sustainable practices have a negative effect on performance success. this finding despite being unexpected, again may be explained by other factors as key drivers dictating this relationship. Increasing managerial experience in terms of developing sustainability knowledge-learning and sharing between operators and suppliers needs initial investment in information technology, which means an increase in the cost associated with sustainability. The knowledge acquisition is a costly and time-consuming venture, which requires training programme for employees to use the sustainability information sharing processes. It has been posited that the lack of knowledge is an important incentive for focal firms to collaborate with third parties on the design and implementation of sustainable practices in the supply chain (Esty and Winston, 2006). Plambeck and Denend (2011) observed that even large firms might lack the technical experience to manage the sustainability of their suppliers and, need to associate with other stakeholders to implement sustainability in supply chains. Simpson et al. (2007) and Delmas and Montiel (2009) concluded that firms with less technical skills may adopt a conservative strategy, implementing sustainability practices after focal firms, lowering their risks.

## 6.9 The influence of individual sustainable supply chain practices on performance outcomes

As the alternative model shown in figure 19 chapter 4, all the sustainable practices have a positive and significant effect on both sustainability and operational performance objectives. This signifies that sustainable supply chain practices can intensified organisational performance. The findings are in line with the existing work (Zhu and Sarkis, 2007; Lee et al., 2012b; Green et al., 2012a). Broadly, sustainable practices are aimed at minimising the environmental impacts and improving the social condition of different entities of the chain, while boosting innovation, resource-efficiency, reputation, and market share. Though, the finding regarding the influence of implementing environmental management practices on operational performance objectives was no significant. The study found that all sustainable practices have a positive impact on organisational performance. The next sections discussed the individual practice influence on performance outcomes.

### 6.9.1 The effect of sustainable design on sustainability performance and operational performance

The result show that the raising implementation of sustainable design has a largest impact on both sustainability performance and operational performance objectives. These findings are consistent with existing work, which suggested that the more organisations implement sustainable design, the higher the level of sustainability performance (Zhu et al., 2008, 2013; Zhu and Sarkis, 2007; Green et al., 2012b). While these results contradict prior research Esfahbodi et al. (2016, 2017), who reported that sustainable design practices have a negative impact on economic performance. In line with Grote et al. (2007, p 4100), the purpose of sustainable design is to minimise the sustainability impacts a product without compromising other design criteria such operational performance. It is, thus, natural that sustainable design has achieved this objective. There are multiple sustainable design options to make products or processes less emission intensive. With total life cycle techniques, operators and contractors could be more motivated to explore sustainable design. Doing so using technology could not only minimise operating costs, but also present a positive economic benefit. Less pollution and waste mean better use of material inputs, resulting in lower costs for raw materials and waste disposal (Zhu et al., 2008). Sustainable design can also reduce cycle time by removing unnecessary steps in production processes. It can provide opportunities to cutdown emissions and reduce organisations compliance and liability costs (Green et al., 2012b). So, this study provide evidence that the implementation of sustainable design practices will lead to better sustainability performance and operational performance.

### 6.9.2 The effect of sustainable procurement on sustainability performance and operational performance

The empirical results indicate that sustainable sources have a positive and significant impact on both sustainability performance and operational performance objectives. These results are in line with prior literature (Esfahbodi et al., 2016, 2017; Tachizawa et al., 2015; Zhu and Sarkis, 2007; Zhu et al., 2013; Green et al., 2015; De Giovanni and Vinzi, 2012), who demonstrated that the implementation of sustainable purchasing initiatives in the supply chain improves sustainability performance. This confirms the position of these empirical results, which are in accordance with most of the recent research.

Broadly speaking, the sustainable procurement practices aimed at reducing waste and pollution emissions from the entire operation processes, while eliminating demands for materials that is directly linked with reusing, recycling, and remanufacturing of products (Sarkis and Dou, 2018; Luthra et al., 2016; Min and Galle, 1997). By sourcing more efficiently, organisations can reduce their sustainability impact while lowering the costs of input and waste disposal (Porter and van der Linde, 1995; Hart and Dowell, 2011). Whilst ignoring environmental and social issues in sourcing can expose an organisation to reputational risks (Hill and Hill, 2012).

In addition, to implement a sustainable procurement practice, it is essential to understand how they are purchased. Aspects such as building the contract with clear clauses and requirements, as well as shared responsibility principles, are currently being discussed among manufacturers. As a result, continuing collaborative relationships and joint efforts are promoted to reduce business impacts on the environment and society. Some organisations support the initiatives to suppress the funding of armed conflicts through the raw material trade (Hofmann et al., 2018).

Another initiative is encouraging the use of digital procurement, which saves paper and time and increases transparency between buyers and suppliers.

### 6.9.3 The effect of investment recovery on sustainability performance and operational performance

More so, the findings reveal that investment recovery has a positive and significant effect on sustainability performance and operational performance objectives. This study contradicts Zhu and Sarkis (2007) findings, which envisaged that asset recovery does not influence sustainability performance. Here, the research findings are compatible with recent work (Green et al., 2012, 2015; Zhu et al., 2012). As explained in the previous section, the sources of more sustainable materials, components, products, and services are associated with waste management. As such, the raising purchase of these materials offers more opportunities for reusing, refurbishing, remanufacturing, and recycling, which can be facilitated amongst other approaches, via closed-loop supply chain (Zhu et al., 2013; Kleindorfer et al., 2005). These are essential tool towards implementing - a circular way of doing business where wastes are recycled as raw materials or with the end-of-life products reused as input (Gupta et al., 2019; De Angelis et al., 2018; Chen et al., 2019; Heydari et al., 2019).

These practices concerned with reducing negative environmental impacts by attempting to integrate obsolete, and excess capital assets back in to reverse logistics processes so that assets may be recovered or disposed of (Zhu et al., 2008). This shift in thinking is likely to generate real competitive benefits and differentiation (Bai and Sarkis, 2016). It can also help organisations to maximise cost savings, which can lead to higher profitability (Chen et al., 2019; Hua et al., 2019). A circular approach provides companies with an alternative pattern of resource use and creating more value from each unit of the resource through recovery and regenerating products at the end of their service lives (Choi and Hwang, 2015).

### 6.9.4 The effect of sustainable transportation on sustainability performance and operational performance

The result shows that the more the implementation of sustainable transport, the greater the impact on both sustainability performance and operational performance. The findings are in support of previous research (Ciardiello et al., 2019; Yu and Cruz 2019), which discovered that this approach is sensitivity to tax policies in terms of decisions to use cleaner technologies across the supply chain, but there are impacts on profit, costs, total emission, and productivity. More so, the presents of sustainable technologies will improve the air quality (Zhu et al., 2005, 2007), as it requires more investment in technology to increase the potential implications of sustainable delivery practices (Christopher, 2016).

When companies decide to invest in providing more sustainable materials and services, this strategy includes avoiding disposable or non-recyclable packaging materials. To minimize any negative impact on the environment as well as additional financial charges due to disposable packaging, organisations are investing more in reusable packaging and containers. Others have established a packaging manual, which is integrated with the terms and conditions of purchase. This document clarifies their requirements, aimed at avoiding packaging, encouraging the use of packaging and reusable materials that can be recycled after the end of its life cycle.

In addition to reducing the product footprint, packaging innovations enable complementary efficiency gains that benefit the environment and society. Industry uses packaging design as an opportunity to identify the ideal density to protect the product as well as to optimize space utilization during transportation loading. To reduce overall material consumption, some organisations reduce the volume of transportation by optimizing packaging on inbound distributions.

Although, this study shows a positive impact of sustainable transport on both sustainability performance and operational performance objectives. But the greater improvement of air quality in the UK, which could have positive impacts on the environment, health, and wellbeing, requires further action at all levels of government and shift in mindset. Pollution emissions reduce life expectancy, which may result in death. These health impacts are related to pollution sources that are produced through the delivery of products, such as motor vehicle emissions. Even though they cannot solve all emission problems, policymakers – particularly at local and regional government level – can influence air pollution impacts through traffic management, wider travel planning decision, and encouraging the use of renewable energy and electric vehicle, often with additional economic and health benefits. Other initiatives of sustainable packaging in transport management are related to the use of transport mode, while several industries use electric rail transport during delivery. These practices can help enhanced air quality, innovation, speed, flexibility, and improved sustainability outcomes.

### 6.9.5 The effect of social sustainable practices on sustainability performance and operational performance

Over the years, several researchers have focused on environmental supply chain practices and two aspects of sustainability performance (environmental and economic performance), partially neglecting the social dimension (Ciccullo et al. 2018; Martínez-Jurado and Moyano-Fuentes, 2014). Investigating the impact of social sustainability practices on sustainability performance and operational performance objectives would help organisations understand how to address the complete set of sustainability performance. As such, the results of this study show that social sustainability practices have a strong positive and significant effect on sustainability performance and operational performance. Hence, it can be said that the greater the implementation of social sustainability practices, the greater the performance outcomes. Social sustainability practices are about the management of social issues in the entire supply chain, which focuses on health, safety, product, and process-related issues. The implementation of these practices will lead to an improvement in the suppliers' social performance. That is, working together with suppliers for social issues, the prime firm will recognise a decrease in the child and labour force issues and human right abuse. These supplier development practices can also contribute to improving the safety and workers conditions in suppliers' facilities. The implementation of social practices will help in boosting supply chain sustainability performance. These findings support existing work, such as (Sancha et al., 2015a; Lee and Klassen, 2008; Foerstl et al., 2010).

As regards to operational performance objectives, when workers are more motivated, the productivity and quality will be enhanced (Pagell et al., 2010). This study extends this view and suggests that better operational excellence can be reached if social sustainability practices contribute to improving suppliers' sustainability performance. Organisations could perceive an increase in operational performance not only because workers are motivated but because the working conditions on supplier facilities have enhanced. Better working conditions at the supply chain may reduce the rate of accidents, avoid the spread of disease, and so reduce disruptions within the supply chain leading to better delivery reliability outcomes (Sancha et al., 2015a, b).

### 6.9.6 The effect of sustainable production on sustainability performance and operational performance

With regards to the influence of environmental management practices on sustainability performance and operational performance, our results show that the effect is different depending on the approach, corroborating the idea suggested in the existing work (Tachizawa et al., 2015; Foerstl et al., 2010). The study found that environmental management practices have a direct and positive effect on sustainability performance, but the relationships between environmental management practices and operational performance were not significant. These results are in line with the work of (Tachizawa et al., 2015; Esfahbodi et al., 2017), which established that environmental management practices can only have an indirect impact on organisational performance. In the context of the supply chain, focusing on environmental management systems might not be enough to achieve operational performance; collaborative practices between operators and suppliers are required (Tachizawa et al., 2015). Because these practices may require that lower-tier suppliers be certified with ISO 14000 and SA 8000 (Simpson et al., 2012; Esty and Winston, 2006; Mena et al., 2013).

Overall, the results of this study clarify the suggestion that the role of the individual sustainable practices on organisational performance may be necessary. However, the relationship between the implementation of environmental management practices and operational performance is no clear. Of the impact explored, sustainable design has the greatest impact on both the sustainability performance and operational performance (standardised coefficient = .436, and .350, $p < 0.001$) *respectively*, followed by sustainable procurement (standardised coefficient = .267 and .339, $p < 0.001$) and social sustainability practices (standardised coefficient = .193, $p < 0.01$; .206, $p < 0.001$) respectively (see figure 19 for details). While investment recovery practices, sustainable transport and environmental practices have the least impact on the sustainability performance and operational performance objectives.

## 6.10 The influence of individual agile capabilities on performance outcomes

As explained in section 5.3, collective agile capabilities have a strong positive and significant effect on sustainability performance and operational performance. But there is no understanding and clarification on which individual agile practices have the greatest influence on the performance outcomes. As such, the next section discussed individual relationships.

### 6.10.1 The effect of technology integration on sustainability performance and operational performance

All five agile practices of market sensitivity, technology integration, process alignment, network collaboration, and employee empowerment were shown as direct precursors of sustainability performance and operational performance objectives, clarifying a significant impact on performance outcomes. Among these five precursors, the integration of technology-based capability appears the largest predictor of operational performance objectives. This finding corroborates the assertions of Gong et al. (2019); Hannibal and Kauppi (2019); Jadhav et al. (2019), who maintained that advanced technology has the potential to improve supply chains performance. The findings support the idea that the diffusion of information reduce information gap and help organisations to modify the way that their supply chains operate (Lechler et al., 2019; Hannibal and Kauppi, 2019). Increasingly, this finding supports the supplier less as an operational 'one-off' relationship, but more as strategic alliance collaborator.

At the enterprise level, digital technology transfer represents the use of analytics, artificial intelligence, robotics, machine learning, integrated sensor, the internet of things, and other advanced technologies to gather and process information to support or fully automate decision making and other activities (Gupta et al., 2019). These types of information exchange play a central role in sustainability competitiveness of supply chains, supporting innovation, driving product development, and providing the impetus for improvements in operational performance. This is in agreement with some previous research, which has shown that agile technology capability can help reduce material or energy use to levels considered sustainable in the long-term; facilitate product personalisation; delivery of innovative new products; higher performance and more flexible manufacturing systems delivery better quality and cost performance; better customisation of products and services, which can intensify operational excellence (de Groote and Marx, 2013; Teece, 2018; Raschke, 2010; Roberts and Grover, 2012).

More importantly, the advances in technologies will lead to new ways of doing business, using new sources of data to make products more tailored to sell complementary service (OECD, 2016). Several organisations use these technologies to optimise distribution networks, planning the most efficient routes for delivery and making the best use of their warehousing capacity. These technologies can help firms do familiar tasks in most agile and sustainable ways. Recent reports Hancock (2015) and Hazarika (2020) noted that the use of robotics and artificial intelligence will create more jobs and lead to increases in social sustainability performance.

Looking at big data more broadly, a recent report on the value of big data and internet of things estimated £240 billion in cumulative benefits; manufacturers should derive the most benefits, with greatest gains across business sectors are to come from efficiency savings (SAS, 2016). Another report (Choudhry et al., 2015a, b) envisages large operational savings using big data, in addition to opportunities for revenue growth and reducing pollution and waste emissions. Equally a study by Bakhshi et al. (2014) found that organisations who make better use of customer and consumer data were 13% more productive than firms who do not. In line with

McKinsey (2015), companies using artificial intelligence and robotics increase their revenues by 23% and productivity by 26%. As resources become scarce, the implementation of advanced technology will reduce energy, water and raw material used in manufacturing. In this end, some of the digital robotics, big data, artificial intelligence, machine learning and autonomous systems can play a key role in enabling sustainability performance and operational performance outcomes.

### 6.10.2 The effect of market sensitivity on sustainability performance and operational performance

The results also showed that the degree of market sensitivity practices affects the level of sustainability and operational performance. Market sensitivity was determined to be the second greater precursor of performance outcomes. This is in line with the assertions that it will be difficult to achieve sustainability successfully without a robust understanding of, involvement with, and knowledge of the customer and other stakeholders (Wu et al., 2016). The market sensing capability of an agile organisation can help in understanding the needs of customers while a lack of sensing capability could render sustainability failure (Wu et al., 2016).

As insight from stakeholders can help shape platforms that create a maximum return for businesses. Agile organisations that combined a deeply embedded strategy with an adaptable approach to value creation can rapidly sense and seize opportunities. Entities across the supply chain individually and proactivity watch for changes in customer preferences and the external environment and act upon them. They seek stakeholder feedback and input in a range of ways. They use tools like customer journey maps to identify new opportunities to serve the customer better and gather customer insights through informal and formal mechanisms that help shape, pilot, launch, and iterate on a new initiative and business models.

### 6.10.3 **The effects of network collaboration on sustainability performance and operational performance**

The study results also show that network collaboration has a strong positive and significant impact on improving sustainability performance and operational performance. That is, collaboration plays a large role in supply chain sustainability performance. The findings oppose Um and Kim (2019), who argued that not all collaboration, lead to good performance outcomes; this is no true for sustainability competitiveness. This finding suggests that the network of teams and multi-stakeholders' alliances are also direct capabilities for advancing sustainable objectives in industries. Sustainability issues are more challenging and complex to tackle alone (Chen n et al., 2017). Without cross-tier collaboration, suppliers will find it difficult to meet customers' needs and expectations (Mueller et al., 2009; Krause and Scannell, 2002; Koh et al., 2012). As such, collaborative network capabilities could help to boost supply chain sustainability performance (Jabbour et al., 2019).

However, many small and medium-sized businesses have limited resources or capabilities to tackle sustainability problems. Collaborative practices can provide a means for businesses to pool resources and improve their performance outcomes (Ağan et al., 2016). In this way, industry supply networking can help contribute to reduce social and environmental impacts (Lu et al., 2012; Ehrgott et al., 2013). There is ample evidence that collaborative practices have a positive impact on improving sustainability performance (Zhu and Sarkis, 2007; Lu et al., 2012; Esfahbodi et al., 2017; Vachon and Klassen, 2006).

Network collaboration can promote manufacturers and suppliers working together and establish better relationships among the partners. When supply chain members jointly try to solve sustainability problems, they will be capable of obtaining superior performance benefit

(Dyer and Singh 1998; Dyer et al., 2018; Lusch and Brown, 1996; Ghijsen et al., 2010). Collaborative initiatives can help manufacturers and suppliers understand the strength and weakness of both parties (Ross et al., 2009). This increased understanding can enable both parties to broaden the scope of their sustainability risk management processes and to mitigate sustainability challenges.

Collaboration with suppliers on sustainability issues can help foster sustainable innovation. Here, sustainable innovation can be classified into sustainable product, sustainable process innovation and sustainable managerial innovation (Zhu and Sarkis, 2004; Chiou et al., 2011). Collaboration practices can also improve products design and production processes and increased the quality of the environmental management system (Chiou et al., 2011). For manufacturers, working closely with suppliers can lead to sustainable suppliers and more sustainability innovation (Rao, 2002). The collaborative network can help increase sustainability knowledge sharing between organisations. In the context of supply chains, interfirm knowledge flow and management are a significant source of competitive objective (Chen et al., 2015). So, to be truly sustainable, manufacturers can rely on using collaborative initiatives that can improve their sustainability performance.

Agile organisations, therefore, maintain a sustainable structure but replace them with a flexible, scalable network of teams. As mentioned before, networks are a natural way to organise efforts because they balance individual freedom with collective coordination. An agile organisation involves a dense network of empowered teams that operate with a high level of alignment, accountability, expertise, and transparency.

Transparency is very critical and one of the reasons for collaborating with suppliers. As the industries under higher pressure to reduce social and environmental impacts of its activity, network collaboration become fundamental to reduce carbon footprint and so greenhouse gas emissions. Likewise, effective collaboration and partnerships can facilitate the sharing of ideas and promote awareness of sustainability impacts within the chain. As the industry encourage networking and partnerships with stakeholders, it can enhance economic growth, strengthen social wellbeing, improve industrial safety, and enhance quality of supply chain operations.

### 6.10.4 The effect of process alignment on sustainability performance and operational performance

The results also show that process alignment has a strong positive impact on sustainability and operational performance. These findings support the assertions of Braunscheidel and Suresh (2009) that the integration of supply chain processes may be necessary for competitiveness. The importance of process integration is consistent with the principles outline by Ebrahim et al. (2018). Therefore, for the suppliers to be agile and sustainable, efforts must be made to eliminate pollution and waste within the supply chain (Hill and Hill, 2012). The literature has highlighted the benefit of aligning cross-functional business processes. The findings of this study also extend the work of Pagell (2004), who established the positive impact of process integration on organisational performance. But, rather than performance, this research suggests that process alignment contributes to sustainability performance and operational excellence.

The cross-functional teams responsible for managing sustainability act as promoters of stakeholder dialogue, not only within the scope of the supply chain but also with stakeholders such as governments, other companies, universities, and non-governmental organisations (NGOs). Closer relations with governments support compliance with current and future laws and the development of industry standards and collaborative platforms that promote better use of resources, cost reductions and a joint training program. Some organisations coordinate stakeholder forums with representatives of all interest groups and collaborate with universities to support employee and supplier development.

On the one hand, companies may reach competitiveness as a first mover when supporting governments in planning future regulations. On the other hand, close relationships with stakeholders keep the company informed about customers' demands, laws that influence its operations, and environmental and social issues raised by NGOs. The capacity to manage these aspects and provide quick answers to differentiates industries' sustainability in the competitive market.

The results also extend the work of Rosenzweig et al. (2003), who revealed the importance of integration have influence on competitive capabilities, with the measure for integration being a combination of external and internal integration. Compatible with our results, which process alignment shows a significant effect on sustainable competitiveness. These findings also support the work of Vickery et al. (2003), who indicate that supply chain process integration contributes towards performance. Our results complement the above research by showing that process alignment or transformation contribute to sustainability.

### 6.10.5 The effect of people empowerment on sustainability performance and operational performance

The results demonstrate that employee empowerment significantly impacts both sustainability performance and operational performance objectives. While the effect of employee empowerment on sustainability performance was significant at a slightly lower level ($p < 0.05$). It appears that employee empowerment contributes more significantly ($p < 0.01$) toward improving operational performance. These findings support the contention that worker education and development can help in enhancing supply chain performance (Sarkis and Dou, 2018). Agile learning puts people at the centre, which engages and empowers everyone in the organisation. In that way, they can contribute to mitigate environmental degradation through the effective management of multi-tier suppliers for sustainability.

Many providers, especially smaller providers, lack access to knowledge and expertise. Thus, larger, and resource-rich suppliers who have acquired knowledge and expertise related to sustainability issues may be able to share this with other providers. The information may be specific to a product or asset of the manufacturer or maybe more general. Knowledge transfer can be done primarily through training activities. Many such training and communication activities can be provided by organising conferences, workshops, web-based training, or act as facilitators to share information among providers.

In this case, manufacturers educate and train suppliers about sustainability issues to improve suppliers' sustainability performance. One focus of education and training is to learn how to elicit economic benefits from improving sustainability performance. As noted above, small, and medium-sized businesses often lack the knowledge and resources for implementing sustainable programs. As such, manufacturers need to allocate human and financial resources to visit and work with suppliers to solve sustainability problems. A key to this kind of education and training is to verify suppliers that better sustainability performance, which can also lead to economic benefits. The other critical issue of this kind of education and training is to build up the sustainability capability of suppliers.

Organisations that have done this well have invested in leadership that empowers and develops their people, a strong community which supports and grows the mindset and underlying processes of people that foster the entrepreneurship and skill-building necessary for sustainability and agility. Agile organisations with leadership skills serve the people, empowering and developing them. Instead of directors, controllers, planners, they become visionaries, architects, and trainers who empower the people with the most relevant skills so that these can lead, collaborate, and deliver exceptional performance outcomes. Such leaders are catalysts who inspire people to act in team-oriented ways and get involved in making strategic decisions that will affect sustainability and operational performance.

Agile organisations create an interconnected community with a common mindset. Such practices are then reinforced through positive members' performance. People processes help sustain clear accountability and freedom to pursue opportunities, and the ongoing chance to have new experiences. Workers in agile organisations exhibit an entrepreneurial drive, taking ownership of team objectives, decisions, and performance. People identify and pursue opportunities to develop new initiatives, knowledge, and skills in daily work. Agile organisations attract young people who are motivated using a passion for their work and who aim for excellence. The talent development in an agile model is about building new capabilities through varied experiences. Agile organisations allow and expect role mobility, where employees move regularly between roles and teams, based on their personal development goals. An open talent marketplace supports this by providing information on sustainability issues and operational.

## 6.11 Assessing the group of agile strategy that have a greater (or the greatest) impact on specific performance

Although the findings are consistent with widespread debates in the literature, they differ from existing explanations of sustainability and agility paradigms. The performance outcome differences across groups correlate well with the expected differences across the agile organisations that excel at both sustainability and agility. In a prior study, we have determined that, to be agile, an organisation need to be both sustainable and dynamic. Sustainable practices cultivate efficiency and reliability through establishing a backbone of elements that do not need to change frequently, while agile practices enable companies to adapt nimbly and quickly to new challenges and opportunities. The survey scored organisations across eleven practices, which this research suggests are all critical for achieving organisational performance. In line with the results, less than half of the performance units are agile. The remaining nonagile companies lack either agility, sustainability, or both. Based on these discoveries, we can argue that sustainable and agile methods tend to occur in practice. However, the practice differences across the industrial groups revealed in our data differ from those suggested by sustainability and agility paradigms.

Firstly, looking at performance differences, the empirical findings create a profile that is well suited to descriptions of moderate agile companies. Moderately agile companies (Group 2) appear to have developed capabilities that emphasise efficiency, quality, reliability, and environmental performance measures. Cost-efficiency, reliability and flexibility improvement are key performance outcome associated with moderately agile companies. According to Hill and Hill, (2018), most sustainable initiatives focus on reducing pollution, waste, and non-value-added activities, highlighting performance improvements in the areas of cost efficiency, quality, reliability, and productivity. In contrast, highly agile companies (Group 3) display performance capabilities that reflect the 'service' emphasis to which Christopher and Towill (2001) refer to agility. They have the highest performance objectives in terms of innovation, speed, flexibility, and sustainability performance measures, following agility paradigm that emphasise responsiveness, shortening new product development lead time, reduced system changes lead time and cost, and efficient scaling up and down operations (Narasimhan et al., 2006; Power et al., 2001).

In short, the survey also confirms that high agile pays off. Ninety-six per cent of highly agile companies report a significant increase in their overall performance (see chapter 4). On average, highly agile companies are 1.5 times more to report financial growth relative to peers, and 1.1 times more to report non-economic measure than their counterparts. Such companies achieve greater innovation, faster time to market, flexibility, and sustainability performance. This was confirmed in recent work by Ahlbäck et al. (2017); Bottani (2010). According to the results, few companies have achieved organisation-wide agility, but many have started pursuing agility in their performance units.

The low agile companies are often associated with firefighting approach, a lack of coordination, collaboration, and sustainable initiatives. These organisations find themselves lacking both sustainable and agile capabilities. Just 2 percent of respondents at low agile companies say they follow investment recovery approach, compared with 63 percent of their highly agile peers. The agility practices in which they are furthest behind are technology integration, market sensitivity, and workers education and empowerment, and process-based capabilities.

Moderately agile companies are low in agility and more often characterised by sustainable design and social sustainability practices. To overcome the established patterns that keep them from moving quickly, these organisations need to develop further their agility practices and modify their sustainable practices, especially practices related to process alignment, network collaboration, sustainable sources, sustainable transport, asset recovery and environmental management system.

When looking more closely at moderately agile companies, they need to address the agility practices, as compared with highly agile companies, they are furthest behind. Only 28 per cent of moderate agile companies' report following process alignment practices, while 66 per cent of highly agile companies say the same. A weakness in this area is the implementation of network collaboration: just 18 per cent of moderate agile companies' report doing so, compared with 76 per cent of high agile companies. After that, the largest gap between moderate agile and highly agile companies is their ability to quickly reconfigure process, people, networking with teams and roll suitable technology that support agile methods of working toward value-creating and value protecting opportunities.

Several researchers have argued that network collaboration, market sensing, process transformations, and innovative technologies are important enablers of agile capabilities (Geyi et al., 2020; Carvalho et al. 2017; Martinez-Sanchez and Lahoz-Leo, 2018; Lin et al., 2006; Eckstein et al. 2015; Conforto et al. 2014; Bottani 2010; McCullen and Towill, 2001). They also emphasize the importance of highly skilled, knowledgeable, and empowered workers. Our findings support these arguments, as these are the areas of practices that seem to differentiate between highly agile and moderately agile companies (see chapter 4).

At the same time, moderate agile companies can improve certain sustainable practices. Moderately agile companies are deteriorating for sustainable transport, sustainable sources, and investment recovery. In highly agile companies, there is a high degree of social interaction and transparency. Most respondents said that their companies' new sustainable products and processes are developed in close interaction with customers and that stakeholders are involved early in the development process so that entities can quickly gather information on possible improvement. Increasingly, leaders should improve workers wellbeing by encouraging greater social sustainability practices and investing in social supplier development. Besides, it is more common in highly agile organisations to create small teams who are accountable for the procurement, delivery, and recovery of assets.

Besides, to explore the impact of business size on correlation amongst major constructs, we assessed if the findings of the standardised coefficients vary among small business, medium-sized businesses, and larger businesses. The results show that the coefficient for business size is significant, indicating that the effects of agility and sustainable practices on performance outcomes are not the same for the business size. This result concurred with previous literature (Pilbeam et al., 2012; Lee, 2008; Tachizawa and Wong, 2014), which argued that small and medium-sized business lack the information, resources, or expertise to manage social and environmental issues, and need external stimulus from large business and government to achieve sustainability.

## 6.12 Contributions of the study

### 6.12.1 Managerial implications

This study provides some insights into how organisations can adapt to sustainability challenges in their supply chains. The sustainable and dynamic models support the definition of agile supply chain paradigms. The importance of sustainability within the supply chain strategy reflects the baseline for setting the level of effort required.

Figure 5.1 shows a potential framework for combining sustainability and agility paradigms. A shift to a more sustainable manufacturing will be critical, requiring manufacturers to use less material, water, energy, and other inputs; make better use of alternative materials. Sustainable products design will be important in helping the economic sustainability and competitiveness of organisations and will make valuable contributions to social and environmental sustainability. Moving towards a more circular economy could reduce waste generation and minimise total greenhouse gas emissions. It will help companies to reduce pressure on the environment; improve security of the supply of raw materials; increase global competitiveness; stimulate innovation; create jobs; and boosting long-term economic growth. It will be empowering customers by providing them with more innovative and sustainable products that will enhance quality of life and save costs. Managers must strive to implement agile practices to increase sustainability performance. They should implement sustainable and agile strategies concurrently to optimise the development of agile capabilities.

Our result also emphasises the importance of suppliers involvement in sustainability initiatives. Therefore, the research argues the need for close collaborative relationships amongst suppliers, customers, government, civil society groups, and other stakeholders in order to resolve social and environmental problems. In conclusion, this study research examined the intervening effect of agile practices in the links between sustainable practices and organisational performance. As resources are becoming increasingly scarce, using advanced technology, as Yusuf et al (2014) contended, will reduce energy, water, and raw materials usage. Sustainable technology will allow companies to reduce material or energy use to levels considered sustainable in the longer term. It will provide clean energy to everyday products, which can improve sustainability performance.

The research also suggests that manufacturers seeking to embed sustainability into an agile supply chain strategy may enforce existing practices (Piercy and Rich, 2015). According to Martinez-Leon and Calvo-Amodio (2017), manufacturers should know that not all individual sustainable practices may be beneficial in terms of economic impact (Carvalho et al., 2017; Esfahbodi et al., 2017). In the context of resource-constrained SMEs, this study identified key sustainable supply chain initiatives that need to be implemented, including sustainable design, sustainable procurement, sustainable transport, investment recovery, and social sustainability practices. These five practices provide managers with useful strategies to evaluate their suppliers. Manufacturers are advised to use these practices collectively.

As mentioned previously, our study shows that true agility comes when all agile attributes are implemented together. These attributes describe the organic system that enables supply chain agility. Linking these attributes, we found a set of significant difference in these organisations.

We establish that highly agile organisations excel at all performance objectives of innovation, speed, flexibility, reliability, cost, quality, and sustainability. More so, when organisations want to embrace sustainability objectives, they must harness agile practices. These practices related to technology integration, market sensitivity, network collaboration, process alignment, and employee empowerment. Managers seeking to maximise the outcomes of their sustainability campaigns should consider the concurrent implementation of sustainable and agile practices.

This research also provides insight for regulators and policymakers on how to support energy-intensive industries to achieve sustainable processes. There is an indication that market forces alone will not produce the right sustainable solution. While evidence from this study suggests that without effective stakeholders' intervention, an important aspect of industries will not be sustainable in the UK. As such, there is a need for positive policy intervention that provides certainty to industry and creates incentives that support the current energy efficiencies. If policymakers can support these industries to become sustainable, the prize is significant: more and better jobs, increase in public health and safety, a stronger economic growth, better waste management, increased energy and material efficiency and reduced water usage. But more changes need to be done to achieve sustainability ambition.

For policymakers, financial support is important tangible resources to build capacity and further improve sustainability performance. Several small businesses find it difficult to access government support to promote investment in new technologies. The UK has the potential to be at the forefront of technological innovations that will be critical to a lower carbon future, but this requires serious investment. If the full technological potential for decarbonising the industrial sectors is to be realised, considerable effort will be made towards innovation. Over the years, the focus has been on improving the efficiency of fossil fuel-based industrial processes and, not on implementing alternative energy sources, maybe because of low oil prices.

Innovation support is necessary to prove promising technologies in energy efficiency and process emissions reductions. Additional support to research and development associated with key technologies is vital for technologies that are still at the early stage. Although, some oil and gas industry has begun to develop new technological capabilities in sustainable technology, electric vehicle technology, advanced services, artificial intelligence, asset recovery, process modelling and approaches to carbon capture technology, amongst others. The government can play a key role in the development of these technologies and do so in a way that builds on the industrial collaboration that will enable their sustainability.

Therefore, policymakers need to focus more on lower carbon and energy tax policies. It needs to understand how to maintain the competitiveness of the UK's industrial sectors and ensure that they contribute to reducing carbon emissions. Yu and Cruz (2019) identified higher carbon emissions tax as key threats to sustainable technologies. Businesses can choose to move production to a lower cost economy, than invest in cleaner technologies. British firms emphasise carbon and energy taxes lessening their ability to invest in emission reduction technologies (Vallack et al., 2011). Chen and Chen (2019) suggested that government policy can affect supply chain sustainability and profitability. So, government intervention can help industries reduce energy bills and lower carbon emissions.

Maintaining sustainable competitiveness is vital to the delivery of a low carbon future. But this will be made possible only with cross-stakeholder cooperation and involvement. Network collaboration is an effective way to lower operational costs and maximise efficiencies while simplifying contractor management. We advise active alliances, virtual environment, and a shared vision for supply chains, joint by government, industry, and other key stakeholders.

More so, co-location and improved alignment of the supply chain processes are also key priorities. It is possible to use one industry's waste as another industry's feedstock. Combining equipment, software and engineering, or other combinations of service offerings can unlock significant value for customers.

Finally, sustainable innovation and development can further enhance only if highly skilled workers and suppliers are available to develop and grow the industry, besides the future of new technologies and processes dependent on workers education and training. Policymakers should provide measures to motivate skills providers and educators with agile and sustainable capabilities. Experts are also encouraged to share their success stories of implementing sustainable practices with suppliers and clearly state the benefits drive from such initiatives. Also, the review of the nature and level of funding, as well as a willingness to work jointly with employers and other stakeholders in education and training, would help drive forward the social suppliers' development opportunities needed to build a sustainable supply chain. Policymakers can benefit from these initiatives, as the study provides an insight that allows manufacturers to look at agility and sustainability as a means of competitive advantage.

### 6.12.2 Theoretical implications

The growing competition for resources and a changing climate has forced manufacturers to act in order to safeguard their future competitiveness. The dynamic capability theory (Beske et al., 2014; Aslam et al., 2018; Blome et al., 2014a, b) can offer important support to the progress of competitive advantage. This is envisaged because sustainable competitive objectives depend largely on the organisation's ability to integrate, build, and reconfigure internal and external resource competencies to address rapidly changing environment. In this regard, this study advances the knowledge of sustainability and operational strategy by exploring the performance effects of agility and sustainable supply chain practices. Our finding confirms that sustainable supply chain practices are drivers of agile capabilities. Further, the result indicates that agile practices, in turn, have impacts on both sustainability performance and operational performance. From the analysis, it is evident that the implementation of the respective dimensions of sustainable practices including sustainable products design, waste reduction initiatives and socially responsible behaviours are supporting organisations to reach expected sustainable competitive objectives. This result has important implications both for operations strategy and sustainability field. Thus, this study contributes to the wider literature in our discipline by providing empirical evidence on the influence of a set of agility and sustainable practices on organisational performance. More importantly, we break new grounds by examining the sustainability performance enhancement and amplification role agility plays as a mediator in the relationship between sustainable practices and the duo of operational performance and sustainability performance.

### 6.12.3 The contribution to methodology

The main methodological contribution of this study is the used of confirmatory approach (i.e., hypothesis testing) to the analysis of a structural model. In particular, the study employed structural equation modelling (SEM) techniques to test the influence of a set of agility and sustainable practices on supply chain performance objectives. The several aspects of SEM techniques enabled the concurrent analysis of a wider range of causal processes under study are represented using a series of structural equations, and this has been modelled to facilitate a clear conceptualisation of the hypotheses under investigation. The hypothesised model has been tested statistically in simultaneous analysis of the entire set of variables to determine the extent to which it is consistent with the data (Byrne, 2016; Blunch, 2013; Tabachnick and Fidell, 2013). In this way, the SEM techniques facilitate a better understanding of the relationships among the proposed study constructs (Kaplan, 2004; Hair et al., 2010).

Unlike the traditional multivariate approaches that are incapable of assessing measurement error, the important feature SEM techniques provide explicit estimates of these error variance parameters. Regression techniques assume those errors in exploratory variable vanishes. Using these methods when there is an error in the exploratory variables is tantamount to the ignoring error that may lead to serious inaccuracies. Such mistakes are avoided when corresponding SEM analysis is used. While analysis of data using regression, methods are based only on observed measurement, SEM methodology helps to combined both latent (unobserved) and observed variables. Besides, SEM methods allow for modelling multivariate relationships or for estimating indirect effect.

Another key benefit of SEM technique is that it can be used to test for significant differences between groups (Pallant, 2013; Tabachnick and Fidell, 2013).  That is, it helps researchers to look at which groups of agile companies have the highest effect on specific performance objectives (Geyi et al., 2020). Here post-hoc analysis was used to determine if there is a significant difference among the various groups under study. In particular, the Scheffe test was used to reduce the risk of a type 1 error. These techniques help to indicate the relative magnitude of the difference between mean value, or the amount of the total variance in organisational performance criteria that is predictable from knowledge of the level of agility and sustainable practices (Tabachnick and Fidell, 2013. P. 54). Notwithstanding this benefit, Hair et al. (2010) argued that the key weakness of SEM technique is the fact that it is intensive, requiring an understanding of SEM concept and its software packages. They maintained that SEM methods are complex and using it demands a certain level of SEM-related quantitative expertise. The second drawback of this technique is the sample size required (Kaplan, 2008).

Despite the highlighted limitations, the proposed SEM technique will help to confirm the earlier research. This methodological contribution supports the theoretical implication by further explaining the relevance of developing a single integrated conceptual model of the relationships between agility, sustainable practices, operational performance objectives and sustainability performance. In general, SEM tends itself well to the analysis for inferential purposes. Before using SEM techniques, other analyses such as exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were considered.

Exploratory factor analysis, on the one hand, was used in the early stage of this study to gather information about the interrelationships among set of agility, sustainable practices, operational and sustainability performance objectives. It was used for the development or evaluation of test and scales. It helps to refine or reduce these scale items to form a smaller number of coherent subscales. As mentioned above, confirmatory factor analysis is a more complex and sophisticated set of techniques used in this research to test (confirm) a series of hypotheses or theories concerning the structure underlying a set of agility, sustainable practices, and performance variables. These techniques help to check for the reliability and validity of measurement scales; common method bias (CMB); Multicollinearity; homogeneity of variance; and determine if the goodness of fit model is adequate. This further support the analytical robustness and severity of methodological significance.

Finally, this study argues that the methodology is of relevance because using structural equation modelling (SEM) and ANOVA techniques support rigorous analysis, and the testing of the structural model (Schumacker and Lomax, 2010; Kline, 2015). This connotes that the methodology is vital to the research framework on drivers, enablers, and outcome effects, which underpins this thesis. Studies seeking to test hypotheses with an integrated conceptual model will benefit from using SEM technique (Bagozzi and Yi, 2012).

### 6.12.4 Empirical contribution

This study examines the intervening effect of agile practices in the relationship between sustainable practices and organisational performance. This is because, although agility have been correlated with financial measures and operational performance objectives of organisations. There is no empirical study currently that examine the influence of agile practices on the extent to which organisations could translate sustainable practices into overall sustainability performance. In particular, it is not clear if agility serves as an effective mediator of sustainability. The importance of agile practices for enhancing or not enhance sustainability is not fully understood. Besides, which groups of agile companies have the greatest impacts on specific performance outcomes is understudy. These are the key motivation for this empirical study.

In this respect, the major contribution of this empirical study is the development of a single integrated model of agility and sustainable practices and their impacts on a new broader set of competitive performance criteria. This advances the knowledge of sustainability and operations strategy by exploring performance effects of agility and sustainability practices. The findings of this study have important implications both for manufacturing and oil and gas industry. Thus, this research contributes to the wider literature in these areas by providing empirical evidence on the influence of a set of agility and sustainable practices on overall organisational performance. More interesting, this research breaks new ground by probing the sustainability performance enhancement and amplification role agility plays as a mediator in the link between sustainability practices and operational performance.

Another empirical contribution of this study, thus, lies in the fact it provides confirmation regarding the role of agile practices as enablers of sustainability performance. This research also provides empirical evidence of sustainability approaches as drivers for the development of agile capabilities. More so, there is a clear indication of a strong positive and significant effect of agile practices on sustainability performance. The empirical findings also demonstrate that sustainable practices are direct sources of sustainable competitiveness, but their performance impacts are improved when facilitated through agile practices. This suggests agile capabilities as an important enablers or facilitator in maximising the impact of implementing sustainable practices on enterprises performance. Finally, the empirical contribution of this research also predicted upon the reliable and unique empirical data gathered from a large sample size (e.g., 311 respondent organisations). The research argue that empirical significance lies on large set of data collected from highly knowledgeable and experienced supply chain professional working within the UK energy-intensive industry.

## 6.13 Summary

This chapter presents a discussion of the study's findings and their implications. The chapter began by providing background information on hypothetical perspectives on the impact of agility and sustainability practices on organisational performance. Subsequently, a discussion of the results of the study was presented. Firstly, the study discussed the combined impact of agility and sustainable practices on sustainability performance and operational performance. Secondly, the mediating effect of agile practices on the impacts of sustainable practices on sustainability performance and operational performance was discussed. Thirdly, the discussion has been addressed about the individual practices and groups of agile companies that have the greatest impact on specific performance objectives.

From the results, there is strong evidence that the UK's industrial sectors have the agile capabilities to meet the challenges of sustainability. The results show that sustainable practices play a key role as a catalyst for the development of agile practices. However, while agile capabilities, serve as a necessary precursor of enhancing sustainability and operational performance objectives.

Besides, the results provide further support for the individual hypothesis that all five agile practices have a strong positive and significant impact on performance outcomes. Amongst these five precursors, the technological capability and market sensitivity seemed to have the largest predictor of operational performance objectives. While market sensitivity and network collaboration capabilities appeared to have the greatest impacts on sustainability performance. Of the five agile practices, employee empowerment has the least impact on sustainability performance. This finding raises intriguing questions regarding nature and extent to which the UK industrial sectors invest in the education and development of workers and suppliers. This is an important issue for future research.

More so, looking closely at the individual effect of sustainable supply chain practices on performance outcome, the results indicate that sustainable design has the highest impact on sustainability performance and operational performance objectives. Sustainable procurement was appeared to be the second greater impact on operational performance and sustainability performance objectives. While there was no significant evidence to suggest that the implementation of environmental management systems (EMSs) contribute directly to operational performance objectives of the industrial supply chain. Rather, the EMSs implementation contributed significantly to improving sustainability performance. Further work should be undertaken to investigate the impact of the EMSs on the economic growth of the supply chain.

The study also looked at groups of agile companies that have the greatest impacts on specific organisational performance objectives. The results reveal that highly agile companies have the highest impacts on each performance objectives. Surprisingly, highly agile companies have a maximum effect on innovation objectives. Though moderately agile companies performed above average in all performance objectives. But low agile companies have the poorest impact on all the organisational performance objectives. Overall, this combination of findings provides evidence for the conceptual premise that agile capabilities are necessary conditions for maximising the outcomes of the implementation of sustainable practices. As such, managers who want to maximise the outcomes of their sustainability campaigns should consider the concurrent implementation of both sustainability practices and agile practices combined. The next chapter concludes this thesis and highlights the research limitation and future study.

# CHAPTER 7: Conclusions and recommendations

## 7.1 Introduction

This chapter presents the conclusions drawn from the study. The chapter start by revisiting the research objectives, methodology, and outline the key findings. It also provides answers to the main research questions. Finally, the chapter highlights some of the major limitations of the study and identifies potential future research directions.

## 7.2 An overview of the study

This study aims to investigate relationships between agility and sustainability and their impacts on the performance of oil and gas enterprises. This is because although agility and sustainability have been separately correlated with organisational performance, there is no empirical study that examines the influence of agile practices on the extent to which organisations could translate sustainable practices into sustainability performance or overall organisational performance, including the traditional financial measures and operational performance criteria. In particular, it is not clear if agility serves as an effective mediator of sustainability. The conceptual and empirical studies of the role of sustainable practices as a source for the development of agile practices is absent. Moreover, which individual practices or groups of agile companies have the highest impact on specific performance objectives are still to be uncovered. The challenges for academics and industrial professionals now, thus, is how to integrate social and environmental sustainability practices with agile supply chain practices to create unique capabilities to enhance their sustainable competitiveness, which are the key issues of survey reported here.

Given the fact that the production and consumption of resources, waste generation are mostly associated with industry supply chains, the survey focused on the UK higher carbon and energy-intensive supply chains. The target organisations were from those involved in the extraction of crude petroleum and natural gas; mining of metal ores, coal, and lignite; manufacture of coke and refined petroleum products; manufacture of chemical and chemical products; manufacture of rubber and plastic products; manufacture of steel and irons, and fabricated metal products; manufacture of electronic and electrical equipment; manufacture of machinery, motor vehicles, trailers, and other transport equipment. These industries are major contributors to global carbon footprint and key consumers of natural resources and therefore, prime candidates for the study of sustainability and related practices of agility.

The UK was chosen as the empirical setting for this study because of its significant share of total global manufacturing outputs and resource demands. According to a most recent report by West and Lansang (2018), the UK, in 2015, was the 9th manufacturing country in the world with an output of $244 billion that accounted for 10% of its national output and 2% of the global manufacturing output. Based on the industrial focus of the study, the oil and gas sectors appear to be a good representative of the UK's energy-intensive industry. These industries consume large amounts of energy as well as gas and petroleum products in manufacturing processes. As the largest industrial energy consumers in the UK. Vallack et al. (2011) highlighted the importance of energy to their overall costs, as most asset-heavy industries have been driven to maximise the energy and cost-efficiency as well as sustainability impacts of their operations.

## 7.3 Research objectives revisited

In specific term, the objectives of this research are to:

RO1: Investigate the influence of sustainable supply chain practices and agile supply chain capabilities on operational performance and sustainability performance of oil and gas industry.

RO2: Examine the interaction between sustainable supply chain practices and agile supply chain capabilities

RO3: Examine the mediating role of agility capabilities on the impacts of sustainable practices on organisational performance.

RO4: Examine the moderating effect of managerial experiences and industry sectors on the relationship between sustainable practices and organisational performance.

RO5: Explore which individual practices or groups of agile companies have the greatest impact on specific performance objectives.

The study follows a positivist epistemological position. The positivism paradigm employed was survey research approach (Dillman et al., 2014). Survey research is suitable for gathering unique and rich empirical data from a large sample size (Wilson, 2014) and because it involves developing and testing hypotheses, it is considered a deductive approach. After undertaking a review of the literature on agility and sustainability in supply chains, four constructs were identified (RO1), resulted in the development of a single integrated conceptual model (RO2). The model suggests the links among constructs. These constructs include agility practices, sustainable supply chain practices, operational performance objectives and sustainability performance measures.

A questionnaire was developed around these constructs. Further, multiple items were used for the measurement of each construct - the scales were developed in accordance with the procedure suggested by Pallant (2013) for developing measures. The questionnaire survey involved five-point Likert scale questions, which are important measures for defining the interactions between the practices and performance measures.

A total of nine hundred and forty-five (945) questionnaire were mailed out to operators and suppliers across the UK energy intensive industries. In the end, 346 valid responses were received, accounting for 36.6%. The responses were obtained from highly knowledgeable and experienced industrial professionals such as managing directors, Chief executive officers, Plant managers, Directors, Logistics managers, Operations managers, Sales managers, Supply chin managers, and Industrial waste managers and Procurement managers.

To operationalise the agility, sustainable practices and the new competitive performance constructs, several statistical techniques were employed to demonstrate non-response bias, reliability, validity, and common method bias. The causality test was also performed before testing research hypotheses. The statistical analysis based on confirmatory approaches – a structural equation modelling techniques - were used to test (confirm) hypotheses.

In short, the results from the survey confirmed that there is a strong correlation between sustainable supply chain practices and agile practices. This result suggests sustainable practices as catalysts for the development of agile capabilities. Likewise, the study shows that agile practices do have a significant influence on both sustainability performance and operational performance objectives. While the link between agility and operational performance is not new, what is new here is the connection between agile practices and sustainability performance (QO3). More so, the findings show that sustainable practices predict sustainability and operational performance objectives. But more importantly, when these relationships are mediated by agile practices, the performance impacts are amplified (RO4). This suggests that agile capabilities are necessary conditions for maximising the impacts of implementation of sustainability practices on enterprise performance.

In the end, the survey further corroborates the above findings that highly agile organisations enjoyed a wide range of specific performance objectives arising from agility and sustainability changes. Most importantly, extremely agile companies have the biggest impact on improved innovation, speed, and flexibility, which contribute to better financial performance. Other benefits such as, reducing environmental impacts and increasing social wellbeing are parts of broader sustainability performance. While the less agile companies have poor organisational performance scores, they had the lowest percentage of the means difference value. At best nonagile organisations focused more on benefits such as cost, quality, and reliability improvement (RO5). One big reason that nonagile organisations could be missing out on sustainability and innovation is that they are not using agile-enabled operating models. More detailed answers to the research questions are given in the following sections.

## 7.4 Answers to the research questions

The research questions and their answers are as follows:

RQ1: *What are the distinct and joint effects of sustainable supply chain practices and agile supply chain capabilities on operational performance and sustainability performance of supply chains?*

RQ2: *Do agile capabilities mediate the relationship between sustainable supply chain practices and performance outcomes?*

*RQ3: What are the effects of managerial experience and industry sector on the relationships between sustainable supply chain practices and operational performance/sustainability performance?*

RQ3 *Which individual practices and group of agile companies have the greatest impacts on specific performance outcomes?*

**Research question 1:** *What are the distinct and joint effects of sustainable supply chain practices and agile supply chain capabilities on operational performance and sustainability performance of oil and gas supply chains?*

**RQ1a. What are the effects of sustainable supply chain practices on operational performance and sustainability performance?**

The major reason for the implementation of sustainable supply chain practices lies in their ability to enhance sustainability performance. The results of this study shown that the implementation of sustainable supply chain practices has a strong effect on operational and sustainability performance objectives. These results suggest that when the UK petroleum industries implement sustainable practices collectively, it can help in mitigating environmental issues and promote the quality of life of different members of the chain while bolstering innovation, carbon and resources efficiency, reputation, and market share, as well as overall sustainable competitiveness (Sancha et al., 2016; Stindt et al., 2016). These results corroborate the findings of a great deal of the existing literature in operations strategy, which linked sustainable practices to cost efficiency, differentiation, and innovation objectives (Zhu et al., 2012; Crittenden et al., 2011; Orsato, 2006; Porter and van der Linde, 1995; Orlitzky et al., 2011; Vachon and Klassen, 2006). This has been particularly through using less energy, minimising pollution, and waste, and reducing other natural resources consumption. Building a genuine attitude of doing the right thing can help prevent reputation from damaged and remove unwanted attention from government, regulators, or civil society, thereby reduced social and environmental risks. There are studies (Prajogo et al., 2014; Crittenden et al., 2011; Dangelico and D. Pujari, 2010; Klassen and Vereecke, 2012), who suggested that the effective development of new sustainable products was related to differentiation strategies. Orsato (2006) observed that environmental sustainability practices are linked to cost savings. Other researchers stressed that social and environmental sustainability are means for improving innovation (Klassen and Vereecke, 2012; Nidumolu et al., 2009). Community engagement can open new markets and opportunities for the oil and gas industry (Ahmad et al., 2017; Silvestre et al., 2017). Implementing social and environmental initiatives can make it easier to recruit and retain good workers, which, in turn, increased employee engagement (Hill and Hill, 2012).

Furthermore, Christmann (2000) demonstrated the potential of sustainable practices in achieving low cost and differentiation. The researcher found that the higher a firm's level of innovation in pollution prevention technologies, the larger the cost advantage it gains from sustainability practices. Through sustainable practices, organisations can achieve significant savings, resulting in cost-efficiency relative to their competitors. These practices not only save operating costs but can strengthen productivity and investment in energy efficiency and clean growth. Ensuring that the heavy industries in the UK implement sustainable approaches will not only helps in transition to net-zero carbon emissions but will also make those businesses more competitive advantage by creating new skilled jobs, which could improve their social performance.

In short, effective waste management means that material is not landfilled but kept in a productive loop; products use smaller amounts of materials and energy; products reused, remanufactured, recycled and redesigned with recovery in mind. As such, sustainable practices could minimise cycle time by eliminating non-value adding activities. Besides, a shift towards a circular flow of materials and services, sustainable sources, sustainable delivery, and socially responsible behaviours could offer the UK businesses with the potential to cut carbon emission well-boosting investment in cleaner technologies and increase profitability. However, the current results rejected the findings of Esfahbodi et al. (2017); Zhu et al. (2007, 2013); Winn et al. (2012); Green et al. (2012b); Hahn et al. (2010) that reported sustainable practices having damaging effect on operational and financial metrics, this study provides strong empirical evidence that the implementation of sustainable practices will lead to improved sustainability performance and better operational performance in terms of cost, quality, speed, reliability, flexibility and innovation objectives.

**RQ1b. How do *agile supply chain capabilities influence sustainability performance and operational performance in the UK oil and gas industry?***

Agile methodologies focus on a network of teams operating in rapid learning and fast decision cycles, which are enables using technology that is guided by a powerful common purpose to co-create value for all stakeholders. Such an agile operating model can quickly and efficiently reconfigure strategy, people, technology, processes while collaborating with customers and adapting to change (Serrador and Pinto, 2015) to take advantage of sustainable competitive opportunities. An agile organisation, therefore, combined velocity and adaptability with resilient and stability, creating a critical source of competitive gains and sustainability performance.

The benefits of agile practices are well recognised in the literature: enhanced customer satisfaction, faster time to market, higher revenue growth, costs efficiency, better worker engagement and greater operational performance (Bazigos et al., 2015). These benefits are reinforcing and generate improved financial performance (Aghina et al., 2020). The results of this survey further confirm that agile practices do have a positive influence on both sustainability performance and operational performance objectives. These results are in line with previous literature Tse et al. (2016); Eckstein et al. (2015); Yusuf et al. (2014); de Groote and Marx (2013); Blome et al. (2013), who observed that the greater the level of agility approaches, the better the overall organisational performance. While this research maintained that the connection between agility and operational performance is not new, what is new here is a strong positive effect of agile practices on sustainability performance objectives.

Using agility approaches can help organisations keep pace with society's changing expectation of businesses; prevent reputation from damaged; as well as, reduced social and environmental risks. This is important now that businesses are called to demonstrate social responsibility and to respond to the interests of stakeholders beside investors. In recent time, oil and gas executives are called upon to expand the scope of their mission, not just concerning themselves only with financial gains, the sectors are becoming more committing to tackling social and environmental concerns.

Agile operating models can help address these emerging priorities. The consolidation of oil and gas supply chain in a geographical area can contribute to the reduction of carbon dioxide emissions and positively influence the social performance by creating jobs in the region. Further, as climate changes will make resources becoming scarce, using advanced technologies and market sensing capabilities could mitigate sustainability risks and improved sustainable supply chain performance (Sivarajah et al., 2020; Stock and Seliger, 2016; Akter et al., 2016; Bag et al., 2020; Bai et al., 2020; Wamba et al., 2020; Ralston and Blackhurst, 2020). The integration of new technology-related capabilities can help minimised material inputs, reduce water usage, and promote better quality of lives, while intensified the overall energy or resources efficiency and eliminated wasteful activities in the oil and gas industry (Brinkman et al., 2016; Choudhry et al., 2015a, b; Bazigos et al., 2015; Aghina et al., 2017, 2018; Engel et al., 2015). The falling cost of new technologies and increasing connectivity of devices provide window of opportunities for oil and gas sectors to further increased employee safety and diversity (Wood, 2014), operational efficiency, and better-quality products and innovative or customised products (Ramadan et al., 2017; Kiel et al., 2017a, b; Kamble et al., 2020).

The petroleum or energy sectors are already applying digital technologies to objectives other than financial returns. Some oil and gas sectors are using digital technologies to support workforce diversity. Other sectors are making social and environmental sustainability objectives their agile transformation efforts. Oil and gas industries are using artificial intelligence and data analytics to measure social and environmental impacts, which, in turn, help meeting aggressive carbon emissions reduction targets. Network sensors and drones are helping in remote monitoring of refineries, pipelines, pumps, platforms, and well monitoring.

In short, the use of agile methods can help increase the speed of decisions and product development, as well as shorten the time between the introduction and release of a product. For example, when oil and gas industries want to reduce the time, it takes to plan and design a new well, the health and safety implications of drilling rely on a variety of technical skills and require huge expenditure and time. By forming a collaborative network with service providers from sustainable sourcing, drilling, geoscience, process change, and petroleum teams, as well as specialists, the sector can eliminate the time needed to plan and design wells and increased quality by eliminating steps and reducing wasteful activities, thereby increase safety and overall efficiency of processes. This approach will also reduce the use of hazardous materials and other inputs during manufacturing processes and save costs. As agile practices are socially built with stakeholders, they are critical source of competitive benefits, and so strengthen sustainable supply chain performance. It will be important for oil and gas sectors to develop and implement agile capabilities. Though, some of these capabilities may rise in the industry naturally. Others may rapidly reach a tipping point where processes realignment to a new way of working becomes necessary.

**RQ1c:** *What are the joint impacts of sustainable supply chain practices and agile practices?*

The joint effect of sustainable supply chain practices and agile supply chain capabilities was supported for both operational performance and sustainability performance. The results support a positive joint effect on operational and sustainability performance. This finding supports the contention that combining the two capabilities can result in enhanced performance because of synergies (Hult et al., 2007). That is, the strategic value of each capability's relative magnitude may increase with an increase in the relative magnitude of other strategic capability (Dierickx and Cool, 1990). Under complementarity, the combined value of sustainable supply chain practices and agile supply chain capabilities may be higher than the cost of developing or deploying each capability individually (Amit and Schoemaker, 1993).

The research consider knowledge or learning to be essential to these capabilities. Learning is the concept that joins sustainable practices and agile capabilities. As such, it can be a basis for supply chain companies looking to take advantage of synergies between sustainable strategies and agile capabilities. In the context of sustainable supply chain, knowledge or learning is the ability of organisations to effectively learn and to implement changes based on what they have learned (Carter and Roger, 2008). Such organisational learning occurs when knowledge is accumulated over time and learned by supply chain members (Aslam et al., 2020). Organisations stored this knowledge not only in their procedures, but also in social communication patterns (Barney, 1991). This knowledge consists of training, as well as experience, social relationship, and the insights of managers and workers in supply chains (Hult et al., 2007).

Aslam et al. (2020) and Carter and Roger (2008) showed that a learning organisation, in concert with a market sensing can lead to competitive advantage. The notion of sustainability knowledge-seeking can be source of agile supply chain capabilities (Grant, 1996). While supply chains are external to the focal firm, they are less transparent and more difficult to imitate. Learning that occurs between operators and suppliers concerning social and environmental sustainability such as working with suppliers to commit to waste reduction objectives and develop capable minority business enterprise suppliers takes time, but such learning can have strong positive influence on supplier performance and reduced operating costs in supply network (Carter, 2005). Supply chain which integrates social and environmental sustainability and agile learning may be more difficult to imitate, thus leading to sustainability performance (Carter and Roger, 2008). Within agile supply chain, learning involves knowledge acquisition and information sharing. The main activities that develop knowledge is common link that permit members to discover shared meanings and effective storing new knowledge in memory of achievement (Gioia and Thomas, 1996). The desire of supply chain members to acquire knowledge and then share it to other members provides a mechanism for achieving sustainable supply chain performance.

Besides, the rate of changes and uncertainty in supply chain environments can contribute to the advancement of new agile capabilities for supply chains. Consistent with the current results, the increases in the implementation of sustainability-related practices drives the development of agile practices such as network collaboration, market sensing, process realignment, technologies integration, and workers empowerment (Yusuf et al., 2020). Equally, the same factor that can dampening sustainability risks – sustainable design, sustainable sources, sustainable transport, investment recovery and socially sustainability practices – are likely to help intensify supply chain agility.

The ability of organisations to design and makes new sustainable products and processes in response to consumers and other stakeholders' pressures can result in increasing agile capabilities. Social and green supply chain practices are considered prerequisites of other attributes for the selection of suppliers in the context of the agile supply chain paradigm (Rajesh and Ravi, 2015). Environmental protection systems and safety practices are considered necessary practices to maintain competitiveness in an agile environment. Therefore, this study suggest that agility capabilities are likely to emerge during a period of greater social and environmental sustainability changes. In this regard, the thesis is that agile capabilities evolve because of organisations' responses to customers, government and civil society expectations and demand for innovative and sustainable products.

**Research question 2:** *Do agile capabilities mediate the relationships between sustainable supply chain practices and performance objectives?*

The examination of indirect effects confirmed that agile capabilities mediate the links between sustainable practices, operational performance objectives and sustainability performance. These findings show that the implementation of agile practices simplifies the implementation of sustainable practices. That is, the implementation of agile practices can help boost the positive impact of sustainable practices on sustainability and operational performance objectives. Market sensing capabilities are essential practices to maintain sustainable competitiveness in supply chains. It is difficult to implement sustainable practices without a strong understanding of, involvement with and knowledge of customers and other stakeholders. Agile organisations with market sensing capability could help to gain a better understanding of customers and other stakeholders' expectations. However, a lack of sensing capability will make sustainable initiatives unsuccessful (Wu et al., 2016). Stakeholder insights can help shape platforms that generate a maximum return on investment and increase profitability. Agile organisations with sensing capabilities will quickly leverage on customer knowledge and information technology capabilities to achieve sustainable supply chain performance. Large and Thomsen (2011) argued that improved knowledge transfer can help suppliers eliminate waste/pollution emissions and improve reputations and operational performance.

Likewise, achieving the carbon saving and sustainability objectives will depend upon the successful deployment of technology-based capabilities. Visibility deep into the supply chain is important for enabling sustainability. Agile organisations with advance technologies can prove valuable for building visibility along multi-tier supply chains. It will allow organisations to capture a large amount of information and sharing it across the supply chain, such that member companies see the real time demand data, and not just a distorted sale forecast. This will reduce the level of waste generation and enhance environmental performance and competitive advantage for organisations (Busse et al., 2017a, b). If the British businesses could integrate new technologies into their business strategies, they will minimise carbon emissions and reach huge productivity gains. Digital technologies including sustainable technologies, artificial intelligence, automation, machine learning, robotics, embedded sensors, and industrial internet of things are key precursors of operational excellence.

A radical rethinking of businesses model requires rethinking of technologies underlying and enabling products and processes innovation, as well as technology practices needed to support sustainability, speed, and flexibility. Agile organisations will make use of new technologies to provide sustainable products and services that can meet changing customer needs and competitiveness. There is a recognition that sustainable practices will require organisations to develop new technology capabilities to deliver sustainability gain. Businesses and government should consider investing research and development initiatives as well as increasing the use of digital technologies to achieve total carbon efficiencies.

According to dynamic capability theory, sustainability initiatives are challenging and complex to tackle alone (Beske et al., 2014), so agile organisations with collaborative capabilities can boost the positive impact of sustainable practices on operational performance and sustainability performance. There are significant benefits to industry from increasing focus on cross-sector cooperation on low carbon opportunities. Longoni and Cagliano (2015) highlighted the importance of cross-sector collaboration for sustainable sources, which can contribute to designing products for reuse, recycling, and disassembly. Industries are part of value chains that link raw materials via extraction, production, and transformation to consumers. Supply chain collaboration will help identify critical carbon hotspot where major energy efficiency and sustainability opportunities can be realised. Sustainable initiatives require organisations to use fewer material, energy in products and services, but success of these initiatives also require a level of collaboration within the supply chain (Lenvis and Gretsakis, 2001). The same is true for circular economy or closed-loop approaches, which demands suppliers to develop new network capabilities to deliver sustainability. This shift in thinking is likely to bring economic growth through reduce costs, maximise energy efficiencies, boost innovation, improved reputation, and waste management (Orlitzky, 2011; Porter and Kramer, 2006).

During the implementation of sustainable practices, oversight, and cooperation with stakeholders (such as government, regulators, and NGOs) could help in sustainability succeed. The inclusion of third parties in decision-making processes can aid in identifying social and environmental issues deep within the supply chain (Marshall et al., 2015). Government, regulators, and civil society groups could play a role as facilitators among different industrial sectors (such as support on clustering). This study indicates that engaging with network parties can help in minimising the use of hazardous chemicals in manufacturing processes. Agile organisations will consider offering extra support for sustainability objectives that involve collaboration across the supply chain to increase participation and transparency. The ability to detect suppliers' sustainability information along the chain is a capability factor that influences sustainability achievement.

Recent trends toward sustainable growth have led to different categories of green supplier development such as sustainable knowledge transfer and communication, investment, and resources transfer. Although, each category of such development could play an important role in enhancing sustainability performance (Wu, 2017), developing sustainability-oriented skills are difficult for small and medium-sized businesses, as they have insufficient resources and expertise to implement such initiatives (Wu, 2017). Agile organisations with collaborative capabilities could help strengthen green supplier development, thus contributing to improving SMEs' sustainability performance (Ehrgott et al., 2013; Lu et al., 2012; Wu et al., 2016). There is much evidence that collaborative practices and green suppliers' development have a positive impact on improving sustainability performance (Lu et al., 2010; Zhu and Sarkis, 2007). When supply chain members jointly solve sustainability problems, they will be capable of obtaining superior operational performance benefits (Paul et al., 2010).

More so, manufacturers and government ability to provide financial incentives to suppliers can help reduce their energy bills and lower carbon emissions, thereby improving environmental performance. Effective governance has been identified as an important factor in sustainability implementation. With leadership support, suppliers tend to be more interested in implementing sustainability practices. Industries require a highly trained and educated workforce to tackle the challenges of implementing sustainable initiatives and energy efficiency technologies. Manufacturers and government provision of the necessary education and training support can help in sustainability realisation. A lack of workforce knowledge about sustainability was identified as key obstacles for the UK industries (Vallack et al., 2011).

The study supports the role of agile capabilities in enhancing the performance outcomes of sustainable supply chain practices implementation. It confirms that agility is an effective mediator of sustainability. This has a significant contribution to the operation strategy and sustainability fields. As several works on agile and sustainability have rarely looked at these practices together. This is the first empirical study that established the effect of agile practices on the extent to which organisations could translate sustainability practices into sustainability performance. The findings support our earlier work Yusuf et al. (2020), which proved agile capabilities as necessary conditions for maximising sustainable supply chain performance. So, this empirical investigation established agility as a significant amplification in multiple organisational performance outcomes. As such, the findings hold true for successful supply chain agility transformation. So, as industries and organisations are under pressure to find innovative ways to remain competitive in today's uncertain times, agility transformation becomes more, not less important.

**Research question 3**: *What are the effects of managerial experience and industry sector on the relationship between sustainable practices and organisational performance?*

The hypothesis that under high carbon and energy intensive supply chain sectors, the relationship between sustainable practices and sustainability performance will be strengthened were partially supported. The results support the contention that industry sector positively moderate the relationship between sustainable practices and sustainability performance. As mentioned earlier, high carbon and energy intensive supply chains are more sustainable sensitive than low polluting supply chains (Tachizawa and Wong, 2014). These companies are characterised by bad environmental reputations because of the high levels of contaminations and other negative externalities to the environment compared to less polluting firms (Bowen et al., 2001). The degree of stakeholder pressures and challenges imposed on high polluting firms are higher than those imposed on less polluting firms (Sharma and Vredenburg, 1998). This posits that high energy intensive supply chains are more interested in increasing sustainability investments in developing social and environmental initiatives to legitimise their operations

(Sharma et al., 1999). Simpson et al. (2012) asserted that when firms operate in high-pollution industries, institutional forces for sustainability enhancement is intense, so they tend to develop superior social and environmental capabilities and adopt a more proactive strategy. While firms that operate in low-pollution sectors face less intense pressures and tend to be less motivated to invest in developing new capabilities to improve their sustainability performance.

While the suggested moderator (managerial experience) is not found to moderate the relationship between sustainable practices and performance success. the fact that management experience did not significantly moderate the link between sustainable practices and sustainable supply chain performance is quite surprising and counter intuitive. Because it posits that the value of implementing sustainability practices is that it allows for superior success regardless of management team experience.

**Research question 4:** W*hich individual practices and group(s) of agile companies have the greatest impacts on specific performance outcomes?*

To answer this question, our survey identified companies groups whose characteristics accord well with agility literature (Narasimhan et al., 2006; Bazigos et al., 2015; Ahlbäck et al., 2017; Bottani, 2010; Braunscheidel and Suresh, 2009). We divided the companies in our sample among different groups based on their relative agility attributes. Of the agile company clusters: 39% of companies in our sample were described as highly agile; 42% were called moderately agile; 19% of organisations were termed less agile.

Based on the results of this analysis, the less agile companies showed poor performance outcomes in each of the indicators. That is, they have the lowest impact on all the performance objectives. This is not surprising, as sluggish organisations would not be expected to succeed. In contrast, moderately agile companies have performed above average. They seem to focus more on benefits such as cost reduction, quality, and delivery reliability improvement. So, while lower agile companies were likely to cite cost efficiency has the most performance outcomes relative with moderately agile organisations. Compatible with prior work Narasimhan et al. (2006), moderately agile firms focus on reducing waste or non-value adding activities, emphasising performance enhancements in cost-efficiency, conformance quality, productivity, and reliability. Moderately agile companies had significantly better mean value than less agile organisations. But their average scores are significantly lower than those of highly agile companies. Though, these values are closer to highly agile organisations than less agile organisations.

By contrast, highly agile companies appear to represent performance capabilities that, according to Christopher and Towill (2001), reflected on “services level”. The findings of this study confirm that highly agile companies exceed other two agile companies in all the performance objectives examined. They enjoyed the greatest impact on innovation, social performance, financial measures, speed, flexibility, and environmental sustainability objectives, as compared to nonagile companies. Most importantly, highly agile companies appear to be a powerful machine for innovation and sustainability outcomes.

Given the enhanced performance of highly agile companies, another test was done to further the understanding of agility. We identified 11 practices that differentiate among agile company groups. The results of this analysis show - process alignment, market sensitivity, network collaboration, technology integration, sustainable design, sustainable procurement, sustainable transport, investment recovery, and social sustainability practices - as the most influence in highly agile companies but not within less agile organisations. This finding suggests the ability of agile organisations to combine sustainability initiatives and agile approaches. Highly agile companies seem to have a strong effect on process alignment, collaborative practices, sustainable design, and social sustainability practices than nonagile organisations.

Compatible with earlier works van Hoek et al. (2001); Harrison et al. (2019); Christopher (2016); Geyi et al. (2020); Yusuf et al. (2004; 2014), who identifies network-based, technology integration, process alignment, market-sensitive, sustainable design, sustainable sources, investment recovery approaches and social sustainability practices as significant capabilities required for agility. They also stress the importance of highly skilled, knowledgeable, and empowered workers. Our results support this view, as these are practices that appear to differentiate highly agile companies from nonagile organisations.

Although, this study shows there is a significant difference between highly agile and nonagile organisations. There appear to be some similarities, as a set of practices of sustainable supply chain paradigm has been identified as being precursor of supply chain agility (Shibin et al., 2016; Rajesh and Ravi, 2015; Geyi et al., 2020). According to Narasimhan et al. (2006), industries move along an evolutionary path, shift from one performing unit to another within supply chains. Our results seem to accept this notion, as companies cannot be in groups 1 and 3 concurrently. Since highly agile companies dominate less agile ones in both practices and performance objectives, transforming to agility requires a significant investment in these practices.

In short, this study deduces that while highly agile organisations were more excel in all aspects of performance objectives. Looking at the comparison between highly agile and moderately agile companies, it shows that practices like process alignment, market sensitivity, network collaboration, sustainable design, sustainable procurement, sustainable transport, investment recovery and social sustainability practices have a strong positive impact on highly agile companies than moderately agile organisations. Therefore, this research suggests that these practices are significant sources for the pursuit of supply chain agility and greater sustainability. As such, using agile capabilities to improve social and environmental sustainability and workforce diversity can help offer direct financial/economic benefits. Reducing carbon footprints or resources use can help oil and gas industries eliminate or avoid costs. Indirect financial benefits are possible as well. As resent Deloitte report have explained how employee diversity (social responsibility) enhances supply chains ability to innovate and identify sustainability risks through promoting greater creativity to resolving problems.

## 7.5 Limitations and recommendations for future research directions

This study has examined the role of agility and sustainability practices in enhancing the overall sustainability performance of the UK oil and gas industry. The findings of this study have some limitations and significant opportunities for further research direction. Considering this, the following areas are suggested for future research.

Although sustainable supply chain practices are a multidimensional construct, we only focused on six key first-order constructs of social sustainability practices, investment recovery, sustainable transport, sustainable design, sustainable procurement, and environmental management practices as a source for valuable agile capabilities. Further empirical research can explore what other dimensions of sustainable supply chain practices lead to the development of agile supply chain capabilities.

Another limitation is that the study was focused primarily on survey data drawn from higher carbon and energy intensive supply chains in the UK. Therefore, the results may not be an accurate reflection of what obtains in the less carbon intensive segment of the economy. There is an ongoing attempt to conduct longitudinal case studies at some of the participant organisations to corroborate and strengthen the findings of this study. This will offer an opportunity for further studies. Due to time constraints, no interviews were conducted for this study. Interviews approaches could have been useful to gain more insight into why certain practices and performance objectives might have been pursued at the supply chain, which not obtained using a survey approach. Further research should validate the industry types we identified with more in-depth field studies. Besides, it is likely that the results of this study are limited to the UK context where practices like public awareness and strict regulations of social and environmental problems are perhaps more widespread than many other countries. Further research thus can replicate and extend the study in other countries, especially the developing countries that are often beset with relatively weaker institutions.

Likewise, the findings of this study indicate that nonagile companies (small and medium-sized enterprises (SMEs)) are rarely involved in agile and sustainable initiatives. It would be interesting to understand how smaller businesses involvement in agile and sustainability implementation could be improved. Again, it was considered that less agile companies have the poorest organisational performance scores than the other did. Thus, further investigation should explore the cause of the declining performance of less agile businesses in the UK oil and gas industry. Especially what role can SMEs play in enhancing the sustainability performance of the UK oil and gas industry? How can SMEs' involvement in agility and sustainability initiatives be improved? What benefit will the industry gain from active inclusion of SMEs in agile and sustainable practice?

In recent years, digital technologies have played a central role in the competitiveness of the UK industrial sectors, supporting innovation, driving product and process development, and providing the impetus for improvements in supply chain performance. The UK has attributes that if focused, could better exploit new technologies to capture future international markets. Underpinning digital technologies such as information technology, embedded sensors, advance materials, biotechnology, and sustainable technologies are becoming widespread in products and services.

Other contingent digital technologies like additive manufacturing, automation and artificial intelligence, big data analytics, robotics, fintech and Blockchain, drones, the cloud and mobile devices and the internet of things will make use of these underpinning technologies; and will be a game-changing for the oil and gas industry. It offers huge potential to enable the creation of new sustainable products using low energy and resource input; adapt to customer needs for high quality; personalisation and customisation of low-cost products; digital supply chain, with connectivity between manufacturers, customers and suppliers, increasing speed and manufacturing efficiency, and enhancing opportunities for network collaboration; greater freedom of design; delivery of innovative new products; higher performance and more flexible manufacturing systems, delivery better quality and cost performance; maximising complementary services.

The digitisation of supply chains will give manufacturers access to a wider range of less expensive materials and services that can be delivered more quickly. Such chains are also easier to manage, enabling suppliers to reduce waste, emissions, and operating costs. In this study, the importance of achieving sustainable competitiveness through integrating technology-based capabilities has been established. However, there still exists significant gaps. The use of these technologies brings with it important questions about governance, ethic, people privacy and possible surveillance use. Regardless of these issues, some prime businesses are investing heavily in these technologies, which offer greater agility. Further research should consider: how SMEs are using digital/data analytics technologies as a potential game-changer? What benefits could digital technologies have in enhancing SMEs performance? How do SMEs best manage ethical and legal risks arising from technologies implementation?

## 7.6 Summary

The purpose of this study was to examine the effect of agility and sustainability practices on the organisational performance of the UK oil and gas industry. The research investigates the role agility play in enhancing the positive impact of sustainable practices on sustainability performance. The chapter begins with an overview of the study, then revisited the key research objectives and discussed how they contributed to answering the research questions. Based on the results of a survey by questionnaire, the chapter offers answers to individual research questions. This chapter concludes by outlining some of the limitations and identifies potential suggestions for future research directions.

# Appendix 1: A copy of cover letter and questionnaire used in the survey

INVESTOR IN PEOPLE

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05 May 2017

Dear Sir/Madam,

**Re: Impacts of agility and sustainability practices on organisational performance**

Dan'asabe Godwin Geyi, a PhD student attached to the Institute of Logistics and Operations Management, University of Central Lancashire, Preston, is undertaking a research into the impacts of agility and sustainable practices on organisational performance in the oil and gas industry. We would very much appreciate your contribution to this important research by completing the enclosed questionnaire. It will take only a short time (approximately twenty minutes) to complete. It will be most helpful if you could return your response within two weeks. In the event that you are unable to respond to some or all of the questions we would welcome your passing the questionnaire to someone within your organisation you think qualified to respond to the questionnaire.

Information for the study and results will be used for academic purposes only, as you and your organization's names will remain confidential. Subsequent use of records and data will be subject to standard data use policies which protect the confidentiality of individuals and institutions. Your participation in this study is voluntary. You may withdraw and discontinue participation before the analysis without any penalty.

If you have any queries please do not hesitate to contact Dan'Asabe Godwin Geyi on mobile phone +44(0)7774939009 or by email at DGGeyi@uclan.ac.uk.

Thanking you so much for your time and support.

Many thanks

Professor Yahaya Yusuf
Director of the Institute of Logistics and Operations Management
University of Central Lancashire, Preston PR1 2HE, UK

UKAS MANAGEMENT SYSTEMS 001

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BE INSPIRED

# SURVEY OF OIL AND GAS SUPPLY CHAIN

1. Name of the company: ………………………………………………………...............
2. Date of establishment: ……………………………………………………………...
3. Position of the respondent: ………………………………………………………
4. What is the total number of the employees in your company? Please put ☒ in the box(es) that apply:

   ☐ Less than 49 employees

   ☐ 50 – 249 employees

   ☐ 250 – 349 employees

   ☐ 350 – 549 employees

   ☐ 550 or more employees

5. What is the total annual turnover of your company? Please put ☒ in the box(es) that apply:

   ☐ Less than £25million

   ☐ £26million - £50million

   ☐ £51million - £100million

   ☐ £101million - £500million

   ☐ £501million or more

6. Which of the following sectors best describe your business operations? Please put ☒ in the box(es) that apply:

| **Industrial sectors** | **Tick ☒** |
|---|---|
| Extraction of crude petroleum and natural gas | ☐ |
| Manufacture of coke and refined petroleum products | ☐ |
| Manufacture of chemicals and chemicals products | ☐ |
| Manufacture of Pharmaceutical products and pharmaceutical preparations | ☐ |
| Manufacture of machinery and equipment | ☐ |
| Manufacture of steel and metal products | ☐ |
| Quarrying of building stones, limestone and iron ores | ☐ |
| Manufacture of motor vehicles | ☐ |
| Manufacture of electricity | ☐ |
| Manufacture of electronic and electrical equipment | ☐ |
| Manufacture of cements | ☐ |
| Transportation | ☐ |
| Other supporting activities for oil and gas extraction | ☐ |
| *If 'Other' please list/describe* | |

7. Please indicate by a tick (√) the level of importance the following agile practices best reflect in your company.

| Dimension | Not important (1) | Less important (2) | Important (3) | Very important (4) | Extremely important (5) |
|---|---|---|---|---|---|
| Market sensitivity | ☐ | ☐ | ☐ | ☐ | ☐ |
| Network collaboration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Process alignment | ☐ | ☐ | ☐ | ☐ | ☐ |
| Technology integration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Employee empowerment | ☐ | ☐ | ☐ | ☐ | ☐ |

8. Please indicate by a tick (√) the level of importance the following agile attributes best reflect in your company.

| Agile attributes | Not important (1) | Less important (2) | Important (3) | Very important (4) | Extremely important (5) |
|---|---|---|---|---|---|
| Concurrent execution of activities | ☐ | ☐ | ☐ | ☐ | ☐ |
| Enterprise integration | ☐ | ☐ | ☐ | ☐ | ☐ |
| Information accessible to employees | ☐ | ☐ | ☐ | ☐ | ☐ |
| Multi-venturing capabilities | ☐ | ☐ | ☐ | ☐ | ☐ |
| Business practise difficult to copy | ☐ | ☐ | ☐ | ☐ | ☐ |
| Empowered individuals working in teams | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cross functional teams | ☐ | ☐ | ☐ | ☐ | ☐ |
| Teams across company borders | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decentralised decision making | ☐ | ☐ | ☐ | ☐ | ☐ |
| Technology awareness | ☐ | ☐ | ☐ | ☐ | ☐ |
| Leadership in the use of current technology | ☐ | ☐ | ☐ | ☐ | ☐ |
| Skill and knowledge enhancing technologies | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexible production technology | ☐ | ☐ | ☐ | ☐ | ☐ |
| Quality over product life | ☐ | ☐ | ☐ | ☐ | ☐ |
| Products with substantial value-addition | ☐ | ☐ | ☐ | ☐ | ☐ |
| First-time right design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Short development cycle times | ☐ | ☐ | ☐ | ☐ | ☐ |
| Continuous improvement | ☐ | ☐ | ☐ | ☐ | ☐ |
| Culture of change | ☐ | ☐ | ☐ | ☐ | ☐ |
| Rapid partnership formation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Strategic relationship with customers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Close relationship with suppliers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Trust-based relationship with customers/suppliers | ☐ | ☐ | ☐ | ☐ | ☐ |
| New product introduction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Customers-driven innovations | ☐ | ☐ | ☐ | ☐ | ☐ |
| Customers satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Response to changing market requirements | ☐ | ☐ | ☐ | ☐ | ☐ |
| Learning organisation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Multi-skilled and flexible people | ☐ | ☐ | ☐ | ☐ | ☐ |
| Workforce skill upgrade | ☐ | ☐ | ☐ | ☐ | ☐ |
| Continuous training and development | ☐ | ☐ | ☐ | ☐ | ☐ |
| Employee satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |

9. Please indicate by a tick (√) the level of importance the following market turbulence influence in your company.

| **Dimension** | **Not important (1)** | **Less important (2)** | **Important (3)** | **Very important (4)** | **Extremely important (5)** |
|---|---|---|---|---|---|
| In our kind of business, customers' product preferences change quite a bit over time | ☐ | ☐ | ☐ | ☐ | ☐ |
| Our customers tend to look for new products all the time. | ☐ | ☐ | ☐ | ☐ | ☐ |
| We have demand for our products from customers who never bought them before | ☐ | ☐ | ☐ | ☐ | ☐ |
| New customers have product needs that are different from our existing customers | ☐ | ☐ | ☐ | ☐ | ☐ |
| We continuously cater to many new customers | ☐ | ☐ | ☐ | ☐ | ☐ |

10. Please indicate, what aspects of your organisation are sustainability measures applied? Tick (√) as many as possible

| **Industrial sectors** | **Tick ☒** |
|---|---|
| Extraction of crude petroleum and natural gas | ☐ |
| Manufacture of coke and refined petroleum products | ☐ |
| Manufacture of chemicals and chemicals products | ☐ |
| Manufacture of Pharmaceutical products and pharmaceutical preparations | ☐ |
| Manufacture of machinery and equipment | ☐ |
| Manufacture of steel and metal products | ☐ |
| Quarrying of building stones, limestone and iron ores | ☐ |
| Manufacture of motor vehicles | ☐ |
| Manufacture of electricity | ☐ |
| Manufacture of electronic and electrical equipment | ☐ |
| Manufacture of cements | ☐ |
| Transportation | ☐ |
| Other supporting activities for oil and gas extraction | ☐ |
| *If 'Other' please list/describe* | |

11. Please indicate how long your organisation has implemented sustainability practices. Tick (√) as applicable.

| **1-5 years** | **6-10 years** | **11-15 years** | **16-20 years** | **21 years above** |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

**12.** Please indicate the extent to which the following practices have been implemented in your company. Tick (√) as applicable.

| **Practices** | **Not at all (1)** | **To a small extent (2)** | **To a moderate extent (3)** | **To a relatively great extent (4)** | **To a great extent (5)** |
|---|---|---|---|---|---|
| Commitment of sustainable supply chain management (SSCM) from senior managers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Support for SSCM from mid-level managers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cross-functional cooperation for environmental improvements | ☐ | ☐ | ☐ | ☐ | ☐ |
| Environmental compliance and auditing programs | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| ISO 14001 certification | ☐ | ☐ | ☐ | ☐ | ☐ |
| Environmental management systems exist | ☐ | ☐ | ☐ | ☐ | ☐ |
| We design products for reduced consumption of energy. | ☐ | ☐ | ☐ | ☐ | ☐ |
| We design products for reduced consumption of materials | ☐ | ☐ | ☐ | ☐ | ☐ |
| We design products for reuse, recycle, recovery of materials/ parts | ☐ | ☐ | ☐ | ☐ | ☐ |
| We design products to avoid or reduce use of hazardous products or their manufacturing process | ☐ | ☐ | ☐ | ☐ | ☐ |
| We design products for easy disassembly | ☐ | ☐ | ☐ | ☐ | ☐ |
| We sells excess capital equipment. | ☐ | ☐ | ☐ | ☐ | ☐ |
| We cooperate with customers for eco-design | ☐ | ☐ | ☐ | ☐ | ☐ |
| We cooperate with customer for cleaner production | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

**13.** Please indicate the extent to which the following statement reflect supplier selection decision in your company? Tick (√) as applicable.

| **Practices** | **Not at all (1)** | **To a small extent (2)** | **To a moderate extent (3)** | **To a relatively great extent (4)** | **To a great extent (5)** |
|---|---|---|---|---|---|
| We cooperate with customers for less use of energy during product transportation | ☐ | ☐ | ☐ | ☐ | ☐ |
| We cooperate with customers for green packaging | ☐ | ☐ | ☐ | ☐ | ☐ |
| We used renewable energy in any mode of products transport | ☐ | ☐ | ☐ | ☐ | ☐ |
| We used renewable energy in the process of products packaging | ☐ | ☐ | ☐ | ☐ | ☐ |
| We upgrade freight logistics and transport systems to minimising empty miles, reducing container weight and improving refrigeration | ☐ | ☐ | ☐ | ☐ | ☐ |
| We tracked and monitored our carbon footprint emissions cause in products delivery | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

14. Please indicate the extent to which your organisation has implemented the following practices during the past years, tick (√) as applicable.

| Practices | **Not at all**<br><br><br>**(1)** | **To a small extent**<br><br>**(2)** | **To a moderate extent**<br>**(3)** | **To a relatively great extent**<br><br>**(4)** | **To a great extent**<br><br>**(5)** |
|---|---|---|---|---|---|
| We collaborate with suppliers for sustainability objectives | ☐ | ☐ | ☐ | ☐ | ☐ |
| We provide suppliers with design specification that include environmental requirements for purchased items | ☐ | ☐ | ☐ | ☐ | ☐ |
| We conduct sustainability audit for supplies' internal management | ☐ | ☐ | ☐ | ☐ | ☐ |
| We work with supplier for sustainable packaging | ☐ | ☐ | ☐ | ☐ | ☐ |
| We require that suppliers be certified with ISO 14001 | ☐ | ☐ | ☐ | ☐ | ☐ |
| We evaluate multi-tier supplier sustainability practices | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

**15.** Please indicate the extent to which your organisation has implemented the following practices during the past years, tick (√) as applicable.

| **Practices** | **Not at all**<br><br><br>**(1)** | **To a small extent**<br><br>**(2)** | **To a moderate extent**<br>**(3)** | **To a relatively great extent**<br><br>**(4)** | **To a great extent**<br><br>**(5)** |
|---|---|---|---|---|---|
| We established health and safety management system | ☐ | ☐ | ☐ | ☐ | ☐ |
| We support community involvement and development | ☐ | ☐ | ☐ | ☐ | ☐ |
| Worker's Skills and capabilities development | ☐ | ☐ | ☐ | ☐ | ☐ |
| Respect for people rights | ☐ | ☐ | ☐ | ☐ | ☐ |
| Provide training for emergency preparedness program to employees, suppliers and community | ☐ | ☐ | ☐ | ☐ | ☐ |
| We guarantee worker's health and safety at work | ☐ | ☐ | ☐ | ☐ | ☐ |
| We make products that protect consumers' health and safety | ☐ | ☐ | ☐ | ☐ | ☐ |
| We support and promote health situation in the community | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

16. Please indicate the extent to which your organisation has implemented the following practices during the past years, tick (√) as applicable.

| **Practices** | **Not at all**<br><br><br>**(1)** | **To a small extent**<br><br>**(2)** | **To a moderate extent**<br>**(3)** | **To a relatively great extent**<br><br>**(4)** | **To a great extent**<br><br>**(5)** |
|---|---|---|---|---|---|
| We periodically evaluate second-tier supplier environmentally friendly practices | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| We visit our suppliers' premises to help improve their eco-design | ☐ | ☐ | ☐ | ☐ | ☐ |
| We sale excess capital equipment | ☐ | ☐ | ☐ | ☐ | ☐ |
| We are redeploying products without the need for refurbishment | ☐ | ☐ | ☐ | ☐ | ☐ |
| We returned products to the performance specification of the original equipment manufacturer | ☐ | ☐ | ☐ | ☐ | ☐ |
| We are extracting a product's raw materials and using them for new products | ☐ | ☐ | ☐ | ☐ | ☐ |
| We used a product's materials for a basic, low value purpose | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

17. Please tick (√) applicable, the impacts of sustainability on the following organisational performance criteria.

| **Measures** | **Very low (1)** | **Low (2)** | **Modest (3)** | **High (4)** | **Very high (5)** |
|---|---|---|---|---|---|
| Costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexibility | ☐ | ☐ | ☐ | ☐ | ☐ |
| Innovation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| Speed | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reliability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify in the box below) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

**18.** Please indicate the degree to which your organisation has achieved the following performance measures during the past years, tick (√) as applicable.

| **Measures** | **Not at all (1)** | **A little bit (2)** | **To some degree (3)** | **Relatively significant (4)** | **Significant (5)** |
|---|---|---|---|---|---|
| Reduction of air emission | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reduction of waste water | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reduction of solid wastes | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reduction of energy used | ☐ | ☐ | ☐ | ☐ | ☐ |
| Carbon footprint reduction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decrease water used | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decrease in use of hazardous, harmful and toxic materials | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decrease in frequency for environmental accidents spills | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improvement in an enterprise's environmental situation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify in the box below) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

**19.** Please indicate the degree to which your organisation has achieved the following performance measures during the past years, tick (√) as applicable.

| **Measures** | **Not at all (1)** | **A little bit (2)** | **To some degree (3)** | **Relatively significant (4)** | **Significant (5)** |
|---|---|---|---|---|---|
| Improved in overall stakeholder welfare | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improved in health and safety of the people | ☐ | ☐ | ☐ | ☐ | ☐ |
| Reduction in environmental impacts and risks to general public | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improved in health and safety of workers | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improved awareness and protecting claims and rights of people | ☐ | ☐ | ☐ | ☐ | ☐ |
| Improved local community initiatives | ☐ | ☐ | ☐ | ☐ | ☐ |
| Good collaboration with workers and other stakeholders | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify in the box below) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

**20.** Please indicate the degree to which your organisation has achieved the following performance measures during the past years, tick (√) as applicable.

| **Measures** | **Not at all (1)** | **A little bit (2)** | **To some degree (3)** | **Relatively significant (4)** | **Significant (5)** |
|---|---|---|---|---|---|
| Decreases in cost of materials purchased | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decreases in cost of energy consumption | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decreases in fee for waste discharge | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decreases in fee for waste treatment | ☐ | ☐ | ☐ | ☐ | ☐ |
| Decreases in fine for environmental accidents (spills) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increases in return on investment | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increases in market share | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increases in sale turnover | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increases in net profit | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increases in customers' satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other (please specify in the box below) | ☐ | ☐ | ☐ | ☐ | ☐ |
| ***If 'Other' please list/describe*** | | | | | |

21. Would you like to participate in the second stage of this study, which is an industrial case study? ☐ Yes ☐ No

22. Do you have any other thoughts in regards to practices and performance management of the oil and gas supply chain?
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………
……………………………………………………………………………………………………………

***Thank you very much for your kind support***


Please return the questionnaire to this address:

Dan'Asabe Godwin Geyi (PhD Student)
Green bank Hub, Institute of Logistics and Operations Management,
University of central Lancashire, Preston, PR1 2HE.

or by email to:

DGGeyi@uclan.ac.uk

# Appendix 2: A codebook for agile capabilities/practices; sustainable practices and performance indicators

| Description of variables | SPSS variable name | Coding instructions |
|---|---|---|
| Name of the company | id | Company identification number |
| Date of establishment | EOE | Year of incorporation |
| Position of the respondent | PR | Rank |
| Total number of the employees | Business size | Each range of business size was given a code |
| Total annual turnover | Turnover | Each range of turnover was given a code |
| Industrial classification (UK SIC – Standard industrial classification | UKSIC | Each industrial sector was given a numerical code |
| Agile capabilities and practices | | |
| Please indicate by a tick (√) the level of importance the following agile capabilities and practices best reflect in your company. | | |
| Customer driven innovation | MS1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Response to changing market requirements | MS2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| New product introduction | MS3 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Customer satisfaction | MS5 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Strategic relationship with customers and stakeholders | MS7 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Close relationship with customer | NC1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Trust-based relationship with customers/suppliers | NC2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Multi-venturing capabilities | NC3 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Rapid partnership formation | NC4 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Teams across company borders | NC5 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |

| | | |
|---|---|---|
| Enterprise integration | NC6 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Decentralised decision making | PA1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Cross functional teams | PA2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Information accessible to employees | PA4 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Concurrent execution of activities | PA6 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Quality over product life | PA7 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Flexible production technology | TI1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Leadership in the use of current technology | TI2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Skill and knowledge enhancing technologies | TI3 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Technology awareness | TI4 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| First time right design | TI5 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Virtual enterprise | TI6 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Employee satisfaction | EE1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Learning organisation | EE2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Workforce skill upgrade | EE3 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Multi-skilled and flexible people | EE4 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Continuous training and development | EE5 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Culture of change | EE6 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| **Environmental dynamism** | | |

| | | |
|---|---|---|
| Please indicate by a tick (√) the level of importance the following market turbulence influence in your company. | | |
| In our kind of business, customers' product preferences change quite a bit over time | ED1 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| Our customers tend to look for new products all the time. | ED2 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| We have demand for our products from customers who never bought them before | ED3 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| New customers have product needs that are different from our existing customers | ED4 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| We continuously cater to many new customers | ED5 | 1 = not important, 2= less important, 3 = important, 4 = very important, 5 = extremely important |
| How long your organisation has implemented sustainability practices | SUSPRA | 1 = 1-5 years, 2 = 6-10 years, 3 = 11-15 years, 4 = 16-20 years, 5 = 21 years above |
| Cooperation with suppliers for sustainability objectives | SPr5 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Providing design specification to suppliers that include sustainability requirements for their process | SPr6 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Supplier' ISO 14000 certification | SPr8 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Multi-tiers suppliers sustainability practices evaluation | SPr9 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Cooperation with customers for eco design | SD1 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Design of products for reduced consumption of materials | SD2 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Design of products for reuse, recycle, remanufacturing, and/or recovery of materials and component parts | SD3 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Design of products for easy disassembly | SD4 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Design of products to avoid or reduce use of hazardous materials | SD5 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Cooperation with customers for cleaner production | SD6 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Design of products for reduced consumption of energy | SD7 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We used a product's materials for a basic, low value purpose | IR1 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |

| | | |
|---|---|---|
| We are extracting a product's raw materials and using them for new products | IR2 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We returned products to the performance specification of the original equipment manufacturer | IR3 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We are redeploying products without the need for refurbishment | IR4 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We sale excess capital equipment | IR5 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We established health and safety management system | SSP1 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We support community involvement and development | SSP2 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Worker's Skills and capabilities development | SSP3 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Respect for people rights | SSP4 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Provide training for emergency preparedness program to employees, suppliers and community | SSP5 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We guarantee worker's health and safety at work | SSP6 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We make products that protect consumers' health and safety | SSP7 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We support and promote health situation in the community | SSP8 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We monitor our suppliers' commitment to sustainability improvement | SPrd 1 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Commitment of sustainability practices from senior manager | SPrd 2 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We helped our suppliers obtain ISO 14001 certification | SPrd 4 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| Support for sustainability practices from mid-level managers | SPrd 6 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We frequently visit our suppliers' premises to help improve their eco innovation | SPrd 7 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We use renewable energy in any model of product transportation | ST1 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We track and monitor carbon footprint caused during product delivery | ST2 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |

| | | |
|---|---|---|
| We frequently upgrade freight logistics and transportation systems | ST3 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| We work together with our customers for using less energy during product delivery | ST4 | 1 = not at all; 2 = to a small extent; 3 = to a moderate extent; 4 = to a relatively great extent; 5 = to a great extent |
| **Organisational performance criteria** | | |
| Please tick (√) applicable, the impacts of sustainability on the following organisational performance criteria | | |
| Operational performance objectives | | |
| Costs | OPO1 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Flexibility | OPO2 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Quality | OPO3 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Innovation | OPO4 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Reliability | OPO5 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Speed | OPO6 | 1 = very low, 2 = low, 3 = modest, 4 = high, 5 = very high |
| Sustainability performance measures | | |
| Please indicate the degree to which your organisation has achieved the following performance measures during the past years, tick (√) as applicable. | | |
| Decreases in cost of materials purchased | FP1 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decreases in cost of energy consumption | FP2 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decreases in fee for waste discharge | FP3 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decreases in fee for waste treatment | FP4 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decreases in fine for environmental accidents (spills) | FP5 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Increases in rate of return on investment | FP6 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Growth in market share | FP7 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Increases in sale turnover | FP8 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Increases in profitability | FP9 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Increases in customers' satisfaction | FP10 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |

| | | |
|---|---|---|
| Improved overall stakeholders' welfare | SP1 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improved health and safety of the community | SP2 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improved health and safety of workers | SP3 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improved community involvement and development | SP4 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improved awareness or protection of human rights | SP5 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improved product responsibility | SP6 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Reduction in solid waste and wastewater | EP1 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Reduction of air emission | EP2 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decrease in use of energy | EP3 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decrease in consumption for hazardous/harmful/toxic materials | EP4 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Decrease in frequency for environmental accidents | EP5 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |
| Improvement of an enterprise's environmental situation | EP6 | 1 = not at all, 2 = a little bit, 3 = to some degree, 4 = relatively significant, 5 = significant |

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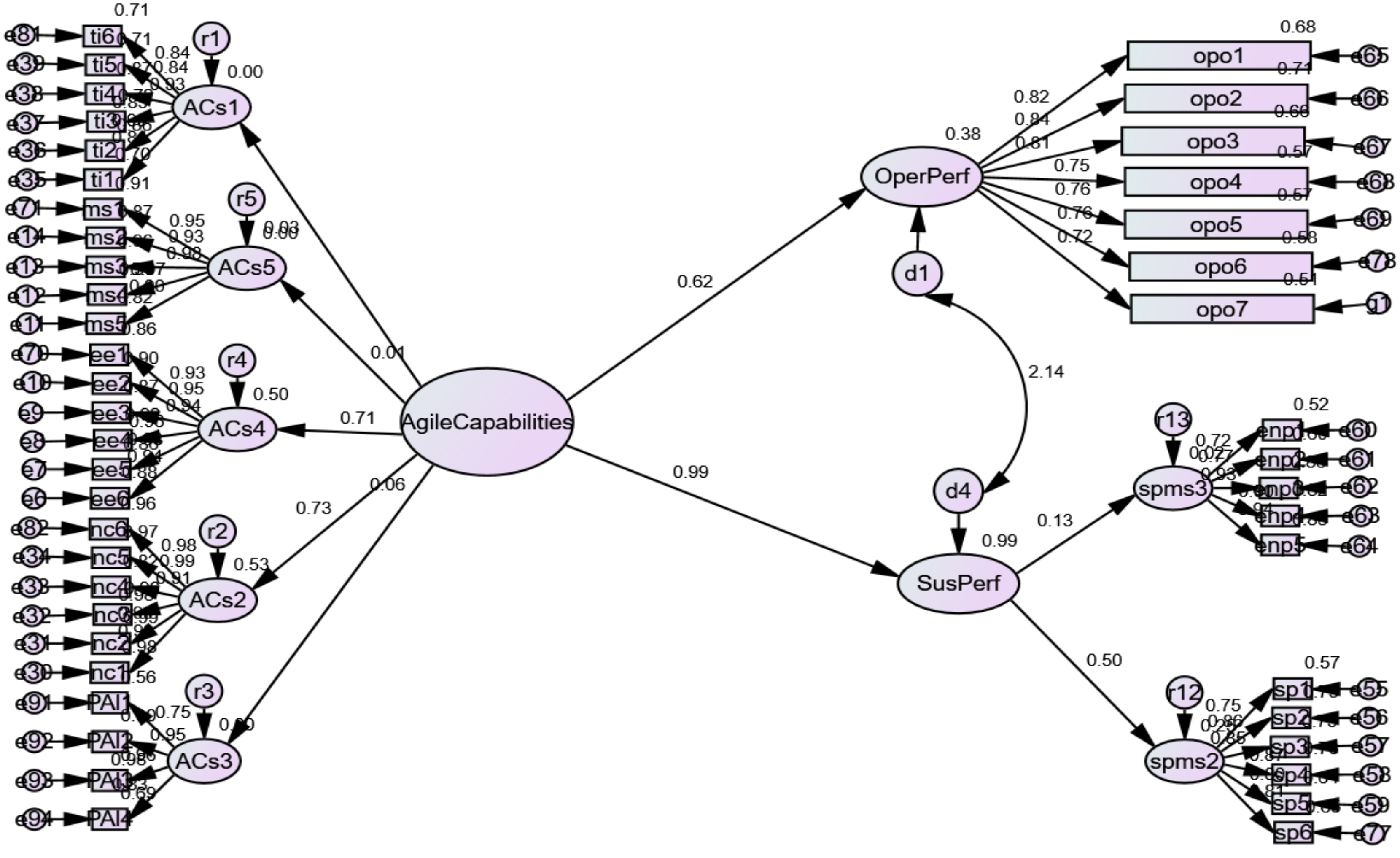
Appendix c: Structural model of agile capabilities and performance outcomes



# Regression Weights: (Group number 1 - Default model)

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| SusPerf | <--- | AgileCapabilities | .098 | .049 | 2.013 | .004 | |
| ACs1 | <--- | AgileCapabilities | .056 | .113 | .490 | .624 | |
| ACs4 | <--- | AgileCapabilities | 1.091 | .132 | 8.239 | *** | |
| spms2 | <--- | SusPerf | 7.489 | 3.750 | 1.997 | .046 | |
| ACs5 | <--- | AgileCapabilities | .012 | .117 | .105 | .916 | |
| ACs2 | <--- | AgileCapabilities | 1.000 | | | | |
| ACs3 | <--- | AgileCapabilities | .054 | .058 | .934 | .350 | |
| spms3 | <--- | SusPerf | 1.000 | | | | |
| OperPerf | <--- | AgileCapabilities | .770 | .105 | 7.362 | *** | |
| ee6 | <--- | ACs4 | 1.000 | | | | |
| ee5 | <--- | ACs4 | 1.026 | .032 | 32.151 | *** | |
| ee4 | <--- | ACs4 | 1.015 | .028 | 36.693 | *** | |
| ee3 | <--- | ACs4 | .982 | .030 | 33.053 | *** | |
| ee2 | <--- | ACs4 | 1.040 | .030 | 35.232 | *** | |
| ms4 | <--- | ACs5 | 1.079 | .033 | 32.818 | *** | |
| ms3 | <--- | ACs5 | 1.101 | .033 | 33.773 | *** | |
| ms2 | <--- | ACs5 | 1.010 | .036 | 28.359 | *** | |
| nc1 | <--- | ACs2 | 1.000 | | | | |
| nc2 | <--- | ACs2 | .991 | .010 | 103.340 | *** | |
| nc3 | <--- | ACs2 | .971 | .013 | 75.375 | *** | |
| nc4 | <--- | ACs2 | .896 | .025 | 36.221 | *** | |
| nc5 | <--- | ACs2 | .979 | .012 | 82.294 | *** | |
| ti1 | <--- | ACs1 | 1.000 | | | | |
| ti2 | <--- | ACs1 | 1.164 | .053 | 22.141 | *** | |
| ti3 | <--- | ACs1 | 1.063 | .056 | 18.909 | *** | |
| ti4 | <--- | ACs1 | 1.142 | .051 | 22.281 | *** | |
| ti5 | <--- | ACs1 | 1.101 | .059 | 18.702 | *** | |
| sp1 | <--- | spms2 | 1.000 | | | | |
| sp2 | <--- | spms2 | 1.128 | .071 | 15.815 | *** | |
| sp3 | <--- | spms2 | 1.082 | .069 | 15.728 | *** | |
| sp4 | <--- | spms2 | .989 | .061 | 16.157 | *** | |
| sp5 | <--- | spms2 | 1.060 | .072 | 14.648 | *** | |
| enp1 | <--- | spms3 | 1.000 | | | | |
| enp2 | <--- | spms3 | 1.039 | .076 | 13.635 | *** | |
| enp3 | <--- | spms3 | 1.258 | .076 | 16.513 | *** | |
| enp4 | <--- | spms3 | 1.233 | .077 | 16.085 | *** | |
| enp5 | <--- | spms3 | 1.280 | .077 | 16.669 | *** | |
| ee1 | <--- | ACs4 | .982 | .031 | 31.906 | *** | |
| ms1 | <--- | ACs5 | 1.021 | .033 | 30.645 | *** | |
| sp6 | <--- | spms2 | .967 | .066 | 14.753 | *** | |
| ms5 | <--- | ACs5 | 1.000 | | | | |
| ti6 | <--- | ACs1 | 1.083 | .058 | 18.622 | *** | |
| nc6 | <--- | ACs2 | .952 | .014 | 69.438 | *** | |
| opo1 | <--- | OperPerf | 1.000 | | | | |

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| opo2 | <--- | OperPerf | 1.031 | .059 | 17.584 | *** | |
| opo3 | <--- | OperPerf | 1.014 | .061 | 16.658 | *** | |
| opo4 | <--- | OperPerf | .906 | .060 | 15.013 | *** | |
| opo5 | <--- | OperPerf | 1.007 | .067 | 15.057 | *** | |
| opo6 | <--- | OperPerf | .948 | .062 | 15.297 | *** | |
| PAl4 | <--- | ACs3 | 1.000 | | | | |
| PAl3 | <--- | ACs3 | 1.163 | .047 | 24.517 | *** | |
| PAl2 | <--- | ACs3 | 1.129 | .048 | 23.372 | *** | |
| PAl1 | <--- | ACs3 | .903 | .058 | 15.664 | *** | |
| opo7 | <--- | OperPerf | .878 | .063 | 13.977 | *** | |

# Standardized Regression Weights: (Group number 1 - Default model)

| | | | Estimate |
|---|---|---|---|
| SusPerf | <--- | AgileCapabilities | .995 |
| ACs1 | <--- | AgileCapabilities | .033 |
| ACs4 | <--- | AgileCapabilities | .708 |
| spms2 | <--- | SusPerf | .499 |
| ACs5 | <--- | AgileCapabilities | .007 |
| ACs2 | <--- | AgileCapabilities | .725 |
| ACs3 | <--- | AgileCapabilities | .063 |
| spms3 | <--- | SusPerf | .131 |
| OperPerf | <--- | AgileCapabilities | .620 |
| ee6 | <--- | ACs4 | .940 |
| ee5 | <--- | ACs4 | .929 |
| ee4 | <--- | ACs4 | .958 |
| ee3 | <--- | ACs4 | .935 |
| ee2 | <--- | ACs4 | .949 |
| ms4 | <--- | ACs5 | .973 |
| ms3 | <--- | ACs5 | .980 |
| ms2 | <--- | ACs5 | .931 |
| nc1 | <--- | ACs2 | .991 |
| nc2 | <--- | ACs2 | .994 |
| nc3 | <--- | ACs2 | .982 |
| nc4 | <--- | ACs2 | .906 |
| nc5 | <--- | ACs2 | .986 |
| ti1 | <--- | ACs1 | .836 |
| ti2 | <--- | ACs1 | .928 |
| ti3 | <--- | ACs1 | .848 |
| ti4 | <--- | ACs1 | .931 |
| ti5 | <--- | ACs1 | .843 |
| sp1 | <--- | spms2 | .753 |
| sp2 | <--- | spms2 | .856 |
| sp3 | <--- | spms2 | .852 |
| sp4 | <--- | spms2 | .872 |
| sp5 | <--- | spms2 | .801 |

| | | | Estimate |
|---|---|---|---|
| enp1 | <--- | spms3 | .724 |
| enp2 | <--- | spms3 | .773 |
| enp3 | <--- | spms3 | .928 |
| enp4 | <--- | spms3 | .904 |
| enp5 | <--- | spms3 | .937 |
| ee1 | <--- | ACs4 | .927 |
| ms1 | <--- | ACs5 | .954 |
| sp6 | <--- | spms2 | .806 |
| ms5 | <--- | ACs5 | .904 |
| ti6 | <--- | ACs1 | .841 |
| nc6 | <--- | ACs2 | .977 |
| opo1 | <--- | OperPerf | .823 |
| opo2 | <--- | OperPerf | .842 |
| opo3 | <--- | OperPerf | .812 |
| opo4 | <--- | OperPerf | .754 |
| opo5 | <--- | OperPerf | .756 |
| opo6 | <--- | OperPerf | .764 |
| PAl4 | <--- | ACs3 | .832 |
| PAl3 | <--- | ACs3 | .982 |
| PAl2 | <--- | ACs3 | .951 |
| PAl1 | <--- | ACs3 | .748 |
| opo7 | <--- | OperPerf | .715 |

# Model Fit Summary

**CMIN**

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| **Default model** | 100 | 1972.296 | 935 | .000 | 2.109 |
| **Saturated model** | 1035 | .000 | 0 | | |
| **Independence model** | 45 | 19169.112 | 990 | .000 | 19.363 |

**RMR, GFI**

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| **Default model** | .032 | .790 | .767 | .713 |
| **Saturated model** | .000 | 1.000 | | |
| **Independence model** | .175 | .184 | .147 | .176 |

**Baseline Comparisons**

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| **Default model** | .897 | .891 | .943 | .940 | .943 |
| **Saturated model** | 1.000 | | 1.000 | | 1.000 |

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| Independence model | .000 | .000 | .000 | .000 | .000 |

**Parsimony-Adjusted Measures**

| Model | PRATIO | PNFI | PCFI |
|---|---|---|---|
| Default model | .944 | .847 | .891 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 1.000 | .000 | .000 |

**NCP**

| Model | NCP | LO 90 | HI 90 |
|---|---|---|---|
| Default model | 1037.296 | 913.505 | 1168.806 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 18179.112 | 17732.764 | 18631.850 |

**FMIN**

| Model | FMIN | F0 | LO 90 | HI 90 |
|---|---|---|---|---|
| Default model | 6.362 | 3.346 | 2.947 | 3.770 |
| Saturated model | .000 | .000 | .000 | .000 |
| Independence model | 61.836 | 58.642 | 57.202 | 60.103 |

**RMSEA**

| Model | RMSEA | LO 90 | HI 90 | PCLOSE |
|---|---|---|---|---|
| Default model | .030 | .056 | .064 | .000 |
| Independence model | .243 | .240 | .246 | .000 |

**AIC**

| Model | AIC | BCC | BIC | CAIC |
|---|---|---|---|---|
| Default model | 2172.296 | 2207.145 | 2546.276 | 2646.276 |
| Saturated model | 2070.000 | 2430.682 | 5940.686 | 6975.686 |
| Independence model | 19259.112 | 19274.793 | 19427.402 | 19472.402 |

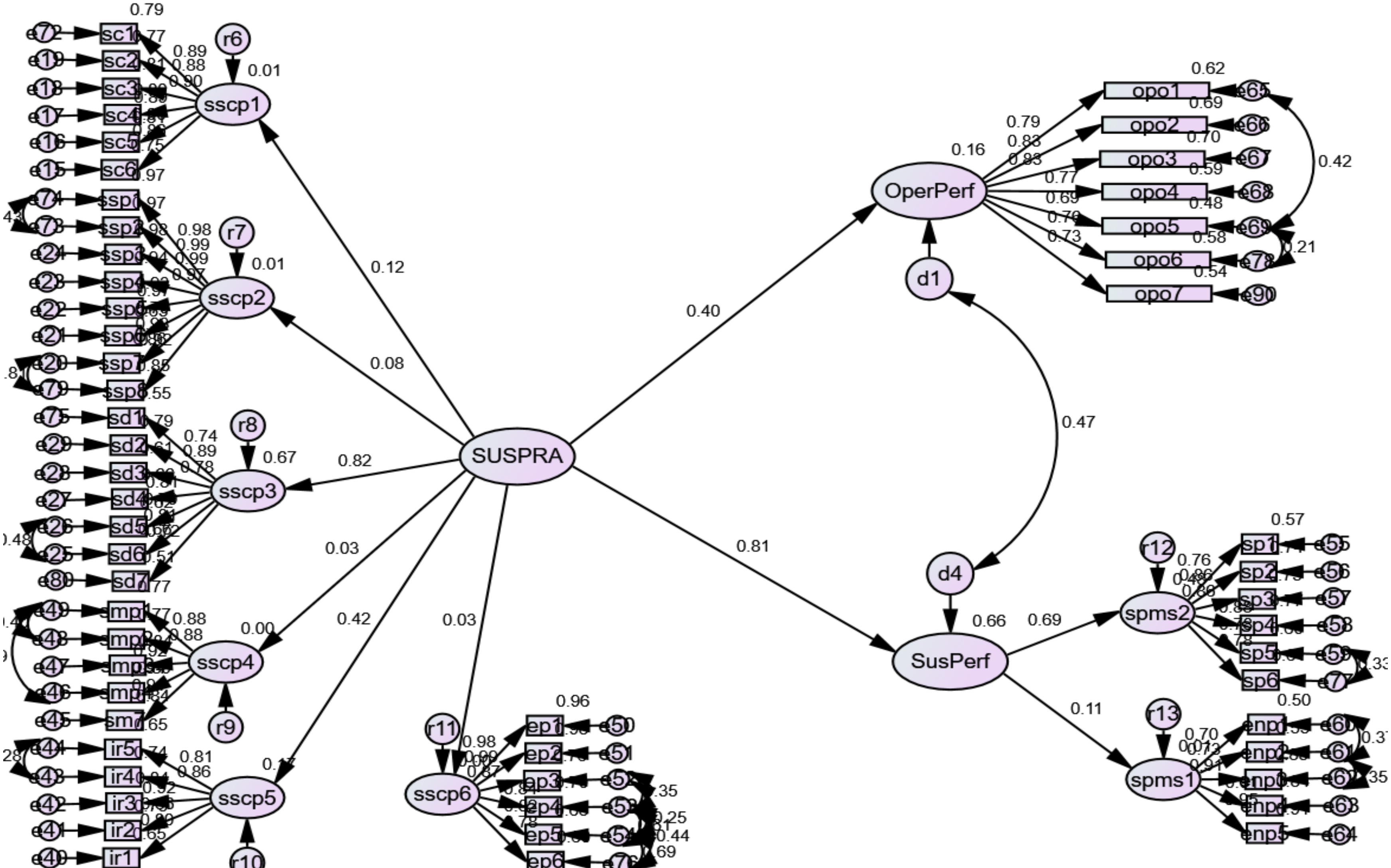
**ECVI**

| Model | ECVI | LO 90 | HI 90 | MECVI |
|---|---|---|---|---|
| Default model | 7.007 | 6.608 | 7.432 | 7.120 |
| Saturated model | 6.677 | 6.677 | 6.677 | 7.841 |
| Independence model | 62.126 | 60.686 | 63.587 | 62.177 |

**HOELTER**

| Model | HOELTER .05 | HOELTER .01 |
|---|---|---|
| **Default model** | 159 | 164 |
| **Independence model** | 18 | 18 |

## Appendix D: Structural model for sustainable practices and performance outcomes



# Regression Weights: (Group number 1 - Default model)

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| SusPerf | <--- | SUSPRA | .616 | .143 | 4.309 | *** | |
| sscp1 | <--- | SUSPRA | .148 | .089 | 1.665 | .096 | |
| sscp2 | <--- | SUSPRA | .130 | .115 | 1.130 | .258 | |
| sscp3 | <--- | SUSPRA | 1.000 | | | | |
| sscp4 | <--- | SUSPRA | .041 | .084 | .483 | .629 | |
| sscp5 | <--- | SUSPRA | .497 | .118 | 4.209 | *** | |
| OperPerf | <--- | SUSPRA | .355 | .094 | 3.775 | *** | |
| spms2 | <--- | SusPerf | 1.000 | | | | |
| spms1 | <--- | SusPerf | .077 | .056 | 1.380 | .168 | |
| sscp6 | <--- | SUSPRA | .035 | .075 | .464 | .643 | |
| sc6 | <--- | sscp1 | 1.000 | | | | |
| sc5 | <--- | sscp1 | 1.070 | .048 | 22.494 | *** | |
| sc4 | <--- | sscp1 | 1.029 | .046 | 22.183 | *** | |
| sc3 | <--- | sscp1 | 1.039 | .046 | 22.614 | *** | |
| sc2 | <--- | sscp1 | .985 | .046 | 21.400 | *** | |
| ssp7 | <--- | sscp2 | 1.000 | | | | |
| ssp6 | <--- | sscp2 | .687 | .034 | 20.194 | *** | |
| ssp5 | <--- | sscp2 | 1.109 | .031 | 35.784 | *** | |
| ssp4 | <--- | sscp2 | 1.102 | .030 | 36.788 | *** | |
| ssp3 | <--- | sscp2 | 1.132 | .028 | 40.655 | *** | |
| sd6 | <--- | sscp3 | 1.000 | | | | |
| sd5 | <--- | sscp3 | .973 | .045 | 21.787 | *** | |
| sd4 | <--- | sscp3 | .997 | .061 | 16.263 | *** | |
| sd3 | <--- | sscp3 | .941 | .061 | 15.536 | *** | |
| sd2 | <--- | sscp3 | 1.062 | .057 | 18.537 | *** | |
| ir1 | <--- | sscp5 | 1.000 | | | | |
| ir2 | <--- | sscp5 | 1.093 | .061 | 17.781 | *** | |
| ir3 | <--- | sscp5 | .994 | .052 | 19.230 | *** | |
| ir4 | <--- | sscp5 | .988 | .056 | 17.548 | *** | |
| ir5 | <--- | sscp5 | .915 | .057 | 16.078 | *** | |
| sm7 | <--- | sscp4 | 1.000 | | | | |
| smp4 | <--- | sscp4 | 1.088 | .037 | 29.703 | *** | |
| smp3 | <--- | sscp4 | 1.041 | .038 | 27.727 | *** | |
| smp2 | <--- | sscp4 | .968 | .040 | 24.322 | *** | |
| smp1 | <--- | sscp4 | .946 | .040 | 23.634 | *** | |
| ep1 | <--- | sscp6 | 1.000 | | | | |
| ep2 | <--- | sscp6 | 1.017 | .015 | 67.643 | *** | |
| ep3 | <--- | sscp6 | .881 | .030 | 29.392 | *** | |
| ep4 | <--- | sscp6 | .817 | .032 | 25.610 | *** | |
| ep5 | <--- | sscp6 | .800 | .033 | 24.293 | *** | |
| sp1 | <--- | spms2 | 1.000 | | | | |
| sp2 | <--- | spms2 | 1.128 | .070 | 16.056 | *** | |
| sp3 | <--- | spms2 | 1.080 | .068 | 15.923 | *** | |
| sp4 | <--- | spms2 | .989 | .060 | 16.392 | *** | |
| sp5 | <--- | spms2 | 1.021 | .072 | 14.189 | *** | |

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| enp1 | <--- | spms1 | 1.000 | | | | |
| enp2 | <--- | spms1 | .998 | .064 | 15.553 | *** | |
| enp3 | <--- | spms1 | 1.269 | .082 | 15.423 | *** | |
| enp4 | <--- | spms1 | 1.283 | .083 | 15.506 | *** | |
| enp5 | <--- | spms1 | 1.340 | .083 | 16.057 | *** | |
| sc1 | <--- | sscp1 | 1.043 | .047 | 22.102 | *** | |
| ssp2 | <--- | sscp2 | 1.138 | .029 | 39.487 | *** | |
| ssp1 | <--- | sscp2 | 1.145 | .029 | 39.423 | *** | |
| sd1 | <--- | sscp3 | .831 | .057 | 14.496 | *** | |
| ep6 | <--- | sscp6 | .764 | .037 | 20.907 | *** | |
| sp6 | <--- | spms2 | .929 | .065 | 14.247 | *** | |
| ssp8 | <--- | sscp2 | .992 | .014 | 68.635 | *** | |
| sd7 | <--- | sscp3 | .832 | .060 | 13.815 | *** | |
| opo1 | <--- | OperPerf | 1.000 | | | | |
| opo2 | <--- | OperPerf | 1.059 | .066 | 15.992 | *** | |
| opo3 | <--- | OperPerf | 1.086 | .068 | 16.081 | *** | |
| opo4 | <--- | OperPerf | .960 | .066 | 14.477 | *** | |
| opo5 | <--- | OperPerf | .968 | .059 | 16.527 | *** | |
| opo6 | <--- | OperPerf | .984 | .069 | 14.342 | *** | |
| opo7 | <--- | OperPerf | .938 | .068 | 13.697 | *** | |

# Standardized Regression Weights: (Group number 1 - Default model)

| | | | Estimate |
|---|---|---|---|
| SusPerf | <--- | SUSPRA | .810 |
| sscp1 | <--- | SUSPRA | .120 |
| sscp2 | <--- | SUSPRA | .078 |
| sscp3 | <--- | SUSPRA | .816 |
| sscp4 | <--- | SUSPRA | .034 |
| sscp5 | <--- | SUSPRA | .415 |
| OperPerf | <--- | SUSPRA | .402 |
| spms2 | <--- | SusPerf | .692 |
| spms1 | <--- | SusPerf | .108 |
| sscp6 | <--- | SUSPRA | .032 |
| sc6 | <--- | sscp1 | .864 |
| sc5 | <--- | sscp1 | .899 |
| sc4 | <--- | sscp1 | .893 |
| sc3 | <--- | sscp1 | .901 |
| sc2 | <--- | sscp1 | .877 |
| ssp7 | <--- | sscp2 | .926 |
| ssp6 | <--- | sscp2 | .794 |
| ssp5 | <--- | sscp2 | .965 |
| ssp4 | <--- | sscp2 | .971 |
| ssp3 | <--- | sscp2 | .990 |
| sd6 | <--- | sscp3 | .811 |
| sd5 | <--- | sscp3 | .788 |

| | | | Estimate |
|---|---|---|---|
| sd4 | <--- | sscp3 | .810 |
| sd3 | <--- | sscp3 | .783 |
| sd2 | <--- | sscp3 | .889 |
| ir1 | <--- | sscp5 | .805 |
| ir2 | <--- | sscp5 | .864 |
| ir3 | <--- | sscp5 | .915 |
| ir4 | <--- | sscp5 | .858 |
| ir5 | <--- | sscp5 | .807 |
| sm7 | <--- | sscp4 | .915 |
| smp4 | <--- | sscp4 | .944 |
| smp3 | <--- | sscp4 | .919 |
| smp2 | <--- | sscp4 | .879 |
| smp1 | <--- | sscp4 | .875 |
| ep1 | <--- | sscp6 | .981 |
| ep2 | <--- | sscp6 | .992 |
| ep3 | <--- | sscp6 | .872 |
| ep4 | <--- | sscp6 | .837 |
| ep5 | <--- | sscp6 | .822 |
| sp1 | <--- | spms2 | .758 |
| sp2 | <--- | spms2 | .863 |
| sp3 | <--- | spms2 | .856 |
| sp4 | <--- | spms2 | .878 |
| sp5 | <--- | spms2 | .777 |
| enp1 | <--- | spms1 | .704 |
| enp2 | <--- | spms1 | .726 |
| enp3 | <--- | spms1 | .909 |
| enp4 | <--- | spms1 | .914 |
| enp5 | <--- | spms1 | .952 |
| sc1 | <--- | sscp1 | .892 |
| ssp2 | <--- | sscp2 | .985 |
| ssp1 | <--- | sscp2 | .985 |
| sd1 | <--- | sscp3 | .743 |
| ep6 | <--- | sscp6 | .776 |
| sp6 | <--- | spms2 | .780 |
| ssp8 | <--- | sscp2 | .922 |
| sd7 | <--- | sscp3 | .717 |
| opo1 | <--- | OperPerf | .790 |
| opo2 | <--- | OperPerf | .831 |
| opo3 | <--- | OperPerf | .834 |
| opo4 | <--- | OperPerf | .767 |
| opo5 | <--- | OperPerf | .695 |
| opo6 | <--- | OperPerf | .761 |
| opo7 | <--- | OperPerf | .733 |

# Model Fit Summary

**CMIN**

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| Default model | 137 | 2085.196 | 1403 | .000 | 1.486 |
| Saturated model | 1540 | .000 | 0 | | |
| Independence model | 55 | 21092.421 | 1485 | .000 | 14.204 |

**RMR, GFI**

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| Default model | .067 | .812 | .794 | .740 |
| Saturated model | .000 | 1.000 | | |
| Independence model | .222 | .203 | .173 | .196 |

**Baseline Comparisons**

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| Default model | .901 | .895 | .965 | .963 | .965 |
| Saturated model | 1.000 | | 1.000 | | 1.000 |
| Independence model | .000 | .000 | .000 | .000 | .000 |

**Parsimony-Adjusted Measures**

| Model | PRATIO | PNFI | PCFI |
|---|---|---|---|
| Default model | .945 | .851 | .912 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 1.000 | .000 | .000 |

**NCP**

| Model | NCP | LO 90 | HI 90 |
|---|---|---|---|
| Default model | 682.196 | 563.776 | 808.574 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 19607.421 | 19141.357 | 20079.919 |

**FMIN**

| Model | FMIN | F0 | LO 90 | HI 90 |
|---|---|---|---|---|
| Default model | 6.726 | 2.201 | 1.819 | 2.608 |
| Saturated model | .000 | .000 | .000 | .000 |
| Independence model | 68.040 | 63.250 | 61.746 | 64.774 |

**RMSEA**

| Model | RMSEA | LO 90 | HI 90 | PCLOSE |
|---|---|---|---|---|
| Default model | .040 | .036 | .043 | 1.000 |
| Independence model | .206 | .204 | .209 | .000 |

**AIC**

| Model | AIC | BCC | BIC | CAIC |
|---|---|---|---|---|
| Default model | 2359.196 | 2419.606 | 2871.548 | 3008.548 |
| Saturated model | 3080.000 | 3759.055 | 8839.281 | 10379.281 |
| Independence model | 21202.421 | 21226.673 | 21408.109 | 21463.109 |

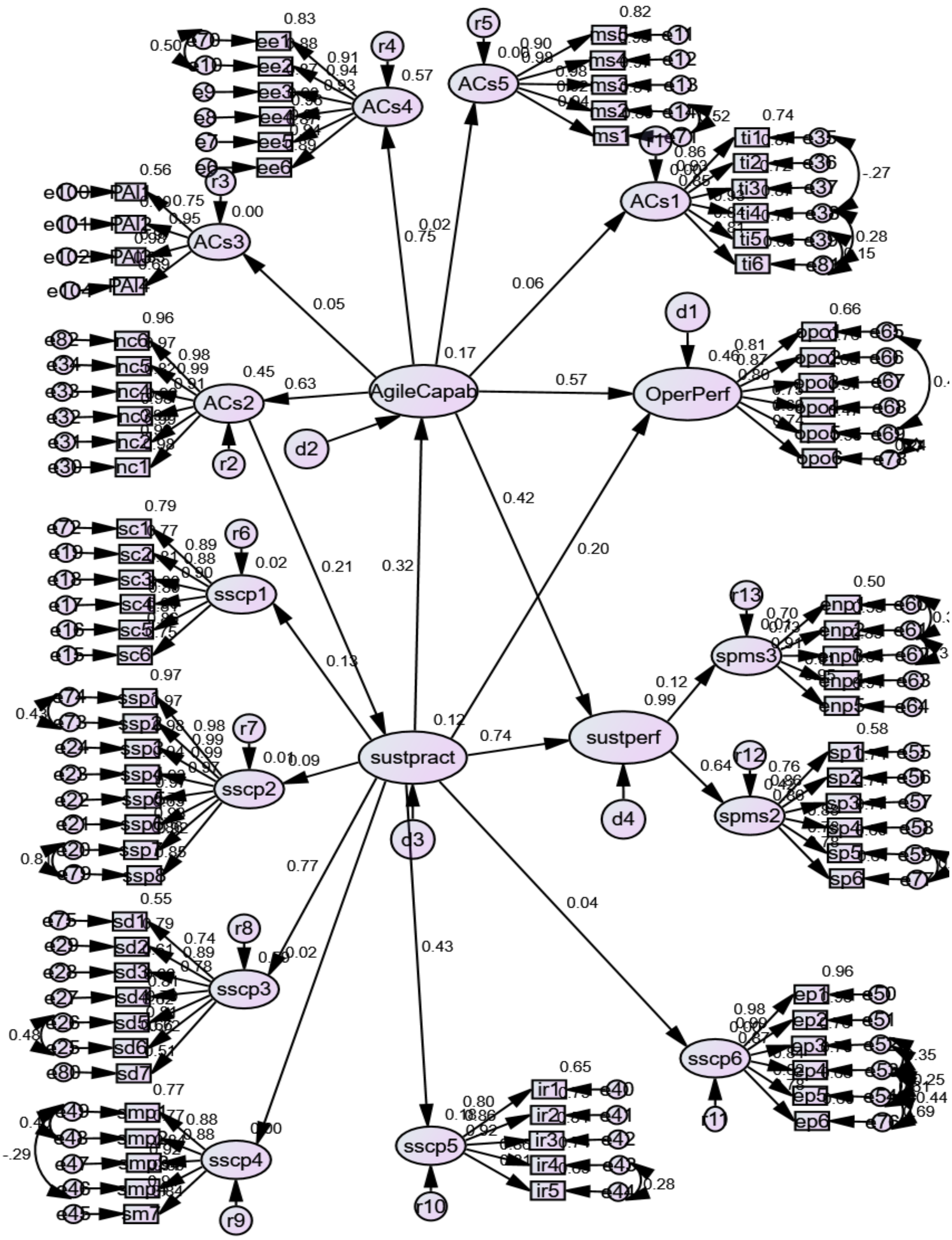
**ECVI**

| Model | ECVI | LO 90 | HI 90 | MECVI |
|---|---|---|---|---|
| Default model | 7.610 | 7.228 | 8.018 | 7.805 |
| Saturated model | 9.935 | 9.935 | 9.935 | 12.126 |
| Independence model | 68.395 | 66.891 | 69.919 | 68.473 |

**HOELTER**

| Model | HOELTER .05 | HOELTER .01 |
|---|---|---|
| Default model | 222 | 228 |
| Independence model | 24 | 24 |

Appendix E: Structural model for mediation effects of agility




# **Regression Weights: (Group number 1 - Default model)**

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| sustperf | <--- | sustpract | .558 | .154 | 3.628 | *** | |
| sustperf | <--- | AgileCapab | .462 | .153 | 3.029 | .002 | |
| ACs1 | <--- | AgileCapab | .110 | .134 | .820 | .412 | |
| ACs4 | <--- | AgileCapab | 1.338 | .220 | 6.089 | *** | |
| sscp1 | <--- | sustpract | .172 | .096 | 1.801 | .072 | |
| sscp2 | <--- | sustpract | .155 | .124 | 1.250 | .211 | |
| sscp3 | <--- | sustpract | 1.000 | | | | |
| sscp4 | <--- | sustpract | .030 | .091 | .325 | .745 | |
| sscp5 | <--- | sustpract | .547 | .118 | 4.647 | *** | |
| spms3 | <--- | sustperf | .088 | .052 | 1.681 | .093 | |
| spms2 | <--- | sustperf | 1.000 | | | | |
| ACs5 | <--- | AgileCapab | .048 | .135 | .354 | .724 | |
| OperPerf | <--- | AgileCapab | .799 | .135 | 5.907 | *** | |
| OperPerf | <--- | sustpract | .189 | .098 | 1.932 | .053 | |
| sscp6 | <--- | sustpract | .046 | .082 | .558 | .577 | |
| ACs3 | <--- | AgileCapab | .046 | .067 | .697 | .486 | |
| ee6 | <--- | ACs4 | 1.000 | | | | |
| ee5 | <--- | ACs4 | 1.028 | .031 | 33.669 | *** | |
| ee4 | <--- | ACs4 | 1.015 | .026 | 38.533 | *** | |
| ee3 | <--- | ACs4 | .976 | .029 | 33.484 | *** | |
| ee2 | <--- | ACs4 | 1.020 | .030 | 33.776 | *** | |
| ms4 | <--- | ACs5 | 1.083 | .033 | 33.234 | *** | |
| ms3 | <--- | ACs5 | 1.104 | .032 | 34.116 | *** | |
| ms2 | <--- | ACs5 | .996 | .037 | 27.165 | *** | |
| sc6 | <--- | sscp1 | 1.000 | | | | |
| sc5 | <--- | sscp1 | 1.070 | .048 | 22.497 | *** | |
| sc4 | <--- | sscp1 | 1.029 | .046 | 22.184 | *** | |
| sc3 | <--- | sscp1 | 1.039 | .046 | 22.617 | *** | |
| sc2 | <--- | sscp1 | .985 | .046 | 21.402 | *** | |
| ssp7 | <--- | sscp2 | 1.000 | | | | |
| ssp6 | <--- | sscp2 | .687 | .034 | 20.194 | *** | |
| ssp5 | <--- | sscp2 | 1.109 | .031 | 35.784 | *** | |
| ssp4 | <--- | sscp2 | 1.102 | .030 | 36.787 | *** | |
| ssp3 | <--- | sscp2 | 1.132 | .028 | 40.655 | *** | |
| sd6 | <--- | sscp3 | 1.000 | | | | |
| sd5 | <--- | sscp3 | .972 | .045 | 21.749 | *** | |
| sd4 | <--- | sscp3 | .999 | .062 | 16.244 | *** | |
| sd3 | <--- | sscp3 | .942 | .061 | 15.495 | *** | |
| sd2 | <--- | sscp3 | 1.065 | .058 | 18.509 | *** | |
| nc1 | <--- | ACs2 | 1.000 | | | | |
| nc2 | <--- | ACs2 | .991 | .010 | 103.277 | *** | |
| nc3 | <--- | ACs2 | .971 | .013 | 75.361 | *** | |
| nc4 | <--- | ACs2 | .896 | .025 | 36.215 | *** | |
| nc5 | <--- | ACs2 | .979 | .012 | 82.260 | *** | |
| ti1 | <--- | ACs1 | 1.000 | | | | |
| ti2 | <--- | ACs1 | 1.134 | .048 | 23.497 | *** | |
| ti3 | <--- | ACs1 | 1.031 | .052 | 19.663 | *** | |
| ti4 | <--- | ACs1 | 1.107 | .052 | 21.270 | *** | |
| ti5 | <--- | ACs1 | 1.061 | .055 | 19.212 | *** | |
| ir1 | <--- | sscp5 | 1.000 | | | | |
| ir2 | <--- | sscp5 | 1.093 | .061 | 17.788 | *** | |
| ir3 | <--- | sscp5 | .994 | .052 | 19.233 | *** | |

| | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| ir4 | <--- | sscp5 | .988 | .056 | 17.549 | *** | |
| ir5 | <--- | sscp5 | .915 | .057 | 16.084 | *** | |
| sm7 | <--- | sscp4 | 1.000 | | | | |
| smp4 | <--- | sscp4 | 1.088 | .037 | 29.703 | *** | |
| smp3 | <--- | sscp4 | 1.041 | .038 | 27.731 | *** | |
| smp2 | <--- | sscp4 | .968 | .040 | 24.320 | *** | |
| smp1 | <--- | sscp4 | .946 | .040 | 23.631 | *** | |
| ep1 | <--- | sscp6 | 1.000 | | | | |
| ep2 | <--- | sscp6 | 1.017 | .015 | 67.644 | *** | |
| ep3 | <--- | sscp6 | .881 | .030 | 29.391 | *** | |
| ep4 | <--- | sscp6 | .817 | .032 | 25.610 | *** | |
| ep5 | <--- | sscp6 | .800 | .033 | 24.293 | *** | |
| sp1 | <--- | spms2 | 1.000 | | | | |
| sp2 | <--- | spms2 | 1.125 | .070 | 16.058 | *** | |
| sp3 | <--- | spms2 | 1.082 | .068 | 16.020 | *** | |
| sp4 | <--- | spms2 | .986 | .060 | 16.391 | *** | |
| sp5 | <--- | spms2 | 1.018 | .072 | 14.187 | *** | |
| enp1 | <--- | spms3 | 1.000 | | | | |
| enp2 | <--- | spms3 | .998 | .064 | 15.557 | *** | |
| enp3 | <--- | spms3 | 1.268 | .082 | 15.427 | *** | |
| enp4 | <--- | spms3 | 1.282 | .083 | 15.509 | *** | |
| enp5 | <--- | spms3 | 1.340 | .083 | 16.064 | *** | |
| ee1 | <--- | ACs4 | .959 | .032 | 30.175 | *** | |
| ms1 | <--- | ACs5 | 1.010 | .034 | 29.623 | *** | |
| sc1 | <--- | sscp1 | 1.043 | .047 | 22.101 | *** | |
| ssp2 | <--- | sscp2 | 1.138 | .029 | 39.487 | *** | |
| ssp1 | <--- | sscp2 | 1.145 | .029 | 39.422 | *** | |
| sd1 | <--- | sscp3 | .833 | .057 | 14.492 | *** | |
| ep6 | <--- | sscp6 | .764 | .037 | 20.907 | *** | |
| sp6 | <--- | spms2 | .928 | .065 | 14.286 | *** | |
| ms5 | <--- | ACs5 | 1.000 | | | | |
| ssp8 | <--- | sscp2 | .992 | .014 | 68.635 | *** | |
| sd7 | <--- | sscp3 | .833 | .060 | 13.787 | *** | |
| ti6 | <--- | ACs1 | 1.010 | .056 | 17.917 | *** | |
| nc6 | <--- | ACs2 | .952 | .014 | 69.449 | *** | |
| opo1 | <--- | OperPerf | 1.000 | | | | |
| opo2 | <--- | OperPerf | 1.076 | .061 | 17.600 | *** | |
| opo3 | <--- | OperPerf | 1.006 | .064 | 15.673 | *** | |
| opo4 | <--- | OperPerf | .913 | .063 | 14.526 | *** | |
| opo5 | <--- | OperPerf | .931 | .057 | 16.437 | *** | |
| opo6 | <--- | OperPerf | .932 | .065 | 14.308 | *** | |
| PAl4 | <--- | ACs3 | 1.000 | | | | |
| PAl3 | <--- | ACs3 | 1.163 | .047 | 24.521 | *** | |
| PAl2 | <--- | ACs3 | 1.128 | .048 | 23.372 | *** | |
| PAl1 | <--- | ACs3 | .903 | .058 | 15.663 | *** | |
| ACs2 | <--- | AgileCapab | 1.000 | | | | |
| AgileCapab | <--- | sustpract | .219 | .121 | 1.806 | .071 | |
| sustpract | <--- | ACs2 | .194 | .122 | 1.596 | .110 | |

# Standardized Regression Weights: (Group number 1 - Default model)

| | | | Estimate |
|---|---|---|---|
| sustperf | <--- | sustpract | .738 |
| sustperf | <--- | AgileCapab | .420 |
| ACs1 | <--- | AgileCapab | .056 |
| ACs4 | <--- | AgileCapab | .753 |
| sscp1 | <--- | sustpract | .131 |
| sscp2 | <--- | sustpract | .088 |
| sscp3 | <--- | sustpract | .766 |
| sscp4 | <--- | sustpract | .023 |
| sscp5 | <--- | sustpract | .428 |
| spms3 | <--- | sustperf | .116 |
| spms2 | <--- | sustperf | .645 |
| ACs5 | <--- | AgileCapab | .024 |
| OperPerf | <--- | AgileCapab | .567 |
| OperPerf | <--- | sustpract | .195 |
| sscp6 | <--- | sustpract | .039 |
| ACs3 | <--- | AgileCapab | .047 |
| ee6 | <--- | ACs4 | .945 |
| ee5 | <--- | ACs4 | .935 |
| ee4 | <--- | ACs4 | .963 |
| ee3 | <--- | ACs4 | .934 |
| ee2 | <--- | ACs4 | .936 |
| ms4 | <--- | ACs5 | .976 |
| ms3 | <--- | ACs5 | .983 |
| ms2 | <--- | ACs5 | .918 |
| sc6 | <--- | sscp1 | .864 |
| sc5 | <--- | sscp1 | .899 |
| sc4 | <--- | sscp1 | .893 |
| sc3 | <--- | sscp1 | .901 |
| sc2 | <--- | sscp1 | .877 |
| ssp7 | <--- | sscp2 | .926 |
| ssp6 | <--- | sscp2 | .794 |
| ssp5 | <--- | sscp2 | .965 |
| ssp4 | <--- | sscp2 | .971 |
| ssp3 | <--- | sscp2 | .990 |
| sd6 | <--- | sscp3 | .810 |
| sd5 | <--- | sscp3 | .787 |
| sd4 | <--- | sscp3 | .810 |
| sd3 | <--- | sscp3 | .783 |
| sd2 | <--- | sscp3 | .890 |
| nc1 | <--- | ACs2 | .991 |
| nc2 | <--- | ACs2 | .994 |
| nc3 | <--- | ACs2 | .982 |
| nc4 | <--- | ACs2 | .906 |
| nc5 | <--- | ACs2 | .986 |
| ti1 | <--- | ACs1 | .861 |
| ti2 | <--- | ACs1 | .931 |
| ti3 | <--- | ACs1 | .848 |
| ti4 | <--- | ACs1 | .930 |
| ti5 | <--- | ACs1 | .837 |
| ir1 | <--- | sscp5 | .805 |
| ir2 | <--- | sscp5 | .864 |
| ir3 | <--- | sscp5 | .915 |

| | | | Estimate |
|---|---|---|---|
| ir4 | <--- | sscp5 | .858 |
| ir5 | <--- | sscp5 | .808 |
| sm7 | <--- | sscp4 | .915 |
| smp4 | <--- | sscp4 | .944 |
| smp3 | <--- | sscp4 | .919 |
| smp2 | <--- | sscp4 | .879 |
| smp1 | <--- | sscp4 | .875 |
| ep1 | <--- | sscp6 | .981 |
| ep2 | <--- | sscp6 | .992 |
| ep3 | <--- | sscp6 | .872 |
| ep4 | <--- | sscp6 | .837 |
| ep5 | <--- | sscp6 | .822 |
| sp1 | <--- | spms2 | .759 |
| sp2 | <--- | spms2 | .861 |
| sp3 | <--- | spms2 | .859 |
| sp4 | <--- | spms2 | .876 |
| sp5 | <--- | spms2 | .776 |
| enp1 | <--- | spms3 | .704 |
| enp2 | <--- | spms3 | .726 |
| enp3 | <--- | spms3 | .909 |
| enp4 | <--- | spms3 | .914 |
| enp5 | <--- | spms3 | .953 |
| ee1 | <--- | ACs4 | .910 |
| ms1 | <--- | ACs5 | .944 |
| sc1 | <--- | sscp1 | .891 |
| ssp2 | <--- | sscp2 | .985 |
| ssp1 | <--- | sscp2 | .985 |
| sd1 | <--- | sscp3 | .744 |
| ep6 | <--- | sscp6 | .776 |
| sp6 | <--- | spms2 | .780 |
| ms5 | <--- | ACs5 | .904 |
| ssp8 | <--- | sscp2 | .922 |
| sd7 | <--- | sscp3 | .716 |
| ti6 | <--- | ACs1 | .808 |
| nc6 | <--- | ACs2 | .978 |
| opo1 | <--- | OperPerf | .814 |
| opo2 | <--- | OperPerf | .870 |
| opo3 | <--- | OperPerf | .796 |
| opo4 | <--- | OperPerf | .752 |
| opo5 | <--- | OperPerf | .688 |
| opo6 | <--- | OperPerf | .743 |
| PAl4 | <--- | ACs3 | .832 |
| PAl3 | <--- | ACs3 | .982 |
| PAl2 | <--- | ACs3 | .951 |
| PAl1 | <--- | ACs3 | .748 |
| ACs2 | <--- | AgileCapab | .632 |
| AgileCapab | <--- | sustpract | .318 |
| sustpract | <--- | ACs2 | .212 |

# Model Fit Summary

### CMIN

| Model | NPAR | CMIN | DF | P | CMIN/DF |
|---|---|---|---|---|---|
| Default model | 202 | 4589.910 | 3119 | .000 | 1.472 |
| Saturated model | 3321 | .000 | 0 | | |
| Independence model | 81 | 36760.599 | 3240 | .000 | 11.346 |

### RMR, GFI

| Model | RMR | GFI | AGFI | PGFI |
|---|---|---|---|---|
| Default model | .054 | .752 | .736 | .706 |
| Saturated model | .000 | 1.000 | | |
| Independence model | .177 | .176 | .155 | .172 |

### Baseline Comparisons

| Model | NFI Delta1 | RFI rho1 | IFI Delta2 | TLI rho2 | CFI |
|---|---|---|---|---|---|
| Default model | .875 | .870 | .956 | .954 | .956 |
| Saturated model | 1.000 | | 1.000 | | 1.000 |
| Independence model | .000 | .000 | .000 | .000 | .000 |

### Parsimony-Adjusted Measures

| Model | PRATIO | PNFI | PCFI |
|---|---|---|---|
| Default model | .963 | .842 | .920 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 1.000 | .000 | .000 |

### NCP

| Model | NCP | LO 90 | HI 90 |
|---|---|---|---|
| Default model | 1470.910 | 1293.732 | 1656.009 |
| Saturated model | .000 | .000 | .000 |
| Independence model | 33520.599 | 32907.158 | 34140.514 |

### FMIN

| Model | FMIN | F0 | LO 90 | HI 90 |
|---|---|---|---|---|
| Default model | 14.806 | 4.745 | 4.173 | 5.342 |
| Saturated model | .000 | .000 | .000 | .000 |
| Independence model | 118.583 | 108.131 | 106.152 | 110.131 |

### RMSEA

| Model | RMSEA | LO 90 | HI 90 | PCLOSE |
|---|---|---|---|---|
| Default model | .039 | .037 | .041 | 1.000 |
| Independence model | .183 | .181 | .184 | .000 |

### AIC

| Model | AIC | BCC | BIC | CAIC |
|---|---|---|---|---|
| Default model | 4993.910 | 5139.208 | 5749.348 | 5951.348 |
| Saturated model | 6642.000 | 9030.789 | 19061.852 | 22382.852 |
| Independence model | 36922.599 | 36980.862 | 37225.522 | 37306.522 |

**ECVI**

| Model | ECVI | LO 90 | HI 90 | MECVI |
|---|---|---|---|---|
| Default model | 16.109 | 15.538 | 16.706 | 16.578 |
| Saturated model | 21.426 | 21.426 | 21.426 | 29.132 |
| Independence model | 119.105 | 117.126 | 121.105 | 119.293 |

**HOELTER**

| Model | HOELTER .05 | HOELTER .01 |
|---|---|---|
| Default model | 220 | 224 |
| Independence model | 29 | 29 |