

Enhanced use of ICT by SMEs in construction: a scenario thinking approach

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Abstract

Information and Communication Technology (ICT) plays a number of significant strategic and operational roles in the construction sector. However, a number of studies have highlighted a series of challenges within this sector, from value-proposition aversion (regarding ICT expenditure), through to lack of awareness (capability), and inability to 'measure' tangible outcomes (benefits) associated with ICT deployment. Given these issues, and also acknowledging the levels of nested fragmentation that exists in sectoral disciplines – especially within small to medium enterprises (SMEs); this paper presents a chronology of interrelated factors peculiar to the sector which has directly/indirectly influenced this slow (low) technology adopter positioning of these organisations. This paper argues that there is a need to break the status quo use of ICT by SMEs, and a need to realise the benefits garnered in other sectors as a means of not only enhancing the existing business, but also creating new innovation opportunities (especially in the early adopter S curve). Using a scenario thinking approach, this research presents a framework which highlights the causal "deficits" associated with low ICT penetration in the sector. This framework also identifies the key forces that influence and impact upon ICT usage in the construction sector, especially the interplay of key pivotal forces (through the competing push-pull continuum). A series of different scenarios for ICT uptake, adoption and diffusion are envisioned. These were developed with the help of industry experts in order to embed relevance and establish priorities against tangible indicators. This framework presents a future state ICT vision for SME's, one which places direct emphasis on SMEs' perspectives (operational and strategic) and future business aspirations.

Keywords: Construction, Deficits, ICT Adoption, Investment decisions, SME, Technology adoption

1. Small and Medium Enterprises in Construction

SME's play an important role in the construction sector globally. SMEs are defined as non-subsidary, independent firms which employ less than 250 employees; where small firms are generally those with fewer than 50 employees, and micro-enterprises have at most 10 employees. However, SMEs account for over 95% of firms, corresponding to 60%-70% of employment in many sectors including construction where they work as consultants, constructors, or suppliers on a variety of construction projects (OECD 2000). Given this, technology and globalisation has been seen to reduce the importance of economies of scale and many of the traditional shortcomings associated with SMEs e.g. lack of financing, difficulties in exploiting technology, constrained managerial capabilities, low productivity, risk-aversion (OECD 2000). It is in this backdrop that a new roadmap is needed for the use of ICT by SMEs in the built environment sector (Love, Irani, and Edwards 2004).

2. Case for ICT in the Construction Sector

Operations in the sector are generally realised through the term "projects" (with well-defined starting and finishing lines and pre-defined outcomes). These projects are often conducted by firms collectively, more often in association with other specialised services providers, each of whom can be conceptualised as a "firm". Together with other stakeholders they make up the "industry". Researchers have argued for the relevance of new production philosophies unfolding in manufacturing that require production activities to be analysed as processes as against functions, controlled for such concepts as minimal variability and cycle-time (Miozzo et al. 1998), with continuous attention to reduce waste (processes, material etc). This process-based view of construction is seen as the basis for a new ICT agenda for the sector. However, construction firms are slow to exploit ICT (Acar

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et al. 2005) and the industry invests little in ICT, with only few contractors being able to fully integrate ICT into their business processes and service delivery.

3. Literature Review

There is a paucity of literature on how stakeholders can purposefully address the problems of the sector with the aid of ICT. Acknowledging this, it is recognised that the ICT landscape cuts across boundaries of organizations, functions, and stakeholders; the products and services of which create a larger picture for the potential ICT use in the sector (Sawhney and Mukherjee 2013). However, coverage is scarce from a project-firm-industry standpoint, taking into account the specific requirements of the SME sector – some of the challenges of which can be seen in Table 2.

Table 2. Summary of Research Literature Reviewed

Publication	Main Findings
Integration Of ICTs With Business Processes: Insights from SMEs (Shiels, Mcivor, and Reilly 1998)	This paper avers that organizations can derive economic benefits as also managerial knowledge, skills and experience to make a significant difference in exploiting new opportunities; and proposes Technical Integration, Operational Integration, Inter-Organizational Integration and Strategic Integration.
A Business Process View of the Impact of ICT in Real Estate (Mazumder and Chatterjee 2007)	The paper highlights the need for control over project resources – materials, manpower, money and time schedules in an overall effort to ensure stakeholder satisfaction (meeting customer satisfaction without compromising on profitability).
3G/WiMAX rollout to propel demand for IP-based networks (Prakash 2010)	This article shows how networks are moving completely to all IP-based networks thus freeing up applications and services from specific requirements of the network. Additionally, it also throws light on how everything could move over the same network- voice, video, text and image. This has far-reaching implications that will potentially impact business models of core ICT operators in the days to come. Major drivers of these networks include (a) price on legacy services; (b) higher and varying bandwidth requirements on mobile networks owing to proliferation of advanced edge clients like iPhones and high-end smart phones; and (c) newer Web-based data applications and increased video content on the network because of the increased use of various networking applications through fixed and mobile networks.

4. Demand-Pull Requirements

Anecdotally the construction sector has been referred to as a sector that has missed the ICT revolution. This may be an overstatement or media-hype; but the sector has not fully embraced ICT compared to other sectors. This may be due to a myriad of issues, including the peculiarities of the sector, operational boundaries, fragmentation etc– see Supply-Side Drivers

On the supply side, developments in ICT including the ubiquity of networks; prevalence of web-based services over multiple devices; convergence of voice, text and video services over IP-based networks; miniaturisation of ICT devices; technological advances and robust all-weather devices; increasing bandwidth availability; low-cost alternatives; proliferation and possibilities over open source integration; cloud-based infrastructure and services; all have an impact on ICT adoption. Table 3 describes this in more detail.

Table 3: Demand Side Requirements for ICT as a Solution in the Construction Sector

Specificity	ICT adoption as a Solution
Unwieldy paper documents	Transmitting heavy and precious documents over ICT networks reduces waste
Geographically separate locations	Multi-member teams are spread out to distant locations and ICT-enabled communications are the only alternative
Lack of information for project management	Lack of consolidated project information at one place delays decision making and impairs project control and monitoring. ICT represents the only way to bridge this gap
Many-to-many relationship and temporary combination of parties	At any point in time team members are potentially members of different projects performing same, similar or completely different roles. A standardized process view as against a function-view enabled subsequently through ICT is the only logical way to reduce confusion and maximize efficiency
Association with big players	Big players often require that smaller players be ICT-enabled sufficiently as a qualification to partner with them
End-user convenience	End user convenience often mean that service providers have to be ICT-enabled (particularly SMEs competing for foothold)
Increasing relevance of Cost, Quality and adherence to	Deviations of time, cost, scope and quality from planned/promised performance and timely decision making for responding to problems and disputes are among common problems faced in the sector today.

Specificity	ICT adoption as a Solution
delivery schedules	Customer expectation will likely rise in the future on these aspects. ICTs represent an indispensable tool to address these issues
Rising Volume of Work and the resultant deluge of data	As the global economy recovers the volume of work will increase manifold with time, implying more information handling by the industry to arrive at the most optimum solution under the emerging constraints. Planners, too, will be deluged with data even as it becomes more imperative for them to take the right decisions at the right time with the right set of information

5. Supply-Side Drivers

On the supply side, developments in ICT including the ubiquity of networks; prevalence of web-based services over multiple devices; convergence of voice, text and video services over IP-based networks; miniaturisation of ICT devices; technological advances and robust all-weather devices; increasing bandwidth availability; low-cost alternatives; proliferation and possibilities over open source integration; cloud-based infrastructure and services; all have an impact on ICT adoption. Table 3 describes this in more detail.

Table 4 Supply-Side Drivers for ICT as a Solution in the Construction Sector

Specificity	ICT adoption as a Solution
Ubiquity of Internet	As penetration rates go up for both PCs and Internet and countries across the world roll out their broadband strategies and plans ubiquity of the Internet over fixed or wireless networks will definitely follow
Prevalence of web-based services over multiple devices	Web-based applications and services are currently the norm and, as a direct fall-out, there is a need to deploy a variety of channels for service delivery for users to consume services anytime (24X7), anywhere (through ubiquity of the Internet) and anyhow (through multiple channels). Besides making available services hitherto inaccessible new channels give users have a free choice to access a service; users would choose the one that realizes the highest relative value for them.
Convergence of voice, text and video services over IP-based networks	All-IP based networks are gradually becoming a preferred technology, as voice, video, and data converge onto a single system, reducing the capital expenditure for service providers. Organizations are migrating from multi-platform based network infrastructure to a single-IP based network with the latter acting as a catalyst for an organization's network convergence between voice, data and video infrastructure. The availability of 3G/4G will further enhance quality and speed, allowing networks to manifest the full extent of their capabilities.
Increasing bandwidth availability and affordability	The Internet revolution is being influenced by telecom players' strategies to reduce cost of access (Smartphone costs are falling rapidly as players achieve scale economies even as the expansion of 3G/4G services is likely to reduce connectivity costs). With time, therefore, bandwidth hungry applications and services would become more common.
Low-cost alternatives	Massive economies of scale will likely drive down prices for lower-end PCs, tablets and smartphones such that large numbers of less affluent families in emerging markets could afford them. This will further increase scale and enable even less expensive devices, such as the \$100 smartphone. This "virtuous circle" will also make possible the perennially improving smartphone, as well as the \$100 tablet (Deloitte 2014).
Proliferation and possibilities over open source	Open Source promises better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in. Since OSS does not limit or restrict who can use the software, the type of user, or the areas of business in which the software can be used, this makes for opportunities for customization and community innovation within agencies as well as with other stakeholders, citizens and SMEs (Waring and Maddocks 2005).
Cloud-based infrastructure and services	Advances in cloud computing make it possible for agencies to share the same ICT infrastructure to access software, services, and data storage through remote infrastructure, making it possible for ICT to become a new "utility" model. For an organization, therefore, for a set or variable, usage-based fee (and sometimes, free) it could contract with a provider to deliver applications, computing power, and storage via the web. Computing therefore becomes location- and device-independent, and computing tasks and information are available anytime, anywhere from any device—so long as there is access to the Internet (AGIMO 2011).

6. The Case for ICT for SMEs

In today's global economy it is important for SMEs to maintain their competitive edge. ICT is a tool for SMEs to improve innovative power and competitiveness, especially to develop a global network of product exchange. Indeed, ICT has become a utility item, just like electricity (Wen, King, and Jaska 2008). For example, increasing wireless penetration by 10 percentage can lead to an increase in gross domestic product of about 0.5% (Foster 2007). Essentially there are three ways in which ICT can bring competitive advantage (Wen et al. 2008):

- by changing the industry structure and altering rules of competition;
- by creating competitive advantage through new ways to outperform rivals; and
- by spawning whole new businesses

For example, an investigation of factors affecting ICT acceptance was undertaken in the UK with 188 SMEs. This concluded that small businesses that readily adopted new ideas and were willing to exploit new knowledge would have a competitive edge over their competition (Selamat, Jaffar, and Kadir 2011). The main incentives behind the adoption of ICTs by SMEs relate ostensibly to 'gain' e.g. reduced transaction costs, lower risk, information gathering/dissemination, increased inventory control and quality control, improved relationships with customers and suppliers and the increased control over distribution and marketing of products.

7. ICT for SMEs in Construction

Love and Irani (2004) noted ICT adoption issues should take into account relevance (a) for SMEs in the sector; (b) for ICT adoption by SMEs in general; and (c) for ICT adoption in construction sector (Figure 2). Figure 2 shows the complexities caused due to the intersection of demand-side factors, supply-side factors, and specificities of the construction sector. These complexities have been encapsulated as "deficit" areas for the sector; which has resulted in low adoption of ICT by the construction sector in general and SMEs in the construction sector in particular (Vitkauskaitė and Gatautis 2008). Through a detailed literature review and expert interviews the following deficit areas relevant to the issue of adoption of ICT by SMEs in the construction sector were identified (Sawhney and Mukherjee 2013): Collaboration Deficit; Standardization Deficit; Service Delivery Deficit; Efficiency Deficit; Decision Support Deficit; Transparency Deficit; and Democratization Deficit, with ICT infrastructure/applications at affordable rates.

From Figure 1, this paper builds on previous work in the following areas:

- It takes into account more holistically the information requirements of all stakeholders including the end-users, regulators and the industry associations;
- It presents three views as illustrated above to provide information and services- the project view, the firm view and the industry view;
- It has a predominant thematic focus on the SME segment of the industry in an overall effort to bring about equitable development of the sector; and
- It also talks about institutional arrangements to operationalise the solutions.

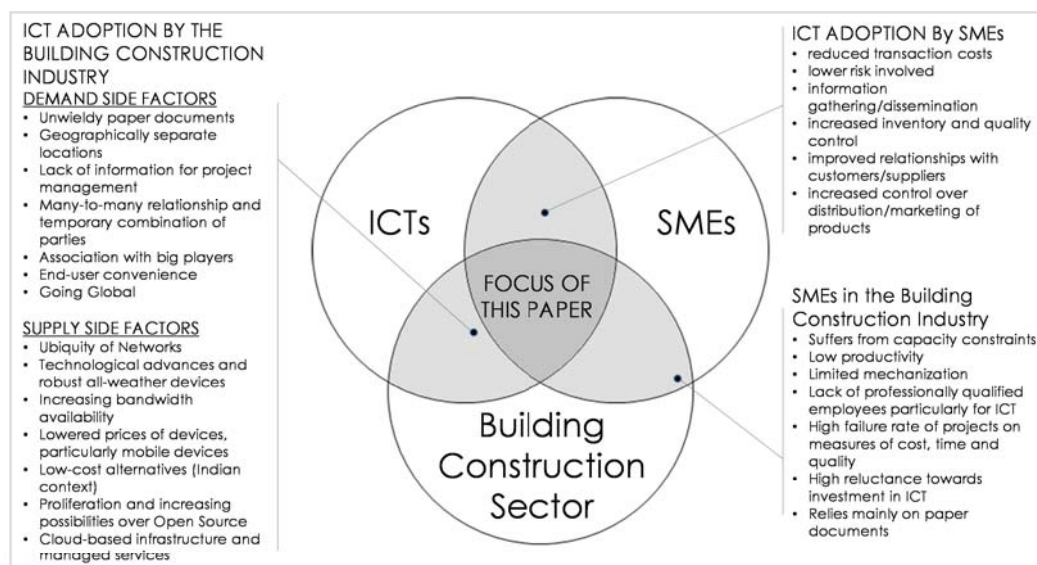


Figure 1: Commonality of Issues to be addressed for ICT adoption for SMEs in the Indian Construction Industry

8. Research Methodology

Scenario thinking or planning concerns planning based on the systematic examination of the future by picturing plausible and consistent images of the future (Chermack 2005). Delphi, in turn, attempts to develop systematically expert opinion consensus concerning future developments and events. Numerous researchers have stressed that both approaches are best suited to be combined. Due to their process similarity, the two methodologies can be easily combined. Generally speaking, the output of the different phases of the Delphi method can be used as input for the scenario method and vice versa. In this case, the methodology adopted was

the "Prospective Process Approach Using Scenario Planning Techniques" in conjunction with Delphi with industry experts across the board. A scenario is the set formed by the description of a future situation and the course of events that enables one to progress from the original situation to the future situation (Godet 2000). Scenario Planning (SP) is a disciplined method for imagining possible futures that organizations/industries have applied to a great range of issues (Schoemaker 1995). Also called scenario thinking or scenario analysis, it is a strategic planning tool/method that enables the development of flexible long-term plans (Erdogan et al. 2009). Ranking the issues and trends according to (a) Level of impact upon the strategic question; and (b) degree of uncertainty (likelihood) of occurrence, four different scenarios as illustrated was constructed (Figure 2). The most favoured "Globally Competitive" was then developed further for elaboration.

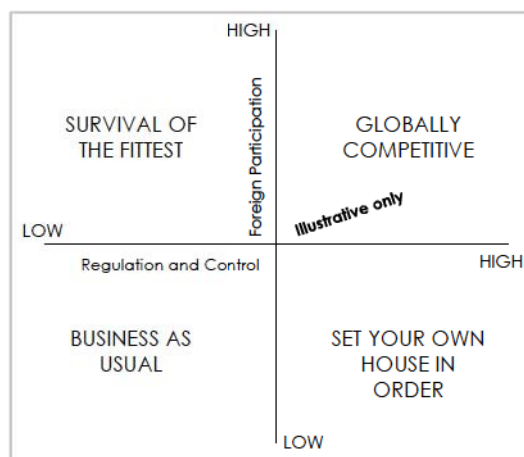


Figure 2. Illustrative Four Scenarios

9. Conceptualising the Landscape

There a direct requirement for ICT systems to transform the SME-centric sector; similarly, it is important to acknowledge the need for: appropriate economies of scale, adopting common standards, protocols and guidelines for solutions that are interoperable to meet the information needs of all stakeholders (Ahuja, Yang, and Shankar 2009; Love et al. 2004). However, different requirements of information and services emerge at each of the levels of project, firm and industry. Cloud-based infrastructures and open source need to be considered for different components of the solution to make these solutions affordable to smaller organisations. It is recognised that a Total Cost of Ownership comparison needs to be made before making a specific choice and a blanket preference is not advisable. Whilst these issues are beyond the scope of this paper, Figure 3 presents the different components of the composite ICT landscape and trends for the building construction industry at each of three levels of project, firm and industry.

	Industry		Firm		Project	
APPLICATIONS AND DATABASES	Whole of Industry Portal		Firm Portals/Websites		Project Portals/Websites	
			Web 2.0 based collaborative solutions (exchange of voice, text, graphics, video over secure IP networks)			
	Matchmaker Service	Landscape Planning	CRM	ERP	Project Mgmt	Alerts & Reminders
	Social Media	Forecasts and Trends	eProcurement	BIM, CAD and Other Engineering Solutions		Payment Utilities
	Statistical Analyses	Data Warehouse and Data Mining Solutions	Electronic Office Solutions		Customer Feedback	
	Multi-stakeholder Knowledge Management Systems					
	Spatially and Temporally Seamlessly Integrated Databases					
SHARED INFRASTRUCTURE	Open Networks		Secure and Privileged Networks			
	Centrally Hosted/Managed Cloud-Based Data Centres					
POLICIES AND PROTOCOLS	User-Driven Content		Interoperability and Security Guidelines			
	Regulatory Requirements		Pre-Agreed Industry-wide processes and protocols			

Figure 3. Components of the Composite ICT Landscape for the Building Construction Industry

10. Conclusion

The ICT landscape for the construction sector is still predominantly fragmented. Solutions are therefore needed. For example, the different categories in the solution landscape could be further decomposed and customised into modules through a conceptual “rack” based on pre-agreed industry-wide standards, protocols and guidelines (to create interoperability). Adherence to such globally accepted standards together with the advantages made available by a ubiquitous networks, affordable devices and cloud-served applications and services would ensure that the best platform is presented to SME’s. Users would then need to make a choice of modules from the rack depending upon their suitability for their operations at each of the three levels of project, firm and industry. In some respects, this is happening through the use of Building Information Modelling. Solution conceptualisation must however consider that data integration and interoperability can completely transform the industry. This may need further strategic roadmaps and support/promotion by regulators and/or industry associations to manage and drive this transition.

References

- Acar, Emrah, Ismail Koçak, Yildiz Sey, and David Arditi. 2005. “Use of Information and Communication Technologies by Small and Medium Sized Enterprises (SMEs) in Building Construction.” *Construction Management and Economics* 23(7):713–22.
- Ahuja, Vanita, Jay Yang, and Ravi Shankar. 2009. “Study of ICT Adoption for Building Project Management in the Indian Construction Industry.” *Automation in Construction* 18(4):415–23.
- Chermack, Thomas J. 2005. “Studying Scenario Planning: Theory, Research Suggestions, and Hypotheses.” *Technological Forecasting and Social Change* 72(1):59–73.
- Erdogan, Bilge, Carl Abbott, Ghassan Aouad, and Pro-vice Chancellor. 2009. “CONSTRUCTION IT IN 2030 : A SCENARIO PLANNING APPROACH.” 14(August):539–55.
- Foster, Malcolm. 2007. “Cellphones Fuel Growth in Developing World.” Associated Press. Retrieved (http://www.usatoday.com/tech/wireless/phones/2007-01-27-cellphones_x.htm?POE=TECISVA).
- Godet, Michel. 2000. “The Art of Scenarios and Strategic Planning.” *Technological Forecasting and Social Change* 65(1):3–22.
- Love, Peter E. D., and Zahir Irani. 2004. “An Exploratory Study of Information Technology Evaluation and Benefits Management Practices of SMEs in the Construction Industry.” *Information & Management* 42(1):227–42.
- Love, Peter E. D., Zahir Irani, and David J. Edwards. 2004. “Industry-Centric Benchmarking of Information Technology Benefits, Costs and Risks for Small-to-Medium Sized Enterprises in Construction.” *Automation in Construction* 13(4):507–24.
- Mazumder, Subhajit, and Anand Chatterjee. 2007. “A Business Process View of the Impact of ICT in Real Estate Sector.” in *The 2007 BPC World Conference*. Mumbai: Business Process Council.
- Miozzo, Marcela, Martin Betts, Andy Clark, and Antonio Grilo. 1998. “Deriving an IT-Enabled Process Strategy for Construction.” *Computers in Industry* 35(1):59–75.
- OECD. 2000. “Small and Medium-Sized Enterprises: Local Strength, Global Reach.” OECD Observer.
- Prakash, Nivedan. 2010. “3G/WiMAX Rollout to Propel Demand for IP-Based Networks.” www.expresscomputeronline.com.
- Sawhney, A., and K. K. Mukherjee. 2013. “eTools for Managing Construction Projects in India: Coming of Age with New Age Solutions.” in *Project Management Institute Research Conference 2013*.
- Sawhney, Anil, and Kamal K. Mukherjee. 2013. “eTools for Managing Construction Projects in India: Coming of Age with New Age Solutions.” in *Project Management Institute Research Conference 2013*. Chennai, India.
- Schoemaker, Paul. 1995. “Scenario Planning: A Tool for Strategic Thinking.” *Sloan Management Review*.
- Selamat, Zarehan, Nahariah Jaffar, and Hazlina Abd Kadir. 2011. “ICT Adoption in Malaysian SMEs.” Pp. 135–39 in *2011 International Conference on Management and Service Science*, vol. 8. Singapore.
- Shiels, Ms Helen, Ronan Mcivor, and Dolores O. Reilly. 1998. “ACHIEVING INTEGRATION OF ICTs WITH BUSINESS PROESSES : INSIGHTS FROM SMEs.” (1994):750–54.
- Vitkauskaitė, Elena, and Rimantas Gatautis. 2008. “E-Procurement Perspectives in Construction Sector SMEs.” *Journal of Civil Engineering and Management* 14(4):287–94.
- Wen, Zhezhu, Jim King, and Patrick Jaska. 2008. “ICT and SMEs in Developing Countries.” Pp. 1126–32 in *The IABPAD Conference Proceedings*, Texas, 2008. Texas: The International Academy of Business and Public Administration Disciplines.