Assessment of Halal Blockchain in The Indonesian Food Industry

Abstract

Purpose: The demand for halal food products is increasing globally. However, fraudulent activities in halal products and certification are also rising. One strategy to ensure halal integrity in the food supply chain is applying halal blockchain technology. However, to date, a few studies have assessed the factors and variables that facilitate or hinder the adoption of this technology. Thus, this study aims to assess the significant factors and variables affecting the adoption of halal blockchain technology.

Design/methodology/approach: A Delphi-based approach, using semi-structured interviews, was conducted with three food companies (chicken slaughterhouses, milk processing plants, and frozen food companies). The cognitive best–worst method determines the significant factors and variables to prioritise halal blockchain adoption decisions.

Findings: The results showed that the most significant factors were coercive pressure and halal strategy. Nineteen variables were identified to establish a valid hierarchical structure for halal blockchain adoption in the Indonesian food industry. The five significant variables assessed through the best-worst method were demand, regulator, supply side, sustainability of the company's existence, and main customers.

Practical implications: The proposed halal blockchain decision structure can assist food companies in deciding whether to adopt the technology.

Originality: Our study proposes 19 variables that establish a valid hierarchical structure of halal blockchain adoption for the Indonesian food industry.

Keywords: Halal blockchain adoption, Food Industry, best-worst method.

1. Introduction

The importance of halal blockchain applications has increased in recent years due to the globalization of the halal market, the occurrence of fraud accidents in halal supply chains, and Muslim customers' concerns about the halal integrity of food products (Standard, 2022; Tan et al., 2017; Soon et al., 2017; Vanany et al., 2020). In 2021, Muslim food spending increased by 6.9%, from $1.19 trillion to $1.27 trillion (Standard, 2022), and Halal food contributes more than 17% of total global food production (Tan et al., 2017). Soon et al. (2017) reported fraudulent incidents in the halal food supply chain.

Many experts believe that blockchain applications in the halal industry benefit companies. Blockchain is an innovative technology that can improve halal food integrity in the supply chain (Soon et al., 2017; Sander et al., 2018). For example, Hew et al. (2020) applied blockchain technology to a halal-traceability system. The application helped ensure security, improved transparency and allowed end users to trace halal information from the source to

final goods (Hew et al., 2020). Similarly, Ali et al. (2021) demonstrated that blockchain applications can assist small and medium food businesses achieve supply chain transparency.

Blockchain technology for halal products has recently gained significant attention from the industry and has accelerated the adoption of this technology. The Digital Chain uses blockchain technology to inform end customers of the certification of halal products (Whitehead, 2019). Korea Telecom has applied blockchain technology to ensure authentication and fraudulent incidents of halal products (Wood, 2019). The Arab-Brazilian Chamber of Commerce has implemented blockchain technology to enhance traceability and increase transparency in the country's halal food supply chain (Hashem, 2020). PT Sierad Produce Tbk adopted halal blockchain applications for halal food traceability, with McDonald's Indonesia as its main customer (Winosa, 2020).

However, unresolved concerns and challenges with blockchain technology still require further research (Kamilaris et al., 2019). Empirical studies on blockchain implementation in halal food supply chains are scarce, especially regarding the relationships between halal food production and blockchain applications, factors, and variables that facilitate or limit blockchain adoption (Duan et al., 2020; Tan et al., 2020). Thus, this study aimed to investigate the following:

(1) To identify the significant factors and variables affecting the adoption of halal blockchain technology in the Indonesian food industry
(2) To prioritise the factors and variables affecting the adoption of halal blockchain technology.

The remainder of this paper is organized as follows. The literature on halal blockchain applications and the proposed factors for halal blockchain adoption are discussed in the second section. Section 3 describes the research design, including case study profiles. In the fourth section, the results of this study are discussed. Finally, section 5 concludes with the findings, our research contributions, research limitations, and future research opportunities.

2. Literature Review

2.1. Halal Blockchain Application

Halal supply chain concerns such as halal counterfeits and fraudulent incidents associated with marketing non-halal food products as halal and using non-halal logistics and distribution systems, continue to be unresolved and igniting public discussion (Tan et al., 2017; Ali & Suleiman, 2018). Such authenticity issues have developed due to the intricate halal supply chain system. Not all supply chain participants, including end customers, have access to information systems, thus risking their integrity (Abidin & Perdana, 2020). However,

transparency can be improved by implementing an additional information system with a ledger for all halal supply chain operators (Ali et al., 2021).

Because of the precision with which product flows can be followed across the supply chain, blockchain applications can help continuously establish trust in product authenticity (Saberi et al., 2019). Supply chain players exchange transparent information about the origins of resources and goods using blockchain ledgers, which improves product provenance, the chain of custody, and authenticity (Montecchi et al., 2019). Blockchain technology, which is open, transparent, and encrypted, can improve the visibility and transparency of supply chain parties, including end customers (Kamble et al., 2020). Improving transparency through blockchain technology is another supply chain benefit achieved by supply chain actors (Kittipanya-ngam & Tan, 2020).

Halal Blockchain applications are believed to be able to replace the role of halal certification from a technological and brand owner perspective; however, this is more complex from a Shariah perspective (Tieman & Williams, 2019). In addition, blockchain technology can facilitate a more structured or streamlined halal certification procedure (A. Tan et al., 2020). In practice, an attempt has been made by the Ministry of Agriculture and Food Industry (MAFI) and Jabatan Kemajuan Islam Malaysia (JAKIM) to commence the implementation of a halal blockchain certification in Malaysia (Mohtar, 2020). Blockchain technology can reduce or eliminate halal certificate fraud (Tan et al., 2020). Additionally, halal blockchain can prevent halal meat fraud on labels/logos and certificates (ElFarnawani et al.,2021). Global halal requirements can be simplified through smart contracts between two parties (buyer and supplier) in the halal supply chain (Ali et al., 2021). Activity, temperature, and motion detection in halal logistics applications can be accomplished using blockchain technology aided by sensor technologies (Rejeb, 2018). Halal blockchain applications can enhance halal logistics transactions between buyers, suppliers, and third-party logistics providers (3PL) by utilising smart contracts in the blockchain application (Vanany et al., 2020). Table 1 summarises the application and the benefits of halal blockchain technology.

Please insert Table 1 here.

Table 1: Application and benefits of halal blockchain technology

2.2. Factors and Variables of Halal Blockchain Adoption

This subsection reviews the literature to propose measures for factors and variables of halal blockchain adoption based on institutional theory and perceived desirability. The dimensions and criteria used in this research are primarily based on those found in Hew et al. (2020)'s work. Two (2) approaches were used to ascertain how companies were driven to pursue isomorphism, sociology, and economics. Organisational isomorphism, concerned with processes and conditions, is defined as the similarity of a focused organisation to other

organisations in its environment (DiMaggio & Powell, 1983). Institutional theory is "*a fundamental idea that external institutions have a role in driving isomorphism among enterprises"* (DiMaggio & Powell, 1983; Yigitbasioglu, 2015).

Additionally, businesses are compelled to act because they are motivated by economic efficiency in achieving isomorphism (Haunschild & Miner, 1997). Our study focuses on institutional theory, given that most prior research on technology adoption has been motivated by a need for legitimacy rather than efficiency. Institutional theory has been applied to blockchain applications for halal traceability systems (Hew *et al*., 2020).

Halal strategy is critical in protecting the halal industry (Zailani et al., 2015). In our study, halal strategy is defined as adopting a halal blockchain to improve services on the demand (customers) side and to ensure halal integrity on the supply side. According to Hew et al. (2020), implementing a halal strategy and policy can influence companies to adopt halal blockchain within the business. The halal integrity of the food supply chain can affect the industry's financial performance (Zailani et al., 2020). In line with Adel et al. (2021), the authors reported that implementing a halal strategy can also affect the success of halal tourism (Adel et al., 2021). Analysis of the performance or improvement of the demand and supply side of the supply chain is a relevant approach, as suggested by Utomo et al. (2021).

2.2.1 Institutional Pressure

Coercive, mimetic, and normative pressures are the three factors of institutional pressure used in our study. First, when a business is subjected to official and informal demands from other enterprises on whom it is reliant, coercive pressures are related to motivation (Sauer & Seuring, 2018). Pressures from influential consumers, suppliers, industry groups, and regulators might cause such pressures (Yigitbasioglu, 2015). The coercive pressure factor in this study can be defined as businesses that adopt halal blockchain because of official and informal pressure from other parties on whom they rely, such as the regulator, industry association, leading suppliers, and main customers.

Second, mimetic pressures arise when a company tries to emulate the practices of other successful companies to eliminate uncertainty in a competitive market and assure its survival (Kauppi, 2013; Hu et al., 2016). Because blockchain data is unchangeable and irrevocable, it can help to eliminate food fraud and ensure sustainable raw resources (Rejeb et al., 2020). In our study, the mimetic pressure factor is described as companies that adopt halal blockchain because they wish to emulate other companies' successes, reduce competition uncertainty, and sustain their existence.

Third, mutually accepted norms between organisations in an association (Son & Benbasat, 2007), such as industry associations (Sauer & Seuring, 2018), as well as supply chain (SC) network members, produce normative pressures. In order to meet social responsibilities, it is common for businesses to fulfil collective agreements (Hu et al., 2016). Supply chain

participants are also encouraged to use the Internet through collective agreements between supply chain members (Liu et al., 2010). Hence, companies use halal blockchain because they are urged to follow mutually established norms, such as by SC network members and industry associations.

2.2.2 Perceived desirability

According to Roger (1995), five criteria influence innovation adoption: relative benefits, compatibility, complexity, trialability, and observability. Only three characteristics, compatibility, complexity, and relative advantage, are consistently connected with adoption decisions among the five factors that influence the success of innovation adoption (Hwang et al., 2016). Compatibility, complexity, and related benefits are critical in evaluating perceived desirability (Alsaad et al., 2019). First, the compatibility factor is the level of consistent innovation from a company's business processes, procedures, and value systems (Fosso Wamba et al., 2016).

Halal blockchain, as a new system and technology, should be compatible with the company's existing company strategy and standards (Williams, 2020), work practices, facilities, equipment, technology and systems, such as the company's payment system (Zhang et al., 2021), and others. Compatibility factors in this study are companies that adopt halal blockchain because they want to conform to the company's beliefs and strategies, work practices, facilities, and equipment.

Second, the complexity factor refers to the degree to which the ease with which innovation technology can be used is increased (Fosso Wamba et al., 2016). The company's size, the IT system's complexity, structure, and decision-making hierarchy affect its adoption of blockchain technology (Post et al., 2018). Blockchain implementation is complex because of the variety of mining processes and the scarcity of knowledge and skills among IT experts, managers (Grover et al., 2019), and employees. Although blockchain applications are generic for some scenarios and industries, customization can sometimes be challenging (Knirsch et al., 2019). However, upon implementation, companies will find it easier to perform reliable searches, and the public and other parties can easily verify the halal integrity of the supply chain owing to the security and transparency afforded by blockchain technology (Xu et al., 2021). As a result, the complexity factor is described in this study as firms that adopt halal blockchain because they want it to be easy to implement and use.

Finally, the advantage is innovation's perceived progress and benefits compared with previously owned technology (Fosso Wamba et al., 2016). Blockchain applications can help improve halal traceability systems from farms to forks (Tan et al., 2020). The use of blockchain in the supply chain is linked to mutual influence with SC integration, and the customizing effort is also more significant if SC integration is performed more generally (Ali et al., 2021). Small- and medium-sized businesses can benefit from blockchain technology to achieve SC

transparency (Ali et al., 2021). Thus, the perceived benefits factor is defined as companies that use halal blockchain to obtain benefits, such as increased halal traceability systems, SC integration, and transparency. Table 2 summarizes the literature on the factors and variables affecting halal blockchains based on institutional theory and the diffusion of innovation theory.

Please insert Table 2 here
Table 2: Factors and variables of halal blockchain adoption

3. Research Design

This research is divided into two phases. In the first phase, a review of related literature, a Delphi-based approach, focus group discussion, and semi-structured interviews were conducted to understand how halal strategies, institutional pressures, and perceived desirability affect the adoption of blockchain applications in Indonesian halal food companies. Delphi, focus group discussion (FGD), brainstorming, and nominal group techniques can be used to understand significant factors and variables in case studies by aiming to create consensus and solve problems with the consent of all parties (Krueger, 2014).

Although there is disagreement regarding this (Powell, 2003), the Delphi method still has drawbacks, including the use of opinions from limited experts (Rowe &Wright, 1991), time-consuming, and expensive (Fitzsimmons & Fitzsimmons, 2001). However, Delphi methods still have many advantages in qualitative research (Elnasr et al., 2012) and are widely used by practitioners in industries and researchers (Mitchell, 1991). In this study, there are still differences in the length of experience, age, and educational background of respondents that may influence other respondents when FGDs are conducted. We choose the Delphi method because it is more appropriate to understand respondents' opinions without influencing each other.

Three companies were identified and invited to participate in our study. The companies were selected based on the following reasons. First, all companies were considering the adoption of halal blockchain technology. Secondly, the companies have the resources to implement the technology. Finally, all three companies processed diverse food categories essential in halal food production and represented Indonesian food companies. Primary data were collected from three Indonesian halal food industries, i.e., chicken slaughterhouse: milk processor and frozen food processing site.

Two rounds were conducted in the Delphi-based study. In round 1, 3 managers were asked several research questions using a semi-structured questionnaire (see appendix A). In the second round, each manager can provide additional or change judgments or opinions after the three judgments and opinions have been presented in the first round.

The cognitive best-worst method (BWM) is used in the second phase to determine the critical variables for halal blockchain adoption choice. The BWM approach can be used to establish the importance of the criterion, and a consistency ratio can be used to ensure that the weights are dependable and legitimate (Rezaei, 2015; Rezaei, 2020). The main variables for the halal blockchain adoption choice are determined in Case Study 1.

4. Results and Discussions

This study adopts two approaches in analysing the data: empirical studies (case and cross-case analysis) and determining and prioritising variables of halal blockchain adoption. Case analysis is used to provide a detailed investigation of each case study. A cross-case analysis was used for in-depth comparisons across cases. The BWM was used to determine and prioritise halal blockchain adoption.

4.1. Case Study Profiles

Table 3 shows the case study profiles and interviewee information.

Please insert Table 3 here
Table 3: Case study profiles and interviewee's information

The first case in this study is a chicken slaughtering company with two plant operations in Java Island, Indonesia. With an estimated 1,200 employees, it is a large-scale food industry and has operated in Indonesia to sell its products throughout Java, Sumatra, Kalimantan, and Papua Island. Chicken carcasses, boneless, parting, and mechanically separated meat (MDM) were among the company's products supplied to their customers in Indonesia. Both factories make chicken meat products from raw materials (chicken) and sell them to fast-food restaurants, catering companies, hotels, and other businesses. Broilers are the primary raw material, with 95% from other chicken farms and 5% from the company's own farm. The Council of Indonesian Ulama (MUI) has certified all the company's products as halal.

Case two is a national firm whose core business is the milk and beverage industry. It produces Ultra-High Temperature (UHT) milk, tea drink, health drink, and other items. The Majority of the market share is in the domestic market and 10-12% exports to other countries. The company has adopted and implemented several quality management systems, including ISO 14001, Hazard Analysis and Critical Control Point (HACCP), food safety system, and Halal certification. Indonesian halal and food safety certification has certified all the company's products as halal.

Case three is a large-scale, privately owned frozen food processing company with around five hundred employees. The company's key markets are East Java Province and numerous provinces in eastern Indonesia, such as South Sulawesi and East Kalimantan. Chicken nuggets, sausage, and meatballs are the company's most popular frozen foods, with a 100% domestic

market. All the finished items have received halal and food safety certification from Indonesia's halal and food safety agencies. The primary raw material is chicken meat from the company's slaughterhouse, halal-certified seasonings, and granulated sugar.

4.2. Empirical studies

Case 1

The first case study in this study is a giant chicken slaughtering company with more than 1,200 employees. The production manager is fully responsible for the products' halal status, from when live chickens were received to delivery. The quality assurance manager assists in controlling of all halal critical factors (chicken receipt, employees, particularly the slaughterer, and equipment employed) that determine the product's halal status. Halal certification is critical for the company because its primary market and headquarters are in Indonesia, which has the largest Muslim population. Halal certification is required for customers, substantial customers such as fried chicken restaurants, hotels, and supermarket chains.

The growth of blockchain technology also prompted Case 1 firms to use it. One company has embraced serves as a catalysis for case 1 to do the same. Respondent in Case 1 recognised that while there were prospects for improvement, there were also impediments to implementation. An example of an opportunity is when a business can provide transparency to its significant customers regarding the halal integrity of the products they have purchased. Examples of impediments include a need for more funding and technical expertise on blockchain technology. Significant factors influencing the adoption of halal blockchain in Case 1 include demand, regulatory pressures, significant customer pressures, reducing uncertainty in competition, the sustainability of the company's existence, SC network members, facilities and equipment, company beliefs and strategies, ease of use, increasing traceability system, and increasing SC transparency.

Case 2

The Department of food safety and quality control is fully responsible for the halal status of its products. The halal certification is critical because the company's Majority market is in Indonesia, a country with a majority Muslim population, and products are exported to Saudi Arabia and other countries. Similarly, halal certification is required for significant customers such as supermarkets and retail companies. The existence of the halal mark from LPPOM MUI, Indonesia's halal authority, provides customers with assurance.

Domestic or foreign suppliers of raw materials must provide a Certificate of Analysis (COA) and halal certification. Raw material checks are carried out on suppliers every year. The raw materials for packing include those confirmed to be halal in the form of plastic material and the lubricating oil used to ensure no porcine materials are present. If the halal certification from the supplier has expired, then the supplier may only supply the raw material once the halal certification is reinstated. Halal has become part of the company's strategy and is also implied in the company's vision and mission.

After years of utilising the Enterprise Recourse Planning (ERP) system, case 2 is considering the adoption of blockchain technology. The goal is to improve monitoring and quality control by implementing a complete traceability system from raw material to customer delivery and addressing food safety and halal concerns. Case 2 understands that halal is a sensitive issue for consumers in Indonesia and several Middle Eastern countries to which they sell. Significant variables in instance two are significantly different from those in case one, namely, industry association is a factor influencing the adoption of halal blockchain in addition to work practises.

Case 3

Due to the variety of additional materials the company requires, the purchasing department requires vendors to obtain halal certificates for the raw materials and the validity term. The primary raw materials have been proven to be halal since the primary source is carcass chicken from a single holding company. The equipment, particularly the packaging, and its logistics (storage and transporting) are also assessed for halal compliance.

As a subsidiary, the reason for implementing halal blockchain technology is that it is one of the new alternative technologies the holding company will utilise to enhance the existing traceability system. The data generated by the traceability system will be transparent and difficult to replicate. It is expected that this will give confidence to their primary consumers regarding the product's halal status in scenario 3. Significant variables affecting halal blockchain adoption in case 3 are the demand, the regulator, the primary customers, and the company's sustainability.

4.3. The Cross-case Analysis

The following section describes the cross-case analysis for internal strategy, institutional pressures, and perceived desirability effects on Indonesian food companies intending to participate in halal blockchain applications (see Table 4). Interviewees were assessed on a scale of 1-3 (1=slight, 2=moderate, 3=significant) for each variable of halal blockchain adoption.

4.3.1. Halal Strategy

The three interviewees stated that their company's internal strategy pays attention to the halal aspect. It is used to fulfil consumer requirements and increase their competitive advantages. Halal strategy is one factor that significantly affects halal blockchain adoption (2,67). They also prefer to enhance halal food integration between customers, particularly the main customers on the demand side (distribution and marketing) (Average cross-case analysis = 3.00) compared to the supply side (2.33). Case 1 prioritises to its primary consumers, namely fast-food chicken companies, case 2 prioritises large retail companies (i.e., supermarkets and convenience stores), and case 3 prioritises strengthening the demand side for their significant customers, such as supermarkets and convenience stores. According to Tieman et al. (2019), by adopting blockchain technology in the halal supply chain, this would promote greater consumer trust in the authenticity of a halal brand. Thus, having a halal strategy in place helps the interviewees to determine the halal requirement of the destination market, what are the halal production certificate requirements, halal storage and transportation, and coding of halal on freight documents (Tieman and Darun, 2017).

Please insert Table 4 here
Table 4. Summary of the cross-case analysis

4.3.2. Institution Pressures Dimension

In the coercive pressures factor, regulator (3.00) and main customer pressures (3.00) are significant variables that compel them to adopt halal blockchain. Cases 1 and 3 pointed out that external pressure from regulators and main customers were the biggest influencers on their adoption of blockchain applications. For example, the chicken processing company will comply if significant customers require case 1 to implement blockchain technology. In case 2, regulators, industry associations and customers are essential to adopting the halal blockchain. BPJPH as the Halal authority of government in Indonesia, is a significant party in pressuring them to adopt the halal blockchain application. This echoes Mohamed et al. (2016) and Zailani et al. () where food industry in Malaysia adopted good traceability system to trace and track product and process information at each stage of the supply chain which helps to enhance the halal status of the product. One of the main factors driving the adoption of effective traceability system was to remain competitive in the halal industry.

In the mimetic pressures factor, the sustainability of the company's existence (3.00) becomes a significant variable of halal blockchain adoption compared to the other two variables (emulate the success of other companies (2.33) and reduce uncertainty in competition (2.67). Case 1 is more pressured to adopt halal blockchain to reduce uncertainty in competition and the sustainability of the company's existence. In contrast to case 2, it is

more motivated to increase the sustainability of the company's existence as significant-pressure factor. In contrast, all three variables pressured Case 3 to adopt the halal blockchain technology.

In the normative pressures factor, the SC network variable (2.67) is more significant in influencing them to adopt halal blockchain then the industry association variable (2.33). Cases 1 and 3 suggested that SC network members put more pressure on them to adopt halal blockchain than industry association variables. On the contrary, case 2 felt that industry associations would be more prominent in influencing them to adopt halal blockchain. This is similar to Abdul Talib et al. (2019) and Sumarliah et al. (2023) where institutional forces were important driving force for halal food industry. Food industry is more likely to adopt blockchain halal technology when faced with pressure from external firms (Sumarliah et al., 2023).

4.3.3. Perceived Desirability

Incompatibility factors, facilities, and equipment (3.00) and company belief and strategies (3.00) were significant variables of halal blockchain adoption which provide more compatibility than work practice variables (2.33). Cases 1 and 3 pointed out that facilities, equipment, and company beliefs and strategies were significant variables. Meanwhile, case 2 stated that all variables were significant and should be compatible and compliant with blockchain applications. For example, if facilities and equipment were neither read nor compatible with blockchain applications, implementing halal blockchain would be highly challenging.

In complexity factors, easy to use variable (3.00) was more desirable than easy to implement variable (2.33) when adopting halal blockchain. In perceived benefits factors, they believed that increasing traceability system (3.00) and increasing transparency (3.00) among supply chain members could be achieved by adopting halal blockchain in the halal food industry.

4.4. Determining and Prioritising the Variables of Halal Blockchain Adoption.

The second phase of this research was conducted to determine and prioritise the significant variables for Halal Blockchain adoption. The Halal blockchain adoption decision structure is proposed, as shown in Table 5.

Please insert Table 5 here

Table 5: Proposed Halal Blockchain adoption decision structure

In BWM methods, pairwise comparisons are used to compare the best and worst dimensions, factors, and variables. This study exemplifies the halal blockchain adoption decision using Case 1 since the interviewee (QC manager) is closely related to halal assurance

and had better experience and understanding of halal critical factors. Case 1 is also able to invest in halal blockchain technology. The manager in case 1 estimated all the best values to others and others to worst dimension, factors, and variables with pairwise comparison. For example, in dimension, the best and worst factors are the institution dimension (B) and the perceived desirability (C). Table 6 shows the estimation value of the best-to-others and others-to-worst pairwise comparison for halal blockchain adoption dimensions, including the weight results of each dimension and the value of the consistency ratio.

Please insert Table 6 here

Table 6: Best-to-others and others-to-worst pairwise comparison for halal blockchain adoption dimensions

A consistency ratio (CR) is calculated to determine the reliability of the results (Rezaei, 2015; Rezaei, 2020). As demonstrated in Table 7, the CR values for all dimensions were less than 0.1, indicating that the indicators were consistent and reliable results, hence confirming the validity and reliability of the study's hierarchical structure (i.e., CR_D= 0.100; CR_b= 0.060; CR_c=0.042). All factors of consistency ratio were also validated (e.g., CR_{A1} = 0.000; CR_{B1} = 0.089; CR_{B3} = 0.000). The value of the consistency ratio for each dimension and factor is shown in Table 7.

Please insert Table 7 here

Table 7: The value of the consistency ratio for each dimension and factor

The cognitive value of each variable is used to identify significant, moderate, and low indicators of halal blockchain adoption. All the indicators' global weights were calculated, and each indication was rated. The significant (more than 0.2100), moderate (0,200- 0.0542), and low (less than 0.0542) factors were identified using a percentage. Coercive pressures (B1-0.3300) and Halal strategy (A1-0.3000) were significant factors that affected the adoption of halal blockchain technology (Table 8 and Figure 1).

Please insert Table 8 here

Table 8: Cognitive best worst method results for factors

Please insert Figure 1 here

Figure 1: Factor's significant diagram.

Similarly, in variables, the percentage value is also used to determine which variables significantly triggered practitioners of the halal industry to adopt halal blockchain. Table 9

shows the Cognitive best-worst method results for variables of halal blockchain decision. This study determines that nineteen variables significantly affect the adoption of halal blockchain technology. The significant variables were identified as the demand side (A11 - 0.2000), regulator (B11- 0.1963), supply-side (A12- 0.1000), the sustainability of the company's existence (B23- 0.0773) and main customers (B14- 0.0752) (Figure 2).

Please insert Figure 2 here
Figure 2: Variables' significant diagram.

Please insert Table 9 here
Table 9: Cognitive best-worst method results for variables of halal blockchain decision.

5. Conclusions

Blockchain application is a promising information technology used in the food industry and has recently been adopted by the halal food industry. The findings of this study contribute to the literature on halal blockchain adoption. Based on some the literatures (e.g, Zailani et al. 2015; Fosso Wamba et al. 2016; Sauer and Seuring, 2018; Hew et al. 2020) and inputs from three cases, the framework linking three main dimensions and seven significant factors underpinning the key dimensions and factors is proposed.

This study has also successfully assessed the halal blockchain adoption factors and variables using the Delphi-based approach and cognitive best-worst method. Halal strategy, institution and perceived desirability were identified as the critical dimensions affecting the adoption of halal blockchain technology. Seven significant factors are halal strategy, coercive pressures, mimetic pressures, normative pressures, compatibility, complexity, and perceived benefits. For example, for perceived benefits, strengthening the consumers' confidence in the reliability of the Halal-certified products is believed to be achieved by the transparency and integrity features of blockchain technology (Hendayani, R., & Fernando, Y. 2023).

Coercive pressures and halal strategy were identified as the most significant factors. The five significant variables assessed through the best-worst method were the demand side, regulator, supply side, the sustainability of the company's existence, and leading customers. Our study proposed nineteen variables that established a valid hierarchical structure of halal blockchain adoption for the Indonesian food industry.

This research contributes theoretical implications for halal blockchain studies (e.g., (Tieman et al., 2019; Hew et al., 2020), particularly assessing dimensions, factors and variables of halal blockchain adoption. Factors and variables of halal blockchain adoption in this study enrich the literature from HBA studies to prioritise and decide on halal blockchain implementation. To increase profits, each food industry in Indonesia must strategically prioritise each of its three dimensions and seven significant factors and also distribute resources effectively. This study also provides practical implications, providing understanding

and promotion of halal food and beverage practitioners in Indonesia on blockchain technology. Halal regulators in Indonesia (BPJH and MUI), halal assurance agencies, and halal supervisors are also encouraged to initiate and participate to increase the adoption of this technology.

This research has limitations, and further research should be conducted. Firstly, the three dimensions, seven factors, and accompanying halal blockchain adoption variables are interrelated. However, this relationship has yet to be explored. Research on the relationship between dimensions, factors and variables will provide a more comprehensive understanding of why food businesses adopt halal blockchain technology. Secondly, the complexity of the halal industry (food, pharmacy, and cosmetics) and the size of the company (small, medium, and large companies) will also have an effect. Yin (2009) recommends expanding to several types of industries and sizes of firms. Another significant limitation is the additional resources required by food businesses to adopt the halal blockchain technology. Therefore, future research is needed to add value to our proposed halal blockchain adoption decision structure. Finally, this research only focuses on Indonesian halal industries, limiting the generalizability of the findings. Future research is needed to investigate halal blockchain adoption factors in other Islamic majority countries or Islamic minority countries.

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Appendix A

Interview Protocol

Interviewees Information	What is your position/title in the company?
	How long have you been in the same company or industry?
	What is your highest level of education?
Halal strategy	Is your company's desire to participate in a blockchain-based halal integrity system in accordance with the objectives of your company's halal strategy?
Institution Coercive pressures	Is the desire to apply blockchain to the halal integrity system driven by (1) regulators, (2) industry associations, (3) main suppliers, or (4) main customers, whether it is done formally and informally?
Institution Mimetic pressures	Is the desire to apply blockchain to the halal integrity system driven by (1) the desire to imitate the success of other companies, (2) reducing uncertainty in competition and (3) sustainability of company's existence?
Institution Normative pressures	Is the desire to apply blockchain to the halal integrity system driven by shared norms among (1) supply chain network members and (2) industry associations, whether done formally and informally?
Perceived Desirability Compatibility	Will the blockchain-based halal integrity system be compatible with (1) facilities and equipment, (2) work practices, values, (3) company beliefs and strategies?
Perceived Desirability Complexity	Is the blockchain-based halal integrity system compatible with (1) easy to implement, (2) easy to use, and (3) easy to integrate.
Perceived Desirability Perceived Benefits	Will your company join the blockchain-based halal integrity system because it hopes (1) to improve the traceability system, (2) to integrate, (3) to increase the transparency of your supply chain?