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Evaluation of Barriers of Blockchain Technology-Based Halal Traceability Systems Adoption: a DEMATEL Approach

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Abstract. The purpose of this research is to examine the barriers to adopting halal traceability systems based on blockchain technology in an Indonesian halal food product. Based on a thorough review of the literature and after validation process with eleven experts, this study identified 19 barriers classified into three aspects (technological, internal, and external organization) related to the regulation, government, supplier, and another third party and consumer). Then, this research used a decision-making trial and evaluation laboratory (DEMATEL) to identify the critical barriers, the primary causal and effect barriers. The result of data processing indicated that financial constraints, massive resources (energy, infrastructure) and initial capital requirements, and inadequate managerial commitment and support are significant barriers (causes) that hinder the adoption of halal traceability systems based on blockchain technology

Keywords: blockchain technology, DEMATEL, food product, halal traceability systems

1. Introduction

Consuming halal products to fulfil religious obligations has grown into a global business opportunity [1]. It has elevated the worldwide halal business to one of the world's biggest consumer marketplaces. According to the World Population Review in 2019, around 1.8 billion Muslims worldwide. According to the Global Islamic Economy Report, the halal industry is now worth $2.2 trillion and is predicted to grow to $3.2 trillion by 2024 [2]. In Indonesia, which has the most significant population of Muslims per capita, the halal industry also has a substantial consumer market. By 2020, Indonesia will have 268 million Muslims, accounting for 80 percent. In 2017, Indonesians spent $218.8 billion on halal products and services. This value might reach US$330.5 billion by 2025, assuming a 5.3 percent annual growth rate [3].

To ensure the halalness of products, especially food products, each partner in the supply chain (from supplier to end-user) must be monitored to satisfy the end consumers with the authenticity of halal food products [4]. As a result, deploying a halal traceability system is critical to reducing and ensuring that contamination does not occur throughout the process along the supply chain. The processing of halal food should be in line with Shariah's compliance. According to [5], traceability may also be used to track the halal status of specific food items at every level of the supply chain, which improves information sharing, transparency and promotes halal integrity.

Moreover, some research indicated that the traditional Halal food traceability system is not enough to facilitate information sharing and transparency across Halal enterprises and their supply chains; it must be upgraded to provide greater transparency and security [6]. The current traceability and tracking system requires manual entry of product information, which is then saved in a specific database and makes this data visibly visible to consumers. The current model scheme has flaws or issues; the first is that the data is recorded by humans, making authentication difficult, and the information is maintained in a centralized data center [7]. In this case, blockchain technology has a lot of potentials and can help improve the traceability and tracking system for halal food products. However, real-world use is still in its infancy and needs new and more intuitive models. Like many countries with the dominance of Muslims, Indonesia wants to use the power of blockchain to meet the growing demand for halal food. This desire builds the need to research and investigate how blockchain is used. It also needs to figure out what barriers the halal food industry considers when adopting it.

To date, previous studies have identified barriers to implementing blockchain technology. According to Scopus databases until 2021, we found 22 relevant articles with the words “blockchain,” “food,” and “barrier” in the title, abstract, and keywords (such as [8]-[19], etc.). However, although we can find 18 relevant documents with the words "blockchain" and "halal" in the title, abstract, and keywords (such as [20]-[28], etc.) we cannot find the relevant document with the word "blockchain," "barrier," "halal," and "food." It is indicated that, although the research related to blockchain, barrier, and food or even blockchain and halal have been done by several authors, there is no empirical study focused specifically to shows the barriers to adopting blockchain system in a halal food product. So, the current study aims to review the barriers of implementing the blockchain technology-based Halal traceability systems and their relationships by considering experts' judgment. Precisely, this research determines barriers to blockchain technology-based Halal traceability systems adoption in the food product or halal food product by evaluating the current literature and incorporating expert opinions to select the appropriate barriers; and using the decision-making trial and evaluation laboratory (DEMATEL) model to develop cause-and-effect relationships between appropriate barriers. This research topic is essential for developing a blockchain technology-halal-based traceability system for food products in Indonesia. It's because even though the first blockchain technology-halal based traceability system was developed by PT Sreeya Sewu Indonesia Tbk (formerly known as PT Sierad Produce Tbk), one of the largest poultry production companies in Indonesia, and the government has encouraged the development of blockchain technology-halal based traceability system for a food product, the adoption of that technology not significantly increased. So, knowing the barrier and the cause-effect relationship between the barriers may help the Indonesian government choose the best policy to the most significant barrier

2. Literature Review

2.1. Blockchain technology-based halal traceability system

"Blockchain technology" is a "shared, cryptographically unaltered distributed ledger" used to record and keep track of the history of digital transactions. Each connected node on the blockchain system has a copy of all the records and transactions that have ever been made on the system in question. As you can see, no one stakeholder owns the system, so it's not centralized, and everyone can see what everyone does on it. Each activity on the system can also be audited. If today's businesses used these systems, they would be sure that people would trust them (Saberi et al., 2018). Since its inception, blockchain's application scope has moved beyond cryptocurrencies (e.g., Bitcoin) to several corporate settings and disciplines [29]: accounting [29], finance [30], healthcare [31], operations and supply chain management [32][33], and, most intriguingly, food distribution [34]. According to [35], the use of blockchain in the supply chain enables and improves product traceability, authenticity, and legality. Blockchain might instil dependability and confidence into Halal food and beverage items by enabling Muslim customers to quickly check the Halal integrity across the supply chain using a QR code on the product labels by using distributed and open ledgers to record all supply chain activities. Because blockchain is irreversible [36], its use in a Halal traceability system might preserve comprehensive supply chain information from the point of origin to the hands of end customers. Furthermore, since all parties involved share the same information, it discourages and prevents fraud within the Halal supply chain, ensuring full-scale Halal integrity Muslim customers [37].

2.2. Barriers of blockchain technology-based halal traceability systems adoption

Referring to [11], [13], [18], and [21], this research can identify 30 barriers that could be relevant for Blockchain Technology-Based Halal Traceability Systems adoption.

Barriers that related to technology

- Existing blockchain technologies are confronted with significant scaling challenges (since the current processing of transactions is limited by parameters such as the size and interval of the transaction block) (TECH1)
- The difficulty of blockchain-based system design (coding flow or loopholes are key problems in the blockchain-based system, and efficient system design necessitates a high level of ability) (TECH2)
- There is a security problem (there are concerns that data and information may be open to security concerns such as hacking, inaccurate information dispersal, and access to sensitive information) (TECH3)
- Immutability challenge of blockchain technology (It's means that data or the information is unchanged. Immutability is a powerful feature that ensures the reliability and authenticity of the information. However,

an issue that arises with immutability is that previous data and errors within the records are permanent, as they will continue to live with the blockchain (TECH4)

- Technology immaturity (since the blockchain technology is currently more latency-sensitive and has lower throughput rates, this means fewer transactions can be processed through the supply chain, and transaction times will be longer) (TECH5)
- No uniform standard of information that make the firms are unable to share data and cannot share data, and technical compatibility between firms in the supply chain is almost impossible to achieve (the absence of a standard information format shared with suppliers, except for the information available regarding halal certification) (TECH6)
- Blockchain solutions have a limited amount of flexibility, which may make them less efficient than similar traditional centralized alternatives in some circumstances (although some aspects of food quality can be assessed objectively with analytical methods, others, especially environmental aspects, are harder to evaluate, assess, and audit) (TECH7)

Barriers that related to internal organization of enterprises

- There is a lack of understanding about blockchain in the food supply chain (because of the scarcity of references and advice on blockchain deployment, in reality, knowledge of blockchain technology in the food supply chain remains conceptual) (ORG1)
- Financial constraints (organizations incur costs when collecting information through the supply chain and converting to new systems) (ORG2)
- Massive resource (energy, infrastructure) and initial capital requirements (energy consumption in the blockchain-based system is relatively high, and adequate infrastructure is required) (ORG3)
- The implementation of blockchain for food traceability has low-profit margins, particularly for supermarkets and restaurants (ORG4)
- Blockchain-based technologies, such as those used to improve traceability in the food supply chain, incur higher expenses without necessarily improving income (ORG5)
- Adopting blockchain technology by a business may need a considerable reorganization, which may affect change management (the most significant challenge in change management is commonly related to human resource management; firms are expected to encourage employees to accept blockchain technology) (ORG6)
- Sophisticated understanding of information technology and equipment is required when implementing blockchain technologies, which is uncommon among the halal food sector, especially for SMEs (ORG7)
- Inadequate managerial commitment and support (some managers fail to have long-term commitment and support for adopting disruptive technology) (ORG8)
- Inadequate information disclosure policies between supply chain partners (suppliers and other industry participants may have different policies and requirements for privacy and data security when using blockchain technology; concerns about data confidentiality, privacy, and economic value could arise.) (ORG9)
- Difficulty altering corporate culture (adopting blockchain technology changes or transforms current organizational culture; organizational culture consists of guidelines of work culture and appropriate behavior through organizations) (ORG10)
- Reluctant to upgrade systems (adopting new systems would require altering or replacing legacy systems; this issue may cause resistance and hesitation from organizations and industries) (ORG11)
- Lack of blockchain implementation tools (lack of standards and appropriate methods, tools, metrics, and techniques for blockchain technology implementation) (ORG12))
- Lack of stakeholder understanding, as well as a belief that the functioning of the blockchain-based system is difficult for them (ORG13)
- Stakeholders' aversion to blockchain culture (ORG14)
- Stakeholders are cautious about implementing the blockchain-based system due to a lack of trust among stakeholders or public perception (ORG15)

Barriers related to external organization of enterprises (government, regulation, customers, and the other third parties)

- Inadequate government regulation and ambiguity about regularity (most countries are still not ready to adopt blockchain and lack adequate regulations; furthermore, the lack of proper legislation for blockchain adoption has contributed to a lack of confidence among stakeholders about these regulations.) (EXS1)
- Cultural variations amongst supply chain participants may inhibit the adoption of blockchain technology (EXS2)
- There are still a limited number of blockchain professionals and experts who can provide training platforms (EXS3)
- Difficulty with information disclosure rules across supply chain partners (confidentiality, privacy, and economic value of data may be concerned) (EXS4)
- Collaboration problems, communication problems, and coordination problems between supply chain partners that have diverging and sometimes conflicting operational objectives/goals (EXS5).
- Lack of support for blockchain technology by external stakeholders (failure to act and conflicting objectives of related NGO and community groups) (EXS6)
- Lack of customers' awareness and tendency about blockchain technology; they don't know how blockchain technology can be used for halal supply chain practices (EXS7)
- There aren't enough rewards and incentives to make sure the data is correct and to encourage these practices by the government and professional organizations (EXS8)

3. Method of Research

3.1. Data processing technique

This research tried to evaluate the barriers to adopting the blockchain technology-based halal traceability systems among food companies in Indonesia. For this purpose, this research used two types of data processing techniques, i.e., content validity analysis and DEMATEL approach.

1. Content validity analysis is used to validate the corresponding barriers which are identified through comprehensive literature. This technique depends on a panel of experts judging how well an item or factor confirms or represents a barrier to halal traceability systems based on blockchain technology. This study employs empirical approaches to construct the content validity index (CVI), which is one of several ways to measure content validity [38]. Then, using Item-CVI, CVI is estimated in this research (I-CVI). The I-CVI is calculated as the number of experts rating each item or factor as "relevant" or "very relevant" (rating it 3 or 4), divided by the total number of experts because the relevance of each barrier to the halal traceability systems based on blockchain technology is quantified on a four-point Likert scale (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = very relevant). I-CVI values range from 0 to 1; if an item or factor's I-CVI value surpasses a threshold value established by the number of respondents, it may be deemed required. The appropriate I-CVI value for two experts, for example, is at least 0.80 [39]. For three to five experts and at least six experts, acceptable I-CVI values should be one and 0.83, respectively [40]. The I-CVI values are 0.83 and 0.78, respectively, for six to eight experts and at least nine experts [41].
2. The DEMATEL technique is used to analyze not only the most significant variables in a system through an impact relation diagram, but also to arrange interdependence interactions into cause-and-effect groups using digraphs and matrixes [42]. The step of data processing with DEMATEL can be explained as follow.
   - Step1: Calculate the "direct relationship matrix" for the group. Assume there are m experts and n constructions to be explored in this case. The expert offers their judgment on the effect of construct I on construct j and similarly for other constructs using an integer scale of 0 until 4 (0=no influence, 1=low influence, 2=medium influence, 3=strong influence, 4=extremely high influence) for each construct. Assume each expert decision matrix is given by $[x_{ij}^{k}]_{n*w}$ then the average "direct influence matrix" ($X=x_{ij_{n*m}}$) is given by (1).

$$x_{ij} = \frac{1}{m}\sum_{k=1}^{m} x_{ij}^{k}\, n*m \qquad i,j = 1,2,3,\ldots\ldots n \tag{1}$$

   - Step 2: normalize the "direct influence matrix". The normalized average "direct influence matrix" ($A=[a_{ij}]_{n*m}$) is given by (2).

$$A = \frac{x}{s} \quad (2)$$

Where $s = \max\,(1 \leq \max j \leq n \sum_{j=1}^{n} x_{ij}, 1 \leq \max i \leq n \sum_{i=1}^{m} x_{ij} \quad (3)$

- Step 3: Find the total influence matrix ($T=[t_{ij}]_{m*n}$) which is calculated trough summing all the “direct and indirect effect”. See the equation (4)

$$T= A+ A^2+A^3+.... +A^h= A(I-A)^{-1} \quad (4)$$

Where h→∞; “I is represented as identity matrix”

- Step 4: Formulate the “influence relationship map” using two vectors R and C. These vectors are the sum of rows and column respectively in the “total influence matrix”. See the equation (5)

$$R = [r_i]_{n*1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n*1}, R = [c_i]_{1*n} = \left[\sum_{j=1}^{n} t_{ij}\right]_{1*n} \quad (5)$$

- Where "ri is the sum of the ith row in the total influence matrix" T and represents the cumulative impact of construct n_i on all other constructs. Similarly, ci is the sum of the jth column in the "total influence matrix" T and represents the total impact that construct n_i receives from all other constructs. An "impact relationship map" is generated using these two vectors, with the (Ri + Ci) value as the x axis and the (Ri-Ci) value as the y axis for each construct. On the horizontal axis, the (Ri + Ci) value of a structure (also called "prominence") indicates its strength and functions as a critical component of the system. Whereas the vertical axis (Ri-Ci), commonly referred to as "relation," reflects the construct's net effect on the system. If the (Ri-Ci) value of a construct is positive, it implies that the construct has an impact on other constructs and may be classified as **a cause group**. When the value of (Ri-Ci) is negative, the construct is impacted by another in the system and may be classified as an **effect group**. The construct is ordered according to the absolute value of the phrase "relation" (Ri-Ci), as calculated by (6).

$$v(X_k) = order\ (X_k)_{R\_C}\ k \in \{1,2,3,\dots\dots n-1\text{In}\} \quad (6)$$
$$n = no\ of\ barrier$$

3.2. Data collection procedure

This research use questionnaire as the data collection procedure. There are two types of questionnaires, namely validation questionnaire and DEMATEL questionnaire. The experts, consisting of 3 representatives from government agencies, five academicians, and three representatives from food companies, should fill out both questionnaires through the online system. They were given a short explanation over the phone prior to completing out the questionnaire, and then the URL for the online questionnaire was sent to them by email or WhatsApp

4. Result and Discussion

4.1. The result of content validity analysis

The result of the content validity analysis indicated that eleven barriers have an I-CVI value of less than 0,78 (the threshold value is 0.78 since this research uses eleven experts or more than nine experts). These barriers should be excluded from the list and not used in the DEMATEL approach data processing. Finally, based on the I-CVI value, this research uses 19 items as a barrier to halal traceability systems based on blockchain technology: TECH2, TECH6, ORG1, ORG2, ORG3, ORG6, ORG7, ORG8, ORG9, ORG11, ORG13, ORG14, ORG15, EXS1, EXS2, EXS3, EXS4, EXS5, EXS6, and EXS7.

4.2. The result of data processing with DEMATEL

Using equation (1), DEMATEL’s questionnaire responses were aggregated to get the “average influence matrix” as depicted in Table I. Then, using the equation (2) and (3), the normalized average “direct influence matrix” can be calculated as seen in Table 2. Moreover, using equation (4) and equation (5), the “total influence matrix” and “degree of prominence and intensity of relationship” can also be calculated and can be seen in

Table 3 and Table 4. Last, based on the calculation (R+C) and (R-C), we can build the influence relation map as seen in Fig. I.

Table 4 shows the degree of prominence and intensity of the relationship of all barriers. Barriers are ranked, based on the prominence Ri+ Ci (global) value as follows: ORG2, ORG14, ORG3, ORG7, ORG15, ORG8, 0RG6, ORG9, ORG13, EXS4, TECH2, ORG11, EXS5, EXS2, EXS3, ORG1, EXS6, TECH6, and EXS7. Among the barriers, "financial constraints" (ORG2), "stakeholders' aversion to blockchain culture" (ORG14), "massive resource (energy, infrastructure) and initial capital requirements" (ORG3), "inadequate managerial commitment and support "(ORG7), and "stakeholders are cautious about implementing the blockchain-based system due to a lack of trust among stakeholders or public perception" (ORG15) are the top five barriers based on the prominence score.

Table 4 also shows that a total of nine barriers, namely, ORG2, ORG3, ORG8, ORG15, ORG7, ORG9, TECH2, EXS2, and ORG1, are classified as cause barriers. Among these, "financial constraints" (ORG2), "massive resource (energy, infrastructure) and initial capital requirements" (ORG3), and "inadequate managerial commitment and support" (ORG8) are seen as the primary causal barriers. ORG2 and ORG3 are also confirmed as prominent barriers. Barriers ORG14, ORG6, ORG13, EXS4, ORG11, EXS5, EXS3, EXS6, TECH6, and EXS7 are classified as effect barriers based on the (Ri – Ci) value. Among these, "stakeholders' aversion to blockchain culture" (ORG14), "need reorganization when adopting blockchain technology by business" (ORG6), and "lack of stakeholder understanding, as well as a belief that the functioning of the blockchain-based system is difficult for them (ORG13)" are seen as the primary effect barriers. The cause barrier influences these barriers, which hinders the adoption of halal traceability systems based on blockchain technology. The lesser score of −0.354 for lack of customers' awareness and tendency about blockchain technology (they don't know how blockchain technology can be used for halal supply chain practices) (EXS7) implies that it is the least influencing barrier for the adoption of halal traceability systems based on blockchain technology.

In the total relationship map (Fig. 2), the right-most barrier (ORG2) is the highly correlated barrier, and EXS7, in the left-most corner, is the least correlated barrier. Then, using a threshold value of as much as 0.067 (an average of elements in "total influence matrix" as pointed out in the work of Gardas et al. (2019)), it is clear that EXS7 only have a limited significant relationship with the other barriers while on the other hand ORG 2 followed by ORG3 are the most correlated barriers

Table 1: Average Influence Matrix

	TECH2	TECH6	ORG1	ORG2	ORG3	ORG6	ORG7	ORG8	ORG9	ORG11	ORG13	ORG14	ORG15	EXS2	EXS3	EXS4	EXS5	EXS6	EXS7
TECH2	0,00	2,18	0,00	1,55	1,91	2,27	1,91	1,91	1,82	1,91	1,73	2,00	1,91	0,46	1,46	1,82	1,82	1,27	1,36
TECH6	0,00	0,00	0,00	0,00	0,36	0,36	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG1	0,00	2,46	0,00	2,64	3,36	2,73	2,82	2,82	2,64	2,91	2,64	2,36	0,00	0,00	0,00	2,73	2,55	0,00	0,00
ORG2	1,46	1,55	0,00	0,00	2,09	2,46	1,91	3,00	2,46	2,64	2,64	3,18	2,55	2,09	2,27	3,00	2,73	1,55	2,36
ORG3	1,55	2,18	3,73	2,09	0,00	2,64	2,55	3,00	2,91	3,27	2,46	2,18	2,00	2,00	2,00	2,18	2,36	2,00	2,27
ORG6	1,55	0,00	0,00	2,55	2,46	0,00	2,27	2,73	2,46	1,91	2,27	2,46	0,00	0,00	0,00	2,36	1,64	0,00	0,00
ORG7	1,27	1,09	0,00	1,91	0,00	2,36	0,00	2,64	2,18	2,55	2,46	2,27	1,18	1,18	2,09	2,46	2,82	2,82	2,09
ORG8	1,09	1,82	0,00	2,64	2,46	1,91	2,82	0,00	2,55	2,73	2,00	3,00	1,82	0,00	2,27	2,27	2,27	1,91	0,00
ORG9	1,09	0,00	0,00	1,91	2,55	2,46	2,18	2,00	0,00	3,00	2,00	2,00	2,09	0,00	1,18	1,82	2,36	1,55	0,00
ORG11	1,64	0,00	0,00	2,91	0,00	0,00	2,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG13	1,55	0,00	0,00	1,82	0,00	2,27	2,00	2,64	2,09	2,55	0,00	2,73	2,00	0,00	1,18	0,00	2,73	1,09	0,00
ORG14	1,36	1,64	0,00	3,46	0,00	2,64	2,82	2,91	2,36	2,46	2,09	0,00	2,36	1,09	2,64	2,73	2,46	1,64	0,00
ORG15	1,09	0,00	0,00	1,82	1,91	2,00	2,18	2,18	2,82	2,27	2,55	1,73	0,00	2,46	2,73	2,55	3,27	0,27	0,00
EXS2	0,00	1,82	0,00	2,82	2,91	2,09	2,00	0,00	2,09	2,82	2,64	2,55	2,64	0,00	2,27	2,00	2,36	0,18	0,00
EXS3	1,27	0,00	0,00	1,27	0,00	1,82	1,82	0,00	0,27	1,91	0,00	2,00	1,73	1,55	0,00	2,46	1,91	0,00	0,00
EXS4	1,55	1,73	0,00	1,73	1,36	2,00	0,00	0,00	0,18	2,09	0,00	2,91	2,64	0,00	2,46	0,00	0,00	0,00	0,00
EXS5	1,36	0,00	0,00	2,36	0,00	2,09	0,00	0,00	0,00	1,82	0,00	1,27	2,27	0,00	0,00	1,55	0,00	0,00	0,00
EXS6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1,46	1,91	1,09	1,55	0,00	0,00	1,00	1,00	0,00	0,00
EXS7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 12: Normalized Direct Influence Matrix

	TECH2	TECH6	ORG1	ORG2	ORG3	ORG6	ORG7	ORG8	ORG9	ORG11	ORG13	ORG14	ORG15	EXS2	EXS3	EXS4	EXS5	EXS6	EXS7
TECH2	0,00	0,05	0,00	0,04	0,04	0,05	0,04	0,04	0,04	0,04	0,04	0,05	0,04	0,01	0,03	0,04	0,04	0,03	0,03
TECH6	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG1	0,00	0,06	0,00	0,06	0,08	0,06	0,07	0,07	0,06	0,07	0,06	0,06	0,00	0,00	0,00	0,06	0,06	0,00	0,00
ORG2	0,03	0,04	0,00	0,00	0,05	0,06	0,04	0,07	0,06	0,06	0,06	0,07	0,06	0,05	0,05	0,07	0,06	0,04	0,06
ORG3	0,04	0,05	0,09	0,05	0,00	0,06	0,06	0,07	0,07	0,08	0,06	0,05	0,05	0,05	0,05	0,05	0,06	0,05	0,05
ORG6	0,04	0,00	0,00	0,06	0,06	0,00	0,05	0,06	0,06	0,04	0,05	0,06	0,00	0,00	0,00	0,06	0,04	0,00	0,00
ORG7	0,03	0,03	0,00	0,04	0,00	0,06	0,00	0,06	0,05	0,06	0,06	0,05	0,03	0,03	0,05	0,06	0,07	0,07	0,05
ORG8	0,03	0,04	0,00	0,06	0,06	0,04	0,07	0,00	0,06	0,06	0,05	0,07	0,04	0,00	0,05	0,05	0,05	0,04	0,00
ORG9	0,03	0,00	0,00	0,04	0,06	0,06	0,05	0,05	0,00	0,07	0,05	0,05	0,05	0,00	0,03	0,04	0,06	0,04	0,00
ORG11	0,04	0,00	0,00	0,07	0,00	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG13	0,04	0,00	0,00	0,04	0,00	0,05	0,05	0,06	0,05	0,06	0,00	0,06	0,05	0,00	0,03	0,00	0,06	0,03	0,00
ORG14	0,03	0,04	0,00	0,08	0,00	0,06	0,07	0,07	0,06	0,06	0,05	0,00	0,06	0,03	0,06	0,06	0,06	0,04	0,00
ORG15	0,03	0,00	0,00	0,04	0,04	0,05	0,05	0,05	0,07	0,05	0,06	0,04	0,00	0,06	0,06	0,06	0,08	0,01	0,00
EXS2	0,00	0,04	0,00	0,07	0,07	0,05	0,05	0,00	0,05	0,07	0,06	0,06	0,06	0,00	0,05	0,05	0,06	0,00	0,00
EXS3	0,03	0,00	0,00	0,03	0,00	0,04	0,04	0,00	0,01	0,04	0,00	0,05	0,04	0,04	0,00	0,06	0,04	0,00	0,00
EXS4	0,04	0,04	0,00	0,04	0,03	0,05	0,00	0,00	0,00	0,05	0,00	0,07	0,06	0,00	0,06	0,00	0,00	0,00	0,00
EXS5	0,03	0,00	0,00	0,06	0,00	0,05	0,00	0,00	0,00	0,04	0,00	0,03	0,05	0,00	0,00	0,04	0,00	0,00	0,00
EXS6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,03	0,04	0,03	0,04	0,00	0,00	0,02	0,02	0,00	0,00
EXS7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 3: Total Influence Matrix

	TECH2	TECH6	ORG1	ORG2	ORG3	ORG6	ORG7	ORG8	ORG9	ORG11	ORG13	ORG14	ORG15	EXS2	EXS3	EXS4	EXS5	EXS6	EXS7
TECH2	0,040	0,076	0,007	0,100	0,078	0,110	0,098	0,093	0,092	0,115	0,088	0,108	0,095	0,033	0,078	0,098	0,100	0,058	0,047
TECH6	0,001	0,001	0,001	0,002	0,010	0,010	0,002	0,002	0,002	0,002	0,002	0,002	0,001	0,001	0,001	0,002	0,002	0,001	0,001
ORG1	0,049	0,090	0,010	0,139	0,118	0,134	0,131	0,127	0,121	0,152	0,118	0,130	0,063	0,025	0,054	0,129	0,127	0,039	0,022
ORG2	0,086	0,072	0,008	0,091	0,096	0,137	0,119	0,133	0,124	0,158	0,125	0,158	0,129	0,077	0,114	0,145	0,142	0,074	0,073
ORG3	0,090	0,091	0,091	0,145	0,058	0,148	0,141	0,141	0,141	0,181	0,129	0,144	0,119	0,075	0,109	0,135	0,142	0,087	0,073
ORG6	0,075	0,030	0,008	0,122	0,090	0,062	0,107	0,113	0,106	0,115	0,100	0,119	0,055	0,022	0,048	0,110	0,096	0,034	0,019
ORG7	0,071	0,052	0,003	0,113	0,039	0,116	0,059	0,109	0,101	0,134	0,106	0,120	0,085	0,048	0,094	0,116	0,126	0,093	0,061
ORG8	0,073	0,073	0,008	0,136	0,095	0,115	0,129	0,061	0,117	0,147	0,103	0,142	0,104	0,028	0,105	0,120	0,122	0,079	0,021
ORG9	0,068	0,029	0,008	0,112	0,093	0,117	0,108	0,099	0,055	0,143	0,096	0,112	0,101	0,025	0,074	0,102	0,116	0,067	0,018
ORG11	0,049	0,010	0,001	0,083	0,011	0,019	0,067	0,018	0,017	0,022	0,017	0,021	0,017	0,009	0,016	0,020	0,020	0,012	0,010
ORG13	0,072	0,024	0,003	0,103	0,033	0,106	0,098	0,106	0,094	0,123	0,046	0,118	0,092	0,021	0,068	0,056	0,117	0,053	0,014
ORG14	0,080	0,069	0,004	0,155	0,046	0,132	0,130	0,124	0,114	0,142	0,106	0,080	0,118	0,052	0,115	0,132	0,128	0,072	0,020
ORG15	0,073	0,033	0,007	0,121	0,086	0,118	0,116	0,106	0,122	0,138	0,114	0,117	0,066	0,081	0,116	0,126	0,145	0,041	0,019
EXS2	0,047	0,071	0,009	0,138	0,104	0,116	0,109	0,060	0,105	0,145	0,114	0,129	0,119	0,029	0,103	0,111	0,122	0,037	0,020
EXS3	0,056	0,019	0,002	0,075	0,025	0,081	0,077	0,033	0,040	0,090	0,033	0,087	0,075	0,051	0,032	0,095	0,082	0,018	0,011
EXS4	0,062	0,058	0,005	0,084	0,055	0,085	0,041	0,036	0,040	0,094	0,034	0,106	0,093	0,019	0,087	0,042	0,042	0,019	0,011
EXS5	0,051	0,014	0,002	0,086	0,020	0,076	0,029	0,027	0,027	0,075	0,025	0,060	0,076	0,013	0,024	0,065	0,029	0,013	0,009
EXS6	0,014	0,007	0,001	0,022	0,010	0,019	0,018	0,016	0,038	0,055	0,057	0,044	0,052	0,007	0,015	0,039	0,042	0,008	0,003
EXS7	0,003	0,002	0,000	0,005	0,001	0,003	0,005	0,003	0,003	0,027	0,003	0,025	0,003	0,001	0,003	0,004	0,003	0,002	0,001

Table 4: Degree of Prominence and Intensity of Relationship

	TECH2	TECH6	ORG1	ORG2	ORG3	ORG6	ORG7	ORG8	ORG9	ORG11	ORG13	ORG14	ORG15	EXS2	EXS3	EXS4	EXS5	EXS6	EXS7
TECH2	0,00	0,05	0,00	0,04	0,04	0,05	0,04	0,04	0,04	0,04	0,04	0,05	0,04	0,01	0,03	0,04	0,04	0,03	0,03
TECH6	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG1	0,00	0,06	0,00	0,06	0,08	0,06	0,07	0,07	0,06	0,07	0,06	0,06	0,00	0,00	0,00	0,06	0,06	0,00	0,00
ORG2	0,03	0,04	0,00	0,00	0,05	0,06	0,04	0,07	0,06	0,06	0,06	0,07	0,06	0,05	0,05	0,07	0,06	0,04	0,06
ORG3	0,04	0,05	0,09	0,05	0,00	0,06	0,06	0,07	0,07	0,08	0,06	0,05	0,05	0,05	0,05	0,05	0,06	0,05	0,05
ORG6	0,04	0,00	0,00	0,06	0,06	0,00	0,05	0,06	0,06	0,04	0,05	0,06	0,00	0,00	0,00	0,06	0,04	0,00	0,00
ORG7	0,03	0,03	0,00	0,04	0,00	0,06	0,00	0,06	0,05	0,06	0,06	0,05	0,03	0,03	0,05	0,06	0,07	0,07	0,05
ORG8	0,03	0,04	0,00	0,06	0,06	0,04	0,07	0,00	0,06	0,06	0,05	0,07	0,04	0,00	0,05	0,05	0,05	0,04	0,00
ORG9	0,03	0,00	0,00	0,04	0,06	0,06	0,05	0,05	0,00	0,07	0,05	0,05	0,05	0,00	0,03	0,04	0,06	0,04	0,00
ORG11	0,04	0,00	0,00	0,07	0,00	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ORG13	0,04	0,00	0,00	0,04	0,00	0,05	0,05	0,06	0,05	0,06	0,00	0,06	0,05	0,00	0,03	0,00	0,06	0,03	0,00
ORG14	0,03	0,04	0,00	0,08	0,00	0,06	0,07	0,07	0,06	0,06	0,05	0,00	0,06	0,03	0,06	0,06	0,06	0,04	0,00
ORG15	0,03	0,00	0,00	0,04	0,04	0,05	0,05	0,05	0,07	0,05	0,06	0,04	0,00	0,06	0,06	0,06	0,08	0,01	0,00
EXS2	0,00	0,04	0,00	0,07	0,07	0,05	0,05	0,00	0,05	0,07	0,06	0,06	0,06	0,00	0,05	0,05	0,06	0,00	0,00
EXS3	0,03	0,00	0,00	0,03	0,00	0,04	0,04	0,00	0,01	0,04	0,00	0,05	0,04	0,04	0,00	0,06	0,04	0,00	0,00
EXS4	0,04	0,04	0,00	0,04	0,03	0,05	0,00	0,00	0,00	0,05	0,00	0,07	0,06	0,00	0,06	0,00	0,00	0,00	0,00
EXS5	0,03	0,00	0,00	0,06	0,00	0,05	0,00	0,00	0,00	0,04	0,00	0,03	0,05	0,00	0,00	0,04	0,00	0,00	0,00
EXS6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,03	0,04	0,03	0,04	0,00	0,00	0,02	0,02	0,00	0,00
EXS7	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00

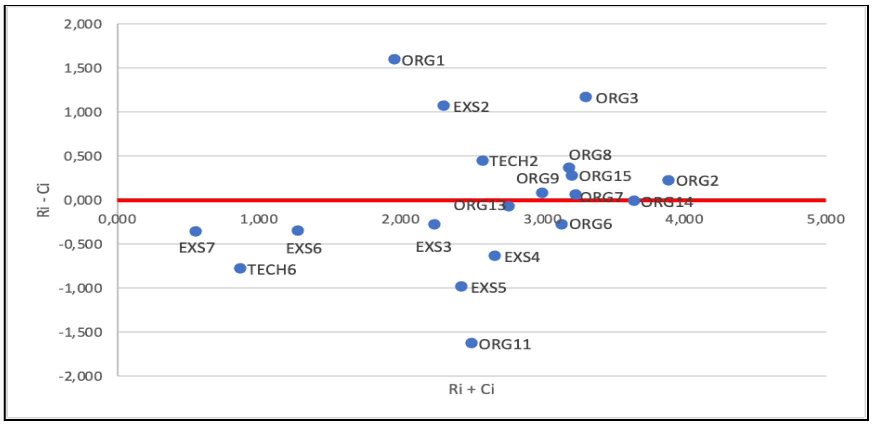

Fig. 1: Total Relation Map.

5. Conclusion

This study identifies the following significant barriers (causes) that hinder the adoption of halal traceability systems based on blockchain technology: "financial constraints" (ORG2), "massive resource (energy, infrastructure) and initial capital requirements" (ORG3), and "inadequate managerial commitment and support" (ORG8). On the other hand, the lack of customers' awareness and tendency about blockchain technology (they don't know how blockchain technology) (EXS7) is the least influencing or influenced barrier based on the prominence/total relations map (Fig.1). This means that a lack of consumer understanding and willingness to embrace halal traceability solutions based on blockchain technology has less impact as a barrier to adoption.

This research has several limitations. First, the barriers identified in the research are unique to the adoption of halal traceability systems based on blockchain technology for halal food products in Indonesia. Future research should expand the study to include other halal products and other Muslim-majority nations for comparison. The second issue concerns the methodology used in this study. This study can only identify the most critical barriers, the least significant barriers, and the relationships using the DEMATEL technique. This study is unable to determine the barriers' hierarchical structure. Future research should use Interpretative Structural Modeling (ISM) to identify the hierarchy of barriers

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