International Journal of Industrial Engineering & Production Research September 2023 Vol. 34, No. 3: 1-18
DOI: 10.22068/ijiepr.34.3.1

RESEARCH PAPER

Analysis and Prioritizing Capability in the Halal Resilience Supply Chain: A Fuzzy AHP Approach

Harwati[1]*, Anna Maria Sri Asih[2] & Bertha Maya Sopha[3]

Received 28 May 2023; Revised 8 July 2023; Accepted 26 August 2023;

ABSTRACT

In recent years, research on halal supply chains resilience (HSCRES) has been growing to deal with the vulnerabilities caused by halal risks that disrupt global halal supply chains. However, empirical studies in this field have been hindered by the lack of identifying halal capabilities that represent the strength of HSCRES. This study aimed to determine and prioritize halal resilience capability. In the first step, extant literature is reviewed to identify capability factors in the context of the halal supply chain. In the second step, the fuzzy analytical hierarchy process (FAHP) approach was used to rank the halal capability indicators. The results of this study indicate that halal integrity is the most important capability factor in enhancing a resilient halal supply chain. The results also reveal that mandatory regulation is the most significant indicator in HSCRES, followed by halal teams, official halal logos, internal halal audits, and communication channels. This finding offers stakeholder recommendations on which capabilities should be prioritized to reduce the impact of halal risks that disrupt supply chains' resilience.

KEYWORDS: *Halal supply chain; Resilience; Capability; Fuzzy; AHP.*

1. Introduction

In recent decades, the demand for halal food has changed significantly owing to an increase in the world's Muslim population. The industry must meet the needs of Muslim consumers to guarantee that the product is unquestionably halal [1]. In other words, the supply chain should be managed to provide halal food not only based on the quality of the ingredients, but also throughout the production system, from the source to the end consumers [2]. Since many actors are involved in the halal supply chain and may have different objectives and concerns, the supply chain is vulnerable to potential disruptions that cause halal risks [3]. According to [4] a resilient supply chain is one of the weapons used to handle risks and gain a sustainable competitive advantage from disruptive events. Resilience is an important factor in the competitiveness of halal supply chain performance and company credibility. Halal resilience is important to ensure the integrity of halal products. A lack of resilience can result in a loss of consumer trust and reputation damage [5]. Therefore, halal supply chain resilience must be analyzed to achieve a competitive halal supply chain.

In the literature, the issue of resilience in halal supply chains has been discussed in some aspects [5]–[8]. For instance, [5] suggested successful supply chain risk management, including prevention, mitigation, and recovery processes, to ensure HSC resilience. [7] stated that consumers' halal awareness and comprehension of the halal management concept increased HSCRES. On the other hand, many studies endeavors within the halal supply chain area focus on the identification and prioritization of halal risk factors [9]–[13]. Although previous literature findings could provide some insight into the resilience of halal supply chains, their scope is limited.

* **Corresponding author:** ***Harwati***
harwati@mail.ugm.ac.id, harwati@uii.ac.id

1. *Industrial Engineering Program, Department of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Yogyakarta Indonesia. Author is an assistant professor at Industrial Engineering Program, Universitas Islam Indonesia, Yogyakarta, Indonesia.*
2. *Industrial Engineering Program, Department of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Yogyakarta Indonesia.*
3. *Industrial Engineering Program, Department of Mechanical and Industrial Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia.*

First, there is a lack of studies that identify the capability factors related to HSCRES. The halal capability factors must be determined to understand the supply chain's ability to comply with halal regulations and standards. The identification of halal risks aids the supply chain in identifying potential vulnerabilities and areas for improvement [5]. However, the identified capabilities will enhance the comprehension of the strengths and weaknesses of the supply chain, thereby enabling the determination of its position. Second, most previous studies have focused on prioritizing halal risks [14]. Compared with previous studies that revealed prioritized halal risks to be coped with, presently, no study examined which halal capability elements should be developed urgently. Prioritizing capability is important for identifying the elements of capability that require ranking for development, with the aim of reducing vulnerability and increasing resilience [15]. Hence, it is important to prioritize halal capability factors to enhance HSCRES.

Motivated by the research gaps identified earlier, this study focuses on the following questions:

(1) What are the resilience capability factors and corresponding indicators that enhance the resilience of the halal supply chain?
(2) How can the quantitative assessment of halal capabilities be determined to indicate improvement priorities?

Thus, to address the research questions, this study aims to identify the halal resilience capability factors and related indicators, and prioritize the capability indicators that are important in enhancing halal supply chain resilience. A fuzzy analytical hierarchy process (FAHP) was adopted to accomplish this purpose. The Analytic Hierarchy Process (AHP) was selected based on its easy-to-use nature and compatibility for prioritizing items involving multiple criteria situations [16]. Furthermore, the fuzzy approach is combined with the traditional AHP to handle the uncertainty and imprecision related to expert judgement [17]. The findings of this study may assist stakeholders, including management and regulators, in prioritizing important strategies to enhance HSCRES by improving related capabilities.

2. Literature Review

2.1. Capability of halal supply chain resilience

Over the last few years, researchers have begun to focus on developing an understanding of halal supply chain resilience [5], [7], [18]. However, halal resilience analysis still primarily focuses on identifying halal risks that cause supply chain vulnerabilities. To the best of our knowledge, no published literature has identified and evaluated the capabilities needed to support resilient halal supply chains. In this study, halal capabilities were derived using two approaches. First, the capabilities of conventional supply chain resilience were adapted for application in the halal supply chain. Second, capabilities are often revealed and utilized to evaluate HSC performance. Figure 1 shows the distribution of capabilities often considered in traditional supply chain resilience.

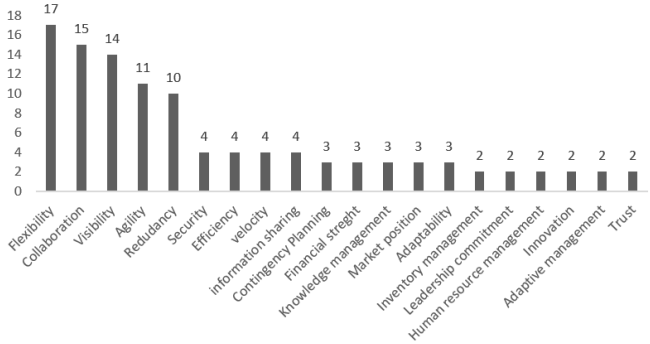

Fig. 1. Resilience Capability in Literature

There is no agreement among the 20 SCRES capability variables regarding which capabilities are essential to support SCRES. This study includes the top five capabilities recommended by previous studies: flexibility, collaboration, visibility, agility, and redundancy.

Flexibility

Flexibility is related to the ability to adapt to risks by developing alternatives, such as flexible transportation systems, flexible production systems, flexible employee work arrangements, and the ease of changing suppliers [19]. However, some studies suggest redundancy capabilities to support the resilience of the supply chain.

Redundancy is the capacity to construct additional assets that may be deployed in the event of risk. Although both capabilities are needed to support SCRES, flexibility and redundancy are diametrically opposed. Flexibility leads to efficiency, whereas redundancy increases costs. In the context of halal supply chains, flexibility is considered more beneficial than redundancy for several reasons. First, according to [20], flexibility is essential and beneficial for dealing with internal supply chain risks. Second, the Halal supply chain is a system that is more vulnerable to risks resulting from within than from external sources [12], [14]. Consequently, anticipating and mitigating halal risks benefits supply chain entities in their daily operations more than long-term objectives. Because the halal supply chain has characteristics that correspond to the aforementioned conditions, flexibility is selected over redundancy as the capability to be improved to develop halal supply chain resilience.

Collaboration

Research of [21] define collaboration as the ability to work effectively with other entities for mutual benefit. Collaboration is important for identifying and mitigating risk. According to [22] collaboration between entities improves supply chain optimization and increases customer trust in halal-certified products. The efficacy of collaboration in HSC can be manifested in the form of trust in the sharing of halal knowledge, necessitating the use of transparent communication channels that provide accessibility and facilitate halal traceability for each participating entity. Effective collaboration among suppliers, manufacturers, distributors, and consumers enables decision synchronization, which contributes to risk reduction in HSC management.

Visibility

Visibility is an important capability for identifying possible risks by obtaining a comprehensive view of the supply chain [23]. Research of [19] proposed the implementation of information technology and situational awareness as key indicators of transparency for increasing visibility. Visibility can be utilized to anticipate halal-related risks, such as contamination of non-halal components, thus allocating an adequate interval in which to devise strategies to counteract potential failures.

Agility

If flexibility is related to the ability to choose between alternatives, agility is related to how quickly these alternatives are used to recover from the risk of failure [24]. Most literature defines agility as the ability to respond quickly to unexpected risks in demand and supply [23]. Although some researchers argue that visibility is a component of agility [25], however [26] state that agility is an important capability in the recovery phase, whereas visibility is important in the readiness phase. Thus, in this study, agility and visibility are considered distinct capabilities. Because agility is closely related to recovery speed [5] believed that it is essential for the HSC to restore its reputation after the occurrence of a risk of failure. Thus, HSC require agility while maintaining operational efficiency to stay competitive in the halal industry.

A second source of identification of HSCRES capabilities is the capability commonly found in HSC literature. Although it did not explicitly refer to the HSCRES capability, a literature study on HSC halal integrity was directly related to anticipating risks while maintaining HSC performance when risk failure occurs. Thus, this study considered halal integrity as an HSCRES capability. According to [27], halal integrity implies that the product is halal from the source to the end of the consumer, free of any activities or procedures that could jeopardize the halal status. In HSC, dedicated halal assets are critical, and complete segregation throughout the supply chain improves halal integrity [28]. Halal integrity also requires a sincere commitment to halal policies by halal food companies to protect halal integrity throughout the supply chain. Management commitment involves initiatives to maintain competent employees, construct a halal team, and retain internal audits. Dedicated employees are needed to ensure that halal products are produced using knowledge and skills [29]. A dedicated team to handle halal products would reduce the possibility of cross-contamination to a minimum, and thus aid in protecting halal integrity [27]. An internal audit guarantees the sustainability of endeavors to uphold the halal status of a product. Finally, regulator commitment must be parallel to management commitment because these two factors are important in the design, execution, and maintenance of halal integrity.

Based on the literature review above, in this study, halal capability was categorized into five major categories: flexibility, collaboration, visibility, agility, and halal integrity. Along with their indicators, the finalized identified halal capability is shown in Table 1.

Tab. 1. Halal capability

Capability factors	Indicators	Code	References
Flexibility	Supplier flexibility	F1	[30]–[33]
	Halal technology flexibility	F2	[34]–[36]
	Halal transportation flexibility	F3	[36]–[39]
Collaboration	Communication channel	C1	[21], [40], [41]
	Halal knowledge sharing	C2	[4], [42]–[44]
	Consumer-supplier relation	C3	[45]–[47]
	Official halal logo	C4	[48], [49]
	Halal traceability	C5	[5], [50]
Visibility	Forecasting accuracy	V1	[51]–[53]
	Identification halal risk	V2	[5], [19], [54]
	Early warning system	V3	[24], [26], [55]
Agility	Non-halal handling	A1	[56]–[58]
	Fast re-routing	A2	[59], [60]
	Speed recovery	A3	[61], [62]
Halal integrity	Employee competency sustainability	H1	[63]–[65]
	Dedicated halal facility	H2	[14], [66]
	Halal team	H3	[64], [67], [68]
	Internal halal audit	H4	[5], [69]–[71]
	Halal regulation	H5	[72], [73]

The halal capability indicators were then validated using the CFA method. A closed questionnaire comprising 19 indicators was distributed to respondents. The first reliability test was conducted on 30 respondents by calculating Cronbach's alpha value. Using SPSS 21 software, Cronbach's alpha value for all capability items is 0.959. These values were above the acceptable level of 0.6, so all the capability items were reliable and worthy of the CFA. The questionnaire was distributed to 145 respondents. A total of 140 responses were completed (96% response rate). Using the ten-time formula, the minimum sample size required is 70. However, the total number of samples taken was 140, so it can be said that this amount of data is enough to move forward. Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were used to determine the feasibility of all indicators as shown in Table 2.

Tab. 2. KMO and bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.814
Bartlett's Test of Sphericity	Approx. Chi-Square	1.854E3
	df	171
	Sig.	.000

2.2. Implementation of fuzzy AHP in supply chain

AHP was initially introduced by [74] and has since become a popular numerical technique of Multi Criteria Decision Making (MCDM) for ranking and prioritizing factors. Research of [75] highlighted the advantage of AHP as an easy-to-use technique for simultaneously assessing multiple criteria. Many criteria can be formalized through a hierarchical structure, resulting in more accurate decisions. It is also stated that AHP item comparison can be performed individually or in an iterative process by a team, with consistent decision judgements confirmed by the consistency measurement process. Under this dominance, AHP methodology has been widely employed by various researchers both in traditional and halal supply chain area to address various multi criteria decision problems [76], [77]. Accroding to [78], the application of AHP approach has several advantages. For example, it is a more systematic procedure than the other MCDM methods, and it is better at capturing a human's appraisal of ambiguity when dealing with complicated multi-criteria decision-making problems.

However, the use of AHP can often be limited due to factors such as its lack of ability to accommodate ambiguity and subjective human judgement in an uncertain environment. Therefore, the fuzzy AHP approach has been suggested to address the aforementioned limitations [78]. In short, the approach provides a means to deal with the inherent uncertainty and

ambiguity of human decision-making practice and allows decision-makers to understand decision problems by providing the required flexibility and robustness in decision-making [79]. Recently, this fuzzy AHP approach has been applied in a variety of research in the area of supply chains for multiple purposes, such as prioritizing SC risks [17], supplier selection [77], and enabler assessment [80], etc. Despite its limited application, fuzzy AHP has been utilized in the context of halal supply chain management. For instance, [9] used fuzzy AHP to prioritize halal risks, while [81] implemented fuzzy AHP to measure the resilience of the pharmaceutical industry. Table 2 presents examples of fuzzy AHP implementation in several supply chain decision-making areas.

Tab. 2. Literatures used fuzzy AHP approach in supply chain area

Authors (year)	Technique	Focus area	Application
[82]	Fuzzy AHP	Supply partner selection	Humanitarian supply chain
[79]	Fuzzy AHP	Risk assessment of implementing green	Fashion supply chain
[83]	Fuzzy AHP	Supply chain risk assessment	A high-end server manufacturing environment
[17]	Fuzzy AHP	Risk analysis	green supply chain
[84]	Fuzzy AHP	Performance measures	Healthcare supply chain
[85]	Fuzzy AHP	Indicators in improving supply chain performance	Manufacturing companies
[86]	Fuzzy AHP	Order allocation among suppliers	Automobile company
[87]	Fuzzy AHP	Information technology barriers	Sugar supply chain
[9]	Fuzzy AHP	Halal risks	Halal food supply chain
[80]	Fuzzy AHP	Enablers of sustainable supply chain innovation	Manufacturing companies
[88]	Fuzzy AHP	Inter relationships among the circular supply chain barriers	Automotive plastic industry

3. Method

In this study, the relative importance of HSCRES capability was evaluated using a two-phase methodology. In the first phase, the capability elements were identified using a systematic literature review. In the second step, the capability elements were evaluated and ranked using the fuzzy AHP approach. The proposed research design is illustrated in Figure 2.

Fuzzy AHP

Consistency in the AHP model is the first issue that must be measured. The consistency index (CI) and consistency ratio (CR) are formulated as follows:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \text{ and } CR = \frac{CI}{RI}. \quad (1)$$

where λ_{max} is the largest eigenvalue of the comparison matrix, n is the number of compared items, and RI is the random AHP index. Expert judgements can be accepted if the consistency ratio is less than 0.1; otherwise, the experts have to establish the pairwise comparison judgement again [74].

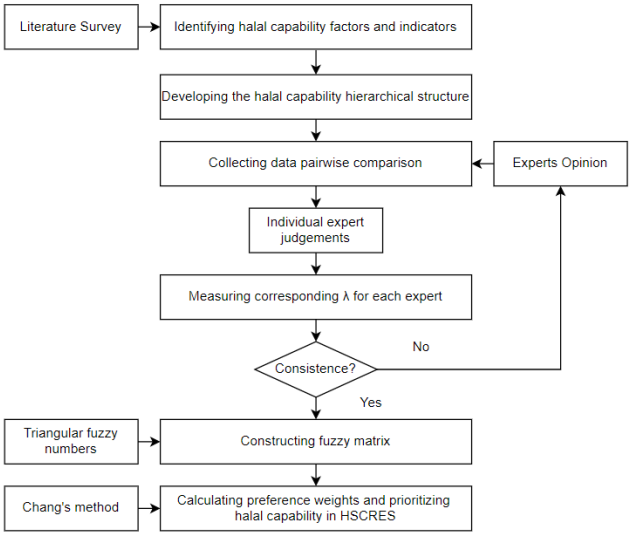

Fig. 2. Stages of conducting a case study

In this study, the extent analysis of the fuzzy AHP of [89] was adopted to calculate the importance weight of each capability indicator. Let the $X = \{x_1, x_2, \dots, x_n\}$ be the criterion set and $Y = \{y_1, y_2, \dots, y_n\}$ be the goal set; then, according to Chang's method, each criterion is considered and an extent analysis is performed for each goal of y_i. The extent value of each criterion set (m_i) can then be obtained as follows:

$$m_{gi}^1, m_{gi}^2, \dots, m_{gi}^n, i = 1,2, \dots, n \quad (2)$$

where all the m_{gi}^n is the triangular fuzzy number (TFNs), as presented in Table 3. Furthermore, the outlines of the fuzzy AHP procedures can be summarized as follows:

Step 1: The value of fuzzy synthetic (S_i) relating to the i^{th} criterion is formulated as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} \quad (3)$$

To obtain $\sum_{j=1}^{m} M_{gi}^j$, an additional fuzzy operation of m values is performed using the following formula:

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}\right) \quad (4)$$

And to results $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1}$ the additional fuzzy operation of $N_{gi}^j (j = 1, 2, \dots, n)$ values are performed using the formula:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \sum_{i=1}^{n} l_{ij}, \sum_{i=1}^{n} m_{ij}, \sum_{i=1}^{n} u_{ij} \quad (5)$$

Then, the vector invers is obtained using the formula:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_1}, \frac{1}{\sum_{i=1}^{n} m_1}, \frac{1}{\sum_{i=1}^{n} l_1}\right) \; where \; \forall u_i, m_i, l_i > 0 \quad (6)$$

Finally, the value of S_i is obtained using the multiplication formula as follows:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \sum_{j=1}^{m} l_j \otimes \sum_{i=1}^{n} l_i, \sum_{j=1}^{m} m \otimes \sum_{i=1}^{n} m_i, \sum_{j=1}^{m} u_j \otimes \sum_{i=1}^{n} u_i \quad (7)$$

Tab. 3. TFN scale of linguistic variables

Linguistic variables	Fuzzy triangular numbers (TFNs)
Equal	(1, 1, 1)
Very Low	(1, 2, 3)
Low	(2, 3, 4)
Moderate	(3, 4, 5)
High	(4, 5, 6)
Very Strong	(5, 6, 7)
Extreme	(7, 8, 9)

Step 2, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is formulated as:

$$V(M_2 \geq M) = sup_{y \geq x}[\min(\mu M_2(y))] \quad (8)$$

Which is equivalently composed as follows:

$$V(S_2 \geq S_1) = hgt(M_1 \cap M_2) = \mu M_2(d) = \begin{cases} 1 & if\ (m_2 \geq m_1) \\ 0 & if\ (l_1 \geq l_2) \\ \frac{(l_2 - u_1)}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \quad (9)$$

where d is the ordinate of the highest intersection value between μm_1 and μm_2. Figure 3 shows point P. Therefore, to compare m_1 and m_2, both values of $V(m_1 \geq m_2)$ and $V(m_2 \geq m)$ are needed.

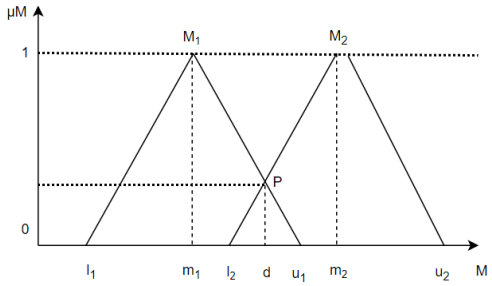

Fig. 3. The degree of possibility of $M_1 \geq M_2$

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i for $i = (1, 2, \dots, k)$ is formulated as:

$$V(M \geq M_1, M_2, \dots, M_k) = V[M \geq M_1)\ and\ (M \geq M_2)\ and \dots and\ (M \geq M_{k)}] = \min V(M \geq M_i)\ for\ i = 1, 2, \dots, k \quad (10)$$

Step 4: the normalized weight vectors are formulated as follows:

$$W = (\min V(S_1 \geq S_k) \min V(S_2 \geq S_k), \dots, \min V(S_n \geq S_k))^T\ for\ k = 1, 2, \dots, n \quad (11)$$

4. Result

4.1. Develop the hierarchical structure

The HSCRES capability elements were identified through the literature review and categorized into five factors and 19 indicators (see Table 1). A graphical representation of the HSCRES capability hierarchy is shown in Figure 4.

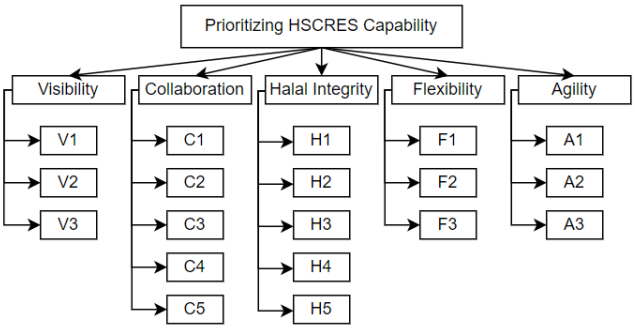

Fig. 4. The fuzzy AHP hierarchical structure of HSCRES capability

4.2. Development of fuzzy AHP pairwise comparison matrix

A fuzzy AHP comparison matrix was developed using the experts' linguistic scale pairwise assessment (see Table 3). A set of pairwise questionnaires was distributed to ten experts and their opinions were accommodated by comparing capability factors and capability indicators on a factor. The experts represented the halal food supply chain entities: halal auditors, academicians, professionals involved with halal food-producing and distributing firms in Indonesia, and the market. The halal auditor was from The Assessment Institute for Foods, Drugs, and Cosmetics, Indonesian Council of Ulama (LPPOM MUI). Academician was a researcher

with over 5 years of experience in the halal SC area. Production was manager of a halal food company with halal understanding and more than 2 years of experience. Distributors were halal-food sellers with more than 5 years of experience. The market consisted of consumers of halal food with halal knowledge. Detailed information about the experts is presented in Table 4.

Tab. 4. Description of the expert

Entities	Gender	Age	Experience
Halal auditor	F	48	20
Academician	L	33	10
Production 1	L	21	3
Production 2	L	39	15
Distributor 1	F	46	20
Distributor 2	F	53	25
Distributor 3	L	28	2
Consumer 1	F	52	32
Consumer 2	F	40	20
Consumer 3	L	44	24

The questionnaire required experts to compare the level of importance among the capability elements in crisp expressions. The experts' assessments were finalized using the geometric mean formula, and TFNs were used to transform the experts' crisp assessment into a fuzzy pairwise comparison matrix. Table 5 shows an example of a fuzzy AHP pairwise comparison matrix for capability factors.

Tab 4. Pairwise Comparison of the five HSCRES Capability Factors

	Visibility	Collaboration	Halal Integrity	Flexibility	Agility
Visibility	(1, 1, 1)	(0.25, 0.33, 0.5)	(0.14, 0.17, 0.2)	(0.25, 0.33, 0.5)	(0.25, 0.33, 0.5)
Collaboration	(2, 3, 4)	(1, 1, 1)	(0.17, 0.2, 0.25)	(0.33, 0.5,1)	(0.33, 0.5,1)
Halal Integrity	(5, 6, 7)	(4, 5, 6)	(1, 1, 1)	(4, 5, 6)	(3, 4, 5)
Flexibility	(2, 3, 4)	(1, 2, 3)	(0.17, 0.2, 0.25)	(1, 1, 1)	(1, 2, 3)
Agility	(2, 3, 4)	(1, 2, 3)	(0.2, 0.25, 0.33)	(0.33, 0.5,1)	(1, 1, 1)

4.3. Calculation of the HCRES capability weight

The preferred weights for each HSCRES capability factor and associate indicator were calculated using Chang's extent analysis method, which is expressed in Formula 2-9. The weight calculation of the HSCRES main capability factors was detailed to illustrate the application of Chang's method in this study. Using Equation (2-6), the fuzzy synthetic extent value (S) for each capability factor is calculated as follows:

$$S_V = (0.29, 0.36, 0.47) \otimes (5.16, 6.77, 8.51)^{-1} = (0.03, 0.05, 0.09)$$
$$S_C = (0.51, 0.68, 1) \otimes (5.16, 6.77, 8.51)^{-1} = (0.06, 0.1, 0.19)$$
$$S_H = (2.99, 3.59, 4.16) \otimes (5.16, 6.77, 8.51)^{-1} = (0.35, 0.53, 0.8)$$
$$S_F = (0.75, 1.19, 1.55) \otimes (5.16, 6.77, 8.51)^{-1} = (0.08, 0.17, 0.3)$$
$$S_A = (0.6, 0.94, 1.31) \otimes (5.16, 6.77, 8.51)^{-1} = (0.07, 0.13, 0.25)$$

Using formula (7) and ((8), V values and minimum degree of possibility are respectively calculated as follows:

$$D(V) = \min V(M_v \geq M_k) = \min(1.586, 2.439, 1.802, 1.715) = 1.586$$
$$D(C) = \min V(M_v \geq M_k) = \min(1, 2.576, 1.368, 1.212) = 1$$
$$D(H) = \min V(M_v \geq M_k) = \min(0.607, 1, 1, 1) = 0{,}607$$
$$D(F) = \min V(M_v \geq M_k) = \min(1, 1, 2.097, 1) = 1$$
$$D(A) = \min V(M_v \geq M_k) = \min(1, 1, 2.312, 1.118) = 1$$

Weight vector is calculated as follow:

$$W_f = (0.629, 0.658, 1, 0.121, 0.015\ 1)^T$$

Final weights after normalization process is determined as follows:

$W = (0.259, 0.271, 0.412, 0.050, 0.006)$

The same procedures were applied to weigh all indicators. The global weights of the factors, indicators, and final rankings are listed in Table 5.

Tab. 5. Weight of capability factors and indicators

Factors	Weight	Indica tors	Sub-Weight	Total Weight	Rank ing
Flexibility	0.067	F1	0.193	0.0130	10
		F2	0.435	0.0292	9
		F3	0.372	0.0249	10
Collaboration	0.364	C1	0.006	0.0021	16
		C2	0.161	0.0584	8
		C3	0.275	0.1001	5
		C4	0.338	0.1229	3
		C5	0.220	0.0801	7
Visibility	0.008	V1	0.039	0.0003	17
		V2	0.420	0.0035	13
		V3	0.541	0.0045	11
Agility	0.008	A1	0.258	0.0022	15
		A2	0.300	0.0025	14
		A3	0.442	0.0037	12
Halal Integrity	0.553	H1	0.179	0.0988	6
		H2	0.104	0.0577	9
		H3	0.229	0.1268	2
		H4	0.215	0.1185	4
		H5	0.273	0.1508	1

4.4. Sensitive analysis

A small change in the relative weights could affect the final ranking of the capability to change [90]. Sensitivy analysis was performed to assess the consistency ranks of specific factors by changing their weights. In this study, among all capability indicators, halal integrity was determined as the highest priority weight; therefore, this factor has the potential to influence other categories of capability indicators. Incremental value from 0.1 to 0.9 is applied to the halal integrity factor (H) to represent the effect of the sensitivity analysis (see Table 6).

Furthermore, the ranking of the individual capability indicators differs owing to variations in the main capability factors. In the sensitivity analysis for this study, when the "halal integrity" factor value is 0.1 the first rank of indicator is attained by "official Halal logo" (C4), while the "forecasting accuracy" (V1) settled in the last rank. The capability indicator C4 holds the first rank until the capability factor of the halal integrity value reaches a normal value (i.e., 0.553). From 0.1 to 0.5, the first rank is acquired by C4, and the ranks of most other capability indicators vary in the same pattern (see Figure 4 and Table 7).

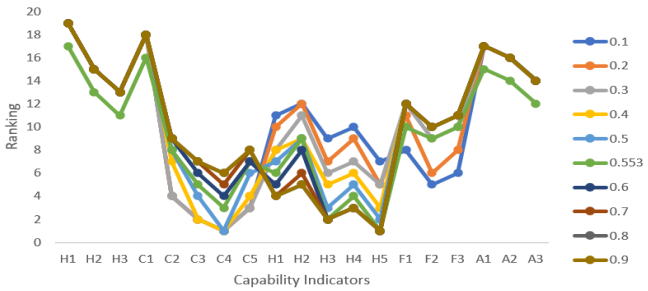

Fig. 4. Variety of rank of capability indicators respect to the increasing of halal integrity factor via sensitivity analysis

From the results of the sensitivity analysis, it can be revealed that specific capability indicator values fluctuate in reference to the change in the main factor values. From this case study instance, the Indicators Halal knowledge sharing (C2), communication channel (C3), official halal logo (C4), halal traceability (C5), halal team (H3), internal halal audit (H4), and mandatory regulation (H5) are very important in developing halal supply chain resilience due to their persistence in the top 10 rankings, regardless of the main factor varies from 0.1 0.9.

5. Discussion and Implications

In the present study, the AHP technique under fuzzy conditions was used to evaluate the capability of HSCRES to measure the degree of halal capability to defeat disruptions. To this end,

key formative factors and indicators of HSCRES capabilities have been identified in the literature and validated by experts. The priority order was halal integrity > collaboration > flexibility > visibility > agility. The results of the FAHP analysis of the main halal capability factor prioritization show that halal integrity is determined most significantly. The outcomes of the study also show that mandatory regulation (W_{H5} = 0.1508), halal team (W_{H3} = 0.1268), official halal logo (W_{C4} = 0.1229), internal halal audit (W_{H4} = 0.1185), and communication channel (W_{C5} = 0.1001) are the top five capability indicators that significantly contribute to sustaining HSCRES. This finding is confirmed by the sensitivity analysis results, which show that mandatory regulation, halal teams, official halal logos, internal halal audits, and communication channels are among the seven important indicators that remain in the top ten rankings despite varying main factor values. Halal mandatory regulation was ranked first among the set of HSCRES capability indicators. Earlier studies also determined that the lack of this capability has ranked 9th among operational halal food risks by [9], 8th among halal risk agents in retailing by [69], and was found to be the most critical risk factor in halal supply chain management.

Halal regulation is required to maintain the halal commitment of management to implement a halal standard in producing and distributing products [67]. In accordance with these findings, [91] argued that halal regulations are related to halal consumer awareness. The more extensive the level of implementation of halal regulations, the higher consumers' halal awareness will be obtained. Hence, paying attention to the regulator through a halal policy is needed to conform to the resiliency of HSC, especially when halal risks can be suppressed [92].

The Halal team has become a second priority in enhancing the capability of HSCRES. Halal teams play a critical role in developing and implementing halal regulations and procedures, monitoring suppliers and products, and conducting audits to ensure compliance with halal standards. The importance of halal teams has been revealed in earlier studies [5] which underlined the reason why halal teams are significant in developing halal resilience. For instance, [5] argued that halal teams muffle halal risks through three supply chain risk cycles: risk prevention, mitigation, and recovery. Furthermore, [93] revealed that the Halal team was needed in developing halal resilience by ensuring Halal compliance. The halal team is responsible for ensuring that all production processes comply with halal standards, including verifying and confirming that all ingredients and procedures used in the production of halal products are permissible. Similarly, [27] also argued that halal resilience could be maintained by building trust in the existence of a halal team. The halal team plays a role in building trust by ensuring that all products are halal-certified through a transparent and credible halal certification process.

The official halal logo is third-ranked in prioritizing the HSCRES capability. This outcome is in line with the views of previous studies by [94]; in which the authors determined the importance of halal logos in halal supply chain performance. For instance, [95] argued that the halal logo is a symbol of authenticity and compliance with Islamic principles. The halal logo is granted by an authorized certification that the products comply with Halal standards. Then, [96] added the argument by revealing that Halal logos reduced Halal risks from the consumer's side. Muslim consumers are interested in purchasing products that contain halal logos. In addition to providing assurance to consumers, [94] completed the argumentation that halal logos could reduce the risks of non-compliance and its associated costs. Halal logos can also reduce reputational damage risks resulting from non-compliant products.

The internal halal audit appeared to be the fourth highest of all identified capabilities. The success of an internal halal audit directly affects HSCRES. [5] stated that by conducting an internal halal audit, potential halal risks can be identified and corrected to improve resilience. Correction involves selecting alternative halal suppliers, implementing contingency plans, and improving communication and collaboration with halal supply chain partners. Moreover, [69] found that a comprehensive internal halal audit program shows commitment to maintaining halal compliance throughout the supply chain, which can enhance reputation and trustworthiness in the market. This, in turn, can help mitigate the negative impact of disruptions on supply chain operations, as stakeholders become habituated to understanding and supportive during times of crisis.

Finally, the communication channel emerged as the fifth profound capability indicator in maintaining HSCRES. Effective communication channels can enhance halal resilience by encouraging collaboration, developing trust, and providing information. Communication channels facilitate collaboration between entities in HSC, such as the government, certification bodies, and

industry stakeholders, as a holistic system [97]. This collaboration allows entities to share halal information and provides a traceability system to strengthen the halal ecosystem and enhance halal resilience.

This study has several implications for regulatory, management, and certification bodies regarding implementation strategies for enhancing HSCRES. These findings offer support for extending the understanding of significant capability indicators to obtain a good level of resilience in HSC.

The results of this study provide a comprehensive list of capability indicators to enhance HSCRES that can help stakeholders develop effective strategies based on the priority ranking of the indicators. The government must establish robust regulations and decisive sanctions for industrial actors to maintain compliance with halal standards. Similarly, [92] suggested the role of regulators in supporting HSCRES in six ways: regulation, financial incentives, taxation, infrastructure, guidance and encouragement, and education and labor supply. The knowledge contained in this paper advises industrial management to make strategic decisions to intensify the company's capability in dealing with possible halal risks. All managers are advised to conduct an internal halal audit program periodically. To support this program, establishing a halal team with enhanced halal knowledge and skills of the personnel helps the management develop a rigorous internal auditing system [98]. Finally, the findings of this study also encourage certification bodies to enhance the resilience of the HSC trough by implementing a convenient and efficient halal certification procedure to complement halal products with official halal logos. As stated by [72] the certification bodies can expand their efforts to socialize and share information to enhance industry awareness. Therefore, a conducive atmosphere is established, and a resilient halal supply chain is obtained.

6. Conclusions and Limitations

This study identified 19 indicators of HCSRES capability using a comprehensive literature review, and categorized them into five main factors. The list of capabilities of HSCRES will certainly facilitate stakeholders' understanding of the theory of halal resilience. The identified indicators were analyzed and prioritized using the fuzzy AHP approach. Assessments from ten experts in HSC were utilized to obtain pairwise comparison data needed for this study, which resulted in the relative weights of various capability factors and indicators. Sensitivity analysis confirmed the calculation by determining the ranking of capability indicators while varying the weight of the factor. The outcome of this study shows that halal integrity is the top rank of the HSCRES capability factor, followed by collaboration flexibility visibility agility. This study also revealed that mandatory regulation, halal teams, official halal logos, internal halal audits, and communication channels are the most prominent capability indicators for strengthening the resilience of HSC. The findings of this study would motivate all HSC stakeholders to develop a set of comprehensive strategies to enhance possible capabilities. Based on priority ranking, management, government, and certification bodies can formulate specific policies, procedures, and programs for halal capability management to improve halal resilience levels.

Similar to other studies, this study had a few limitations. First, this study only reveals 19 capability indicators that are grouped into five factors from the literature review; more capabilities may not have been recognized and classified. Hence, future research could investigate and select studies from a large and different sample set. Further research should conduct quantitative research based on a survey to determine the selection and categorization of capability indicators through factor analysis. Second, as the use of FAHP is natural, the views of decision-makers may be subjective. Future research could apply different MCDM approaches, such as ANP, DEMATEL, BMW, TOPSIS, and VIKOR, to prioritize capability factors and indicators, so that the results can be compared to obtain comprehensive outcomes. Third, this study was restricted to the classification and ranking of indicators of halal capability in HSCRES. Further research can be performed to determine the immediate effect of capability indicators on halal resilience and construct a strategic approach to enhance this capacity.

Tab. 6. Variation in weights of capability factors after increasing the H weight value

Factors	Run 1	Run 2	Run 3	Run 4	Run 5	Normalized weight	Run 6	Run 7	Run 8	Run 9
F	0.135	0.120	0.105	0.090	0.075	0.067	0.060	0.045	0.030	0.015
C	0.731	0.650	0.569	0.488	0.406	0.364	0.325	0.244	0.163	0.081
A	0.017	0.015	0.013	0.011	0.009	0.008	0.008	0.006	0.004	0.002

V	0.017	0.015	0.013	0.011	0.009	0.008	0.008	0.006	0.004	0.002
H	0.100	0.200	0.300	0.400	0.500	0.553	0.600	0.700	0.800	0.900
Total	1	1	1	1	1	1	1	1	1	1

Tab. 7. Rank of capability indicators when variying halal integrity factor via sensitivity analysis

Indicators	Run 1 0.1	Run2 0.2	Run 3 0.3	Run 4 0.4	Run 5 0.5	Normalized weight (0.553)	Run 6 0.6	Run 7 0.7	Run 8 0.8	Run 9 0.9
F1	8	11	12	12	12	10	12	12	12	12
F2	5	6	9	10	10	9	10	10	10	10
F3	6	8	10	11	11	10	11	11	11	11
C1	18	18	18	18	18	16	18	18	18	18
C2	4	4	4	7	8	8	9	9	9	9
C3	2	2	2	2	4	5	6	7	7	7
C4	1	1	1	1	1	3	4	5	6	6
C5	3	3	3	4	6	7	7	8	8	8
V1	19	19	19	19	19	17	19	19	19	19
V2	15	15	15	15	15	13	15	15	15	15
V3	13	13	13	13	13	11	13	13	13	13
A1	17	17	17	17	17	15	17	17	17	17
A2	16	16	16	16	16	14	16	16	16	16
A3	14	14	14	14	14	12	14	14	14	14
H1	11	10	8	8	7	6	5	4	4	4
H2	12	12	11	9	9	9	8	6	5	5
H3	9	7	6	5	3	2	2	2	2	2
H4	10	9	7	6	5	4	3	3	3	3
H5	7	5	5	3	2	1	1	1	1	1

7. Acknowledgment

This study was supported by the Ministry of Research, Technology and Higher Education-Republic of Indonesia with the Indonesian Endowment Fund for Education (LPDP), Ministry of Finance, and the Republic of Indonesia under BUDI DN for doctoral study.

References

[1] H. Rahim, H. M. Irpan, and M. S. A. Rasool, "Consumers Attitude toward Halal Food Products in Malaysia: Empirical Evidence from Malaysian Millenial Muslims," *Int. J. Ind. Eng. Prod. Res.*, Vol. 33, No. 3, (2022), pp. 1-15.

[2] M. H. Zulfakar, M. M. Anuar, and M. S. A. Talib, "Conceptual Framework on Halal Food Supply Chain Integrity Enhancement," *Procedia - Soc. Behav. Sci.*, Vol. 121, (2014), pp. 58-67.

[3] H. C. Wahyuni, I. Vanany, and U. Ciptomulyono, "Food Safety and Halal Food Risks in Indonesian Chicken Meat Products: An Exploratory Study," *IEEE Int. Conf. Ind. Eng. Eng. Manag.*, Vol. 2019-Decem, (2019), pp. 1011-1015.

[4] S. Y. Ponomarov and M. C. Holcomb, *Understanding the concept of supply chain resilience*, Vol. 20, No. 1, (2009).

[5] M. Tieman, "Halal risk management: combining robustness and resilience," *J. Islam. Mark.*, (2017).

[6] O. Aigbogun, Z. Ghazali, and R. Razali, "Collaborative Regulation and Supply Chain Resilience: A Conceptual Paper," *SHS Web Conf.*, Vol. 56, (2018), p. 05002.

[7] E. N. Omar, H. S. Jaafar, and M. R. Osman, "Halal supply chain: Assessing the Islamic values of the poultry industry," *Int. J. Supply Chain Manag.*, Vol. 8, No. 2, (2019), pp. 1191-1199.

[8] M. L. Tseng *et al.*, "Data-driven on sustainable food supply chain: a comparison on Halal and non-Halal food system," *J. Ind. Prod. Eng.*, Vol. 39, No. 6, (2022), pp. 430-457.

[9] S. Khan, M. I. Khan, A. Haleem, and A. R. Jami, "Prioritising the risks in Halal food supply chain: an MCDM approach," *J. Islam. Mark.*, (2019).

[10] N. Rishelin and R. Ardi, "Prioritizing risks of halal meat supply chain in Indonesian downstream sector using DEMATEL-

based ANP," *IEEE Int. Conf. Ind. Eng. Eng. Manag.*, Vol. 2020-Decem, (2020), pp. 711-715.

[11] M. H. Ali, K. H. Tan, K. Pawar, and Z. M. Makhbul, "Extenuating food integrity risk through supply chain integration: The case of halal food," *Ind. Eng. Manag. Syst.*, Vol. 13, No. 2, (2014), pp. 154-162.

[12] A. Sarwar, A. Zafar, and A. Qadir, "Analysis and prioritization of risk factors in the management of Halal supply chain management," *Discov. Sustain.*, Vol. 2, No. 1, (2021).

[13] H. C. Wahyuni, I. Vanany, U. Ciptomulyono, and J. D. T. Purnomo, "Integrated risk to food safety and halal using a Bayesian Network model," *Supply Chain Forum*, Vol. 21, No. 4, (2020), pp. 260-273.

[14] S. Khan, A. Haleem, and M. I. Khan, "Risk management in Halal supply chain: an integrated fuzzy Delphi and DEMATEL approach," *J. Model. Manag.*, Vol. 16, No. 1, (2021), pp. 172-214.

[15] N. Alemsan, G. Tortorella, C. M. Taboada Rodriguez, H. Balouei Jamkhaneh, and R. M. Lima, "Lean and resilience in the healthcare supply chain – a scoping review," *Int. J. Lean Six Sigma*, (2022).

[16] T. Saaty, *Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks*. RWS Publications, (2005).

[17] S. K. Mangla, P. Kumar, and M. K. Barua, "Risk analysis in green supply chain using fuzzy AHP approach: A case study," *Resour. Conserv. Recycl.*, Vol. 104, (2015), pp. 375-390.

[18] O. Aigbogun, Z. Ghazali, and R. Razali, "Resilience attributes of halal logistics on the pharmaceutical supply chain," *Glob. Bus. Manag. Res.*, Vol. 7, No. 3, (2015), pp. 34-43.

[19] Y. Han, W. K. Chong, and D. Li, "A systematic literature review of the capabilities and performance metrics of supply chain resilience," *Int. J. Prod. Res.*, (2020), pp. 4541-4566.

[20] G. A. Zsidisin and S. M. Wagner, "Do Perception Become Reality? The Moderating Role of SCM on Disruption Occurrence," *J. Bus. Logist.*, Vol. 31, No. 2, (2010), pp. 1-20.

[21] T. J. Pettit, "Ensuring Supply CHain Resilience Development of A Conceptual Framework," *J. Bus. Logist.*, Vol. 31, No. 1, (2010).

[22] M. Tieman, "Halal reputation management: Combining individual and collective reputation management strategies," *ICR*, Vol. 8, No. 1, (2017), pp. 115-119.

[23] B. R. Tukamuhabwa, M. Stevenson, J. Busby, and M. Zorzini, "Supply chain resilience: Definition, review and theoretical foundations for further study," *Int. J. Prod. Res.*, Vol. 53, No. 18, (2015), pp. 5592-5623.

[24] J. Stone and S. Rahimifard, "Resilience in agri-food supply chains: a critical analysis of the literature and synthesis of a novel framework," *Supply Chain Manag.*, Vol. 23, No. 3, (2018), pp. 207-238.

[25] N. Johnson, D. Elliott, and P. Drake, "Exploring the role of social capital in facilitating supply chain resilience," *Supply Chain Manag.*, Vol. 18, No. 3, (2013), pp. 324-336.

[26] N.-O. Hohenstein, E. Feisel, E. Hartmann, and L. Giunipero, "Research on the phenomenon of supply chain resilience: A systematic review and paths for further investigationNo Title," *Int. J. Phys. Distrib. Logist. Manag.*, Vol. 45, No. 1/2, (2015), pp. 90-117.

[27] Y. H. Mohamed, A. R. Abdul Rahim, and A. Ma'aram, "The effect of halal supply chain management on halal integrity assurance for the food industry in Malaysia," *J. Islam. Mark.*, Vol. 12, No. 9, (2020), pp. 1734-1750.

[28] J. D. Smith and M. Hasan, "Quantitative

approaches for the evaluation of implementation research studies," *Psychiatry Res.*, Vol. 283, No. August 2019, (2020), p. 112521.

[29] M. I. Khan, S. Khan, and A. Haleem, "Analysing barriers towards management of Halal supply chain: a BWM approach," *J. Islam. Mark.*, Vol. 13, No. 1, (2022), pp. 66-80.

[30] M. Kamalahmadi and M. Mellat-Parast, "Developing a resilient supply chain through supplier flexibility and reliability assessment," *Int. J. Prod. Res.*, Vol. 54, No. 1, (2016), pp. 302-321.

[31] C. R. Pereira, M. Christopher, and A. Lago Da Silva, "Achieving supply chain resilience: the role of procurement," *Supply Chain Manag.*, Vol. 19, No. January, (2014), pp. 626-642.

[32] P. Mukucha and F. Chari, "Supply chain resilience: the role of supplier development in the form of contract farming in fast-food outlets in Zimbabwe," *Contin. Resil. Rev.*, Vol. 4, No. 3, (2022), pp. 280-299.

[33] S. Hosseini, D. Ivanov, and A. Dolgui, "Review of quantitative methods for supply chain resilience analysis," *Transp. Res. Part E Logist. Transp. Rev.*, Vol. 125, No. February, (2019), pp. 285-307.

[34] A. D. Diamantidis and P. Chatzoglou, "Factors affecting employee performance: an empirical approach," *Int. J. Product. Perform. Manag.*, Vol. 68, No. 1, (2019), pp. 171-193.

[35] J. S. L. Lam and X. Bai, "A quality function deployment approach to improve maritime supply chain resilience," *Transp. Res. Part E Logist. Transp. Rev.*, Vol. 92, (2016), pp. 16-27.

[36] H. Carvalho, A. P. Barroso, V. H. MacHado, S. Azevedo, and V. Cruz-Machado, "Supply chain redesign for resilience using simulation," *Comput. Ind. Eng.*, Vol. 62, No. 1, (2012), pp. 329-341.

[37] Y. Sheffi and J. B. Rice, "A supply chain view of the resilient enterprise," *MIT Sloan Manag. Rev.*, Vol. 47, No. 1, (2005).

[38] P. Priya Datta, M. Christopher, and P. Allen, "Agent-based modelling of complex production/distribution systems to improve resilience," *Int. J. Logist. Res. Appl.*, Vol. 10, No. 3, (2007), pp. 187-203.

[39] M. Kamalahmadi, M. Shekarian, and M. Mellat Parast, "The impact of flexibility and redundancy on improving supply chain resilience to disruptions," *Int. J. Prod. Res.*, Vol. 60, No. 6, (2022), pp. 1992-2020.

[40] M. Nunes, A. Abreu, J. Bagnjuk, E. Nunes, and C. Saraiva, "A Strategic Process to Manage Collaborative Risks in Supply Chain Networks (SCN) to Improve Resilience and Sustainability," *Sustain.*, Vol. 14, No. 9, (2022).

[41] B. Chaudhuri and L. Kendall, "Collaboration without consensus: Building resilience in sustainable agriculture through ICTs," *Inf. Soc.*, Vol. 37, No. 1, (2021), pp. 1-19.

[42] Y. Sheffi and J. B. R. Jr, "A Supply Chain View of the Resilient Enterprise," *MIT Sloan Manag. Rev.*, Vol. 47, No. 1, (2005), pp. 41-48.

[43] M. Umar and M. Wilson, "Supply chain resilience: unleashing the power of collaboration in disaster management," *Sustain.*, Vol. 13, No. 19, (2021).

[44] M. Lotfi and A. Larmour, "Supply chain resilience in the face of uncertainty: how horizontal and vertical collaboration can help?," *Contin. Resil. Rev.*, Vol. 4, No. 1, (2022), pp. 37-53.

[45] M. Kamalahmadi and M. M. Parast, "A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research," *Int. J. Prod. Econ.*, Vol. 171, (2016), pp. 116-133.

[46] Y. Fan, M. Stevenson, and F. Li, "Supplier-initiating risk management behaviour and supply-side resilience: the effects of

interpersonal relationships and dependence asymmetry in buyer-supplier relationships," *Int. J. Oper. Prod. Manag.*, Vol. 40, No. 7-8, (2020), pp. 971-995.

[47] S. Sikombe and M. A. Phiri, "Exploring tacit knowledge transfer and innovation capabilities within the buyer–supplier collaboration: a literature review," *Cogent Bus. Manag.*, Vol. 6, No. 1, (2019).

[48] N. S. Mohd Riza, M. F. Md Ariffin, M. N. Hamdan, and N. Ramli, "Halal food: a social responsibility on cartel meat issue in Malaysia," *Food Res.*, Vol. 6, No. 3, (2022), pp. 92-100.

[49] M. S. Ab Talib and A. B. A. Hamid, "Halal logistics in Malaysia: A SWOT analysis," *J. Islam. Mark.*, Vol. 5, No. 3, (2014), pp. 322-343.

[50] M. S. Ab Talib, A. B. A. Hamid, and M. H. Zulfakar, "Halal supply chain critical success factors: A literature review," *J. Islam. Mark.*, Vol. 6, No. 1, (2015), pp. 44-71.

[51] A. Patidar, M. Sharma, R. Agrawal, and K. S. Sangwan, "Supply chain resilience and its key performance indicators: an evaluation under Industry 4.0 and sustainability perspective," *Manag. Environ. Qual. An Int. J.*, (2022).

[52] S. Mandal, "Supply chain resilience: A state-of-the-art review and research directions," *Int. J. Disaster Resil. Built Environ.*, Vol. 5, No. 4, (2014), pp. 427-453.

[53] S. J. Juan, E. Y. Li, and W. H. Hung, "An integrated model of supply chain resilience and its impact on supply chain performance under disruption," *Int. J. Logist. Manag.*, Vol. 33, No. 1, (2021), pp. 339-364.

[54] B. R. Tukamuhabwa, M. Stevenson, J. Busby, and M. Zorzini, "Supply chain resilience: Definition, review and theoretical foundations for further study," *Int. J. Prod. Res.*, Vol. 53, No. 18, (2015), pp. 5592-5623.

[55] R. K. Singh, A. Gupta, and A. Gunasekaran, "Analysing the interaction of factors for resilient humanitarian supply chain," *Int. J. Prod. Res.*, Vol. 56, No. 21, (2018), pp. 6809-6827.

[56] A. Jabbarzadeh, B. Fahimnia, and F. Sabouhi, "Resilient and sustainable supply chain design: sustainability analysis under disruption risks," *Int. J. Prod. Res.*, Vol. 56, No. 17, (2018), pp. 5945-5968.

[57] E. Bottani, T. Murino, M. Schiavo, and R. Akkerman, "Resilient food supply chain design: Modelling framework and metaheuristic solution approach," *Comput. Ind. Eng.*, Vol. 135, No. May, (2019), pp. 177-198.

[58] A. H. Abdelaal, G. McKay, and H. R. Mackey, "Food waste from a university campus in the Middle East: Drivers, composition, and resource recovery potential," *Waste Manag.*, Vol. 98, (2019), pp. 14-20.

[59] R. Yarveisy, C. Gao, and F. Khan, "A simple yet robust resilience assessment metrics," *Reliab. Eng. Syst. Saf.*, Vol. 197, No. September 2019, (2020), p. 106810.

[60] P. Childerhouse, M. Al Aqqad, Q. Zhou, and C. Bezuidenhout, "Network resilience modelling: a New Zealand forestry supply chain case," *Int. J. Logist. Manag.*, Vol. 31, No. 2, (2020), pp. 291-311.

[61] U. Jüttner and S. Maklan, "Supply chain resilience in the global financial crisis: An empirical study," *Supply Chain Manag.*, Vol. 16, No. 4, (2011), pp. 246-259.

[62] A. Wieland and C. M. Wallenburg, "The influence of relational competencies on supply chain resilience: A relational view," *Int. J. Phys. Distrib. Logist. Manag.*, Vol. 43, No. 4, (2013), pp. 300-320.

[63] F. Lestari, M. Mawardi, M. Yola, Y. Muda, and A. B. Abdul Hamid, "A model for assessment of Halal Good Manufacturing Practice in meat industry," *Prod. Manuf. Res.*, Vol. 10, No. 1, (2022), pp. 666-695.

[64] A. Susanty, N. B. Puspitasari, S. Jati, and O. Selvina, "Impact of internal and external factors on halal logistics implementation," *J. Islam. Mark.*, Vol. 13, No. 5, (2022), pp. 1143-1170.

[65] A. N. Ahmad, R. Abdul Rahman, M. Othman, and U. F. Ungku Zainal Abidin, "Critical success factors affecting the implementation of halal food management systems: Perspective of halal executives, consultants and auditors," *Food Control*, Vol. 74, (2017), pp. 70-78.

[66] S. Zailani, M. Iranmanesh, A. A. Aziz, and K. Kanapathy, "Halal logistics opportunities and challenges," *J. Islam. Mark.*, Vol. 8, No. 1, (2017), pp. 127-139.

[67] M. Tieman and M. C. Ghazali, "Principles in halal purchasing," *J. Islam. Mark.*, Vol. 4, No. 3, (2013), pp. 281-293.

[68] Kohilavani, W. Zzaman, N. A. Febrianto, N. S. Zakariya, W. N. W. Abdullah, and T. A. Yang, "Embedding Islamic dietary requirements into HACCP approach," *Food Control*, Vol. 34, No. 2, (2013), pp. 607-612.

[69] U. Maman, A. Mahbubi, and F. Jie, "Halal risk mitigation in the Australian–Indonesian red meat supply chain," *J. Islam. Mark.*, Vol. 9, No. 1, (2018), pp. 60-79.

[70] M. H. Ali, M. Iranmanesh, K. H. Tan, S. Zailani, and N. A. Omar, "Impact of supply chain integration on halal food supply chain integrity and food quality performance," *J. Islam. Mark.*, Vol. 13, No. 7, (2022), pp. 1515-1534.

[71] B. Othman, S. M. Shaarani, and A. Bahron, "Evaluation of knowledge, halal quality assurance practices and commitment among food industries in Malaysia," *Br. Food J.*, Vol. 118, No. 8, (2016), pp. 2033-2052.

[72] S. Prabowo, A. A. Rahman, S. A. Rahman, and A. A. Samah, "Revealing factors hindering halal certification in East Kalimantan Indonesia," *J. Islam. Mark.*, Vol. 6, No. 2, (2015), pp. 268-291.

[73] M. S. Ab Talib, S. S. Siti, A. B. Abdul Hamid, and T. Ai Chin, "Emerging Halal food market: an Institutional Theory of Halal certificate implementation," *Manag. Res. Rev.*, Vol. 39, No. 9, (2016), pp. 987-997.

[74] T. Saaty, *The Analytic Hierarchy Process*. University of Pittsburgh, Pittsburgh, (1993).

[75] Y. T. Abdul-Hamid, A. K. Kochhar, and M. K. Khan, "An analytic hierarchy process approach to the choice of manufacturing plant layout," *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, Vol. 213, No. 4, (1999), pp. 397-406.

[76] A. Susanty, N. B. Puspitasari, Silviannisa, and S. Jati, "Prioritizing Indicators for Measuring Halal Logistics Implementation," *2021 IEEE Int. Conf. Ind. Eng. Eng. Manag. IEEM*, (2021), pp. 73-77.

[77] F. Bagheri and M. . Tarokh, "A fuzzy approachfor multi-objective supplier selection," *Int. J. Ind. Eng. Prod. Res.*, Vol. 21, No. 1, (2010), pp. 1-9.

[78] A. Esfahanipour and H. Davari-ardakani, "A hybrid Multi Criteria Approach for Performance Evaluation : The Case of a," *Int. J. Ind. Eng. Prod. Res.*, Vol. 26, No. 4, (2015), pp. 287-309.

[79] X. Wang, H. K. Chan, R. W. Y. Yee, and I. Diaz-Rainey, "A two-stage fuzzy-AHP model for risk assessment of implementing green initiatives in the fashion supply chain," *Int. J. Prod. Econ.*, Vol. 135, No. 2, (2012), pp. 595-606.

[80] P. C. Shete, Z. N. Ansari, and R. Kant, "A Pythagorean fuzzy AHP approach and its application to evaluate the enablers of sustainable supply chain innovation," *Sustain. Prod. Consum.*, Vol. 23, (2020), pp. 77-93.

[81] O. Aigbogun, Z. Gazhali, and R. Razali, "The Mediating Impact of Halal Logistics

on Supply Chain Resilience: An Agency Perspective," *Int. Rev. Manag. Mark.*, Vol. 6, No. S4, (2016), pp. 209-2016.

[82] V. Venkantesh, J. Y. L. Thong, and Xi. Xu, "Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology," *MIS Q.*, Vol. 36, No. 1, (2012), pp. 157-178.

[83] F. Aqlan and S. S. Lam, "A fuzzy-based integrated framework for supply chain risk assessment," *Int. J. Prod. Econ.*, Vol. 161, (2015), pp. 54-63.

[84] D. Adebanjo, T. Laosirihongthong, and P. Samaranayake, "Prioritizing lean supply chain management initiatives in healthcare service operations: a fuzzy AHP approach," *Prod. Plan. Control*, Vol. 27, No. 12, (2016), pp. 953-966.

[85] K. Govindan, S. K. Mangla, and S. Luthra, "Prioritising indicators in improving supply chain performance using fuzzy AHP: insights from the case example of four Indian manufacturing companies," *Prod. Plan. Control*, Vol. 28, No. 6-8, (2017), pp. 552-573.

[86] D. Kumar, Z. Rahman, and F. T. S. Chan, "A fuzzy AHP and fuzzy multi-objective linear programming model for order allocation in a sustainable supply chain: A case study," *Int. J. Comput. Integr. Manuf.*, Vol. 30, No. 6, (2017), pp. 535-551.

[87] R. Kumar and S. Kansara, "Information technology barriers in Indian sugar supply chain: an AHP and fuzzy AHP approach," *Benchmarking*, Vol. 25, No. 7, (2018), pp. 1978-1991.

[88] S. Lahane and R. Kant, "Evaluating the circular supply chain implementation barriers using Pythagorean fuzzy AHP-DEMATEL approach," *Clean. Logist. Supply Chain*, Vol. 2, No. September, (2021), p. 100014.

[89] D. Y. Chang, "Applications of the extent analysis method on fuzzy AHP," *Eur. J. Oper. Res.*, Vol. 95, No. 3, (1996), pp. 649-655.

[90] C. W. Chang, C. R. Wu, C. T. Lin, and H. C. Chen, "An application of AHP and sensitivity analysis for selecting the best slicing machine," *Comput. Ind. Eng.*, Vol. 52, No. 2, (2007), pp. 296-307.

[91] A. Norhayati Rafida, A. Siti Mashitoh, and A. Alina, "Perception Towards Halal Awareness and its Correlation with Halal Certification among Muslims," *Middle-East J. Sci. Res.*, Vol. 13, (2013), pp. 1-4.

[92] M. S. Ab Talib, L. L. Pang, and A. H. Ngah, "The role of government in promoting Halal logistics: a systematic literature review," *J. Islam. Mark.*, Vol. 12, No. 9, (2020), pp. 1682-1708.

[93] A. Susanty, N. B. Puspitasari, S. Silviannisa, and S. Jati, "Measuring halal logistics implementation," *J. Islam. Mark.*, (2022).

[94] D. S. Sayogo, "Online traceability for halal product information: perceptions of Muslim consumers in Indonesia," *J. Islam. Mark.*, Vol. 9, No. 1, (2018), pp. 99-116.

[95] M. Aliff Abdul Majid, I. Hafifi Zainal Abidin, and C. Tamby Chik, "Issues of Halal Food Implementation in Malaysia FOOD SERVICE MANAGEMENT View project HALAL Management View project," *J. Appl. ...*, no. January, (2015).

[96] Z. Mohamed, M. N. Shamsudin, and G. Rezai, "The Effect of Possessing Information About Halal Logo on Consumer Confidence in Malaysia," *J. Int. Food Agribus. Mark.*, Vol. 25, No. SUPPL1, (2013), pp. 73-86.

[97] N. Noordin, N. L. M. Noor, and Z. Samicho, "Strategic Approach to Halal Certification System: An Ecosystem Perspective," *Procedia - Soc. Behav. Sci.*, Vol. 121, No. September 2012, (2014), pp. 79-95.

[98] M. I. Khan and A. Haleem, "Understanding ' Halal ' and ' Halal Certification & Accreditation System ' - A Brief Review,"

Saudi J. Bus. Manag. Stud., Vol. 1, No. 1, (2016), pp. 32-42.