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Implementing Traceability Systems in Specific Supply Chain Management (SCM) through Critical Success Factors (CSFs)

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Abstract: Traceability plays a vital role in the success of Halal Supply Chain (HSC). HSC revolve around the essential dimension of Halal Integrity (HI), whereas traceability is seemed to be medium to assure integrity. Thus, a need is felt to identify the factors which are critical to the successful implementation of traceability in Halal Supply Chain Management (HSCM). Identified Twelve Critical Success Factors (CSFs) through an extensive review of literature and opinion of experts. Further, a contextual relationship among the CSFs is developed using Total Interpretive Structure Modelling (TISM) approach and derived a model. The structural model is analyzed using Fuzzy MICMAC (Matrice d'Impacts Croises-Multipication Applique and Classment-cross-impact matrix multiplication applied to classification) approach to identify the importance of CSFs by driving and dependence power. The primary result indicates towards; that improving the HSCM with the higher level of Halal awareness. Assuring HI will enhance the consumer satisfaction which leads to a competitive advantage for the organization. Academic researchers, industrial practitioners and Supply Chain executives can understand the complex interrelationship of CSFs by visualizing the TISM. It can help the management, lobbies and government to develop the policies regarding the implementation.

Keywords: Critical Success Factor (CSF); Halal Supply Chain (HSC); Integrity; fuzzy MICMAC; traceability system; Total Interpretive Structure Model (TISM)

1. Introduction

In the present scenario, consumers are becoming concerned about the products which they consume. They are bothered about product origin, raw materials, production method, the labor standards implemented, animal welfare and the environmental impact of production [1]. This awareness is positively contributing towards incorporating traceability in the supply chain. Traceability provides a set of continuous information about the source of raw material, process, logistics and location of the product along the supply chain. It also acts as tracking and communication mechanism to ensure that information is accessible along the supply chain. The main aim of a traceability system is to provide the history of the product, for example, to provide a source of cross-contamination [2].

Traceability systems have prominence in food supply chain, cold supply chain and supply chain of fish etc. [3]. Similar to these supply chains, Halal Supply Chain (HSC) gives great prominence to

traceability system to assure Halalness (or Halal status) of its product to the customer. An efficient traceability system can reduce the risk associated with the Halal products (risk of contamination, non-Halal raw material and non-Halal process).

Halal is not only a matter of final product, but it depends on the ingredient/raw material, procurement, production process followed, packaging, transportation, storage, handling, distribution and retailing of the product. Halal status of a product is maintained with the complete compliance to product integrity from origin to consumption [4]. Studies report that implementation of traceability is beneficial to maintain the Halal Integrity (HI) [4,5]. Thus, traceability plays a significant role in the success of the Halal Supply Chain Management (HSCM). Further, it effectively identifies product attributes, process attributes, logistic information, participant node attributes, along with marketing attributes in the supply chain for upstream as well as for the downstream and this information is recorded at each node & stored in the database.

Implementation of a traceability system for the whole supply chain is not an easy task and required an appropriate strategy. Critical Success Factors (CSFs) of effective implementation of traceability system and interaction among them may help in developing an effective strategy for the system. In this paper, CSFs of effective implementation of traceability system in HSC are identified and interaction among these contextual CSFs is modelled using Total Interpretive Structure Modelling (TISM) [6]. Further, these CSFs are analyzed using Fuzzy-MICMAC (Matrice d'Impacts Croises-Multipication Applique and Classment-cross-impact matrix multiplication applied to classification) approach. The interpretation of these provides a recommendation to stakeholders for the overall performance of HSC and better customer satisfaction.

2. Background of the Study

2.1. Definitions of Traceability

The traceability can be defined through different perceptions of legislation, organizations and research literature. The International Organization for Standardization (ISO) defines traceability as "*ability to follow the movement of products through specified stage(s) of production, processing and distribution*" [7]. This definition is redefined by Olsen and Borit [8] as "*the ability to access any or all information relating to that which is under consideration, throughout its entire lifecycle, using recorded identifications*".

The available definitions in the literature were tried to define the "product based" traceability such as "food traceability". However, ISO definitions are for "generic traceability" and not specific to a product or a commodity. Most of the definitions of traceability are treated as "*a tool to trace and follow*", "*a tool for information retrieval*", "*a record-keeping system*", "*a part of logistics management*" and "*tool for communication*".

However, generic definition of traceability does not reflect the particular characteristics of traceability as required for Halal products. Traceability of Halal product has one additional focus on Halal transparency in the supply chain along with the general traceability purposes. The primary objective of a traditional traceability system is to precisely log the history and the location of the various products along the supply chain. More Halal transparency is leading to an increase in the consumer trust of the Halal status of product due to a significant amount of information about the raw material, production process, storage, transportation and retailing.

2.2. Principles of Traceability

There are many studies describes the principle of traceability in several types of industries. Fox, Barbuceanu and Gruninger [9] introduced traceable resource unit (TRU). TRU is the name of an entity which is traceable. In industrial application, TRU is referring to batch or lot, which is the smallest uniquely identified unit during the production. Traceability depended on the defined relationship between these units.

Moe [10] has a similar view but the special focus is on the unique identification number of the product. In case of batch processes, a TRU is a unique unit from the traceability perspective but in the event of a continuous process, it depends on the raw material TRUs or processing conditions.

Storøy et al. [11] follows the same approach but deals in a very elaborative manner. According to them, trade units must be uniquely identified, through additional information linked to these units using the unique identification number. In addition to this information, all transformations (split and joints) are recorded. Transformations are points where the resources are added or/and split up/transferred/mixed [12].

Opara [13] suggested that traceability consists of six elements:

- "product traceability" (which ascertains the location of a product)
- "process traceability" (which determines the nature and orders of activities on product)
- "genetic traceability" (which determines the genetic composition of the product)
- "input traceability" (which determines the nature and source of inputs)
- "disease and pest traceability" (which traces the epidemiology of pests and biotic hazards)
- "measurement traceability" (relating individual measurements results through an unbroken chain of calibrations to accepted reference standards).

Based on the use of traceability Jansen-Vullers et al. [14] identified that traceability has to be viewed in an active and passive sense. In passive-sense traceability, the location of the item is provided from origin to consumed point. In the active-sense traceability, apart from keeping the historical record, the real-time tracking information has an additional use to optimize and control processes within and between the different stages of the supply chain.

Golan et al. [15] argue that efficient traceability system is characterized by "*breadth*", "*depth*" and "*precision*". Breadth is defined as "*the amount of information collected*", whereas he defines depth as "*how far back or forward the system tracks the relevant information*?" And precision specified as "*degree of assurance to pinpoint a movement of a product*".

2.3. Conceptualizing Halal Integrity

Halal Integrity deals with the integrity of raw materials/ingredients (resources), production process, packaging, information, transportation, handlings, distribution, retailing and other related operations in such a way that the Halal status of the product is not breached (intentionally or unintentionally) at any stage of the supply chain. Alqudsi [16] argues that maintenance of the HI throughout the whole supply chain is a difficult task as it requires effective monitoring. For the effective monitoring of HSCM, a traceability system is required. The traceability system as adopted in HSCM is different from the other traceability system, regarding captured data which are traced during the stages of the supply chain. In the context of HSCM, the captured data also have the information regarding Halal status (i.e., the ingredients are Halal or not; using the Halal logistics or other means etc.). The integrity of this data is utilized towards maintaining the Halal transparency. Halal transparency means that the Halal status is clearly accessible to the supply chain partners as well as consumers in the forward and the backward direction of flow. Therefore, traceability system is used as a mechanism to assure the maintenance of "HI" during supply chain.

3. Need of the Research

Traceability system is used for many purposes such as quality and safety [17,18], call back the unsafe product [19], product information [18,20]. Effective implementation of traceability system increases in consumers' satisfaction [21]; improvement in the supply chain [22,23] and legal and market requirements [24]. The focus of traceability system in HSCM is to increase the Halal transparency and maintain the HI by providing the product information.

Various studies have carried out on Traceability system for a different product such as Fish, meat and cold supply chain [23,25,26]. However, limited literature is available for the traceability in HSC.

Thus, this research focuses on the HSC to implement the traceability system. In this study, we identify the critical factors of implementation of a traceability system for HSCM and develop a structural model and analyze this model which can be helpful to the Halal industry in making strategies to improve their performance.

3.1. Problem Definition

There is limited literature available for traceability system implementation in the context of HSCM. Studies are carried out on the requirement and benefits of the traceability system [4,27,28]. However, it is difficult to find literature related to the implementation of traceability system in Halal context. However, traceability plays a vital role to maintain the HI.

Maintenance of the integrity of Halal systems through the traceability system is necessary for the supply chain. However, implementation of an effective traceability system is complex. CSFs of traceability system implementation' can be helpful to overcome/reduce these complexities.

This research identifies the CSFs of implementing the traceability system in HSC and provide the structured model of these CSFs using TISM and analyze this model using Fuzzy MICMAC. This Model can be helpful for the companies that provide Halal products to make a strategy for maintaining Halal status throughout the supply chain.

3.2. Objectives of the Paper

The principal purpose of this research article is as follows:

(a) Identify the CSFs of implementation of traceability system for Halal product in supply chain environment by literature review;
(b) Develop the structural Model of CSFs for implementing the traceability system in HSCM using TISM with expert opinion;
(c) Analyzing the contextual relationship using Fuzzy MICMAC and obtain the driving and dependence power of CSFs;
(d) Clustering of CSFs based on driving and dependence power using Fuzzy MICMAC;
(e) Recommendation to the management for effective implementation of traceability system in HSC.

4. Critical Success Factors of Implementation of Traceability System for Halal Product

Daniel [29] introduced the concept of "CSF" and later the concept was developed by Rockart [30]. According to Daniel, management approach must be in-line with factors that are significant to the success of the organization. Digman [31] had a similar view and stated that CSFs are the areas where things must go apt for the flourishing of business. Contemporary studies show the effectiveness of CSFs in different areas of management [32–34].

Through a systematic literature review and support of expert's opinion, CSFs of implementing "traceability systems" for the HSC were identified. Table 1 shows twelve significant CSFs along with substantial finding and the associated supporting reference.

Table 1. Critical Success Factors for implementing traceability systems in HSCM.

S. No.	Critical Success Factors	Major Findings	References
CSF 01	Training of Employees	Effective training to improve communication for implementing traceability system Effective training enables employees to utilize the IT infrastructure Training helps in effective coordination within the organization Enabling employees to work in HSC environment	[25,35,36]
CSF 02	Efficient and Effective Communication	Effective communication plays a significant role in assurance of HI Effective and efficient communication will support the selection and adoption of technology for traceability Building trust and exchange of ideas with other supply chain partners	[17,35,37]
CSF 03	Dedicated IT Infrastructure	IT infrastructure supports Training and improves learning of the employee Selecting appropriate IT infrastructure to support traceability in SC environment Generating, processing, storing and sharing Information with other SC partners	[38–40]
CSF 04	Halal Integrity Assurance	Enhancing the consumer satisfaction and loyalty with the assurance of the integrity of Halal Organization gain competitive advantage with improved HI Providing the information of raw material, processing, transportation and distribution	[4,16,41–43]
CSF 05	Top Management Support	Support of senior management will help employees to get proper training on Halal related issues especially HI Effective coordination and collaboration through top Management support Directly effecting Halal awareness among different stakeholders of the organizations with the support of the top management Effective communication with other supply chain partners with full support of the top management Providing the adequate resources for building a successful traceable system Implementing the appropriate traceability policy	[25,35,44–47]
CSF 06	Selection and Adoption of Appropriate Technology for Traceability System	Appropriate selection and adoption of traceable technology positively affect and support the communication Appropriate technology for traceability system and its effective adoption to improve the HI Using RFID, NFC, DNA barcoding etc. as per the product requirements	[48–52]
CSF 07	Halal Awareness	Halal awareness among different stakeholders especially with the consumer to put the pressure on organization With awareness among the organizations and the customer may garner government support	[16,53]
CSF 08	Consumer Satisfaction	Improving satisfaction of the consumer, thus bringing more organizations into the Halal market. However, organizations with effective traceability systems will get competitive advantage Safeguarding the customer from fake claims on traceability	[26,54–61]
CSF 09	Coordination and Collaboration among Supply Chain Partners	Facilitating enriched training among Supply Chain partners Maintaining good relationship within organization as well as supply chain partner Credibility and Integrity of product information Enhancing the trust among the supply chain partners	[5,27,35,44,62,63]
CSF 10	Government Support	To develop the IT infrastructure through Tax reform and digitalization of business Supporting multifaceted Halal awareness through policies and compliance related to Halal product by Government or its designated agencies Positive support by the Government is vital for the effective codification and standardization of the process. Driving the process of codification by the government or its supported agencies Motivating the Halal industry to adopt traceability technology by providing—funding, technology, training, equipment and tax concessions Supporting the adoption of the traceability system through effective government policies	[41,64–66]
CSF 11	Competitive Advantage	Improved consumer satisfaction will bring more organization into the ambit of Halal and that organization with higher level of integrity and customer satisfaction will get competitive advantage	[26,67–70]
CSF 12	Standardization and Codification	Standardization and proper coding system help in effective implementation of IT infrastructure Standard framework and suggesting the suitable traceable technology for different product Codification of process support in coordination within the organization Reducing the process complexities	[23,47,66,71]

5. Methodology

The primary purpose of this research article is to identify and develop effective and performance-based relationships among major CSFs of the traceability systems as implemented for Halal products in supply chain environment. The contextual relationships can be obtained with the involvement of some experts from the area of "Halal" and "Supply Chain Management". However, for an empirical study, many experts are required but we see a paucity of experts. Thus, a system based tool requiring lesser experts who have excellent subject knowledge can be used gainfully for identifying the contextual relationship among the CSFs. Therefore, for this type of situation, the contemporarily advanced tool "TISM" seems to be quite relevant for structural modelling and analysis [72].

The opinion of the expert obtained with the help of idea engineering workshop. Ten experts participated in the idea engineering workshop. Six were from the industry and four from the academia. In six experts, three are the SC managers and were working in the field for more than eight years and one expert from the Halal logistics service provider who has international experience and two from the Halal certification bodies of India.

The authors discussed with the same experts to complete the knowledge base table (Please see Appendix A) and the responses were used to develop the reachability matrix. Further, this matrix was used in the development of TISM for the CSFs for implementing a traceability system. Results of TISM are treated as input to fuzzy MICMAC.

Driving and dependence power of the CSFs were calculated based on the Fuzzy MICMAC result. Then, CSFs are clustered into four groups as dependent, independent, relay and autonomous. The result is plotted graphically and analyzed in tandem with the findings from quality research publications. In this multifarious activity, a research direction was obtained along with the validation of the model.

5.1. Developing the Structural Model of CSF Implementation through Total Interpretive Structural Modelling

The main objective of Interpretive Structural Modelling (ISM) is to identify the relationship among the considered elements, which further lead to perceiving the structure of the system in a better way [32,73]. However, several limitations of ISM lead to the development of TISM [6]. TISM is an upgraded qualitative modelling technique that is the recent extension of traditional ISM [6,74]. When ISM is integrated with the interpretive matrix, it directs, to develop a methodology and framework of TISM. The development of TISM is undertaken as per the guidelines of [6].

5.1.1. Development of Total Interpretive Structural Model

After extensive deliberations with the domain experts, twelve CSFs were finalized. These twelve factors are stored in the interpretive logic knowledge base. As there were twelve CSFs, the logic knowledge base table has ($12 \times 11 = 132$) one hundred thirty-two rows (see Appendix A). Each row of knowledge base table was discussed with the same expert and results were filled in the knowledge base. If sixty percent of experts is approving the influential relationship between two CSFs, then it is taken as "Y" otherwise "N". All the responses for Y were analyzed regarding the interpretations given by the experts and a combined statement integrating all responses was developed. Further using the responses to establish the reachability matrix are shown in Table 2.

Table 2. Initial Reachability Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	1	1	1	0	0	1	0	0	1	0	0	1
CSF 02	0	1	0	1	0	1	0	0	0	0	1	0
CSF 03	1	1	1	0	0	1	0	0	1	0	0	1
CSF 04	0	0	0	1	0	0	0	1	0	0	1	0
CSF 05	1	0	1	0	1	0	1	0	1	1	0	1
CSF 06	0	1	0	1	0	1	0	0	0	0	0	0
CSF 07	1	0	1	0	1	0	1	0	1	1	0	1
CSF 08	0	0	0	0	0	0	0	1	0	0	1	0
CSF 09	1	1	1	0	0	1	0	0	1	0	0	1
CSF 10	1	0	1	0	1	0	1	0	1	1	0	1
CSF 11	0	0	0	0	0	0	0	1	0	0	1	0
CSF 12	1	1	1	0	0	1	0	0	1	0	0	1

5.1.2. Developing Final Reachability Matrix

The final reachability matrix is derived from the initial reachability matrix with some additional entries (i.e., transitivity 1 *) and shown in Table 3. Transitivity can be described as if element 'p' relates to element 'q' and element 'q' relates to element 'r'; then transitivity implies, that element 'p' relates to element 'r'.

Table 3. Final Reachability Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	1	1	1	1 *	0	1	0	0	1	0	0	1
CSF 02	0	1	0	1	0	1	0	1 *	0	0	1	0
CSF 03	1	1	1	1 *	0	1	0	0	1	0	0	1
CSF 04	0	0	0	1	0	0	0	1	0	0	1	0
CSF 05	1	1 *	1	0	1	1 *	1	0	1	1	0	1
CSF 06	0	1	0	1	0	1	0	1 *	0	0	1	0
CSF 07	1	1 *	1	0	1	1 *	1	0	1	1	0	1
CSF 08	0	0	0	0	0	0	0	1	0	0	1	0
CSF 09	1	1	1	1 *	0	1	0	0	1	0	0	1
CSF 10	1	1 *	1	0	1	1 *	1	0	1	1	0	1
CSF 11	0	0	0	0	0	0	0	1	0	0	1	0
CSF 12	1	1	1	1 *	0	1	0	0	1	0	0	1

1 * = Transitivity.

The reachability and antecedent set of each CSFs are determined and placed in Table 4. The common element between them is positioned in the interaction set. The CSFs are having the identical element in reachability and intersection set named as level I. In the next iteration, these elements which are labelled in the previous iteration are removed from the sets. This procedure is repeated iteratively till all the levels are determined. Table 4 shows these iterations and the final level of each element (i.e., CSFs).

Table 4. Iterations for level Partitioning.

CSFs No.	Reachability Set	Antecedent Set	Intersection Set	Level
CSF 01	1,3,9,12	1,3,5,7,9,10,12	1,3,9,12	IV
CSF 02	2,6	1,2,3,5,6,7,9,10,12	2,6	III
CSF 03	1,3,9,12	1,3,5,7,9,10,12	1,3,9,12	IV
CSF 04	4	1,2,3,4,6,9,12	4	II
CSF 05	5,7,10	5,7,10	5,7,10	V
CSF 06	2,6	1,2,3,5,6,7,9,10,12	2,6	III
CSF 07	5,7,10	5,7,10	5,7,10	V
CSF 08	8,11	2,4,6,8,11	8,11	I
CSF 09	1,3,9,12	1,3,5,7,9,10,12	1,3,9,12	IV
CSF 10	5,7,10	5,7,10	5,7,10	V
CSF 11	8,11	2,4,6,8,11	8,11	I
CSF 12	1,3,9,12	1,3,5,7,9,10,12	1,3,9,12	IV

An initial digraph is formed through these five levels and it illustrates the relationship between the CSFs. Obtained initial digraph was formed by dropping the transitive relationships step-by-step and by examining their interpretation from the knowledge base. Figure 1 shows only those transitive links which have meaningful interpretation and that are used in forming the final digraph.

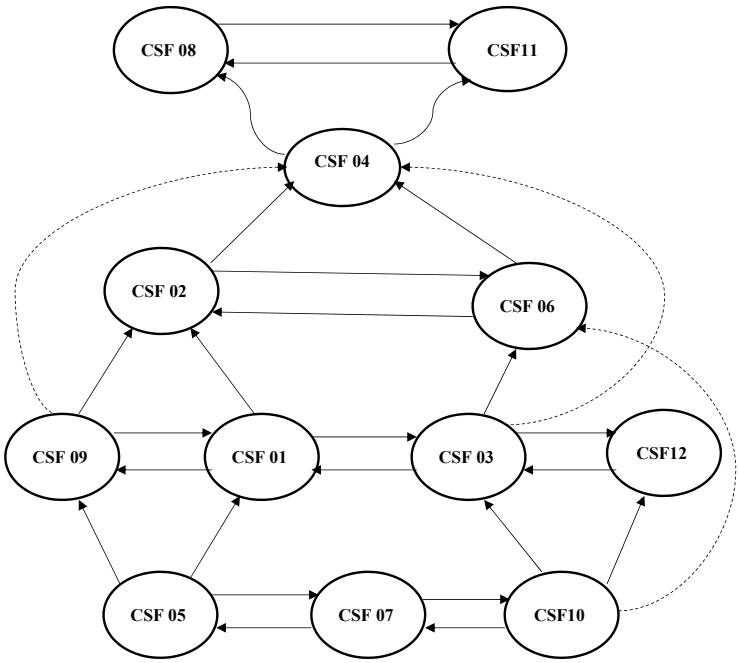

Figure 1. Digraph with significant transitive links.

In the next step, binary interaction matrix is obtained from the final digraph. The interaction among the CSFs is represented by "1" in binary interaction matrix (as shown in Table 5). Further, we construct the Interpretive Matrix by interpreting the entries which are significant and having "1" in the cell of the binary matrix. This interpretation is made by picking the relevant interpretation from the knowledge base.

Table 5. Binary Interaction Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01		1	1						1			
CSF 02				1		1						
CSF 03	1			1		1			1			
CSF 04								1			1	
CSF 05	1	1^a	1					1	1			
CSF 06		1		1								
CSF 07					1					1		
CSF 08											1	
CSF 09	1	1		1^a								
CSF 10			1			1^a	1					1
CSF 11								1				
CSF 12			1			1			1			

$1 \rightarrow$ Direct interaction; $1^a \rightarrow$ indirect interaction.

The digraph and interpretive matrix (See Table 6) are utilized to develop a TISM for CSFs for implementing a traceability system. The nodes in the digraph are assisted by interpretation bullets of the CSFs placed in boxes. The interpretation which is placed in interaction matrix cell is represented along with the link to the structural model. Figure 2 shows a final TISM-based model for CSFs.

Table 6. Interpretive Interaction Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	—	Effective training to improve communication for implementing traceability system	Effective training of employees to enable them to utilize the IT infrastructure						Training helps in effective coordination within organization			
CSF 02		—		Assuring HI with effective communication		Effective and efficient communication will support the selection and adoption of technology for traceability						
CSF 03	IT infrastructure supports Training and improves learning of the employee		—	*Halal related information is generated & processed through IT support*		IT infrastructure to support in selecting appropriate technology						Effective Implementation of codification
CSF 04				—				Consumer satisfaction will be improved if HI gets maintained			Organization gain competitive advantage with improved HI	
CSF 05	With the support of management. Employee will get proper training on Halal related issues especially HI	*Top management established efficient communication with other supply chain partners*			—		With effective management support, Halal awareness among different stakeholders of the organizations will be directly affected		Management support is vital for effective coordination and collaboration			
CSF 06		Appropriate selection and adoption positively affect and support the communication		Appropriate technology and its effective adoption to improve the HI		—						
CSF 07					Halal awareness among different stakeholders especially with the management may influence positively	*Transitive Link*	—			With awareness among the organizations and the customer may garner Government support		

Table 6. *Cont.*

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 08											Better consumer satisfaction to create more organization in the systems and provide the higher consumer satisfaction	
CSF 09	Facilitating enriched training among Supply Chain partners	Good relationship within organization as well as supply chain partner		*Enhance the credibility and integrity of information*					—			
CSF 10			To develop the IT infrastructure through Tax reform and digitalization of business			*Provide subsidies for traceable technology*	Govt to support Halal awareness multifaceted through policies and compliance related to Halal product			—		Positive Government support is vital for the effective codification and Standardization of the process and Government directly drives the process of codification.
CSF 11								Improved consumer satisfaction and broadening the Halal market, where org with higher integrity to get more customer satisfaction and obtain competitive advantage			—	
CSF 12			Standard and codify system help in effective implementation of IT infrastructure			Standard framework suggests the suitable traceable technology for particular product			Codification of process help in coordination within the organization			—

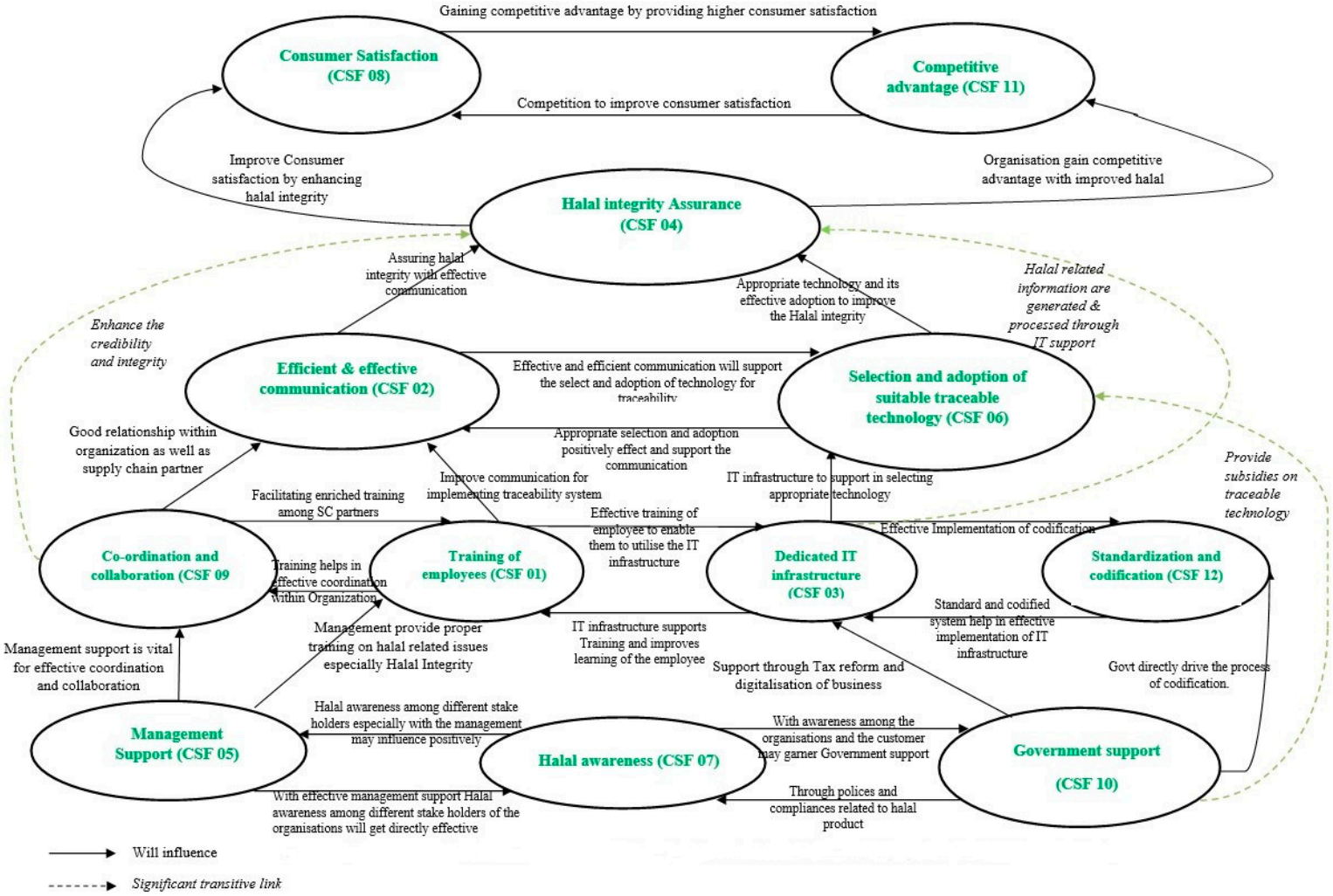

Figure 2. Total interpretive structural model (TISM) of implementation of "Traceability system" in Halal Supply Chain.

5.2. Fuzzy MICMAC

The MICMAC was introduced by Duperrin and Godet [75] for a systematic analysis of complex issues and seen as an indirect classification method. In fuzzy MICMAC analysis, the driving and dependence power of CSFs is determined with the help of Fuzzy MICMAC-stabilized matrix.

The limitation of conventional MICMAC analysis is that it only deals with the binary type of relationships. To overcome this limitation fuzzy set theory is integrated with MICMAC analysis which enhances the sensitivity of MICMAC analysis [76]. It introduces an additional input of possibility of interaction among the elements. The analysis is further augmented by considering the strength of relationships.

5.2.1. Binary Direct Relationship Matrix (BDRM)

Obtained a BDRM through examining the direct connection among the CSFs in the TISM as depicted in Table 3. In Table 3, the diagonal items are replaced with zero. Hence, the BDRM is derived and the same is shown in Table 7.

Table 7. Binary direct reachability matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	0	1	1	1 *	0	1	0	0	1	0	0	1
CSF 02	0	0	0	1	0	1	0	1 *	0	0	1	0
CSF 03	1	1	0	1 *	0	1	0	0	1	0	0	1
CSF 04	0	0	0	0	0	0	0	1	0	0	1	0
CSF 05	1	1 *	1	0	0	1 *	1	0	1	1	0	1
CSF 06	0	1	0	1	0	0	0	1 *	0	0	1	0
CSF 07	1	1 *	1	0	1	1 *	0	0	1	1	0	1
CSF 08	0	0	0	0	0	0	0	0	0	0	1	0
CSF 09	1	1	1	1 *	0	1	0	0	0	0	0	1
CSF 10	1	1 *	1	0	1	1 *	1	0	1	0	0	1
CSF 11	0	0	0	0	0	0	0	1	0	0	0	0
CSF 12	1	1	1	1 *	0	1	0	0	1	0	0	0

1 * = Transitivity.

5.2.2. Development of Linguistic Assessment Direct Reachability Matrix (LADRM)

In the fuzzy set, the triangular function is expressed through a lower limit "*l*", upper limit "*r*" and a value "*m*", which is between "*l*" and "*r*". These points are represented in the form of a triplet (*l*, *m*, *r*) and shown on the horizontal axis. The member function (μ_A) is represented on the vertical axis in a fuzzy set A (see Figure 3). The membership function of μ_A~(x) expressed by the following function (Equation (1)).

$$\mu_A = \begin{bmatrix} 0 & x < l \\ \frac{x-l}{m-l} & l \le x \le m \\ \frac{r-x}{r-m} & m \le x \le r \\ 1 & x > r \end{bmatrix} \quad (1)$$

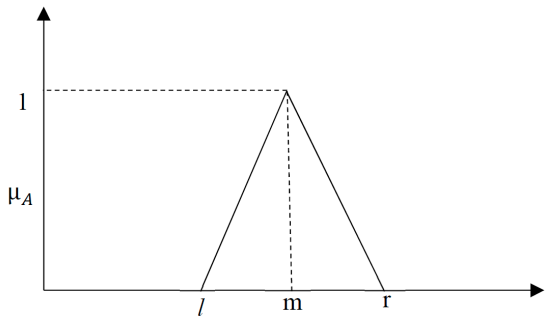

Figure 3. Triangular fuzzy number.

Table 8 presents the linguistic scale for the evaluation of alternatives. The opinion of an expert is taken to rate the relationship among two CSFs. LADRM (please refer Table 9) is obtained by putting the values of relationships among two CSFs and then superimposed.

Table 8. The Fuzzy Linguistic Scale.

Linguistic Variable	Triangular Fuzzy Number
No influence (N)	(0, 0, 0)
Very low influence (VL)	(0, 0.1, 0.3)
Low influence (L)	(0.1, 0.3, 0.5)
Medium influence (M)	(0.3, 0.5, 0.7)
High influence (H)	(0.5, 0.7, 0.9)
Very high influence (VH)	(0.7, 0.9, 1)
Complete influence (C)	(1, 1, 1)

Table 9. Linguistic Assessment Direct Reachability Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	0	M	M	L	0	M	0	0	M	0	VL	L
CSF 02	0	0	0	VH	0	M	0	L	0	0	M	0
CSF 03	H	0	0	L	0	H	0	0	M	0	0	L
CSF 04	0	0	0	0	0	0	0	VH	0	0	H	0
CSF 05	H	L	H	0	0	H	VL	0	VH	VL	L	VL
CSF 06	0	M	0	H	0	0	0	VL	0	0	VL	0
CSF 07	VL	VL	L	0	M	VL	0	0	L	M	0	VL
CSF 08	0	0	0	0	0	0	0	0	0	0	M	0
CSF 09	L	H	M	H	0	M	0	0	0	0	0	M
CSF 10	M	L	M	0	M	L	M	0	M	0	0	H
CSF 11	0	0	0	0	0	0	0	M	0	0	0	0
CSF 12	VL	M	L	H	0	L	0	0	M	0	0	0

Matrix operations are not suitable for the fuzzy numbers. Thus, fuzzy numbers are converted into a crisp number using best non-fuzzy performance (BNP) and shown in Table 10. This process is known as defuzzification and the following expression calculates BNP value (Equation (2)).

$$\mathrm{BNP}_{ij} = \frac{[r - l) + (m - l)]}{3} + l \tag{2}$$

Table 10. Fuzzy Direct Reachability Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12
CSF 01	0	0.5	0.5	0.3	0	0.5	0	0	0.5	0	0.1	0.3
CSF 02	0	0	0	0.9	0	0.5	0	0.3	0	0	0.5	0
CSF 03	0.7	0	0	0.3	0	0.7	0	0	0.5	0	0	0.3
CSF 04	0	0	0	0	0	0	0	0.9	0	0	0.7	0
CSF 05	0.7	0.3	0.7	0	0	0.7	0.1	0	0.9	0.1	0.3	0.1
CSF 06	0	0.5	0	0.7	0	0	0	0.1	0	0	0.1	0
CSF 07	0.1	0.1	0.3	0	0.5	0.1	0	0	0.3	0.5	0	0.1
CSF 08	0	0	0	0	0	0	0	0	0	0	0.5	0
CSF 09	0.3	0.7	0.5	0.7	0	0.5	0	0	0	0	0	0.5
CSF 10	0.5	0.3	0.5	0	0.5	0.3	0.5	0	0.5	0	0	0.7
CSF 11	0	0	0	0	0	0	0	0.5	0	0	0	0
CSF 12	0.1	0.5	0.3	0.7	0	0.3	0	0	0.5	0	0	0

5.2.3. Development of Fuzzy Direct Reachability Matrix (FDRM)

Starting the process with BDRM and this matrix is repeatedly multiplied until the hierarchies of the driver power and dependence stabilizes. This multiplication follows the fuzzy matrix principles and performing the multiplication through the given rule:

$$C = A \times B = \max k\ [(\min a_{ik}, b_{kj})] \text{ where } A = [a_{ik}], = [\ b_{kj}]$$

Table 11 shows the stabilized matrix. The driving power of a CSF is calculated through the summation of all the entries in a row and all entries determine the dependence power of CSF in that particular columns.

Table 11. Fuzzy MICMAC-Stabilized Matrix.

CSFs No.	CSF 01	CSF 02	CSF 03	CSF 04	CSF 05	CSF 06	CSF 07	CSF 08	CSF 09	CSF 10	CSF 11	CSF 12	Driving Power
CSF 01	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0.5	0	0.5	0.5	4.5
CSF 02	0	0.5	0	0.5	0	0	0	0.5	0	0	0.5	0	2
CSF 03	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0.5	0	0.5	0.5	4.5
CSF 04	0	0	0	0	0	0	0	0.5	0	0	0.5	0	1
CSF 05	0.5	0.5	0.5	0.5	0.1	0.5	0.1	0.5	0.5	0.1	0.5	0.5	4.8
CSF 06	0	0	0	0.5	0	0.5	0	0.5	0	0	0.5	0	2
CSF 07	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	5.6
CSF 08	0	0	0	0	0	0	0	0.5	0	0	0	0	0.5
CSF 09	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0.5	0	0.5	0.5	4.5
CSF 10	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	5.6
CSF 11	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5
CSF 12	0.5	0.5	0.5	0.5	0	0.5	0	0.5	0.5	0	0.5	0.5	4.5
Dependence power	3.5	4	3.5	4.5	1.1	4	0.7	5.5	3.5	0.7	5.5	3.5	

5.3. Classifications of CSFs

After obtaining driving and dependence power of each CSF from Table 11, they are plotted in driving and dependence graph (as shown in Figure 4). The obtained graph is clustered into four groups and same is discussed in the subsequent subsections.

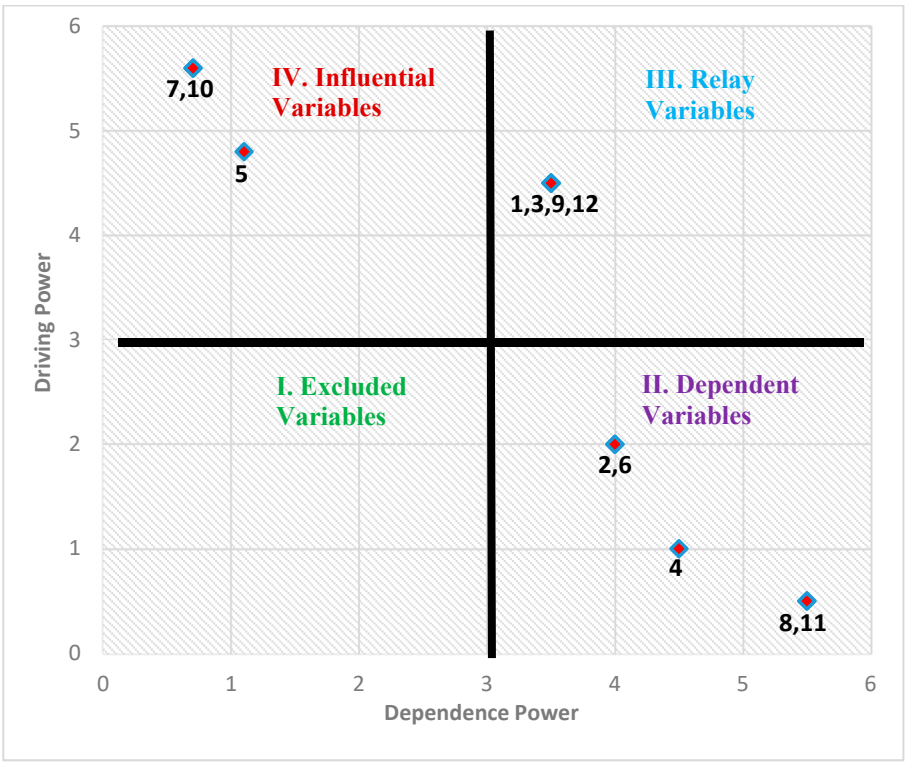

Figure 4. Driving-Dependence Graph of CSFs.

5.3.1. Influent/Determinant Variables

Cluster IV shows the influential variable that acts on the systems as a key force of inertia or movement. They are considered as entry variables and we also call them as environmental variables. Thus, they strongly condition the system. In this case "Halal Awareness", "Government Support" and "Top Management Support" are clustered as influential variables. This infers that awareness regarding

the Halal product may push the Government to legislate the implementation of traceability system in HSC. Also, a robust traceability system can stop fake claims and its effective implementation may control issues like food security & safety.

5.3.2. Relay Variables

The Cluster III of driving dependence graph is of relay variables that are also the stake variables because they represent a high level of driving power and high level of dependence. In this case "Training of Employees", "Dedicated IT Infrastructure", "Coordination and Collaboration among Supply Chain Partners" and "Standardization and codification" are clubbed into this category and is further validated from the TISM.

5.3.3. Dependent Variables

The cluster (Cluster II) of these types of variables are sensitive to the evolution of influent variables and relay variables. They are the output of the system. Figure 4 observes that "Efficient and Effective Communication", "Selection and Adoption of Appropriate Technology for Traceability System", "HI Assurance", "Consumer satisfaction" and "Competitive Advantage" fall under this category. It is evident here that through the integration of robust traceability system with HSC may result in the assurance of HI which in turn will satisfy customer and firm will be able to maintain a competitive advantage.

5.3.4. Autonomous or Excluded Variables

Autonomous variables (Cluster I) are those variables which have a low level of dependence and low level of driving power. They are referred as excluded variables as they do not affect the functioning of the systems. In this study, no such variables fall into this category, validating that all variables have some driving and dependence power.

6. Results and Discussions

Due to increase in safety incidents about food, traceability systems have gained considerable importance [77]. Also, these safety incidents have breached the trust of consumers who are concerned more about the integrity of the products. In response to growing safety and quality issues in the global supply chain of consumables, many countries have developed the laws, policies and standards [78]. Government have asked the industries to incorporate traceability systems in their supply chains to minimize the integrity issues and same for the Halal. To implement a safety and quality management system in a consumer packaged goods (CPG) industry, assuring HI may become a basis for safety policy [77]. Top management of leading manufacturing industry has realized traceability systems as a tool to comply with legislation and to gain consumer confidence in Halal products/services [79]. The summary of major finding of this research are:

- 'Government Support', 'Awareness about Halal product' and 'Top Management Support' are the major driver for implementing traceability systems in the management of supply chain with Halal credentials.
- Standardization, codification & industry guidelines, knowledge/training and dedicated infrastructure, persuade top management to coordinate & collaborate with other members so that information captured through traceability systems regarding HI can be extended to the consumers.
- Selection of appropriate technology is an important issue to achieve transparency and the smooth transfer of information among the supply chain actors.
- All the supply chain partners must prepare themselves to implement traceability and comply with the standards and practices of traceability systems to assure HI to the consumers.
- Using robust traceability systems and information management regarding HI can help in better communication with the customer and other stakeholders.

- Efficient traceability system provides the HI to the consumers which leads the consumer satisfaction along with competitive advantage to the organization

Consumer Halal awareness creates the demand for a traceable Halal product which motivates the Top management and government to implement the traceability system in HSCM.

To assure that the HI of the product is maintained from farm to fork, close coordination/collaboration is required to be maintained among various supply chain partners. Also, traceability system is critically reliant on recording and retrieving of information this needs that all the supply chain members should be in sync with each other [17]. Traceability can only be effectively accomplished if built upon the global standards that enable interoperability between traceability systems across the supply chain. Standardization and codification, training and dedicated infrastructure, persuade top management to coordinate & collaborate with other members so that HI can be extended to the consumers through effective traceability.

Fundamentally, a traceability system for Halal products requires, identifying locations from where the product originates, i.e., sourcing of raw materials to processing, packaging and storage, including every agent in the supply chain till it reaches the final consumers. Selection of appropriate technology is an important issue to achieve transparency along with a smooth transfer of information among the actors in the supply chain. This depends upon various factors such as product identification, product routing, data to trace and traceability tools for effective traceability of Halal products. Through efficient communication among different supply chain actors, a suitable technology can be identified to implement robust traceability systems.

Traceability is an important practice to assure HI to the consumers [60]. Robust traceability system can reduce the risk of contamination and associated vulnerability of the Halal products. It is concluded that all the supply chain actors involved must prepare themselves to implement traceability and comply with the standards & practices of traceability systems as to assure HI to the final consumers.

Availability of adequate information to the customer regarding characteristics of the product increase the consumer confidence [80]. Using robust traceability systems information regarding HI of the product can easily be communicated to the customer and other stakeholders.

Traceability systems may minimize the risk of production and distribution of non-Halal products; may facilitate the product recall management; may fix the liability in case of HI assurance system failure. These characteristics of traceability systems may provide the competitive advantage in the market to the industry by directly connecting to the consumers.

The qualitative nature and subjectivity are the significant limitations of this study. Any biases in expert opinion may influence the result. These biases can somehow reduce the use of fuzzy triangular numbers for MICMAC analysis.

7. Implications

The implication of this study is discussed as follows:

Academic Implications: Researchers may gain an idea of CSFs of traceability system implementation in HSCM and how these CSFs are interacting with each other. This model may be helpful in qualitative research for hypothesis construction and mental model. Further validation of the model can be done through structural equation modelling (SEM). The fuzzy MICMAC analysis shows the nature (Driver or dependent) of the CSFs and opens the door for new research avenues.

Managerial implications: This research gives an idea to policy maker in for implementation of traceability system in HSCM. This model can be helpful for the manager in deciding on the application of a traceability system. Management can easily identify which factors crucial to their organization. From the fuzzy MICMAC analysis, the driving and dependence power give an idea about the importance of every factor. Thus, managers can develop a strategy.

8. Conclusions

The principal objective of this study is to identify factors that are critical in implementing robust traceability systems to assure HI to the consumer. An extensive review of the available literature dealing with the definitions and principles of traceability makes its focus and its key components quite instrumental in consolidating twelve CSFs of implementation of a traceability system for managing HSC.

This study focused on the effective implementation of traceability system in HSCM. A significant number of studies are reported in the literature regarding the traceability but a very few of them focus on the implementation aspects. This study identifies the CSFs to implement the traceability system in HSCM. Academic researchers, industrial practitioners and Supply Chain executives can understand the complex interrelationship of CSFs by visualizing the TISM. These CSFs are beneficial for the managers in developing the strategy to implement the traceability system. The outcome of the TISM provides the hierarchy of the CSFs to implement the traceability system in HSCM effectively. Previous studies rarely report the implementation of traceability systems in HSCM. This study is done in the context of the HSCM, which is an emerging area for the research and practice.

Expert's opinion established the interaction among these CSFs and TISM development. The success factors which are critical in implementing traceability system are found to be awareness among consumers regarding flouting Halal practices in supply chain operations and realizing traceability as a tool to gain consumer confidence by the major market player. Further, these CSFs were classified by their driving and dependence power as obtained from fuzzy MICMAC analysis. Results obtained from this study are discussed in the light of contemporary developments and an implication of this research is presented. It is suggested that assuring HI to the consumers in an uncertain environment can be realized through a proper selection of traceability technology and effective communication with the consumers regarding information possessed by the products.

9. Scope for Future Research

HSCM is an emerging area which requires more attention to the researchers and practitioner. This research is a qualitative study based on the expert opinion and literature review. Similarly, other system based tool such as digraph, Physical Systems Theory (PST), system dynamics can also be used for developing and analyzing the model. TISM model can be further used for empirical research, where SEM or systems dynamics modelling (SDM) could be used for validating the relationships of the model. This study can be further extended with the help of case studies and one can gain some other practical insights.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The knowledge-based table is given in this appendix.

Table A1. Interpretive logic-knowledge base.

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF1-CSF2	Training of employee influence Efficient & Efficient communication	Y	Effective training to improve communication for implementing traceability system
CSF1-CSF3	Training of employee influence Dedicated IT infrastructure	Y	Effective training of employees to enable them to utilize the IT infrastructure
CSF1-CSF4	Training of employee influence Halal Integrity	Y	*Better Training to enable the implementation of Halal integrity*
CSF1-CSF6	Training of employee influence Selection and adoption of suitable traceable technology	Y	Aware the available traceable technology
CSF1-CSF9	Training of employee influence Co-ordination & collaboration among supply chain partners	Y	Training helps in effective coordination within Organization
CSF1-CSF12	Training of employee influence Standardization and codification	Y	Develop the integration of information
CSF2-CSF4	Efficient & Efficient communication influence Halal Integrity	Y	Assuring Halal integrity with effective communication
CSF2-CSF6	Efficient & Efficient communication influence Selection and adoption of suitable traceable technology	Y	Effective and efficient communication will support the selection and adoption of technology for traceability
CSF2-CSF8	Efficient & Efficient communication influence Consumer satisfaction	Y	*At the consumer end of the supply chain effective communication.*
CSF2-CSF11	Efficient & Efficient communication influence Competitive advantage	Y	*Transitive Link*
CSF3-CSF1	Dedicated IT infrastructure influence Training of employee	Y	IT infrastructure supports Training and improves learning of the employee
CSF3-CSF2	Dedicated IT infrastructure influence Efficient & Efficient communication	Y	IT infrastructure facilitated the efficient communication
CSF3-CSF4	Dedicated IT infrastructure influence Halal integrity assurance	Y	*Halal related information is generated & processed through IT support*
CSF3-CSF6	Dedicated IT infrastructure influence Selection and adoption of suitable traceable technology	Y	IT infrastructure to support in selecting appropriate technology
CSF3-CSF9	Dedicated IT infrastructure influence co-ordination & collaboration among supply chain partners	Y	Effective coordination is possible through IT support
CSF3-CSF12	Dedicated IT infrastructure influence Standardization and codification	Y	Effective Implementation of codification is possible through IT infrastructure
CSF4-CSF8	Halal integrity assurance influences consumer satisfaction	Y	Consumer satisfaction will be improved if Halal integrity gets maintained
CSF4-CSF11	Halal integrity assurance influence Competitive advantage	Y	Organization gain competitive advantage with improved Halal integrity
CSF5-CSF1	Management Support influence training of employee	Y	With the support of the management, employee will get proper training on Halal related issues especially on Halal Integrity
CSF5-CSF2	Management support influence Efficient & Efficient communication	Y	*Top management established efficient communication with other supply chain partners*
CSF5-CSF3	Management Support influence Dedicated IT infrastructure	Y	Develop IT infrastructure
CSF5-CSF6	Management Support influence Selection and adoption of suitable traceable technology	Y	*Based on workforce skills and knowledge as well as financial support*
CSF5-CSF7	Management Support influence Halal awareness	Y	With effective management support, Halal awareness among different stakeholders of the organizations will get directly effective
CSF5-CSF9	Management Support influence Co-ordination & collaboration among supply chain partners	Y	Management support is vital for effective coordination and collaboration

Table A1. *Cont.*

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF5-CSF12	Management Support influence Standardization and codification	Y	Codify the process according to standard of Halal product
CSF6-CSF2	Selection and adoption of suitable traceable technology influence Efficient & Efficient communication	Y	Appropriate selection and adoption of suitable traceability technology positively affect and support the communication
CSF6-CSF4	Selection and adoption of suitable traceable technology influence Halal integrity assurance	Y	Appropriate technology and its effective adoption to improve the Halal integrity
CSF6-CSF8	Selection and adoption of suitable traceable technology influence Consumer satisfaction	Y	Consumer can trace at the purchase due to suitable traceable technology
CSF6-CSF11	Selection and adoption of suitable traceable technology influence Competitive advantage	Y	*Provide quality and credibility of the information*
CSF7-CSF2	Halal awareness influence Efficient & Efficient communication	Y	*Consumer Halal awareness motivates the SC partner for comm.*
CSF7-CSF3	Halal awareness influence Dedicated IT infrastructure	Y	Halal awareness improve the sales; hence supplier develop good IT infrastructure
CSF7-CSF5	Halal awareness influence Management Support	Y	Halal awareness among different stakeholders especially with the management may affect positively
CSF7-CSF6	Halal awareness influence Selection and adoption of suitable traceable technology	Y	Transitive link
CSF7-CSF9	Halal awareness influence Co-ordination & collaboration among supply chain partners	Y	Halal producing organization collaborate to maintain the Halal integrity assurance
CSF7-CSF10	Halal awareness influence Government support	Y	With awareness among the organizations and the customer may garner Government support
CSF7-CSF12	Halal awareness influence Standardization and codification	Y	Aware customer would demand standard items
CSF7-CSF1	Halal awareness influence Training of employee	Y	Awareness motivate the employee to gain training and acquire skills
CSF8-CSF11	Consumer satisfaction influence Competitive advantage	Y	Better consumer satisfaction to create more organization in the systems and improves competitive advantage
CSF9-CSF1	Coordination & collaboration among supply chain partners influence Training of employee	Y	Facilitating enriched training among Supply Chain partner
CSF9-CSF2	Coordination & collaboration among supply chain partners influence Efficient & Efficient communication	Y	Good relationship within organization as well as supply chain partner
CSF9-CSF3	Coordination & collaboration among supply chain partners influence Dedicated IT infrastructure	Y	Collaboration among the supply chain partner helps in developing the IT infrastructure by providing their specific requirement
CSF9-CSF4	Coordination & collaboration among supply chain partners influence Halal integrity assurance	Y	Enhance the credibility and integrity of information
CSF9-CSF6	Coordination & collaboration among the partners of supply chain influence selection & adoption of suitable traceable technology	Y	Collaboration among the SC partners reduce the difference in traceable method & granularity level
CSF10-CSF1	Government support influence Training of employee	Y	Provide the expert with training
CSF10-CSF2	Government support influence Efficient & Efficient communication	Y	Making the policies to implement the Traceability System
CSF10-CSF3	Government support influence Dedicated IT infrastructure	Y	To develop the IT infrastructure through Tax reform and digitalization of business

Table A1. *Cont.*

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF10-CSF5	Government support influence Management Support	Y	Provide funding and tax concession
CSF10-CSF6	Government support influence Selection and adoption of suitable traceable technology	Y	Provide subsidies on traceable technology
CSF10-CSF7	Government support influence Halal awareness	Y	Govt. to support Halal awareness multifaceted through policies and compliance related to Halal product
CSF10-CSF9	Government support influence Co-ordination & collaboration among supply chain partners	Y	Government Policies help in effective collaboration among the SC Partners
CSF9-CSF12	Coordination & collaboration among supply chain partners influence Standardization and codification	Y	Better coordination within organization helps in codify the process
CSF10-CSF12	Government support influence Standardization and codification	Y	Positive Government support is vital for the effective codification and Standardization of the process. Govt. directly drive the process of codification.
CSF11-CSF8	Competitive advantage influence Consumer satisfaction	Y	Improved consumer satisfaction will bring more organization into the ambit of Halal, and those organizations with higher level of integrity and customer satisfaction will get competitive advantage
CSF12-CSF1	Standardization and codification influence Training of employee	Y	Providing training according to the standard
CSF12-CSF2	Standardization and codification influence Efficient & Efficient communication	Y	Codification simplifies the process which enhances the efficient comm.
CSF12-CSF3	Standardization and codification influence Dedicated IT infrastructure	Y	Standard and codify system help in effective implementation of IT infrastructure
CSF12-CSF4	Standardization and codification influence Halal Integrity	Y	Transitive link
CSF12-CSF6	Standardization and codification influence Selection and adoption of suitable traceable technology	Y	Standard framework suggests the suitable traceable technology for particular product
CSF12-CSF9	Standardization and codification influence Co-ordination & collaboration among supply chain partners	Y	Codification of process help in coordination within the organization
CSF12-CSF10	standardization and codification influence competitive advantage	Y	Transitive Link
CSF1-CSF5	Training of employee influence Management Support	N	
CSF1-CSF7	Training of employee influence Halal awareness	N	
CSF1-CSF8	Training of employee influence Consumer satisfaction	N	
CSF1-CSF10	Training of employee influence Government support	N	
CSF1-CSF11	Training of employee influence Competitive advantage	N	
CSF2-CSF1	Efficient & Efficient communication influence Training of employee	N	
CSF2-CSF3	Efficient & Efficient communication influence Dedicated IT infrastructure	N	
CSF2-CSF5	Efficient & Efficient communication influence Management Support	N	

Table A1. *Cont.*

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF2-CSF7	Efficient & Efficient communication influence Halal awareness	N	.
CSF2-CSF9	Efficient & Efficient communication influence Co-ordination & collaboration among supply chain partners	N	
CSF2-CSF10	Efficient & Efficient communication influence Government support	N	
CSF2-CSF12	Efficient & Efficient communication influence Standardization and codification	N	
CSF3-CSF5	Dedicated IT infrastructure influence Management Support	N	
CSF3-CSF7	Dedicated IT infrastructure influence Halal awareness	N	
CSF3-CSF8	Dedicated IT infrastructure influence Consumer satisfaction	N	
CSF3-CSF10	Dedicated IT infrastructure influence Government support	N	
CSF3-CSF11	Dedicated IT infrastructure influence Competitive advantage	N	
CSF4-CSF1	Halal integrity assurance Influence Training of employee	N	
CSF4-CSF2	Halal integrity assurance Influence Efficient & Efficient communication	N	
CSF4-CSF3	Halal integrity assurance Influence Dedicated IT infrastructure	N	
CSF4-CSF5	Halal integrity assurance Influence Management Support	N	
CSF4-CSF6	Halal integrity assurance Influence Selection and adoption of suitable traceable technology	N	
CSF4-CSF7	Halal integrity assurance Influence Halal awareness	N	
CSF4-CSF9	Halal integrity assurance influence Co-ordination & collaboration among supply chain partners	N	
CSF4-CSF10	Halal integrity assurance influence Government support	N	
CSF4-CSF12	Halal integrity assurance influence Standardization and codification	N	
CSF5-CSF4	Management Support influence Halal integrity assurance	N	
CSF5-CSF8	Management Support influence Consumer satisfaction	N	
CSF5-CSF10	Management Support influence Government support	N	
CSF5-CSF11	Management Support influence Competitive advantage	N	
CSF6-CSF1	Selection and adoption of suitable traceable technology influence Training of employee	N	
CSF6-CSF3	Selection and adoption of suitable traceable technology influence Dedicated IT infrastructure	N	
CSF6-CSF5	Selection and adoption of suitable traceable technology influence Management Support	N	
CSF6-CSF7	Selection and adoption of suitable traceable technology influence Halal awareness	N	

Table A1. *Cont.*

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF6-CSF9	Selection and adoption of suitable traceable technology influence Co-ordination & collaboration among supply chain partners	N	
CSF6-CSF10	Selection and adoption of suitable traceable technology influence Government support	N	
CSF6-CSF12	Selection and adoption of suitable traceable technology influence Standardization and codification	N	
CSF7-CSF4	Halal awareness influence Halal integrity assurance	N	
CSF7-CSF8	Halal awareness influence Consumer satisfaction	N	
CSF7-CSF11	Halal awareness influence Competitive advantage	N	
CSF8-CSF1	Consumer satisfaction influence Training of employee	N	
CSF8-CSF2	Consumer satisfaction influence Efficient & Efficient communication	N	
CSF8-CSF3	Consumer satisfaction influence Dedicated IT infrastructure	N	
CSF8-CSF4	Consumer satisfaction influence Halal integrity assurance	N	
CSF8-CSF5	Consumer satisfaction influence Management Support	N	
CSF8-CSF6	Consumer satisfaction influence Selection and adoption of suitable traceable technology	N	
CSF8-CSF7	Consumer satisfaction influence Halal awareness	N	
CSF8-CSF9	Consumer satisfaction influence Co-ordination & collaboration among supply chain partners	N	
CSF8-CSF10	Consumer satisfaction influence Government support	N	
CSF8-CSF12	Consumer satisfaction influence Standardization and codification	N	
CSF9-CSF5	Co-ordination & collaboration among supply chain partners influence Management Support	N	
CSF9-CSF7	Coordination & collaboration among supply chain partners influence Halal awareness	N	
CSF9-CSF8	Co-ordination & collaboration among supply chain partners influence Consumer satisfaction	N	
CSF9-CSF10	Coordination & Collaboration among supply chain partners influence Government support	N	
CSF9-CSF11	Co-ordination & collaboration among supply chain partners influence Competitive advantage	N	
CSF10-CSF4	Government support influence Halal integrity assurance	N	
CSF10-CSF8	Government support influence Consumer satisfaction	N	
CSF10-CSF11	Government support influence Competitive advantage	N	
CSF11-CSF1	Competitive advantage influence Training of employee	N	

Table A1. *Cont.*

Element Pairing Nos.	Comparison	Y/N	In What Way an Enabler Will Influence/Enhance Another Enabler? Give Reason in Brief
CSF11-CSF2	Competitive advantage influence Efficient & Efficient communication	N	
CSF11-CSF3	Competitive advantage influence Dedicated IT infrastructure	N	
CSF11-CSF4	Competitive advantage influence Halal integrity assurance	N	
CSF11-CSF5	Competitive advantage influence Management Support	N	
CSF11-CSF6	Competitive advantage influence Selection and adoption of suitable traceable technology	N	
CSF11-CSF7	Competitive advantage influence Halal awareness	N	
CSF11-CSF9	Competitive advantage influence Co-ordination & collaboration among supply chain partners	N	
CSF11-CSF10	Competitive advantage influence Government support	N	
CSF11-CSF12	Competitive advantage influence Standardization and codification	N	
CSF12-CSF5	Standardization and codification influence Management Support	N	
CSF12-CSF7	Standardization and codification influence Halal awareness	N	
CSF12-CSF8	Standardization and codification influence Consumer satisfaction	N	
CSF12-CSF11	Standardization and codification influence Government support	N	

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