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PRIORITISING REQUIREMENTS OF INFORMATIONAL SHORT FOOD SUPPLY CHAIN PLATFORMS USING A FUZZY APPROACH

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Abstract:
Short food supply chains emerged from initiatives for reducing distances and intermediaries in food supply chains, substantiated in part by a shift in consumer's perceptions on sustainability of global systems. Short food supply chains attract consumers due to the reduced distance to the origin of food. Informational platforms can help these types of supply chains achieve desirable network effect and add value for relevant stakeholders. This paper explores prioritisation of requirements for informational short food supply chains. It uses seventeen requirements selected by a panel of experts. Prioritisation is accomplished through a Fuzzy MoSCoW method. Results suggest that track and trace, real-time operations and supply chain related data exchange, and real-time supplier data exchange are must have/top ranked functional requirements for informational short food supply chains. Real-time sustainability related data exchange is categorised as should have and is likely to rank higher as short food supply chains increasingly embrace sustainability.

Keywords: Short food supply chains; Informational Platforms; Requirements Prioritisation; MoSCoW.

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1. Introduction

Short food supply chains (SFSC) emerged from initiatives for reducing distances and intermediary actors between food producers and consumers [1]. Essentially, SFSC shorten food supply chains and result in important benefits such as environmental sustainability through for example less transportation [2], job creation on farms, development and satisfaction for farmers, and the dissemination of sustainable agricultural practices [3]. There is also the positive concept of local food with the benefits of distinctive product characteristics, ecological raw materials and methods, and direct revenues for families [4].

The desire to buy local, with expectations of sustainability, quality and safe food motivates consumer to move towards short food supply chains [5]. Despite the advantages, some challenges of short food supply chains have been highlighted and they include a) difficulty to prove and communicate locality, and b) governance, as food must be deemed essential for society [6]. A key success factor, amongst others, is the ability to communicate accurate, real-time information within the supply chain [7].

In short food supply chains, information flow is a critical need. Information flow can improve transparency within a supply chain [8], and platforms developed to support information flow should be built around sharing real-time information [9]. Ability to share real-time information improves business processes internally and externally between supply chain stakeholders [10]. Accessible informational platforms for effective communication and bi-directional information sharing by all stakeholders in a short food supply chain is essential. Characteristics of information shared in a short food supply chain platform suggests that information should be consistent, on-time, and open [11].

Integration and connectivity are also important [12] [13]. [12] suggest that IT platforms should not only focus on effectiveness, but also connectivity. For improved connectivity, the enablers include technology, trust, collaboration, and to promote information sharing. In discussing the importance of integrating supply chain activities, [13] showed that through a cloud platform supply chains could become more responsive and improve flexibility.

Generally, supply chains are complex systems and they typically involve many actors and activities supported by a complex network of information flows that can be difficult to manage without an appropriate digital platform in place. Digital, informational, platforms allow information management across an entire short food supply chain, facilitating information sharing and enabling absorptive capacity to transform the supply chain using the information shared.

To overcome challenges in food supply chains, smart manufacturing tools and techniques are adopted. Networked, real-time information platforms provide an opportunity for companies to increase competiveness [14]. Current techniques in smart supply chains include information technology such as the Internet of Things; Process automation, through the use of tools such as radio frequency identification and related sensor embedded system; Advanced analytics such as big data; and informational platforms such as blockchain [15]. Smart Informational platforms offer benefits to supply chains through improved visualization, reliable information flow, enhanced business processes, reduction of fraud, and improved levels of collaboration over the supply chain. When managed and implemented correctly, informational platforms provide the ability to utilize the network effect and create competitive advantage throughout the supply chain.

In relation to informational food supply chain platforms requirements commonly cited include requirements for data accumulation, access, security, and monitoring. The multitude of requirements would need to be prioritised for appropriate implementation of short food supply chain platforms. Otherwise, less user satisfaction can arise when there is disconnection between an expected system and the actual system [16].

The aim of this paper is to report on a study that seek to prioritize a consolidated list of requirements for an informational food supply chain platform, from the perspective of stakeholders involved with short food supply chains. Data for the prioritisation is obtained through a panel of experts consisting of the stakeholders. A fuzzy method is used in deriving a prioritisation model based on the data collected.

The remainder of the report is structured as follows. Section 2 contains a description of related work and this is followed in Section 3 by the research methodology used in the study. Results are presented in Section 4. Section 5 shows the discussion of results and the study ends in Section 6 with conclusions and highlight of areas of future work.

2. Background and related work

[17] define SFSCs as a supply chain that needs to be traceable to a producer. Furthermore, the structure of the chain should include a producer, consumer, and a maximum of one intermediary between. [18] highlight three categories of short food supply chains: a) Face-to-face, which makes use of farm stores, road sales, you-picks, box plans, and mail order, b) Proximate, which includes farm shop groups, consumer cooperatives, and local retailers, and c) Extended, which includes certification labels, production labels and reputation labels.

SFSCs offer several benefits such as job creation, and a stronger sense of community [3]. Consumers are interested in these chains, which is related to the perception of buying local, food safety, and community involvement. In order to create a successful SFSC, it is important to include sustainable operations, offer of local brands, create direct relationships, and include traceability and ability to confirm the origin of products. To enhance value throughout an entire SFSC, actors should be willing to participate and there should exist network effect, amongst others. For example, farmers must share a strong sense of community [19]. Young farmers are more attracted to participate in SFSCs and are willing invest in supporting technology [20]. Network effect term refers to the level that stakeholders within a network jointly determine the value of a product or service [21]. This term is critical in relation to informational SFSCs, as each platform needs to determine requirements based on the purpose of that network [22].

[7] identified two critical factors in order to create SFSCs. The first is aggregation in order to compete with global markets. The second is information flow, as the ability to communicate accurate, real-time information within the supply chain is needed. The emergence of informational platforms supports the information flows factor.

Smart food supply chains aim to connect business processes and extend beyond individual company applications, to systematic smart implementations throughout an entire supply chain network. The characteristics of smart supply chains are; instrumented, interconnected, intelligent, automated, integrated, and innovative [15]. The digital supply chain is the interconnected activities in a supply chain between producers and customers through the use new technologies and tools [23]. Digitalization enables a collaborative supply chain, therefore creating lower transaction costs, improved relationships, and risk mitigation between partners. [24] discuss that digitalization alone does not lead to benefits, as implementation of platforms and technologies must be developed according to supply chain strategy and goals.

In the context of short food supply chains, digital and smart technologies have been adopted to overcome traditional management challenges. [25] present a conceptual short food supply chain model to improve distribution issues. [25] suggest that digitalization improves inefficiencies in short food systems, leads to improved sustainability, and can increase coordination in the distribution of local food products. Current research on smart short food supply chain technologies includes informational platforms [26], smart farming applications [27], sensor embedded systems [28], and novel technologies such as Blockchain [29].

In the context of supply chain management, an informational platform is designed to enable the consistent and real-time information throughout the supply chain [30]. [31] suggest informational platforms can improve supply chains through lower costs, quality, service, improved inventory levels, and increased transparency/collaboration within the supply chain. Current research on informational platforms in relation to food supply chains includes a focus on buying and selling products, improving track and trace, governance, and sustainability.

[32] research the application of a smart informational platform and the effect on supply chains. An important benefit being improved coordination amongst managers throughout the supply chain. Smart informational platforms make use of tools such as the Internet of Things and Blockchain to enhance visualization, collaboration, provide better planning and control over business processes, and to stimulate real-time information flow throughout the entire supply chain. [33] discuss how blockchain technology has been adopted to a number of cases in the food industry, showing benefits in product verification and trust (organic, Demeter, and protection against fraud).

Several informational platforms in the food industry are emerging. Examples include Horticube, CyberGIS, Tracefood, FLspace, and E-Hub. [34] present the platform Horticube, built to enable transaction-oriented data and includes requirements such as inventory, import and export, and is designed to understand how much supply is needed to meet demand throughout the year. [35] present the CyberGIS platform and it includes requirements such as data integration, computing, and enhanced visualization capabilities. Tracefood is an informational platform that improves traceability of products throughout the supply chain; it includes requirements such as the unique identification of products, documentation, electronic data interchange, and guidelines for traceability [36]. [37] describes the FLspace platform, which uses IoT technology to create virtualization within the supply chain. E-Hub is a platform based on information sharing within a supply chain; it includes features such as inventory levels, shipping notices, and replenishment notification [38].

When building an informational platform, [39] suggests that it is critical to align requirements, features, and functions to the competitive position of the organization. In relation to informational food supply chain platforms common requirements include data input, storage, and output. Furthermore, many informational platforms include the requirements of data exchange and electronic data interchange. Requirements in relation to real-time information flow are also shown within current platforms. These include, visualization, virtualization, accessibility, portability, and real-time data exchange on operations, supply chain, sustainability, and supplier related factors. [40] compiled a consolidated list of feature requirements for Informational Short Food Supply Chain Platforms. The consolidated list is the basis of the prioritised feature model developed in this paper. Requirements prioritisation is accomplished using a Fuzzy MoSCoW approach.

[41] describes the MoSCoW Model as a strong requirements prioritization tool in the initial phases of requirements engineering. The MoSCoW model includes four categories of requirements based on an ordinal scale, which are 'Must Haves', 'Should Haves', 'Could Haves', and 'Won't Haves' [42]. [43] critique the MoSCoW method, as it can be difficult to rank requirements based on perceptions, leading to many ties. [44] conducted a research evaluating the MoSCoW method against an Apriori technique. The MoSCoW method illustrated a better time/accuracy rating when analysing up to 100 requirements, while the Aprioir technique had a better rating above 100 requirements. [45] state several benefits of adopting the MoSCoW model. These include a high confidence from participating user group, consistency, lower degree of difficulty, and able to handle many alternative inputs. [46] use fuzzy logic with the MoSCoW method to overcome issues related to the conventional MoSCoW. Based on the results, [46] discuss that top ranked/'must have' requirements should be included in the first version of the software, while, 'should haves' and 'could haves' being introduced in later stages of platform development.

3. Research methodology

The primary objective of the study reported in this paper is to prioritise the requirements of informational short food supply chain platform using the Fuzzy MoSCoW method. This is achieved in three main stages and using a panel of three experts to complete the fuzzy assessment. Experts had multiple specializations and experience, Table 1 summarizes these aspects in respect to the participants.

Table 1 Expert Background Overview

Function	Small Organization	Medium Sized organization	Large organization
Director		1	
Consultancy/Product Manager	1		1
Research and Education			2
Logistics and Supply Chain Management	1		2
Sustainability	1		1

In the first stage, the consolidated list of [40] were reviewed and 17 requirements selected by the experts for prioritisation. In the second stage, the selected requirements were then each classified as either functional or non-functional using evidence from the literature as a guide. A functional requirement (FR) is a requirement stating what a system should do while a non-functional requirement (NFR) states how the system will do it [47]. Finally, in the third stage, the fuzzy logic with the MoSCoW method [46] is used to prioritise the requirements using evaluation data obtained from the experts.

As proposed by [46], following the identification of the functional and non-functional requirements, the Fuzzy MoSCoW method is applied in four main steps: a) Triangular Fuzzy Numbers (TFNs) are established for each of the four categories of MoSCoW i.e. 'Must Haves', 'Should Haves', 'Could Haves', and 'Won't Haves', b) the experts fuzzy assessments for the set of FRs and NFRs identified in this study, c) a graded mean integration on the established TFNs are applied to the assessment data to obtain ranking values, and d) a Fuzzy MoSCoW model is identified using the resulting ranking value. Below provides a detailed overview of the applied steps in this research.

Step 1: For the fuzzy assessment, a selection of requirements was completed selecting relevant FRs and NFRs for SFSCs based the research by [40]. Similar requirements were grouped for further reduction. For example, social and environmental sustainability requirements are grouped as sustainability indicators. Only requirements that were clearly defined as NFR or FR through an additional literature were used in the Fuzzy Analysis. Table 2 and Table 3 show the verified FRs and NFRs for this research. The supporting source is shown for verification of each FR and NFR.

Table 2 Non-Functional Requirements

LV	Requirement Description	Source
NFR 1	Data-backup	[48]
NFR 2	Data handling capability	
NFR 3	Platform security and privacy	
NFR 4	Constant real-time data flow	
NFR 5	Data maintenance	
NFR 6	Electronic data interchange	
NFR 7	Transparency	[49]

Table 3 Functional Requirements

LV	Requirement Description	Source
Fr1	Real-time operations and supply chain related data exchange	[50]
Fr2	Real-time sustainability related data exchange	
Fr3	Real-time supplier data exchange	
Fr4	Track and trace	[51]
Fr5	Notifications	[52]
FR6	Learning and development	[53]
FR7	KPI Dashboard	[54]
FR8	Alerts to supply chain changes	[55]
FR9	Supply Chain Resilience	[56]
FR10	Real-time document collaboration	[53]

Step 2: Defining Triangular Fuzzy Numbers (TFNs) and Linguistic Variables (LV). Table 4 presents the TFNs and LVs adopted for this research.

Table 4 TFNs and LVs for Fuzzy MoSCoW

Type of requirement	LV	TFN
Functional requirement	Must have (Mo)	(0.66, 1, 1)
Functional requirement	Could have (Co)	(0, 0.33, 0.66)
Functional requirement	Should have (So)	(0.33, 0.66, 1)
Functional requirement	Won't have (Wo)	(0, 0, 0.33)
Non-functional requirement	Could have (CoH)	(2.5, 2.5, 5)
Non-functional requirement	Should have (SoH)	(2.5, 5, 7.5)
Non-functional requirement	Must have (MoH)	(5, 7.5, 1)
Non-functional requirement	Won't have (WoH)	(7.5, 1, 1)

(Adopted from [46])

Step 3: For the fuzzy assessment, experts were asked to evaluate each FR in respect to each NFR. NFRs were further assessed independently for the Fuzzy MoSCoW. **Step 4:** A second round of questionnaires was sent to experts to create consensus in the fuzzy assessment and to create a joint decision cross table. **Step 5:** Computing the fuzzy assessment through Equation 1. **Step 6:** The functional requirements are ranked.

$$P(W_1 \times W_2) = \left(\frac{m_1 + 4q_1 + s_1}{6}\right) \times \left(\frac{m_2 + 4q_2 + s_2}{6}\right) \quad (1)$$

4. Results

Table 5 shows the joint cross-table data obtained from the panel of experts in their assessments of the functional requirements, with respect to the non-functional requirements.

Table 5 Joint Fuzzy Assessment Cross-Table

NFR	NFR 1 (MoH)	NFR 2 (MoH)	NFR 3 (MoH)	NFR 4 (MoH)	NFR 5 (SoH)	NFR 6 (SoH)	NFR 7 (MoH)
FR 1	Mo	Mo	Mo	Mo	Mo	So	Mo
FR 2	So	Mo	Mo	So	So	Mo	Mo
FR 3	Mo	Mo	Mo	Mo	So	Mo	Mo
FR 4	Mo	Mo	Mo	Mo	Mo	Mo	Mo
FR 5	So	Mo	Co	Mo	Mo	Co	Mo
FR 6	So	Mo	Mo	Mo	So	Mo	Mo
FR 7	So	Mo	So	Mo	Mo	Mo	Mo
FR 8	Mo	Mo	Co	Mo	So	Mo	Mo
FR 9	Mo	Mo	Mo	So	So	Mo	Co
FR 10	So	Mo	Mo	So	Mo	So	Mo

Based on the results in Table 5 the values are computed. In order to compute the values for each FR, Equation 1 was applied. Equation 2 shows the application to Real-time operations and supply chain related data exchange (FR 1) In respect to Data Backup (NFR 1).

$$FR1\ in\ Respect\ to\ NFR1 = \left(\frac{.66+(4*1)+1}{6}\right)*\left(\frac{5+(4*7.5)+1}{6}\right)$$
$$=5.6600 \qquad (2)$$

This was applied to FR1 in respect to all NFRs as shown in Equation 3.

$$FR1 = 5.6600 + 5.6600 + 5.6600 + 5.6600 + 4.7167 + 3.3083 + 5.6600$$
$$FR1=36.3250 \qquad (3)$$

Table 6 shows the values and rankings of FRs as a result of the analysis.

Table 6 Ranking of FRs for Informational SFSCs

Rankings of FR for Informational Short Food Supply Chains		
FR 4	37.7333	Track and trace
FR 1	36.3250	Real-time operations and supply chain related data exchange
FR 3	36.3250	Real-time supplier data exchange
FR 6	34.6350	Learning and development
FR 7	34.3533	KPI dashboard
FR 2	32.9450	Real-time sustainability related data exchange
FR 10	32.9450	Real-time document collaboration
FR 8	32.6450	Alerts to supply chain changes
FR 9	30.9550	Supply Chain Resilience
FR 5	29.2967	Notifications

5. Discussion

The Fuzzy MoSCoW technique has been valuable in providing a rank of functional requirements for short food supply chains. Applying fuzzy logic has provided the ability to reduce the number of ties between the informational short food supply chain platform requirements analysed in this study. The technique allows users to compare FRs in respect to NFRs, which provides insight into the functional aspects of an informational platform. The controlled rounds of questionnaires provided consensus amongst experts, therefore, suggest a Fuzzy MoSCoW can be applied to multiple supply chain stakeholders. The Fuzzy MoSCoW adopts limitations of MoSCoW as some FRs have the equal and nearby values.

Based on the theory of [46] it is important to categorize FRs to understand requirements to implement in early stages of a platform, and those to implement in later stages of platform development. A division of 'must have', 'should have' and 'could have' requirements is made. The closeness in FR values suggest difficulty in categorization. In this research there are no requirements in the 'won't have' category. This can be explained by noting that the seventeen requirements ranked were initially selected by the panel of experts and the requirements were seen by the panel to be important. Figure 1 presents the MoSCoW results.

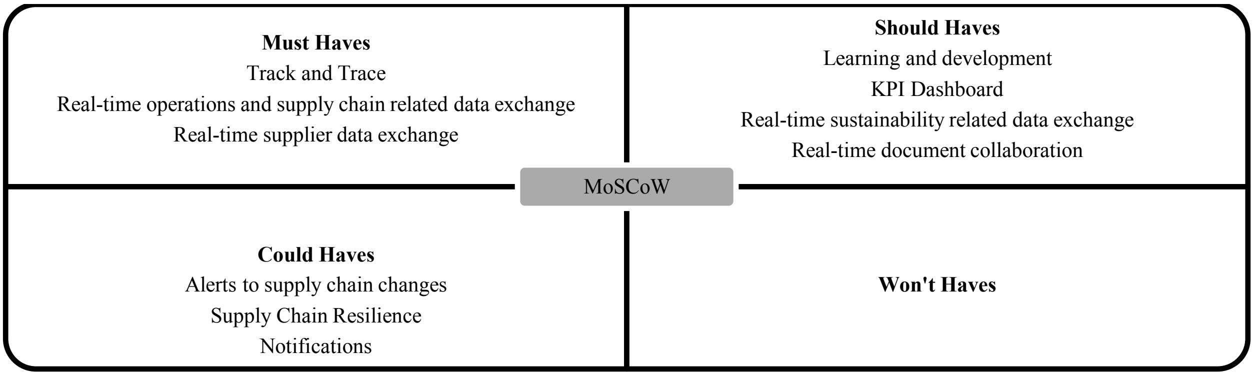

Figure 1 MoSCoW SFSC Platforms

Track and Trace, Real-time operations and supply chain related data, and Real-time supplier data exchange are found to be critical requirements for informational short food supply chains. The ‘must have’ requirements support literature in respect to SFSCs as Track and Trace helps in confirming the locality of products and is seen by the experts as the most critical requirement. Real-time data exchange on operations, supply chain, and supplier related information is needed to improve planning and control over the supply chain. Furthermore, supplier information can help reduce physical and social distances between suppliers and consumers.

In the ‘should have’ category are learning and development, KPI Dashboard, Real-time sustainability related data exchange, and real time document collaboration. Learning and development, is arguably a ‘should have’ requirement however its ranking value came as a surprise. Sustainability is undoubtedly a key requirement and correlates to literature for both short food supply chains and informational platforms. It is likely that with increasing sustainability transitions in the context of short food supply chains, the ranking value of the real-time sustainability related data exchange will increase. A KPI dashboard can use data and display how SFSCs are performing to provide an overview of various indicators, and therefore ‘should’ be included within informational short food supply chains. Real-time documents collaboration ‘should’ be included to enhance real-time information flow.

In the ‘could have’ category are alerts to supply chain changes, supply chain resilience, and notifications. This suggests that although these requirements would be nice to have, they are not top priorities. The ranking value of the supply chain resilience requirement is interesting. In relation to IT platforms and SFSCs, this requirement was suggested for inclusion by participants in a focus group used by research reported by [30] in their compilation of the consolidated list of requirements used in this study.

6. Conclusion

This research provides results of a study that seek to prioritise requirements of informational short food supply chain platforms. Seventeen requirements were assessed and ten functional requirements are prioritised using data supplied by experts. Results show that track and trace, Real-time operations and supply chain related data exchange, and real-time supplier data exchange are ‘must have’/top ranked functional requirements for informational short food supply chains. The ‘must have’ requirements strongly support core values of short food supply chain such as reduced social distance, improved operations to support economic return, and the desire to understand the origin of food. Alerts to supply chain changes, supply chain resilience and notifications are the lowest ranked/’could have’ requirements for informational short food supply chains, amongst the ten functional requirements analysed. Literature supports the ‘could have’ requirements for informational food supply chain platforms, but there is little correlation to short food supply chain objectives. Real-time sustainability related data exchange is categorised as ‘should have’ and it is expected that as short food supply chains increasingly embrace sustainability this requirement is likely to rank higher. The results are based on subjective opinion of a panel of experts and this is a limitation of the research as its conclusions may not be generalizable. Further research should be conducted to understand the prioritization of requirements for a larger group of stakeholders of short food supply chains. Whilst the Fuzzy MoSCoW method used in this study is useful, an alternative prioritization model for a much larger set of participants and requirements can be used.

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