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Resilient Reverse Logistics with Blockchain Technology in Sustainable Food Supply Chain Management during COVID-19

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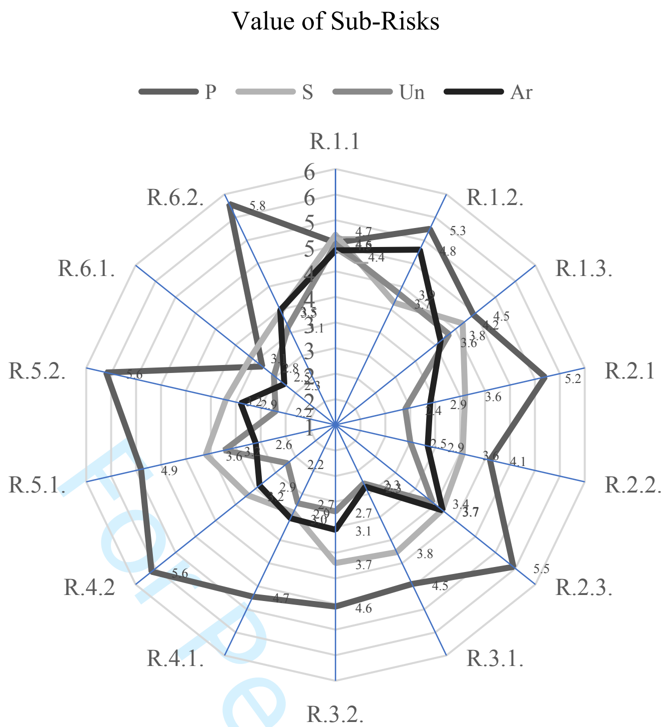

Figure 1. Radar Chart of Value of Sub Risks

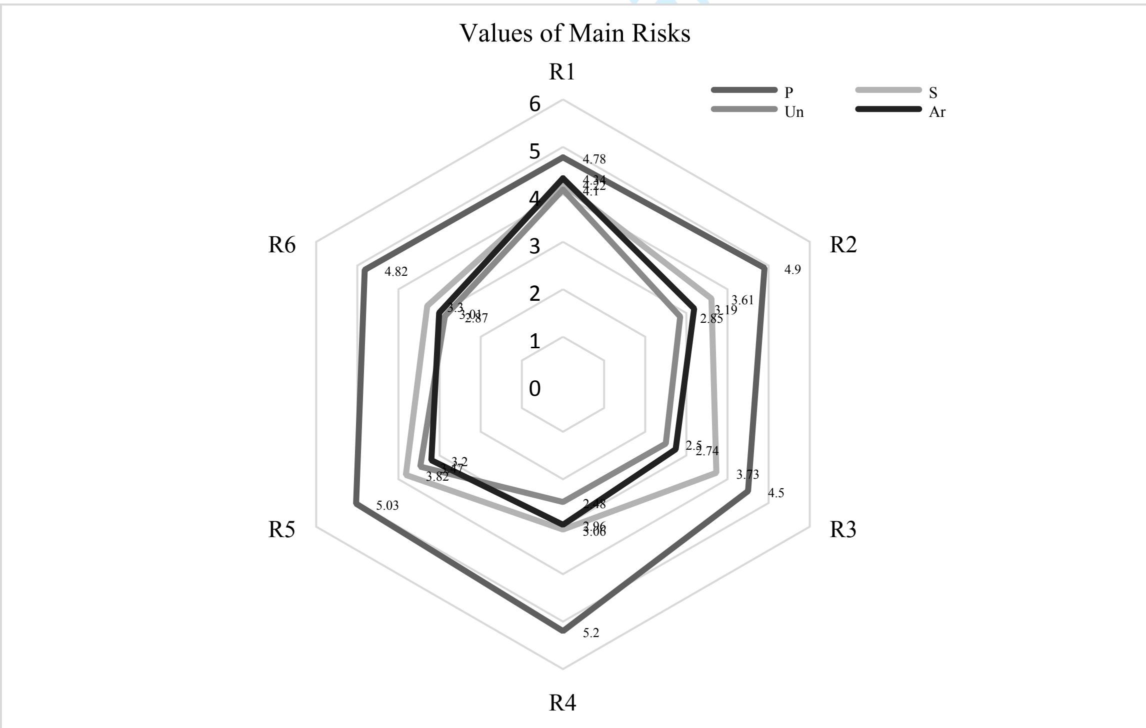

Figure 2. Radar Chart of Value of Main Risks

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Abstract

COVID-19, which is a global problem affects the all supply chains throughout the world. One of the supply chains most affected by COVID-19 is food supply chains. Since the sustainable food supply chain processes are complex and vulnerable in terms of product variety, it has been negatively affected by the operational effects of COVID-19. While the problems experienced in the supply chain processes and raw material constraints caused stops in production, the importance of new business models and production approaches came to the fore. One of the issues of increasing importance is the adoption of reverse logistics activities in sustainable food supply chains and increasing the resilience of food supply chains by integrating blockchain technology into processes. However, adapting blockchain technology to increase the resilience of reverse logistics activities in the food supply chain has advantages as well as risks that need to be considered. Therefore, it is aimed to determine these risks by using Fuzzy Synthetic Evaluation method for eliminating the risks of blockchain adaptation for flexible reverse logistics in food supply chains to increase resiliency. The novelty of this study is that besides discussing about the benefits of BC-T, it is to identify the risks it can create, to eliminate these risks and to guide the establishment of resilience in reverse logistics activities of SFSCs. According to results, the risks with the highest value among the sub risks is determined as data security risks. Data Management risks is calculated as the risk with the highest value.

Keywords: *Blockchain Technology; Sustainable Food Supply Chain; Resilience; Reverse Logistics*

List of Abbreviations

SFSCs; food supply chains

BC-T; blockchain technology

FSE; fuzzy synthetic evaluation

1. Introduction

Sustainable food supply chains (SFSCs) consists of vulnerable processes that are challenging to manage due to their complex and multi-stakeholder structure (Benedek et al., 2022). Hence, its resiliency is threatened in the face of events that will occur in the supply chains (Panwar et al., 2022). The COVID-19 pandemic, which affects almost all supply chains around the world, has also caused disruptions in SFSCs (Godrich et al., 2022). Problems have arisen in every process from the first stage to the last stage of SFSCs, and the resiliency of the supply chains has been endangered (Ozdemir et al., 2022).

With COVID-19, the importance of issues such as supply chain management (Prataviera et al., 2022; Hervani et al., 2022), resiliency of supply chains (Ivanov, 2021; Fu et al., 2022), reverse logistics activities (Heiman et al., 2022) have increased. Moreover, COVID-19 and its devastating effects on supply chains highlight the importance of reverse logistics since provides transparency and traceability in SFSC' processes and also contributes to the circular economy (Garnett et al., 2020). Reverse logistics can be defined as the activity of planning, implementing and controlling the effective flow of raw materials, semi-finished products, finished products and related information from the point of consumption to the point of origin, in order to ensure that the value is gained or destroyed properly (Binalla & Mateo, 2022). Especially since SFSCs are vulnerable and contain perishable products, effective management of reverse logistics activities also increases its resilience against sudden events such as COVID-19 (Sharma et al., 2021). In addition, it is seen that companies/countries that encounter problems in advanced SFSCs processes can manage their reverse logistics activities in the context of circular economy, and it is seen that they get rid of the devastating effects of COVID-19 with the least damage (Beheshti et al., 2022).

Recently, COVID-19 has necessitated the adoption of "new normal" for almost all industries and supply chains (Coluccia et al., 2021; Sarkis, 2020). With these "new normal" adaptation, the most important factor to be considered in both forward and reverse logistics is technological developments such as Blockchain Technology (BC-T) (Govindan, 2022; Parmentola et al., 2022). BC-T adaptation has become an extremely important issue in reverse logistics activities of SFSCs (Hrouga et al., 2022) since it can provide radical changes with its disruptive technology approach for the "new normal" created by COVID-19 (Muduli et al., 2022). Furthermore, BC-T provides to easily monitor all processes in SFSCs, to keep all data under control, and to take quick actions against sudden disruptions (de Sousa Jabbour et al., 2018). Although there is an increase in technological adaptations and studies on the subject in advanced SFSCs, these studies are insufficient for reverse logistics activities (Wu et al., 2022; Hrouga et al., 2022). By considering studies, it can be stated that advantages and disadvantages of BC-T are known for advanced supply chains (Srivastava & Dashora, 2022; Rejeb & Rejeb, 2020) and especially in SFSCs (Saurabh & Dey, 2021), however; the knowledge about BC-T adaptation in reverse logistics, especially in SFSCs is not yet adequately researched (Samadhiya et al., 2022; Münch et al., 2021). As mentioned before, increasing the resiliency of especially vulnerable and complex SFSCs can be achieved with BC-T adaptation to supply chain processes.

For this reason, in this study, it is aimed to answer the following research question.

- **Research Question: What are risks of BC-T adaptation for resilient reverse logistics in SFSCs?**

To give an answer of the research question, Fuzzy Synthetic Evaluation Method (FSE) is used for the risk's assessment of BC-T adaptation for resilient reverse logistics in SFSCs. As an answer of the research question, it is aimed to identify the most important criteria and finding a roadmap for it by using FSE. With this motivation, one of the main purposes of the study is to increase the resiliency of SFSCs, to reveal the importance of BC-T adaptation and at the same time to reveal the risks that may occur. In addition to the advantages of BC-T adaptation, it is extremely important to identify these risks, eliminate risks and ensure resiliency in reverse logistics activities of SFSCs, which is discussed in the literature scarcely any. One of the biggest contributions of this study is to make a deeper research about resiliency of reverse logistics activities in SFSCs and the necessity of BC-T to achieve this resiliency. Other critical contribution and the uniqueness of this study is that besides discussing about the benefits of BC-T, it is to identify the risks it can create, to create awareness to eliminate these risks and to guide the establishment of resilience in reverse logistics activities of SFSCs. Although the importance of BC-T is a topic discussed in the literature (Nandi et al., 2021; Farouk & Darwish, 2020), the determination of BC-T risks and especially their examination in terms of reverse logistics creates a research gap in the literature.

Section 2 covers the importance of BC-T adaptation for resilient reverse logistics in SFSCs and Section 3 consist of determination risks of BC-T adaptation for resilient reverse logistics in SFSCs. Moreover, methodology is given in Section 4. Section 5 presents the implementation and results. Section 6 highlights the discussions and implications and lastly conclusion. First of all, BC-T adaptation for resilient reverse logistics in SFSCs are explained in details.

2. BC-T Adaptation for Resilient Reverse Logistics in SFSCs

The reverse logistics, which is called reverse material flow from customers to suppliers, has an important role in supply chain management due to product returns and sustainability problems and contributes to the circular economy (Binalla & Mateo, 2022). Reverse logistics can be used as a competitive strategy, a profit center, an asset recovery and a tool to increase customer satisfaction (Beheshti et al., 2022). The wastes obtained throughout the supply chain are returned to the manufacturer as raw materials by the reverse logistics system and are put into production again (Lai et al., 2022). Moreover, the importance and impact of reverse logistics varies from sector to sector and according to the location of the enterprise in the distribution channel (Heiman et al., 2022). Reverse logistics activities are of great importance in sectors where product value, diversity and recycling rates are high (Shahidzadeh & Shokouhyar, 2022).

With COVID-19, the importance of reverse logistics activities and its contribution to the circular economy in supply chains has been understood (Lai et al., 2022). Raw material problems in supply chains, production stoppages, and logistics problems have highlighted the necessity of reverse logistics applications (Orlando et al., 2022). During COVID-19, it has become imperative to adopt new approaches in SFSCs, especially in order to adapt to increasing competition conditions and meet consumer demands (Sharma et al., 2021). Moreover, problems that may occur in the processes of the chain caused by disruptions such as COVID-19 can cause significant losses in product quality (Spieske et al., 2022). For this reason, it has become extremely important to record, monitor and track the SFSCs in order to carry out resilient forward and reverse logistics activities, especially during COVID-19 (Kamalakshi, 2022). Although the adoption of new approaches and technologies in the forward supply chain has become widespread, the application of reverse logistics activities in SFSCs still remains in limited areas.

In order to achieve more efficient results, especially in reverse logistics activities of SFSCs, it is necessary to benefit from developing technologies in new supply chain designs, as in every field (Klimczuk-Kochańska, 2018). Some of these technologies such as electronic data interchange, internet, enterprise resource planning, radio frequency identification is recently adopted in reverse logistics activities of SFSCs. Moreover, one of the most important issues in reverse logistics activities of SFSCs is coordination and information sharing (Bottani et al., 2019). By considering structure of SFSCs, RFID technology, barcodes and sensors are used quite frequently (Kim and Laskowski, 2018). In addition to these technologies, BC-T, whose popularity is increasing day by day, has gained importance (Khan et al., 2022). Redesigning supply chains with BC-T is expected to facilitate the traceability of reverse logistics activities, processes, and increase reliability and efficiency (Wong et al., 2020).

BC-T is a digitally signed record of account transactions that cannot be tampered with and therefore assumed to be trustworthy (Hrouga et al., 2022; Muduli et al., 2022). The BC-T, which will be integrated into resilient reverse logistics in SFSCs, enables users to consume reliable, transparent, traceable and quality products, while making it easier for managers to take quick actions in case of sudden situations (Burgess et al., 2022). In addition, the adaptation of BC-T to the SFSCs, especially to reverse logistics activities, will be less costly than different applications (Leng et al., 2018). Moreover, the use of this technology in the reverse logistics activities of the SFSCs ensures that the entire process from the beginning to the last stage of reverse logistics activities is integrated with each other and constantly shares information (Kamilaris et al., 2019) and this information is visible to all parties involved in the chain (Wu et al., 2022; Pandey et al., 2022).

To sum up, with sudden disruptions such as COVID-19, especially the supply chain and reverse logistics are under active threat (Raja Santhi & Muthuswamy, 2022). The vulnerable nature of SFSCs, which is one of the supply chains most affected by COVID-19, has made it necessary to ensure their resilience in reverse logistics activities. With the use of BC-T in reverse logistics activities, which have a more complex structure, many improvements such as instant tracking and information sharing are provided (Govindan, 2022), and it is expected that the resiliency of SFSCs in reverse logistics activities will increase. Considering all these reasons, BC-T adaptation is needed in order to carry out resilient reverse logistics activities in SFSCs. However, adapting BC-T to increase the resilience of reverse logistics activities in the SFSC has advantages as well as risks that need to be considered. Some of restrictions in front of BC-T can be described as the risks of BC-T. Therefore, by eliminating the risks of BC-T adaptation for flexible reverse logistics in SFSCs, resilient reverse logistics activities can be achieved.

Hence, detailed information about risks of BC-T adaptation for resilient reverse logistics in SFSCs are explained in the following section.

3. Determination Risks of BC-T Adaptation for Resilient Reverse Logistics in SFSCs

Enhancing awareness of concepts of circular economy have been caused increasing forward and reverse logistics activities in the SFSCs and this transition have led to effective digital system that can be dealing with the increased data and multi-stakeholders nature of SFSCs as well. Thus, BC-T is disruptive technology that pave the way for effective data management, handling complex supply chain structure, and providing effective collaboration between stakeholders that can provide secure data with the open and distributed networks. However, apart from these benefits of BT, it has various risks that need to consider when creating resilient SFSCs.

Main risks can be classified as a data management, financial, supply chain, quality management, operational and planning risks. Data security is one of the sub risks of the data management risks that need to be dealing with effectively in order to create resilient SFSCs (Dwivedi et al., 2020). Increasing data with the adding reverse logistics activities in the SFSCs is required effective data management tools and approaches (Calle et al., 2019).

Nevertheless, data security risk is occurred due to the blockchain network depend on the real-time movement of enormous amounts of data. This data is vulnerable to cyber-attack and lead to loss of supply chain resilience. Thus, data security risks of BC-T Adaptation are critical for achieving resilient reverse logistics in SFSCs. In the same line, data privacy issue has become significant with the adaption BC-T because this technology provides open distributed ledger and all partners in the supply chain can trace all activities of stakeholders (Torky & Hassanein, 2020; Zamani et al., 2020). With the expand networks within the supply chain can cause risk privacy issue (Kumar et al., 2020). Other critical risks of BC-T Adaptation for resilient reverse logistics in SFSCs is risks in real time data analysis (Ivanov & Dolgui, 2021). To be resilient in the supply chain, real time data analysis is required to adopt rapidly changing conditions, but not effective data management system may increase risks by causing a vulnerable structure (Narwane et al., 2021).

Financial risks can be divided into three fundamental risks which are infrastructure and development cost, storage and processing data costs and fraud risks. However, BC-T arises requirements of significant initial investment due to the strengthen infrastructure (Zhao et al., 2017; Narwane et al., 2021; Wen et al., 2021). Besides, BC-T will require more storage for the network due to the increasing number of transactions within the supply chain. BC-T uses the decentralized network structure and it becomes a serious problem because there is no central authority to approve for the identification of users (Kumar et al., 2020; Nurgazina et al., 2021). The storage and processing of data costs are very expensive since all important information related to delivery time and quantity need to storage and BC-T is provide for tracking all these data (Abdelmaboud et al., 2022). However, BC-T is vulnerable to the hacker or cyber-attack due to the misusing digital identity. Fraud risk can occur for the business transaction in the SFSCs (Xie et al., 2020).

BC-T create quality management risks due the lack of fundamental standard for the supply chain processes. This technology is based on certain, defined and basic standard through smart contracts between partners that aim to increase traceability and trust (Banyai, 2018; Iftekhar et al., 2020). All stakeholders must comply these basic standards (Behnke et al., 2020). Besides, BC-T is causes expanding networks within the supply chain processes and this extending the processing timelines increases the risk of the data losing (Drljevic et al., 2021).

Supply chain risks discussed in the two categorize such as complexity and risk in managing supply and demand uncertainties. Businesses may need to cope with complex structures while integrating these technologies into their processes. Apart from the strengthen infrastructure, well-design supply chain network, well-explained strategic plan and well-trained worker is required for dealing with the complexity nature of the BC-T (Duan et al., 2020; Tenorio et al., 2021). Thus, complexity risks may occur because of the usage and understanding of the BC-T. Managing with the risk in supply and demand uncertainties is evitable effects on the resilience in the SFSCs (Jabbarzadeh et al., 2017). By coping with the uncertainties in the demand and supply risk can be mitigated with the effective resilience strategies (Choi et al., 2019).

Operational risks include process related risks and ineffective system integration. Since, BC-T can be applied through effective integration of system actors such as manufacturers, wholesalers, and retailers (Salamai et al., 2018). Complexity of supply chain can be deal with the developing the system to aim protect data between stakeholders by providing system actors' benefits (Narwane et al., 2021). Since, due to the ineffective system integration may cause the delay in the transportation and logistics process that can affect the food quality, freshness (Khan et al., 2022). In order to increase the quality of the items, supply chain partners need to be had increased collaboration in order to deal with operational risks (Dasaklis et al., 2022).

Planning risk consist of the two main risks which are insufficient specialized expertise and lack of resource planning. BC-T needs skilled workers that are capable of assigned tasks (Di Vaio & Varriale, 2020; Bag et al., 2020). These technologies involve technical tasks and the complexity of performing these tasks is obvious and requires skilled workers. However, hiring new employees instead of employees who are reluctant to fulfil these duties creates an additional cost for businesses (Sislian & Jaegler, 2022; Perboli et al.2018).

Proposed main and sub-risks of BC-T adaptation for resilient reverse logistics in SFSCs are presented in the Table 1. These risks are symbolized as a R in this study.

Table 1. Main and Sub Risks of BC-T Adaptation for Resilient Reverse Logistics in SFSCs

Based on the literature, BC-T adaptation is important to create resilient reverse logistics activities in SFSCs. There are various risks can occur when adoption of BC-T in the SFSCs. Thus, BC-T, apart from their benefits, have led to increase some risks for achieving resiliency in SFSCs. Resilience in SFSCs can be only achieved by minimizing or eliminating proposed risks. Identifying the risks that need to be focused on to increase resilience in the supply chain and making suggestions for strategies that can be developed will contribute to the literature. Proposed research methodology is discussed in the next section.

4. Research Methodology: Fuzzy Synthetic Evaluation

FSE is firstly introduced by Zadeh (1965). This method provides an assessment of uncertain multi-attribute or multi-criteria and solving complex problems. Since risk evaluation process are complex and it need to be handled with the uncertain environments. Evaluation of risk mainly based on the expert opinions and qualitative analysis. Thus, this method is also suitable to transform qualitative judgements to quantitative terms through memberships functions and FSE provides to quick and certain analyses for fuzzy problems (Wu & Zhou, 2019). Moreover, A-according to the implementation results, it provides a lot of information to decision makers. When comparing other methods such as AHP, SWARA etc., this method considers different risk parameters such as probability of occurrence and severity/impact to evaluate risk assessment in the literature (Akter et al., 2019). There are many studies that considered two parameters probability of occurrence and its magnitude in order to assess risk but two parameters can be not enough to observe impacts of proposed risks. By considering the literature review, it has been seen that the parameters discussed in the FSE implementation can be changed according to the problem needs (Wu & Zhou, 2019). Over the years, these parameters can differentiate in researches (Akter et al., 2019). For example, Yazdani-Chamzini et al. (2013) focused on uncertainty, impact, likelihood and ability to respond parameters in their study. Moreover, Sarkar & Panchal (2015) considered probability, severity and exposure parameters in their researches. Therefore, many parameters such as probability, uncertainty, impact, severity, unpredictability, uncontrollability, event measure quantity or ability to respond etc. can be discussed in researches (Wu & Zhou, 2019). The critical thing is to choose the parameter for the problem type taken in studies. Hence, in this study, problem is identified as to define the risks of BC-T adaptation for resilient reverse logistics in SFSCs. Moreover, to purpose of the use FSE in this study is to determine risks by for eliminating the risks of blockchain adaptation for flexible reverse logistics in food supply chains to increase resiliency. According to the problem requirement, in this study, probability (P), severity (S), uncontrollability (Un) and ability to respond (Ar) parameters are taken into consideration. However, in the recent literature, studies used two additional parameters, i.e., uncontrollability and urgency along with probability. Thus, this study is also based on the four parameters such as probability x severity x uncontrollability x ability to respond.

Steps of the FSE for evaluating the overall risk value for sub and main risks and also contribution of individual risk factors is presented below.

- First step is identifying risk factors.
- Second step is the selecting risk parameters for assessment: Four parameters which are probability x severity x uncontrollability x ability to respond are used in this study.

$$\Phi = \sqrt[4]{(probability\ x\ severity\ x\ uncontrollability\ x\ ability\ to\ respond)} \quad (1)$$

- Basic three elements are used in this method.

  Risk factor set: F= {f_1, f_2, f_3 , …., f_j } where i is the number of risk factors

  Assessment set= A= {a1, a2, a3, …aj}, where j is the evaluation levels

  Risk evaluation matrix R= $(rmn)_{ixj}$, where rmn state the extent to which evaluation level a meet the risk factor fm.
- Determination of risk value for sub-risks: membership function of parameters are presented as a matrix which is shown in the Equation 3.

$$(R_m^p)_{1x5} = r_{m1}^p, r_{m2}^p, r_{m3}^p, r_{m4}^p, r_{m5}^p \quad (2)$$

- Risk value of each sub-risk, P, S, Un, and Ar are calculated with the equations (3), (4), (5), and (6), respectively.

$$P_m = \sum_{n=1}^{5} (c_n\ x\ r_{mn}^p) \quad (3)$$

$$S_m = \sum_{n=1}^{5} (c_n\ x\ r_{mn}^s) \quad (4)$$

$$Un_m = \sum_{n=1}^{5} (c_n\ x\ r_{mn}^{Un}) \quad (5)$$

$$Ar_m = \sum_{n=1}^{5} (c_n \ x \ r_{mn}^{Ar}) \qquad (6)$$

where c_n (=1,2,3,4,5) is the rate of the risk assessment to sub-risk m.

In order to evaluate the risk value for sub-risks, equation 7 is used.

$$\Phi m = \sqrt[4]{(Pm \ X \ Sm \ X \ Unm \ X \ Arm)} \qquad (7)$$

- Determination of risk value for main risks: The weight calculation for P, S, Un and Ar of sub-risk 'm' is calculated with the equation (8), (9), (10) and (11).

$$w_m^p = \frac{Pm}{\sum_{m=1}^{k} Pm} \qquad (8)$$

$$w_m^S = \frac{Sm}{\sum_{m=1}^{k} Sm} \qquad (9)$$

$$w_m^{Un} = \frac{Unm}{\sum_{m=1}^{k} Unm} \qquad (10)$$

$$w_m^{Ar} = \frac{Arm}{\sum_{m=1}^{k} Arm} \qquad (11)$$

$$d_{tn}^p = \sum_{m=1}^{k} (w_m^p \ x \ r_{mn}^p) \qquad (12)$$

- In order to find the evaluation results, the fuzzy composition of weight vector and evaluation matrix is calculated, D is indicated the membership function of main risk 't' can be calculated Equation (13) and (14).

$$(D_t^p)_{1x5} = (w_m^p)_{1xk} + (R_m^p)_{kx5} = (d_{t1}^p, d_{t2}^p, d_{t3}^p, d_{t4}^p, d_{t5}^p) \qquad (13)$$

$$d_{tn}^S = \sum_{m=1}^{k} (w_m^S x \ r_{mn}^S) \qquad (14)$$

$(w_m^p)_{1xk}$: *weight matrix*, $(R_m^p)_{kx5}$:*membership matix, k sub − risks present in main risk* t.

- With the similar way, the membership function of main risk for S, Un, and Ar are calculated with the Equation (15), (16), (17), (18), and (19).

$$(D_t^S)_{1x5} = (w_m^S)_{1xk} + (R_m^S)_{kx5} = (d_{t1}^S, d_{t2}^S, d_{t3}^S, d_{t4}^S, d_{t5}^S) \quad (15)$$

$$d_{tn}^{Un} = \sum_{m=1}^{k} (w_m^{Un} x\, r_{mn}^{Un}) \quad (16)$$

$$(D_t^{Un})_{1x5} = (w_m^{Un})_{1xk} + (R_m^{Un})_{kx5} = (d_{t1}^{Un}, d_{t2}^{Un}, d_{t3}^{Un}, d_{t4}^{Un}, d_{t5}^{Un}) \quad (17)$$

$$d_{tn}^{Ar} = \sum_{m=1}^{k} (w_m^{Ar} x\, r_{mn}^{Ar}) \quad (18)$$

$$(D_t^{Ar})_{1x5} = (w_m^{Ar})_{1xk} + (R_m^{Ar})_{kx5} = (d_{t1}^{Ar}, d_{t2}^{Ar}, d_{t3}^{Ar}, d_{t4}^{Ar}, d_{t5}^{Ar}) \quad (19)$$

- P, S, Un and Ar of main risks can be calculated with the equation (20)-(23) respectively.

$$P_{Gt} = \sum_{n=1}^{5} (c_n\ x\ d_{tn}^{p}) \quad (20)$$

$$I_{Gt} = \sum_{n=1}^{5} (c_n\ x\ d_{tn}^{s}) \quad (21)$$

$$Un_{Gt} = \sum_{n=1}^{5} (c_n\ x\ d_{tn}^{Un}) \quad (22)$$

$$Ar_{Gt} = \sum_{n=1}^{5} (c_n\ x\ d_{tn}^{Ar}) \quad (23)$$

- The risk value calculation for main risk is presented in the Equation (24).

$$\Phi_{Gt} = \sqrt[4]{(\mathrm{PGt} \times \mathrm{SGt} \times \mathrm{UnGt} \times \mathrm{ArGt})} \quad (24)$$

- Next step is the determination of overall risk value. Thus, the weight calculation for P, S, Un and Ar for main risk 't' is calculated in equations (25)-(28).

$$w_{Gt}^{p} = \frac{(\sum_{m=1}^{k} Pm)_t}{\sum_{m=1}^{l} (\sum_{m=1}^{k} Pm)_t} \quad (25)$$

$$w_{Gt}^{S} = \frac{(\sum_{m=1}^{k} Sm)_t}{\sum_{m=1}^{l} (\sum_{m=1}^{k} Sm)_t} \quad (26)$$

$$w_{Gt}^{Un} = \frac{(\sum_{m=1}^{k} Unm)_t}{\sum_{m=1}^{l}(\sum_{m=1}^{k} Unm)_t} \quad (27)$$

$$w_{Gt}^{Ar} = \frac{(\sum_{m=1}^{k} Arm)_t}{\sum_{m=1}^{l}(\sum_{m=1}^{k} Arm)_t} \quad (28)$$

- P, I, Un and Ur membership function of overall risk is estimate with the equations (29) to (36).

$$d_{Ovn}^{p} = \sum_{t=1}^{l} (w_{Gt}^{p} \ x \ d_{tn}^{p}) \quad (29)$$

$$(D_{Ov}^{p})_{1x5} = (w_{G}^{p})_{1x1} + (D_{G}^{p})_{1x5} = (d_{Ov1}^{p}, d_{OV2}^{p}, d_{Ov3}^{p}, d_{OV4}^{p}, d_{OV5}^{p}) \quad (30)$$

$$d_{Ovn}^{S} = \sum_{t=1}^{l} (w_{Gt}^{S} \ x \ d_{tn}^{S}) \quad (31)$$

$$(D_{Ov}^{S})_{1x5} = (w_{G}^{S})_{1x1} + (D_{G}^{S})_{1x5} = (d_{Ov1}^{S}, d_{OV2}^{S}, d_{Ov3}^{S}, d_{OV4}^{S}, d_{OV5}^{S}) \quad (32)$$

$$d_{Ovn}^{Un} = \sum_{t=1}^{l} (w_{Gt}^{Un} \ x \ d_{tn}^{Un}) \quad (33)$$

$$(D_{Ov}^{Un})_{1x5} = (w_{G}^{Un})_{1x1} + (D_{G}^{Un})_{1x5} = (d_{Ov1}^{Un}, d_{OV2}^{Un}, d_{Ov3}^{Un}, d_{OV4}^{Un}, d_{OV5}^{Un}) \quad (34)$$

$$d_{Ovn}^{Ar} = \sum_{t=1}^{l} (w_{Gt}^{Ar} \ x \ d_{tn}^{Ar}) \quad (35)$$

$$(D_{Ov}^{Ar})_{1x5} = (w_{G}^{Ar})_{1x1} + (D_{G}^{Ar})_{1x5} = (d_{Ov1}^{Ar}, d_{OV2}^{Ar}, d_{Ov3}^{Ar}, d_{OV4}^{Ar}, d_{OV5}^{Ar}) \quad (36)$$

- The overall values of P, S, Un and Ar can be evaluated through equations (37)-(40).

$$P_{ov} = \sum_{n=1}^{5} (c_n \ x \ d_{ovn}^{p}) \quad (37)$$

$$S_{ov} = \sum_{n=1}^{5} (c_n \ x \ d_{ovn}^{S}) \quad (38)$$

$$Un_{ov} = \sum_{n=1}^{5} \left(c_n \ x \ d_{ovn}^{Un}\right) \quad (39)$$

$$Ar_{ov} = \sum_{n=1}^{5} \left(c_n \ x \ d_{ovr}^{Ar}\right) \quad (40)$$

- In the last step, overall risk value is calculated with the equation (41).

$$\Phi_{ov} = \sqrt[4]{(\text{Pov} \times \text{Sov} \times \text{Unov} \times \text{Arov})} \quad (41)$$

Implementation of this study is presented in the next section.

5. Implementation & Results

For the implementation of this study, a questionnaire is prepared by using Google forms and 21 respondents are answered the questions. By considering profile of respondents it can be seen that all of these respondents are working on food industry and have an expertise in reverse logistics, food supply chain and BC-T technologies. Moreover, 80 percent of the respondents in the study have 5 or more years of work. Moreover, these respondents are working as various position such as food engineer, R&D manager, software engineer, planning specialist, production manager i.e. These respondents are asked to evaluate 14 risk factors under 5 main risks. Moreover, risks are representing as *"R"*. Experts evaluated the *P, S, Un, Ar* of the identified risks and used a 5-point scale for this (1 = very low; 2 = low; 3 = moderate; 4 = high; and 5 = very high). As stated in the Methodology section, the membership function of each parameter is obtained based on the percentile expressions of the expert opinions. After determining the membership functions of the parameters, the *P, S, Un* and *Ar* values of the sub-risks are calculated. In addition, the Φ_m value of each sub-risk is determined and the sub-risks are ranked among themselves as shown in Table 2.

Table 2. Risk Value, Φ_m Value and Rank Order of Sub-Risks

Moreover, a radar chart is prepared to shows the comparison of sub-risks based on values of sub-risks as shown in Figure 1.

Figure 1. Radar Chart of Value of Sub Risks

After that parameter weights of main and sub-risks are calculated separately as shown in Table 3.

Table 3. Weights of Main and Sub-Risks

As a final step, membership functions of parameters for overall risk are found and results are given in Table 4.

Table 4. Risk Values of Main and Sub-Risks and Rank Order of Main Risks

According to results the implementations, another radar chart is prepared to shows the comparison of the values of main risks as shown in Figure 2.

Figure 2. Radar Chart of Value of Main Risks

According to the results, the risks with the highest value among the sub risks are "*Data Security (R.1.1.)*", "*Data Privacy (R.1.2.)*", and "*Risks in Real Time Data Analysis (R.1.3.)*" are determined. The last three risks with the lowest value are "*Insufficient Specialized Expertise (R.6.1.)",* "*Complexity (R.3.1)*" and "*Storage and processing data costs (R.2.2.)*" from top to bottom. Considering the values of main risks, the top 3 main risks with the highest values are calculated as "*Data Management Risks (R1)",* "*Operational Risks (R5)"* and "*Financial Risks (R2)"*, respectively.

6. Discussion & Implications

Apart from the benefits of BC-T adaptation, this technology has also led to increase risks in SFSCs. Thus, for developing suitable policies and strategies, identification of these risk is significant. Minimizing or elimination of these risk are critical to ensure resiliency in reverse logistics activities of SFSCs. This study aims to provide deep insight for resiliency of reverse logistics activities in SFSCs.

According to this study, *Data Security (R.1.1.)* risks are determined a first rank, "*Data Privacy (R.1.2.)*", and "*Risks in Real Time Data Analysis (R.1.3.)"* are followed the "data security risks". Similarly, Dutta et al. (2020) and Torky & Hassanein (2020) stated that the data security, storage and management are some of the key risks for BC-T, and data privacy and security are still significant problems for adoption of this technology to increase resilience in SFSCs (Calle et al., 2020). Increasing *"Risks in Real Time Data Analysis"* have causes collaboration problems between stakeholders for creating transparency and security issues. Rogerson & Parry (2020) is also stated that traceability of food supply chain is one of the main requirements to increase security and process controls. However, lack of real time data analysis is SFCs need tom be considered fundamental risk.

However, "*Insufficient Specialized Expertise (R.6.1.)*", "*Complexity (R.3.1)*" and "*Storage and processing data costs (R.2.2.)*" are determined the last three risk of BC-T adoption that need to be focused on the achieving resiliency in reverse logistics activities of SFSCs. In align with this priority, Di Vaio & Varriale (2020) pointed out BC-T requires high skilled employment that are capable of involvement of the technical tasks and dealing with the complexity of performing these tasks. Menon & Jain (2021) has been discussed the importance of the knowledge and skill to implement BC-T and they highlighted technical training and skill development is required to adopt BC-T in the SFSCs. In addition, BC-T uses the decentralized network structure by increasing transaction in the network and thus it creates a serious challenge by creating financial risks due to the not control authority to track all transaction in the supply chain (Nurgazina et al., 2021).

Among the main dimensions, "*Data Management Risks (R1)*", "*Operational Risks (R5)*" and "*Financial Risks (R2)"* are determined as the important risk that need to be considered. BC-T are required significant infrastructure.

Businesses consider high financial expectations and return from this high investment. Thus, these high-yield technologies can be achieved by taking high risks. In the same line, Rejeb et al. (2020) indicate that BC-T can cause technical considering data management risks and operational challenges in the SFSCs. These high-yield technologies have high risks as the initial cost and data processing processes are too high and costly (Wen et al., 2021). Kamilaris et al. (2019) stated stat specific platforms are needed to be transmitted, processed, stored the data. Thus, they discussed that BC-T is required highly investment in cost of equipment and operating process.

The main contribution of this study is to investigate the resiliency of reverse logistics activities in SFSCs and the necessity of BC-T to achieve this resiliency. Apart from benefits of BC-T, it is critical to determine the risks of BC-T and to provide suggestion to business, policy makers and academia for eliminating these risks to enhance resilience in reverse logistics activities of SFSCs.

Implications can be inferred from the results are indicated as follows. To deal with the unexpected situations and to enhance resiliency in SFSCs, proposed approach is based on the contingency and resilience theory. It is important that businesses should increase their ability to cope with challenges and recover quickly from them through these theoretical approaches. Implementation of BC-T in the SFSCs can create various risks of resilience and directly affects to operational performance of SFSCs. The SFSCs should be considered as a system for dealing with complexity and appropriate policies should be implemented by all stakeholders to increase traceability to ensure quality and reduce food waste. Besides, government policies and incentives are among the factors that most affect the SFSCs. Governments should adopt policies to reduce food waste and strengthen the SFSCs. Risks that may arise in transportation and distribution in the SFSCs should be determined and precautions should be taken. Business and governments should develop proactive strategies instead of reactive strategies.

Thanks to BC-T, traceability and transparency will increase, and solutions to problems such as the tracking of food products at risk of food fraud will be found. With trainings, companies can reduce food waste and achieve a healthy diet. Governments can improve public health with these technologies, and society's adoption of healthy eating can be achieved. To deal with such risks, policy makers should establish a robust risk management strategy to provide rapidly respond for unexpected conditions. Existing policies should be updated by reflecting new business processes to increase resiliency in the SFSCs. Thus, policy makers should make an investment for additional technology. Governments should investigate their ecosystem dynamics. Developing these ecosystems is the key government functions to be provide resilience in the SFSCs. Policy makers should develop the effective data strategy to prevent unsafety issue caused by BC-T.

Through effective trainings, ability to the adaptation of employees to new technologies can increase and thus it can be ensured that employees are informed about the effective management of data, data processing process, confidentiality, and that they use the data correctly and effectively. Moreover, in order to minimize operational risk, BC-T can be used as a managing supply and demand uncertainties. Accurately prediction demand and supply allow the supply chain manager to deal with the unpredictable conditions in the difficulty time such as pandemic time, economic instability conditions. If there is lack of sufficient infrastructure for BC-T in SFSCs can cause an operational performance disruption in the processes.

7. Conclusion

Since SFSCs are vulnerable, effective management of reverse logistics activities are needed to have resilient supply chains against COVID-19. Considering the problems occurring in supply chains, it is possible to ensure continuity in production and contribute to the circular economy with reverse logistics activities. One of the new approaches that has increased in importance with COVID-19 is the understanding of the importance of reverse logistics activities. However, the adaptation of BC-T is also needed for the implementation of reverse logistics activities in SFSCs. In addition to the advantages of BC-T, some risks also arise during the implementation process. In order to ensure the applicability of reverse logistics activities in SFSCs, the risks that arise with BC-T must first be eliminated.

Therefore, one of the main aims of the study is to increase the resilience in the SFSCs, to investigate the importance of BC-T adaptation to deal with the risks that reveal from digital transition. Besides, elaborating resiliency of reverse logistics activities in SFSCs is significant contribution of this study. Thus, it is aimed to determine these risks by using FSE method to have resilient reverse logistics in SFSCs in this study. Hence, totally 14 risks under 5 main risks are determined based on literature and expert opinions. For implementation of this study, a questionnaire is prepared by using Google forms and 21 respondents are answered the questions. According to the results, the risks with the highest value among the sub risks is determined as data security risks. Considering the values of main risks, Data Management risks is calculated as the risk with the highest value.

The main limitation of this study is based on expert opinions and subjective judgments. Proposed risks are developed for specific sector. Thus, the results cannot be generalized. Besides, proposed risks can vary and other risks may occur for this problem over time. Besides, the other limitation of this model is that this study cannot consider causality relations between proposed risks. For further researches, the study can be implemented in different sectors and comparative analysis can be made. Moreover, parameters that is used in the implementation can be differentiated according to the needs of the industry and the supply chain. Besides, this method can be integrated with the different multi-criteria decision-making techniques. Moreover, businesses aim to increase SC resilience by enlarging capabilities with the pave the way for the effective usage of BC-T in SCs and they can protect unexpected SCs disruptions.

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TABLES

Table 1. Main and Sub Risks of BC-T Adaptation for Resilient Reverse Logistics in SFSCs

Main Risks	Sub-Risks	Author(s)
R1 Data Management Risks	R.1.1. Data Security	Dwivedi et al. (2020); Calle et al. (2019)
	R.1.2. Data Privacy	Torky & Hassanein (2020); Zamani et al. (2020); Kumar et al. (2020)
	R.1.3. Risks in real time data analysis	Ivanov & Dolgui (2021); Narwane et al. (2021)

R2 Financial Risks	R.2.1. Infrastructure and development cost	Zhao et al. (2017); Narwane et al. (2021); Wen et al. (2021)
	R.2.2. Storage and processing data costs	Kumar et al. (2020); Nurgazina et al. (2021)
	R.2.3. Fraud Risks	Abdelmaboud et al. (2022); Xie et al. (2020)
R3 Supply Chain Risks	R.3.1. Complexity	Duan et al. (2020); Tenorio et al. (2021)
	R.3.2. Risk in Managing supply and demand uncertainties	Jabbarzadeh et al. (2017); Choi et al. (2019)
R4 Quality Management Risks	R.4.1. Lack of data availability	Banyai (2018); Iftekhar et al. (2020)
	R.4.2. No standardization of process	Behnke et al. (2020); Drljevic et al. (2021)
R5 Operational Risks	R.5.1. Process related risks	Salamai et al. (2018); Narwane et al. (2021)
	R.5.2. Ineffective System Integration	Khan et al. (2022); Dasaklis et al. (2022)
R6 Planning Risks	R.6.1. Insufficient specialized expertise	Di Vaio & Varriale (2020); Bag et al. (2020)
	R.6.2. Lack of resource planning	Sislian & Jaegler (2022); Perboli et al. (2018)

Table 2. Risk Value, Φ_m Value and Rank Order of Sub-Risks

Risk	Sub-Risks	Parameter	Value	Φ_m	Rank
R1	R.1.1.	P	4.56	4.55	1
		S	4.71		
		Un	4.53		
		Ar	4.41		
	R.1.2.	P	5.25	4.34	2
		S	3.65		
		Un	3.85		
		Ar	4.80		
	R.1.3.	P	4.45	4.01	3
		S	4.18		
		Un	3.84		
		Ar	3.63		
R2	R.2.1.	P	5.20	3.38	8
		S	3.60		
		Un	2.40		
		Ar	2.90		
	R.2.2.	P	4.10	3.19	12
		S	3.55		
		Un	2.50		
		Ar	2.85		
	R.2.3.	P	5.45	3.99	4
		S	3.67		
		Un	3.43		
		Ar	3.68		
	R.3.1.	P	4.45	3.07	13
		S	3.76		
		Un	2.27		

R3		Ar	2.34		
	R.3.2.	P	4.55	3.43	7
		S	3.70		
		Un	2.69		
		Ar	3.05		
R4	R.4.1.	P	4.73	3.25	11
		S	2.90		
		Un	2.70		
		Ar	3.03		
	R.4.2.	P	5.60	3.27	9
		S	3.20		
		Un	2.20		
		Ar	2.90		
R5	R.5.1.	P	4.90	3.49	6
		S	3.60		
		Un	3.23		
		Ar	2.60		
	R.5.2.	P	5.60	3.27	9
		S	3.20		
		Un	2.20		
		Ar	2.90		
R6	R.6.1.	P	2.83	2.67	14
		S	3.12		
		Un	2.54		
		Ar	2.28		
	R.6.2.	P	5.79	3.85	5
		S	3.46		
		Un	3.13		
		Ar	3.49		

Table 3. Weights of Main and Sub-Risks

Risks	**Sub-Risks**	**P**			**S**			**Un**			**Ar**		
		Value	**Sub-Risk Weight**	**Risk Weight**	**Value**	**Sub-Risk Weight**	**Risk Weight**	**Value**	**Sub-Risk Weight**	**Risk Weight**	**Value**	**Sub-Risk Weight**	**Risk Weight**
R1	R.1.1.	4.56	0.32	**0.21**	4.71	0.38	**0.09**	4.53	0.37	**0.29**	4.41	0.34	**0.29**
	R.1.2.	5.25	0.37		3.65	0.29		3.85	0.32		4.80	0.37	
	R.1.3.	4.45	0.31		4.18	0.33		3.84	0.31		3.63	0.28	
R2	R.2.1	5.20	0.35	**0.22**	3.60	0.33	**0.07**	2.40	0.29	**0.20**	2.90	0.31	**0.21**
	R.2.2.	4.10	0.28		3.55	0.33		2.50	0.30		2.85	0.30	
	R.2.3.	5.45	0.37		3.67	0.34		3.43	0.41		3.68	0.39	
R3	R.3.1.	4.45	0.49	**0.13**	3.76	0.50	**0.07**	2.27	0.46	**0.12**	2.34	0.43	**0.12**
	R.3.2.	4.55	0.51		3.70	0.50		2.69	0.54		3.05	0.57	
R4	R.4.1.	4.73	0.46	**0.15**	2.90	0.48	**0.06**	2.70	0.55	**0.12**	3.03	0.51	**0.13**
	R.4.2	5.60	0.54		3.20	0.52		2.20	0.45		2.90	0.49	
R5	R.5.1.	4.90	0.47	**0.16**	3.60	0.53	**0.07**	3.23	0.59	**0.13**	2.60	0.47	**0.12**
	R.5.2.	5.60	0.53		3.20	0.47		2.20	0.41		2.90	0.53	
R6	R.6.1.	2.83	0.33	**0.13**	3.12	0.47	**0.06**	2.54	0.45	**0.14**	2.28	0.40	**0.13**
	R.6.2.	5.79	0.67		3.46	0.53		3.13	0.55		3.49	0.60	

Table 4. Risk Values of Main and Sub-Risks and Rank Order of Main Risks

Risks	Parameter	Wt	Value	Membership Function					Φ	Rank
R1	P	0.21	4.78	0.00	0.02	0.22	0.33	0.55	4.35	**1**
	S	0.09	4.22	0.00	0.01	0.20	0.26	0.51		
	Un	0.29	4.10	0.00	0.01	0.11	0.28	0.52		
	Ar	0.29	4.34	0.00	0.01	0.10	0.27	0.59		
R2	P	0.22	4.99	0.00	0.22	0.38	0.44	0.33	3.58	**3**
	S	0.07	3.61	0.00	0.15	0.33	0.27	0.25		
	Un	0.20	2.85	0.00	0.10	0.25	0.19	0.23		
	Ar	0.21	3.19	0.00	0.12	0.30	0.26	0.20		
R3	P	0.13	4.50	0.02	0.25	0.45	0.25	0.32	3.27	**6**
	S	0.07	3.73	0.03	0.20	0.50	0.20	0.20		
	Un	0.12	2.50	0.02	0.11	0.35	0.11	0.15		
	Ar	0.12	2.74	0.02	0.10	0.40	0.10	0.18		
R4	P	0.15	5.20	0.02	0.25	0.45	0.25	0.32	3.29	**5**
	S	0.06	3.06	0.00	0.20	0.25	0.30	0.14		
	Un	0.12	2.48	0.00	0.14	0.24	0.25	0.09		
	Ar	0.13	2.96	0.00	0.17	0.18	0.40	0.10		
R5	P	0.16	5.03	0.00	0.19	0.37	0.26	0.50	3.82	**2**
	S	0.07	3.80	0.00	0.13	0.25	0.20	0.39		
	Un	0.13	3.47	0.00	0.08	0.29	0.11	0.40		
	Ar	0.12	3.20	0.00	0.07	0.25	0.10	0.38		
R6	P	0.13	4.82	0.03	0.24	0.27	0.35	0.42	3.42	
	S	0.06	3.30	0.04	0.28	0.14	0.25	0.25		
	Un	0.14	2.87	0.04	0.30	0.10	0.25	0.19		
	Ar	0.13	3.01	0.04	0.26	0.10	0.19	0.28		**4**
OVERALL	P		**4.90**	**0.01**	**0.20**	**0.34**	**0.37**	**0.40**	**3.04**	
	S		**1.59**	**0.00**	**0.07**	**0.12**	**0.11**	**0.13**		
	Un		**3.22**	**0.01**	**0.11**	**0.20**	**0.21**	**0.31**		
	Ar		**3.41**	**0.01**	**0.11**	**0.21**	**0.23**	**0.33**		