



Article

Supply Chain Complexity and Its Impact on Knowledge Transfer: Incorporating Sustainable Supply Chain Practices in Food Supply Chain Networks

Hareer Fatima Ahmed ^{1,*}, Amin Hosseinian-Far ¹, Dilshad Sarwar ¹ and Rasoul Khandan ²

¹ Department of Business Systems and Operations, University of Northampton, Northampton NN1 5PH, UK; amin.hosseinianfar@northampton.ac.uk (A.H.-F.); dilshad.sarwar@northampton.ac.uk (D.S.)

² Institute of Continuing Education, University of Cambridge, Madingley, Cambridge CB23 8AQ, UK; rasoul.khandan@ice.cam.ac.uk

* Correspondence: hareer.ahmed@northampton.ac.uk

Abstract: *Background:* The dynamics of supply chain networks have changed due to increasing complexities. Global expansions and knowledge transfer in supply chain networks bring efficiency and effectiveness to companies. However, the probability of supply chain complexity has also been seen increasing. The barriers to sustainable supply chain networks need to be tackled in an effective manner as they impact business operations. Therefore, it is essential to eliminate and reduce the supply chain complexities, as it will facilitate the process of knowledge transfer and increase the implementation of sustainable practises in supply chain networks. In the previous research, four supply chain complexity drivers were identified. Previous research identified four supply chain complexity drivers by conducting a systematic review. This study investigates which of the four complexity drivers impacts knowledge transfer in the context of the food supply chain sector. *Methods:* In this research, knowledge transfer is therefore examined from the perspective of sustainable food supply chains. Thirty exploratory qualitative interviews were conducted in this study and analysed using Nvivo (v12) software. This study utilised thematic analysis techniques for the evaluation of the interviews to gather results. *Results:* The results illustrated six main factors classified under broad categories: integration of Knowledge Transfer, incorporation of technological advancements in supply chain networks, supply chain complexity solutions, supply chain complexity drivers, sustainable supply chain networks, and capability to reduce supply chain complexity. The findings of this study highlight that process complexity significantly influences the process of knowledge transfer in food supply chain networks. The research findings contribute to both academic and practical domains. This study contributes to the aggregation of supply chain complexity and its impact on Knowledge Transfer. Additionally, the findings support supply chain networks, which strive to achieve efficient Knowledge Transfer to attain sustainable value in business operations. *Conclusion:* This study has proven that robust knowledge transfer reduces supply chain complexity as it makes supply chain systems more resilient and well-coordinated in many potential ways.

Keywords: supply chain complexity factors; knowledge transfer; sustainable supply chain networks; process complexity



Citation: Ahmed, H.F.; Hosseinian-Far, A.; Sarwar, D.; Khandan, R. Supply Chain Complexity and Its Impact on Knowledge Transfer: Incorporating Sustainable Supply Chain Practices in Food Supply Chain Networks. *Logistics* **2024**, *8*, 5. <https://doi.org/10.3390/logistics8010005>

Academic Editors: Mladen Krstić, Željko Stević and Snežana Tadić

Received: 25 October 2023

Revised: 17 December 2023

Accepted: 25 December 2023

Published: 3 January 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Businesses at present are trying to adopt innovative strategies to cope with challenges and disruptive environments [1]. According to Del Giudice and Maggioni, firms should constantly update and enhance their learning processes, share information and knowledge, and create new information to cater to the difficulties [2]. Over the past 20 years, there have been several studies about the theory and practise of supply chain networks, but the area is still undergoing significant development and enhancement. The market is seeing intense rivalry because of the economy's growing globalisation and technological improvements.

It results in the fact that the supply chain's complexity has grown in recent years, and supply chain systems are now more disruptive than ever because of the growing business environment's uncertainties [3].

The firms should be able to handle the disruption in all three stages, and strategies should be formulated beforehand. Despite disruptions, firms learn from each event and generate new knowledge and experience, and this learning remains an implicit component of supply chain resilience. Supply chain practices demand the incorporation of sustainability metrics, as sustainability encourages organisations to perform things in a responsive manner. Disruptions provide an opportunity for constant learning within organisations so they can understand, learn, and implement from the actions, previous interventions, and experiences. Thus, complexity creates greater uncertainty throughout the supply chain, providing firms with additional opportunities for learning [4]. Pant et al. provide a benchmarking tool, also known as a standardised measurement framework, to measure the levels of complexity in an organisation. Furthermore, the relationship is accessed by firms' performance levels if the complexity level increases or decreases. The results highlight that complexity has a negative and essential impact on firms' performance levels when measured through a matrix. It further emphasises that knowledge plays a significant role in decreasing the level of complexity within organisations [5]. Supply chain complexity has a significant impact on organisational performance. Providing goods and services with unprecedented speed and precision requires the best supply chain strategies of today to have a demand-driven operating model that integrates individuals, processes, and technology [6]. Accordingly, this study focuses on the following research question:

What are the impacts of Supply Chain Complexity on Knowledge Transfer, and which of the supply chain complexity drivers has the most impact on Knowledge Transfer?

This research aims to identify and investigate the main supply chain complexity factor that influences the process of knowledge transfer. This study is distinctive and provides new results in the domain of knowledge transfer from the perspective of the food supply chain sector. Efficient Knowledge Transfer is essential in driving supply chain networks in a sustainable manner, and therefore, supply chains are now making a daily effort to implement strategies and mitigate barriers for robust business operations. Previous studies lack information and practices related to smooth knowledge transfer in food supply chain networks. To bridge this gap in literature and industry, this research conducts qualitative interviews to evaluate and identify the factors that affect effective Knowledge Transfer in supply chain networks the most. This research employed thematic analysis techniques for data analysis to evaluate the data generated from the interviews. The interviews have been transcribed and coded within the NVivo (v12) software. In this study, novelty stems from the exploration of factors resulting in supply chain complexity and identifying pertinent strategies that can support overcoming such complexities.

The research rationale or significance highlights that mitigating factors that contribute to supply chain complexity is essential for effective knowledge transfer. The research is significant in the field of food supply chains and Knowledge Transfer as it allows greater insights and understanding related to impactful factors that influence the process of knowledge transfer. Additionally, the qualitative method of expert elicitation to capture decision makers' and relevant stakeholders' viewpoints allows an efficient and well-coordinated running of supply chain operations in a sustainable way. The research is also significant in sustainable food supply chain networks as it advances knowledge by identifying the specific factor that has the highest impact on knowledge transfer. This study findings contribute to academia and professional practice by providing the opportunity for future decision-makers to avoid the supply chain complexity factor and improve the process of knowledge transfer to ensure efficient and sustainable supply chain operations.

This paper is structured as follows: Section 1 provides an introduction to this study context. Section 2 entails the literature review of this study, providing a review of relevant theories and models that depict the impact of Knowledge Transfer in supply chain networks. Furthermore, Section 3 presents the adopted methodology of this study, outlining the

methodological steps and stages. Section 4 discusses the findings of this research, which demonstrate the most significant supply chain complexity factor affecting the process of Knowledge Transfer. Section 4 further elaborates on the six main themes identified for having sustainable supply chain networks. This paper concludes in Section 5.

2. Literature Review

In previous studies on complex supply chain networks [7–9], researchers and industry professionals have examined the supply chain networks with regards to the associated complexities. Nevertheless, the growing focus on supply chain complexity reflects the growing developments in the field of supply chain management. More researchers are looking at systems and networks rather than just dyadic partnerships to better reflect on the complex structure of global supply chain networks [10,11]. Choi et al. shed light on the recent pandemic episodes that have made it necessary to perform a deeper analysis of supply chain complexity [12]. Several papers in the field of supply chain management have investigated mitigation tactics without considering how complexity and disruption interact [13].

According to Sabahi and Parast, supply chains are systems made up of several entities and processes with various risk perceptions and vulnerabilities [14]. The problem of supply chain complexity has received widespread recognition in both academic research and practice. The complexity of the supply chain raises several ambiguities, difficulties, and sensitive issues for supply chain management [15]. Iftikhar et al. highlight that supply chains are becoming more disruptive, and if the complexity is not successfully handled, it might have negative effects on organisations [16]. Supply chain collaborations and internal activities contribute both externally and internally to the complexity of supply chain networks [17]. Marriotti argues that managerial decisions are also compromised due to the intricacies of supply chain systems, a challenge further exacerbated by the elevated complexity of goods, processes, and collaborations [18]. While complex linkages and interactions between entities are presented by global supply chains, higher operating expenses, lower customer satisfaction, delayed deliveries, a lack of knowledge transfer, and integration among supply chain partners are some of the essential negative effects of supply chain complexity [19]. A rising proportion of customers in industrialised regions view sustainability initiatives as more of an obligation than an added value, and this trend is particularly prevalent where growing populations are placing greater strain on the environment. Chand et al. define sustainability in supply chain networks as the control of social, economic, and environmental effects as well as the promotion of ethical behaviour throughout the lifespan of products and services [20].

Figure 1 is a conceptual model by Wilding that illustrates a framework for explaining the uncertainties within a supply chain. Wilding argues that the three elements of Amplification, Deterministic Chaos, and Parallel Interactions, when combined, may dramatically raise the supply chain's level of complexity and unpredictability [21]. However, without any analytical model or empirical investigation, this study does not offer a compelling case. Using survey data, Milgate conducted an empirical investigation into the connection between supply chain complexity and delivery performance [22]. To further comprehend the notion, Milgate identified three characteristics of supply chain complexity: uncertainty, technical complexity, and organisational system. Bozarth et al. provide an alternative theory that organisations are facing a growing challenge of supply chain complexity that must be addressed in order to reduce its adverse effects [23]. According to relevant literature, supply chain complexity is defined as the degree of detail and dynamic complexity displayed by the goods, procedures, and connections that comprise a supply chain. This is also the definition adopted in this study. Detail complexity is the quantity of parts or components that make up the system, while dynamic complexity is the unpredictable way in which a system reacts to a set of inputs that is partially influenced by its interconnectedness. Aitken et al. developed a conceptual model of how each business unit should respond to supply chain complexity, which later broadened this viewpoint [24]. Figure 1 further

demonstrates the supply chain complexity triangle and the components associated with supply chain complexity.

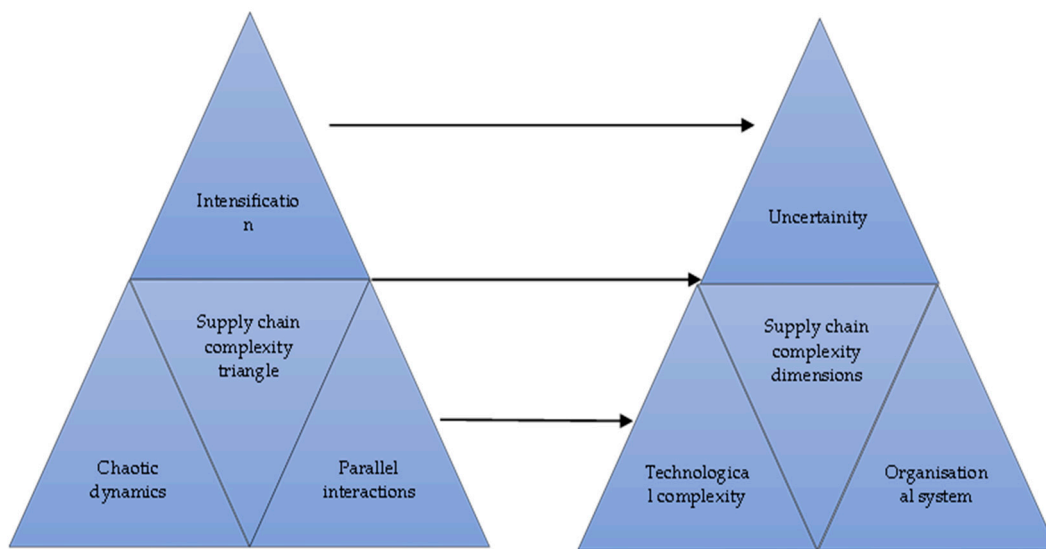


Figure 1. Supply chain complexity triangle and dimensions of supply chain complexity (adapted from [21,22]).

Knowledge transfer is one of the most promising ways to increase firms' competitiveness. It is a complex process that necessitates firms handling several tasks, such as creating routines that promote communication and collaboration. Along with collaborative networks, it facilitates sharing ideas and solutions with partners. According to Christopher and Lee, knowledge transfer in supply chain networks contributes to risk reduction, and it should be a top priority for firms [25]. Large businesses practise knowledge transfer internally and externally to promote supply chain resilience [26]. Knowledge transfer and adequate experience enhance the system's capacity to handle any disruption. It can be further broken down into three main phases: before, during, and after a disruption [27]. According to Jenssen and Nybakk, knowledge networks, which are formed through cooperative knowledge associations, and social networks, which relate to interactions with stakeholders, are the foundations of firm innovation [28]. In order to be relevant and competitive in a volatile environment, a firm's dynamic capability is viewed as an organisational capability to solve issues, identify opportunities, and reduce risks through the creation of new resources and capabilities [14].

The adoption of new technologies and their capacities in knowledge production, according to Papa et al., have an impact on the constantly evolving nature of knowledge creation, generation, and dissemination in companies [29]. To achieve this, they make use of their current resources by transforming large amounts of data into fresh, insightful, and useful knowledge utilising predictive and prescriptive business analytics. These skills enable businesses to excel at managing forecasts, production, and quality control while also giving customers access to new data for better decision-making to achieve a competitive edge [30]. By enhancing communication between suppliers and customers, new information may be produced [31]. Furthermore, knowledge growth can have a favourable impact on supply chain performance. Knowledge creation and information sharing are essential in supply chains. By enhancing communication between suppliers and customers, new information may be produced [31]. Furthermore, knowledge growth can have a favourable impact on supply chain performance. Organisational learning may be accomplished in two ways, according to Schoten et al.: knowledge production via critical internal analysis and experience and knowledge transfer through leveraging information across borders [32]. Knowledge transfer, for instance, might take place between occupational groups, organisational units, or other supply chain participants and stakeholders.

The term “complexity science” is ambiguous and has been studied by a variety of academic fields, including the social sciences, biology, and management sciences. Supply chain complexity has been examined in management science using a variety of theoretical frameworks, including complex adaptive systems [33], contingency theory [34], system theory [35], and natural accident theory [36]. Each of these theoretical perspectives highlights a different characteristic of supply chain complexity, with the most frequently emphasised components being variety, unpredictability, randomness, and uncertainty [37].

2.1. Contingency Theory

To achieve higher performance, contingency theory considers the contextual factors in the business’s decision-making environment. The basic concept of contingency theory is that businesses need to be adaptable and should be able to understand their operating environment [38]. This is especially important when examining supply chain complexity since both structural and dynamic factors can have an advantageous or disadvantageous impact on a variety of company outcomes [34], and numerous environmental elements, including geographic location, national culture, institutional circumstances, as well as dynamic environmental features such as excessive complexity or uncertainty, have an impact on these results [39]. Some studies focused on evaluating the influence of various forms of supply chain complexity on firms’ resilience and the ability of firms to continue operating in disruptive circumstances. These strategies are particularly relevant to the applicability of contingency theory [40]. The potential of dynamic capabilities is further explored in the existing literature by considering the dynamic environmental settings of supply chain networks [41]. Firms need to be clear about what competencies are successful in boosting their resilience while coping with high levels of supply chain complexity and uncertain conditions.

2.2. Complex Adaptive System

An interconnected network of numerous firms that demonstrates adaptive behavior in response to both the environment and the system of entities itself is referred to as a complex adaptive system [33,42]. A complex adaptive system is a self-organising system that continuously evolves over time by reconfiguring its internal and external links [43]. According to Kim et al., a complex adaptive system is a suitable theory for understanding the topologies of supply chain networks [44]. Supply networks are described as a typical example of a complex adaptive system by Pathak et al., since a supply chain will adapt because of interactions between network nodes and change over time [42]. When applied to supply chain networks, a complex adaptive system is a network made up of interconnected autonomous units that must make decisions to exist. The system develops and self-organises over time. This is especially relevant when examining how disruptions spread throughout supply systems. In a supply chain network, a disruption like a failed supplier may prompt the agent (focal business) to look for an alternate source to change the network’s structure.

2.3. Natural Accident Theory

Although it has not been commonly used in supply chain disruption literature, natural accident theory can contribute to supply network interruptions [45]. Systemic risk and natural accident theory are complementary approaches that help us comprehend disruption prorogation. Natural accident theory is based on complex and strongly connected systems. Accidents are unavoidable or even common in this system, and catastrophic failures are just regular flaws that go out of control [46]. Links to supply chain disruptions should be taken into consideration in order to avoid accidents. The interaction complexity of the system can create problems in supply chain networks [47]. Accidents can arise in situations in which systems are complex and tightly coupled. A modest failure can cascade into increasingly bigger problems. A failure in one area of the system can affect and disturb the operation of other areas of the system [48]. The structure of a system that might provide obstacles to

the recognition, understanding, and adjustment of variation in the system is shown by the natural accident theory in a supply chain system. Tight coupling may worsen the failure of the system, while the system's structure and complexity may make it difficult to detect and fix errors [48].

2.4. Systems Theory

The field of information systems discusses the application of general systems theory [49]. The goal of systems theory is to analyse dynamic relationships between components and relationships between the organisation and the environment [50]. To predict the system's response to changes and hindrances, it is crucial to assess its functionality and flexibility [51]. According to the first principle, a system's ability to adapt to changing circumstances decreases as it becomes more complex. The second principle is that more resources are required to sustain a larger system. The third principle illustrates how smaller systems frequently interact with bigger ones and are components of them. The fourth principle, which has obvious implications for the second principle, is about the creation of systems. The structural and dynamic aspects of complexity are two that are well-established in the supply chain literature [52]. The presence of various elements or sub-elements in the system gives rise to structural complexity, also known as static complexity or dynamic complexity. One factor that affects structural (static) complexity is the number of suppliers, customers, and products in a system, as well as their geographic distribution. On the other hand, from the perspective of operations management, dynamic complexity is fueled by the structure of supply chain operations [53] and is also known as operational complexity [54]. Dynamic difficulties result from factors like suppliers, demand, and possible delays incurred, reflecting the dynamic (time and unpredictability) characteristics of processes [55].

Supply chain complexity refers to the extent to which an organisation's supply chain consists of many different elements that interact in unpredictable ways [56]. Supply chain organisations may address a variety of consumer expectations by employing blockchain technology, quickly recalling products from the market when disrupted, and automating business processes with integrated responses to product quality by tracking product chains. Downstream complexity, which is generally linked to customer numbers and product categories, is typically referred to as customer base complexity. When the core enterprise's goals meet shifting consumer requirements and expectations, a large customer base and a wide range of completed items with a shorter life cycle add to the complexity of the customer base [57]. Customers with a significant divergence in their demands can negatively impact an enterprise's ability to operate efficiently when the complexity of the client base is great [58]. As customer diversity continues to grow, transaction costs also rise, decreasing the effectiveness of businesses in managing their clientele. At times, businesses see an increase in inventory costs and cash withdrawal periods as consumers become more geographically separated [59]. Additionally, a diversified customer base can be useful for assessing the effects of demand swings in downstream supply chains, which can be determined by the profitability of the company. Figure 2 outlines the role of knowledge transfer and technological advancements in supply chain systems. Figure 2 also highlights the significance of management structures, as when they expand, knowledge transfer and technological advancements increase; however, with the increasing size and structure of an organisation, uncertainty and complexity also increase. This denotes that complexities can arise as knowledge transfer and technological advancements increase. Therefore, it is essential to handle the uncertainties and complexities associated with it. Furthermore, Figure 2 also elaborates on the factors of uncertainty and complexity, which are delayed delivery times, delays in product delivery, and the impact on scheduling times eventually being late or changed. The management and structure are to be taken into consideration when exchanging knowledge and incorporating technology, as it is crucial to understand the factors affecting the organisation. For instance, some of these factors include the size of the organisation, the size of the client base, the location of suppliers, etc.

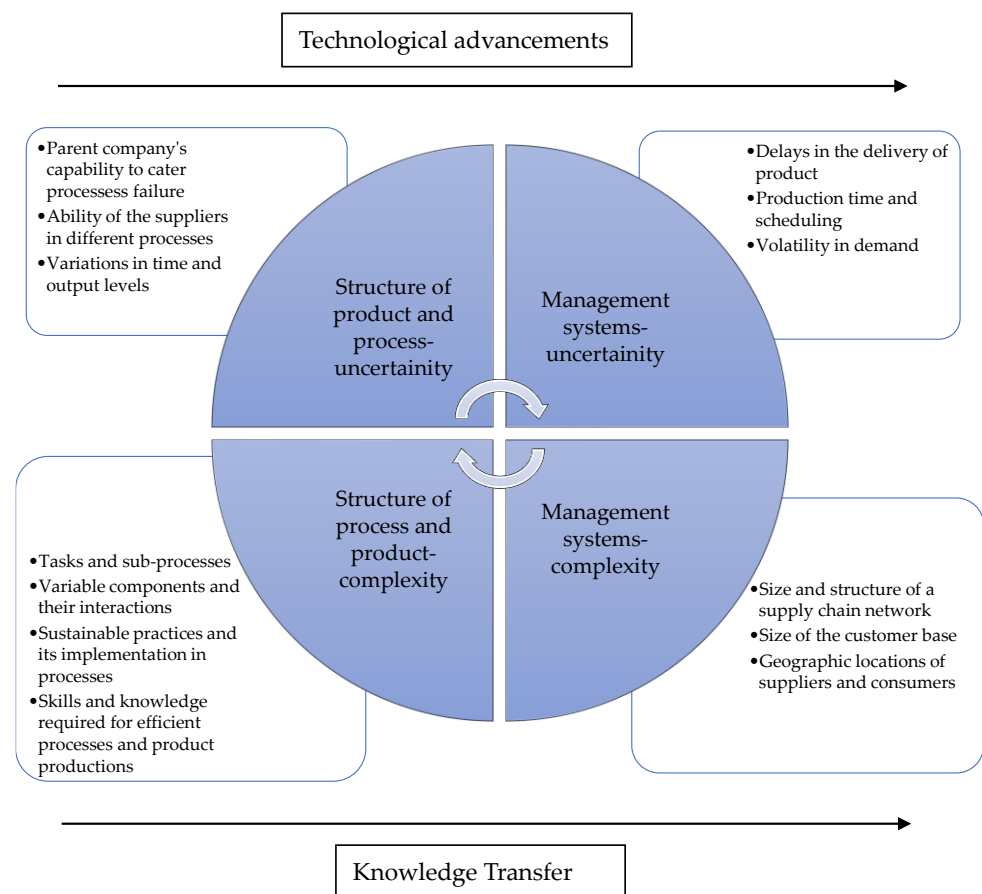


Figure 2. Role of Knowledge Transfer and technological advancements on Supply chain complexity (Adapted from [60]).

Xiao and Qi further elaborate that information exchange and effective communication across various levels and channels are crucial measures to prevent supply chain disruptions [61]. Since the ideal design for one product could not work for another, product variety is also a significant indicator of consumer base diversity. Consequently, when there is a large range of products, supply chain coordination has to be more effective [62]. While product complexity may not directly affect customer integration, businesses that produce complex products often employ both internal and supplier integration. Product variety has been shown to be positively correlated with supply chain integration parameters [63]. Yin and Ran emphasise the product life cycle as it is another important component that contributes to supply chain complexity; a shorter product life cycle results in quicker supply chain design modifications to accommodate varying degrees of demand uncertainty at various phases, as well as faster manufacturing and shorter lead times [64].

Even though supply chain complexity is unavoidable, successful businesses strive to comprehend it, reduce it to a minimum, and maintain efficient operations in supply chain networks. This article investigates and focuses on the food supply chain, which strives to reduce, manage, and control complexity to enhance system resilience, operations, and productivity in today's disruptive business environments [65,66].

Understanding the variables that influence the spread of a supply chain disruption is necessary to be able to solve supply chain complexity. Table 1 provides definitions of product complexity, process complexity, decision-making complexity, and consumer complexity, which were identified as the four factors that influence the process of Knowledge Transfer in supply chain systems. Companies will benefit from these elements to control disturbances and stop them from escalating across supply chain systems.

Table 1. Definitions of supply chain complexity factors that impact the process of knowledge transfer in supply chain systems.

Supply Chain Complexity Factors	Definitions
Process complexity	Process complexity can be defined as the degree to which a process is difficult to understand or implement [67]. Essentially, process complexity refers to the number of steps that comprise a process, as well as the flow of goods, activities, or decisions before they reach the output stage [68].
Product complexity	A product's complexity is a measure of its variety, diversity, and interconnectedness within an entire production system, or a range of products within a single production system [69].
Decision-making complexity	In the supply chain, decision-making complexity is determined by the volume and nature of the information required to make decisions related to the supply chain [70].
Consumer complexity	Consumer complexity can be illustrated by delays in the fulfillment of customer needs and requirements. It is essential to remove complexity in order to build sustainable and resilient supply chain partnerships with customers. Several factors play an essential role in consumer complexity, which includes trust building and building knowledge [71].

This study, therefore, focuses on finding out which supply chain complexity factor has the most impact on knowledge transfer. Furthermore, this study gives an insight into the challenges faced within food supply chain networks. This study integrates the concept of supply chain complexity drivers and provides different strategies to overcome supply chain complexity for sustainable supply chain networks.

3. Methodology

The three types of research interviews are unstructured, structured, and semi-structured and are considered methods of research that are commonly used in different studies. Semi-structured interviews are known as a method that is universal and is known as an exploratory interview. Furthermore, it is focused on a pattern or a specific theme, which gives the researcher the opportunity to go deeper into discovering the topic [72]. On the other hand, the structured interviews are quite limited in terms of formalised questions and less flexibility. Nevertheless, interviews are a recognised form of qualitative research [73]. Therefore, this study conducted primary data collection through semi-structured interviews in which certain questions were prepared to support and provide direction to the respondents while keeping the focus on the main aspect of the research.

Figure 3 provides a step-by-step guide used for conducting this study. A description of the supply chain complexity drivers was also presented to participants. Furthermore, this study has conducted semi-structured interviews with industry experts in supply chain and logistics. In the third phase of this study, long-term strategies to combat the supply chain complexities are discussed. Moreover, since it is important to provide strategies and techniques to minimise supply chain complexities in supply chain networks, it is essential to identify which supply chain complexity factor has the most impact on the knowledge transfer process. This information will help streamline supply chain operations in food supply chain systems.

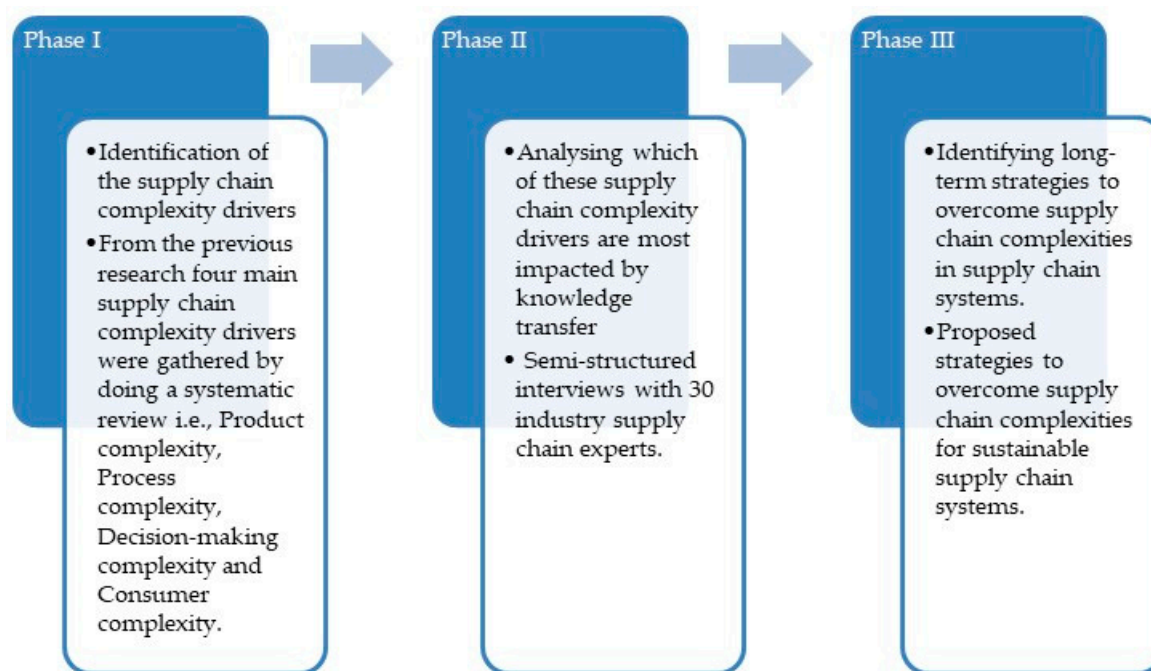


Figure 3. Step-by-step guide for this study (Author's Work).

3.1. Interviews

In this study, experts were selected from a pool of individuals who had knowledge, background, and experience in the supply chain or logistics and a strong understanding of the implications of knowledge transfer. It is highly essential to maintain the anonymity of the participants contributing to a research study [74]. Anonymity was maintained throughout the process during interviews. In the selected sample, this study highlighted those firms that are represented in corporate networks with a strong focus on food supply chain networks. In addition to this, a key selection criterion was prepared before conducting the research, according to which the respondents should have at least mid-stage supply chain experience. In detail, the criteria set to interview the experts had to be defined to distinguish the experts in the field of supply chain and logistics. Therefore, the interviewees were selected based on the following criteria: (1) The individuals should have experience in the field of Supply chain or Logistics; (2) The individuals should have a minimum of 5 years of experience in the field; and (3) The individual should have a relevant degree/s or certification/s in the respected field. In total, 30 semi-structured interviews were conducted with experts in the field of supply chain and Logistics who possessed knowledge around supply chain complexity and knowledge transfer. This study was conducted among well-known supply chain and logistics companies in the UK. Accordingly, the majority of the respondents were recruited from these particular logistics and supply chain companies. Nevertheless, to ensure the comprehensiveness and diversity of the participants, random sampling was also adopted to recruit experts from food supply chain networks. All interviews were conducted in English, and no translation was required. Table A1 (in Appendix A) demonstrates the length of each interview along with the experience of each respondent. To anonymise interviews, codes have been assigned to each respondent.

3.2. Qualitative Data Analysis

Qualitative data analysis is one of the major aspects of a research study as it has huge amounts of data, which is quite time-consuming, lengthy, and difficult to deconstruct [75]. As presented in Table 2, there were different stages involved in the data analysis process, which included understanding the data, coding, and distributing the data in specified themes formulated given the vast quantity of the empirical data. The accumulative duration of the interviews was 1208 min, and 126 pages of transcriptions were derived from the

interviews conducted. Furthermore, the transcriptions were transferred into NVivo (v12) to code the data collected, and then they were reviewed several times to ensure the accuracy of the data references. NVivo (v12) was used to transcribe and code the text to ensure the originality and authenticity of the coding, as it was carried out manually by the researcher. There were five stages involved in the entire process, which led to the identification of the themes and then sub-themes for further clarification. A concept and a structure were given for the direction of this study with the help of these stages.

Table 2. The stages involved in the data analysis process (Author's work).

Stages	Interpretation
Stage 1: Data description and cleaning	Transcription of the data
Stage 2: Data coding	Systematic distribution of the data by identifying the important themes
Stage 3: Data analysis and thematic evaluation	Distributing the data into the respective code as per the themes formulated along with repeated reading.
Stage 4: Overview and definition of the themes formulated	Extracting sets of data which are not coming under the specified themes in order to define the themes in more specified way to enhance the analysis of each code created
Stage 5: Final analysis and Reporting	The inspection of each code created and extracting the most engaging data to connect the research questions to the data extracted

3.3. Results

In previous studies of supply chain systems, one of the focal points of the system was to understand the supply chain networks and to enhance the system. As the world has become increasingly dynamic and turbulent, it is essential to keep the network stable. In today's fast-paced environment, the global economy is not only dynamic but also turbulent. To perform so, it is essential to promote supply chain collaboration and knowledge transfer with the help of technological advancements [76]. It is often seen that when these strategies are integrated, they tend to fail quickly. This happens due to the lack of effective knowledge transfer before the process begins. This paper highlights the importance of integrating sustainable supply chain systems by removing supply chain complexities and addressing the causes of supply chain complexities in the first place, targeting the food supply chain industry. The supply chain systems are observed to be in a better position if the supply chain complexities are identified in a timely manner and knowledge transfer is practised effectively. The sustainability of the supply chain system is also enhanced if the technology is used efficiently in the food industry, e.g., for monitoring demand and supply. The blend of knowledge transfer and technological advancements, if used adequately, will deliver much better results in integrating supply chain networks and help towards building sustainable supply chain networks. Figure 4 provides an insight into the main nodes created in NVivo (v12) to categorise the themes and concepts in this study.

Figure 5 explains the first-order themes as categorised by the interviewees, which are further broken down into second-order concepts. The six first-order themes are the key takeaways from the interviewees' elaboration of each node into second-order concepts. It is to explore each theme in detail and break it down into different concepts to demonstrate each aspect explained by the interviewees. Based on the results, the following themes are categorised, which helps in understanding the final framework presented at the end of this section.

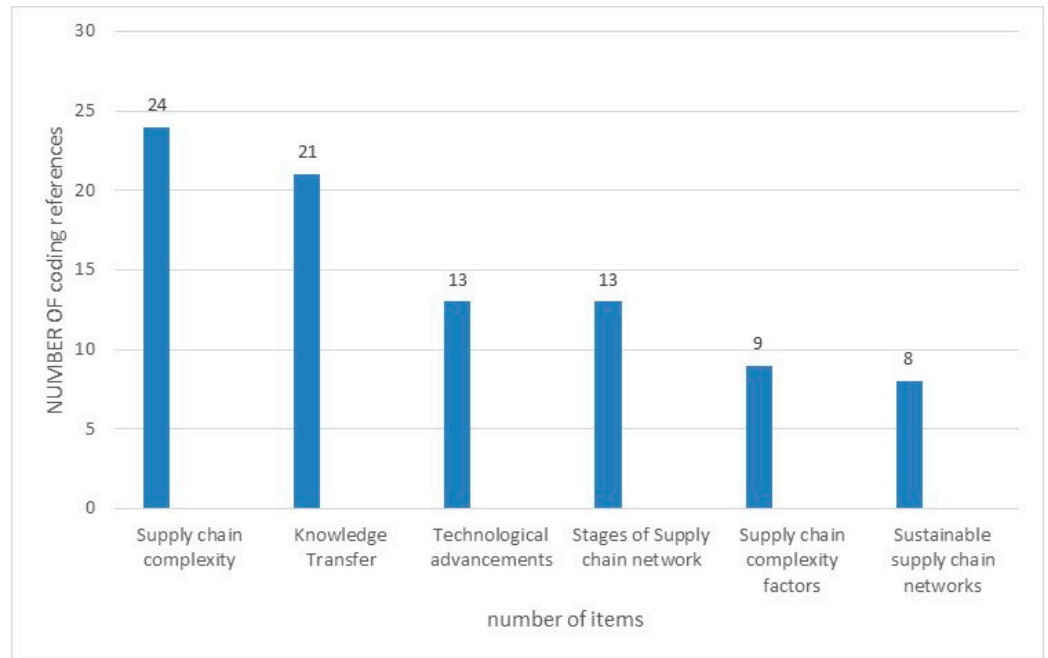


Figure 4. Nvivo Charts highlighting the main nodes in supply chain networks—Phase 1 (Author’s work).

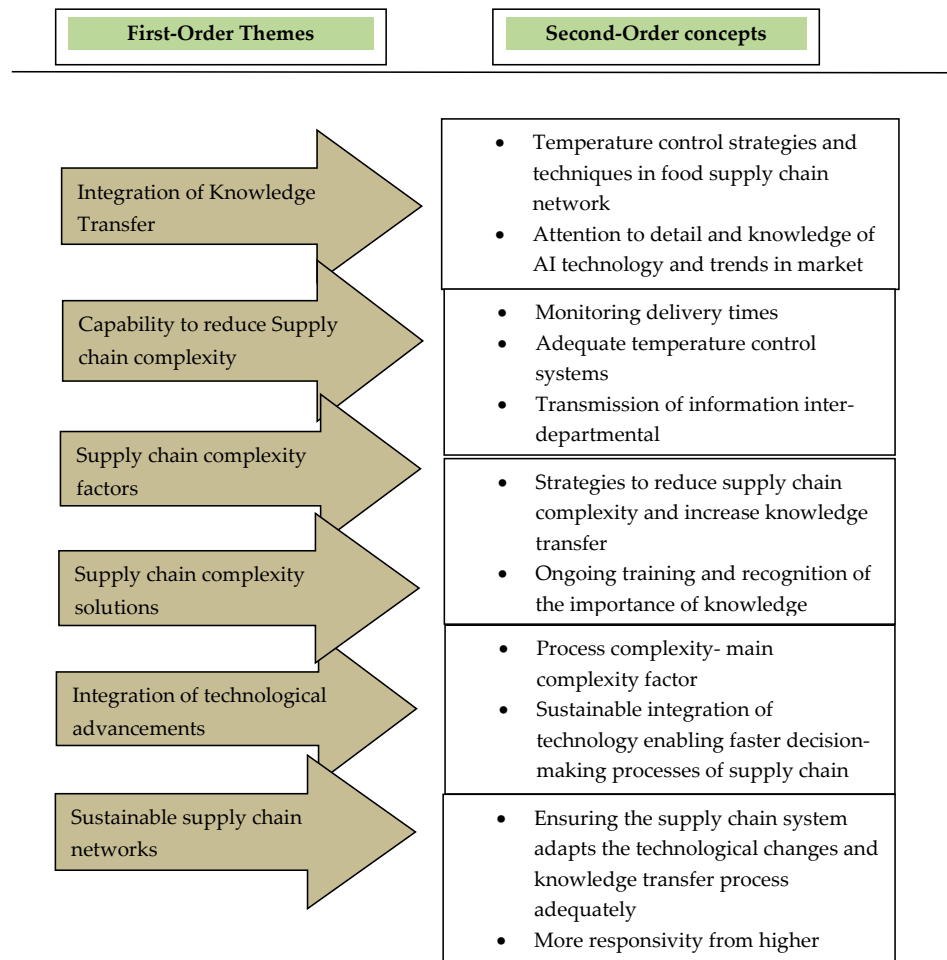


Figure 5. First-order themes and second-order concepts derived from the interviews (Author’s work).

3.4. Integration of Knowledge Transfer

The first category depicts the importance and implementation of knowledge transfer as one of the essential aspects of a supply chain network. Furthermore, it draws attention to the fact that innovation and teamwork are two important factors that help in the process of knowledge transfer. It can be perceived that firms' employees should have a deeper understanding of knowledge transfer, as there is still a lot of room for improvement. On a minimum level, the employees should have a basic understanding of knowledge transfer and its importance, as stated by one of the interviewees:

"Knowledge transfer is important for your company since it fosters better innovation, teamwork, and comprehension. You are better equipped to create a comprehensive understanding of challenging topics rather than depending solely on facts and figures to communicate information across departments. Since we are discussing knowledge, which is somewhat intangible, this procedure is completely imperfect. Your team can't read your mind, but you can come close."

In addition to this, De Barnardi et al. explain that, from various perspectives, knowledge has been considered a strategic asset or an essential driver leading to success in organisations [77]. It is essential to have techniques and strategies to transmit knowledge through a proper channel. One of the interviewees emphasised the need for multiple ways to transfer knowledge:

"The best way to transfer knowledge inside an organization is to start by thinking about how knowledge is transmitted from one person to another because knowledge only lives in the mind. You know, there are other strategies one might use here, such as telling, exhibiting, or writing. The approach you take is determined by how you and the other person communicate and how they process information. For effective transfer of information across many domains and persons, you need use a number of strategies and techniques."

Furthermore, one of the interviewees focused on the importance of knowledge transfer, specifically in the food sector, as constant training strategies should be incorporated. Inter-departmental knowledge transfer brings efficiency and effectiveness to the overall process and is considered good learning. practise for an organisation. The interviewee elaborates as follows:

"In my opinion knowledge is the key aspect and holds a lot of importance specially in food sector. Although a lot of training is provided to the employees since day one still the need for refreshing the skills and knowledge base remains a challenge. So let me get this right that knowledge is what holds the departments and not just the departments but the organization in a sum. It is the building block of food handling organizations as it brings efficiency in the process if all the employees are skillful in what they do. A common practice in my organization is that different employees work in different departments as we always have staff shortage, so we believe in helping out if we have time on our hands. In this manner we learn a lot of things from different departments and soon enough we realize that we are skilled in a lot of aspects. That is a good learning practice in this organization which I can easily say that it is knowledge being transferred."

3.5. Integration of Technological Advancements

In previous studies of supply chain systems, one of the focal points of the system was to understand the supply chain networks and enhance the system. However, in today's fast-paced environment, the world is not only dynamic but also tempestuous; therefore, it is essential to stabilise the overall network. To perform so, it is essential to promote supply chain collaboration and knowledge transfer with the help of technological advancements. It is often seen that when these strategies are integrated, they tend to fail quickly. This happens due to the lack of effective knowledge transfer before the process begins. This paper highlights the importance of integrating sustainable supply chain

systems by removing supply chain complexities and addressing the causes of supply chain complexities in the first place, targeting the food supply chain industry. The supply chain systems are observed to be in a better position if the supply chain complexities are identified in a timely manner and knowledge transfer is practised in an effective manner. The sustainability of the supply chain system is also enhanced if the technology is used effectively and efficiently in the food industry, such as when demand and supply are monitored. The framework has been constructed as a blend of knowledge transfer and technological advancements that, if used adequately, will deliver much better results in integrating supply chain networks and help towards building sustainable supply chain networks.

“It is now more comfortable and simpler to delegate tasks to a computer or phone rather than performing them directly thanks to technology. It’s kind of a hard fact now that new technology improves quality of life. It is impossible to imagine how we managed without technology in the past 20 years alone due to how far it has come. As a result, it is crucial in everything. In my opinion, it’s really necessary. Extremely. Since robots work far more quickly than people do, they can complete jobs that would otherwise take a tremendous amount of manual labour and attention to detail. Accuracy is also increased because to technology. Technology utilisation in some areas can also contribute to significant cost savings.”

Supply chain collaborations, if not practised properly, can quickly lead to supply chain complexities and conflicts within organisations [78]. Due to this, the companies involved in collaboration will not be relying on each other with the same level of dependency as they are in an asymmetrical relationship due to a lack of knowledge transfer.

“Using a coordinated system is one of the best ways to get and maintain organizational information, honestly. It’s kind of crucial to make sure essential employees don’t take crucial information with them when they leave. Learning about knowledge transfer can enhance productivity and teamwork within an organization. Knowledge Transfer, in my opinion, is essential because it enables a company to keep expertise despite personnel turnover. An effective knowledge transfer system enables you to incorporate an individual’s experience into the institution’s overall body of knowledge. Teams can readily access and preserve information in this way, despite member turnover. Information can be misplaced or transmitted ineffectively in an informal system.”

It is important to understand the commitment levels and advantages of knowledge transfer before entering supply chain collaborations, as it makes the overall process smooth and, with the use of technology, further enhances the structure of supply chain collaboration. Another respondent illustrates the importance of knowledge transfer and states that it is a structured process:

“Transferring knowledge is meant to spur and support innovation. The goal of knowledge transfer is to make knowledge more accessible to users in the future by organizing, producing, capturing, or disseminating it. Knowledge transfer can be performed through several different methods in addition to communication, memos, and meetings. Sharing knowledge or concepts within your organization is referred to as knowledge transfer. It’s a structured procedure that keeps talent in your business. Applying what you’ve learnt in a different setting is one way to demonstrate your learning as part of the process. So, yeah, it’s quite significant, at least to me. If you want to maintain a business.”

3.6. Supply Chain Complexity Factors

Supply chain complexity factors were previously gathered by conducting research on supply chain complexity drivers and their impact on knowledge transfer [79]. The four supply chain complexity factors that were identified are product complexity, process complexity, decision-making complexity, and consumer complexity. This study emphasises the identification of the factor(s) that have the most impact on knowledge transfer. The results suggest that process complexity has the most impact on knowledge transfer, as it is

one of the most important factors in food supply chain systems. One of the interviewees shed light on process complexity being the most important factor among the four complexity factors, which are process complexity, product complexity, consumer complexity, and decision-making complexity. The respondent highlights it as:

“From one to four, the most crucial factor is process complexity, which must be taken into account because it has an impact on knowledge transmission.”

As seen in Figure 6, key elements have been discussed with regards to process complexity, which is one of the major supply chain complexity drivers that has the most impact on knowledge transfer. The percentages have been drawn from the number of times each complexity factor was highlighted as an important complexity factor by the respondents at different stages of supply chain networks.

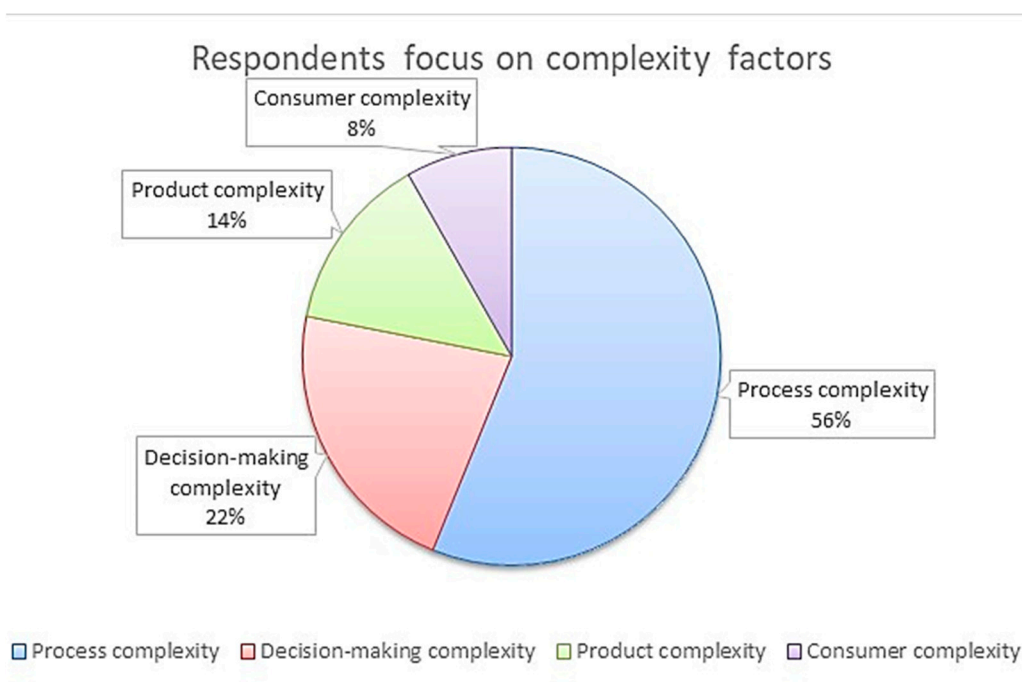


Figure 6. Highlighting process complexity as the main factor affecting knowledge transfer (Author’s work).

The stages and steps of a process determine how difficult it can become. Long lead times result from lengthy processes. The process’s sub-steps and the dependency of one sub-process on another can be one of the factors that affect the performance of a process [80]. Food sectors pay attention to detail when it comes to the overall process of a supply chain, as time efficiency and productivity are two key elements. Furthermore, the quality has to be maintained at all times. It has been further elaborated by one of the interviewees as follows:

“One of the key elements of process complexity is how your organisation handles it if any organisation experiences stock shortages, scheduling conflicts, and delivery delays. It shouldn’t happen in the first place. The rationale for this is that there shouldn’t be any problems if the account managers and the purchasing department makes sure that they’re working with suppliers who they can trust to deliver those goods on time. However, I am aware that it does occasionally happen. For examples a possible reason for the delays can be traffic. There can be delays because some things are sent from Germany. There were delays during the coronavirus pandemic, but the delay itself is not the issue.”

Another interviewee confirmed that process complexity can be a major cause for scheduling problems, as delays with respect to supplies or the delivery of products can cause a disruption in the overall process. The interviewee stated that:

“My understanding is that we have more of these situations here the harder we try to prevent them. How will you handle the delay is the question. The procurement department must make sure that their first action is to review what has been provided that day and get in touch with the companies to make sure they are delivered on schedule. There ought to be enough supply to make up for any delays. There is typically plenty to go around. Is it required? I think every company will stock up on supplies in case something similar happens. Process complexity is one of the major ones for me.”

An interviewee elaborated on how process complexity is one of the most important supply chain complexity factors that impacts knowledge transfer:

“In my opinion, each of them is essential if you work in the food industry because different divisions demand various skills to perform daily tasks. However, I think one of the most crucial elements in this case is the complexity of the procedure. That relates to our discussion of delivery windows because working in the food industry necessitates a total disregard for delays. It requires near-perfect execution of the process or the ability to overcome challenges in order to be successful.”

Process complexity is considered one of the most prominent and significant complexity drivers in supply chain networks. Therefore, the elimination of process complexity plays an essential role in the effective functioning of business operations and in efficient knowledge transfer.

3.7. Capability to Reduce Supply Chain Complexity

Supply chain collaborations with respect to organisations' strategies and behaviour can be one of the biggest challenges and can lead to the failure of supply chain systems. Therefore, it is essential to manage these issues from two perspectives. The first one indicates that individuals working together should have adequate knowledge about the importance of knowledge transfer. Incentive benefits can easily become difficult if companies are forced into collaborations without knowing the advantages and disadvantages of knowledge transfer. If the individuals lack knowledge and understanding of collaborations, then it often leads to unequal and minimum input from the employees, as eventually it affects the efficiency of collaborations [66].

“The organisation occasionally faces difficulties or complications because of the nature of the work. The focus is on the answer and maintaining the process, so it is quickly fixed.”

Furthermore, one of the interviewees focused on the efficiency and effectiveness of time management in food supply chain networks:

“Efficiency and efficacy are crucial in the food sector since there is a window and a time constraint.”

Delivery times in the food supply chain sector play a vital role in the effective functioning of business operations. Therefore, the emphasis is on the efficient and effective delivery of products and services in the food sector. Moreover, a reduction in supply chain complexities enhances the overall quality of the processes.

3.8. Supply Chain Complexity Solutions

Food supply chain networks are promoted and become stronger when organisations understand the need for competition, as the world is now globally competitive [81]. Knowledge assets and knowledge sharing in the food sector enhance the results of the organisations for better results. Figure 7 highlights the stages involved in a food supply chain system.

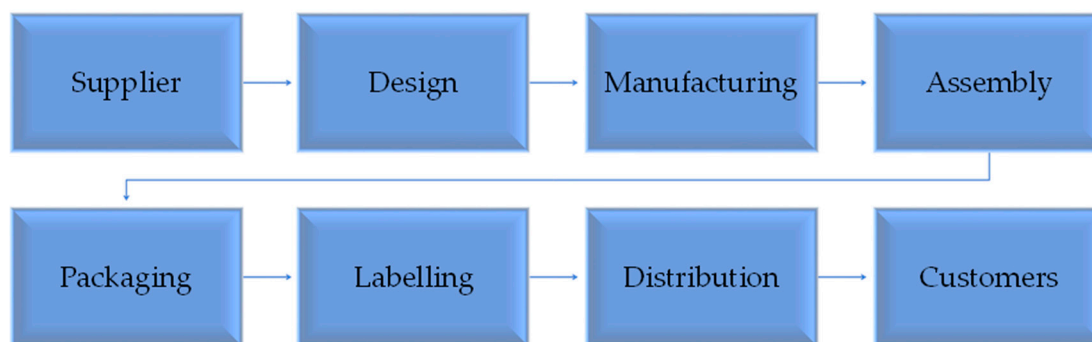


Figure 7. Stages of a food supply chain (Author's work).

Knowledge creation and knowledge transfer are essential sources for competitive advantage in organisations [82]. A major solution for supply chain complexity is to enhance the process of knowledge transfer, as inter-departmental knowledge transfer as well as knowledge transfer between different departments exchange ideas, skills, and knowledge. This helps the organisation have a competitive edge, and it boosts process productivity and efficiency. One of the interviewees elaborated on this:

“Education, particularly in the food industry, is in my opinion the most crucial aspect. Although staff receive thorough training from the beginning, the need to update skills and knowledge continues to be a challenge. Just to be clear, knowledge is what unites departments—and not just departments, but the entire organisation. It serves as the cornerstone of businesses that handle food since trained employees boost process effectiveness.”

Continuous training and development help in effective knowledge transfer. Therefore, it is advisable that training and development be carried out on a regular basis for individuals working in the supply chain sector. It increases the knowledge base and updates the required skills to tackle the complexities and challenges at different stages of the supply chain system.

3.9. Sustainable Supply Chain Networks

The decisions taken in supply chain networks can be divided into three parts, which are strategic, tactical, and operational. In other words, the decisions can be long-term, medium-term, or short-term [83]. It is expected that the food sector will have developmental plans for sustainable supply chain systems. However, one of the biggest challenges faced by organisations is related to the associated costs. Therefore, the organisations have shifted the concept towards long-term investment decisions to have sustainable practises in place.

“Cost, in my opinion, is the main barrier to the development of sustainable supply chains, with smaller businesses finding it especially challenging to bear the initial expenses involved. However, a long-term investment in something like compact packaging, for instance, can result in fewer and smaller shipments, a smaller environmental impact, and cost savings.”

Hou et al. confirm that the process of designing and packaging waste should be decreased, as it contributes to cost savings and promotes reuse and recycling [84].

“Some businesses discover that there are just no sustainable component options available or that they have supplier chains from acquisitions that are challenging to convert to sustainable practices due to complexity or organizational design. Some businesses find it challenging to justifiably justify the extra cost or effort as a result.”

According to Zhu et al., food production has more sustainable practises than before due to the increasing awareness and understanding of important environmental, economic, and social challenges in the food supply chains [85]. It is essential to have sustainable

supply chain practices, as they benefit individuals and overall communities. Environmental damage can be seen in various dimensions in the food supply chain industries. Therefore, it is an added challenge for the organisations to tackle. It can be further understood by one of the interviewees describing the objectives of sustainable development of supply chain systems:

“The objective is to have a beneficial impact on the people and communities in and around their operations while minimizing environmental harm from elements like energy consumption, water consumption, and waste creation. These worries are in addition to the regular issues about revenue and profit in the corporate supply chain.”

Figure 8 outlines the framework of this study as it illustrates the relationship between the types of supply chain complexities that impact the process of knowledge transfer. This research focused on the identification of the supply chain complexity factor, which has the most impact on the process of knowledge transfer. Process complexity factor has the highest impact on the process of knowledge transfer, as explained by several respondents. It has been identified that sustainable supply chain practises should be incorporated for effective knowledge transfer in supply chain networks. Technology also plays a vital role in enhancing the effectiveness of knowledge transfer in organisations. In Figure 8, the solid lines with a one-way arrow denote different complexity factors affecting the process of knowledge transfer. Each supply chain complexity factor illustrates the impact level based on the findings of this research. Furthermore, the two-way arrows between effective knowledge transfer, sustainable supply chains, and technological advancements in supply chain networks imply a cause-and-effect relationship. Moreover, the dotted lines imply that each supply chain complexity factor is affecting the transfer of knowledge.

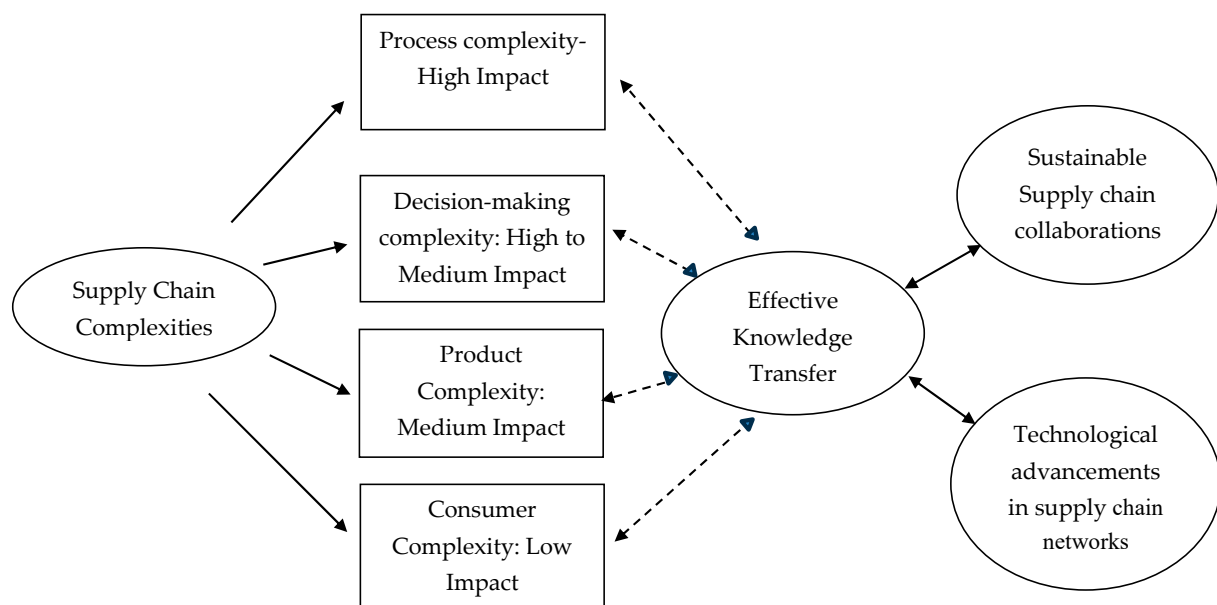


Figure 8. Framework of supply chain complexity drivers and its impact on knowledge transfer (Author’s work).

4. Discussion

The supply chain theory suggests that value is an essential element that should be added to the process and is more important than costs [86]. It is essential to address the issues of the food supply chain from a theoretical and practical perspective. This study highlights the complexities of the supply chain faced in the food supply chain industry. Specifically, the focus is to integrate effective knowledge transfer to have sustainable supply chain networks. Previous studies have shed light on the supply chain complexity factors that impact knowledge transfer. However, there are many supply chain complexity drivers.

This research specifies which supply chain complexity driver has the most impact on knowledge transfer in food supply chain systems. The presented framework highlights the significance of effective knowledge transfer by reducing supply chain complexity factors and enabling sustainable supply chain solutions. Technology also plays a significant role in maintaining the knowledge transfer process, as it provides organisations with a competitive advantage in gaining adequate skills and competencies. Furthermore, the high impact of process complexity on the effectiveness of knowledge transfer shows that more focus is required to standardise the processes of the food industry to minimise complexities and enhance overall productivity. The framework mainly focuses on the characteristics that firms should operationalise for maintaining and regulating supply chain systems in the long term, which will evolve into sustainable supply chain networks. It furthermore focuses on the importance of collaboration, as it is required to increase knowledge transfer in organisations. It further demonstrates that supply chain complexity is present in supply chain networks, and it is essential to control the increased complexity by identifying which complexity has the most impact on knowledge transfer. The results highlight that process complexity has the most impact on knowledge transfer. Decision-making complexity has also been highlighted, as it also has an impact on the knowledge transfer process. Collaboration, along with technological advancements, will allow supply chain members to automate supply chain processes and ultimately create a sustainable supply chain network in the food supply chain industry. The utilisation of the framework can be conducted in both theoretical and practical aspects, as it provides the necessary roles and responsibilities required for effective supply chain management, specifically in the food supply chain industry. Firstly, the results suggest that long-term sustainable practises should be implemented in supply chain systems. Effective knowledge transfer helps in long-term sustainable supply chain networks as it enables the individuals working in the organisations to be more efficient. Moreover, this study was conducted to identify which of the four supply chain complexity factors has the most impact on the process of knowledge transfer. The four factors are product complexity, process complexity, customer complexity, and decision-making complexity [79]. Among the four supply chain complexity drivers, process complexity is the major supply chain complexity driver that needs more focus in food supply chains. The processes involved in food supply chain networks involve the procurement of raw materials, their manufacture, storage, distribution, and every transportation connection. Time management is one of the major factors in food supply chain networks, as delivery time is very crucial and most of the processes revolve around it. Coordination and effective communication among employees help eliminate process complexity and enhance the process of knowledge transfer. The learning curve of knowledge transfer has to be transmitted and embedded in the individuals working in the organisations, as it increases the importance and understanding of knowledge transfer. Silvestre et al. further elaborate that the knowledge created or transferred to the key players of an organisation operating in different supply chain facilities enhances supply chain evolution, and vast improvements can be seen in the learning capacity of the individuals [87]. The results highlight that an increasing number of organisations are focusing on technological advancements to have effective communication and strategy in place for efficient supply chain systems. It also plays an imperative role in an effective knowledge transfer process within supply chain networks. A new framework is derived from the empirically extracted interview data. The framework highlights the main themes derived from conducting this research and identifies the emerging concepts. The implications of the findings will help decision-makers, policymakers, managers, and food supply chain industries efficiently use them for practice. This framework can be used as a basic concept that is designed to facilitate the prospects of sustainable supply chain systems by eliminating and reducing the main complexity factor of food supply chain networks.

The findings of this research have contributed to both academic and professional domains. This study adds to academic knowledge by providing insights regarding the supply chain complexity factor—process complexity that has a significant impact on knowledge

transfer. Furthermore, the findings also provide a framework that sheds light on efficient knowledge transfer processes in food supply chain networks. The framework also adds information in the supply chain complexity domain by providing sustainable solutions for an efficient and robust knowledge transfer process. Moreover, this study also provides the results of interviews conducted, which highlight that process complexity was considered a significant supply chain complexity factor that has the potential to change the dynamics of organisations if not tackled in a systematic way. Therefore, the findings of this study are significant in the process of creating and maintaining sustainable supply chain networks within food supply chains.

This study findings also support professional practise through the identification of the factor that affects knowledge transfer most within food supply chain networks. It further allows business users to assess and evaluate beforehand through efficient planning and reduce or eliminate food supply chain complexity for an effective knowledge transfer process. The framework produced in this research can also be potentially utilised by supply chain systems to minimise supply chain complexity. This will allow food supply chains to become more resilient and add value to business operations. In this study, food supply chain experts were interviewed, and the results showed that efficient solutions and strategies will help the food sector reduce and eliminate any complexities associated with supply chain networks. Elimination of barriers in supply chain networks will allow a resilient organisational structure and a smooth process of knowledge transfer.

5. Conclusions

This study projects the importance of knowledge transfer at different stages of supply chain networks. It also signifies the importance of reducing supply chain complexity drivers, which impact the process of knowledge transfer. This study conducted interviews with experts who have expertise, knowledge, and experience in the field of supply chain or logistics. The interviews were then analysed using the NVivo (v12) software, in which the data were transcribed and coded. NVivo (v12) improves the accuracy of the qualitative data and facilitates the transparency of the data analysis procedure [88]. The complete process carried out in this research through NVivo (v12) and the established framework give an opportunity to assess the validity of the method used and validate the results. Effective knowledge transfer and long-term sustainable supply chain networks have a huge role on a global level, as they reflect the foundation of changing practises in supply chain networks. This study focuses on sustainable supply chain networks by identifying the main supply chain complexity factor that has the most impact on knowledge transfer. As food supply chain networks have time constraints, it is important to identify complexity in a timely manner and resolve it appropriately. To regulate sustainable practises in supply chain networks, challenges must be addressed in a responsive manner.

This study had its limitations as it primarily focused on process complexity, which was seen as a significant factor in food supply chain networks with respect to knowledge transfer. This research focused on process complexity, product complexity, consumer complexity, and decision-making and their impact on knowledge transfer within food supply chain networks. As only these types of supply chain complexity were considered in this study, this was seen as a limitation. Studies in the future can potentially focus on other types of supply chain complexity in the food sector, such as managerial complexity, supplier complexity, information complexity, organisational complexity, dynamic complexity, static complexity, etc., to generate and produce new results in the domain. Another limitation observed in this research was that results were transcribed, generated, and analysed using one software, which was NVivo (v12), and future works can employ other software for the generation of results. Moreover, as stated before, this research uses NVivo software only for conducting qualitative analysis, which is another limitation of this study. Future work in the field can also employ other software, such as MAXQDA, ATLAS, etc., for in-depth qualitative analysis to produce results. A study can use other software to generate results that may focus on other supply chain complexity factors that impact knowledge transfer in

food supply chains. The use of other software in future works within the domain of the food industry can help generate new data and information by focusing on and considering other complexity factors. Additionally, the focus of this research was to conduct exploratory qualitative interviews, which can be seen as another limitation of the research. Furthermore, the interviews were only conducted specifically targeting the UK logistics and food supply chain sectors. Only the experts within the supply chain and food sector were considered for interviews, and all other participants working within the organisation were not included as a specific criterion has been outlined for this exploratory study; this was seen as a potential limitation to the work undertaken. Furthermore, other types of participants can be interviewed in the future from other supply chain networks, such as the automotive sector, retail sector, transportation sector, agriculture sector, etc., for data analysis and the provision of new results to observe how knowledge transfer impacts different supply chain systems. Different sectors might have different types of supply chain complexities, given the nature of the stages and steps involved in different supply chain networks. Therefore, future works can interview experts from different sectors to identify and understand which complexity factor is most impactful in that specific sector. Personal bias is an evident limitation in exploratory qualitative interviews, as the interviewee's stance can be informed through their opinions and experiences, and this was seen as a potential limitation in this research. However, this limitation was tackled through conducting various interviews with experts following a structural and systematic criteria of interview questions that were very focused.

This research conducted qualitative interviews within the UK related to food supply chain networks to evaluate the most impactful factor in supply chain complexity. Future work in the field could potentially put more focus on other geographical locations and organisations to generate results in the domain of efficient knowledge transfer. Moreover, the findings were generated and paid attention to food supply chain networks only; works in the future can also consider other supply chain networks such as retail, logistics, and other industries to see the impact of complexities factors affecting knowledge transfer. Additionally, experts in the future can also pay attention to other complexity factors, such as managerial complexity, organisational complexity, logistics complexity, demand complexity, etc., to analyse and evaluate their influence in the process of knowledge transfer within the food sector. Furthermore, experts in the field can also utilise other mediums, software, and techniques to generate results and assess knowledge transfer in food supply chain networks. As this research was in a specific direction, future research works can also use quantitative methods to gather and generate results and explore solutions and strategies for resilient and green supply chain networks.

Author Contributions: Conceptualization, H.F.A., A.H.-F., D.S. and R.K.; methodology, H.F.A., A.H.-F. and D.S.; software, H.F.A. and D.S.; validation, H.F.A., A.H.-F., D.S. and R.K.; formal analysis, H.F.A. and A.H.-F.; investigation, H.F.A.; resources, A.H.-F. and D.S.; writing—review and editing, H.F.A., A.H.-F., D.S. and R.K.; supervision, A.H.-F., D.S. and R.K.; project administration, A.H.-F. and D.S.; funding acquisition, A.H.-F. and D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The presented data in this study can be made available upon request from the corresponding author. Informed consent was obtained from all subjects involved in the study.

Acknowledgments: The authors would like to acknowledge the efforts and support from the University of Northampton's Department of Business Systems and Operations for providing access to the NVivo (v12) software, which was highly effective in conducting this research project.

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

Appendix A

Table A1. Respondents' profiles and interview duration (Author's work).

Code	Interview Length	Experience
R1	42 min	10+ years
R2	40 min	8+ years
R3	46 min	6+ years
R4	35 min	10+ years
R5	38 min	12+ years
R6	35 min	18+ years
R7	41 min	7+ years
R8	42 min	6+ years
R9	45 min	5+ years
R10	32 min	10+ years
R11	40 min	8+ years
R12	47 min	20+ years
R13	41 min	12+ years
R14	38 min	10+ years
R15	32 min	6+ years
R16	40 min	5+ years
R17	42 min	5+ years
R18	44 min	10+ years
R19	41 min	5+ years
R20	42 min	6+ years
R21	41 min	8+ years
R22	31 min	10+ years
R23	35 min	5+ years
R24	41 min	12+ years
R25	45 min	7+ years
R26	48 min	5+ years
R27	41 min	10+ years
R28	44 min	5+ years
R29	41 min	15+ years
R30	38 min	5+ years

References

1. Weber, Y.; Tarba, S.Y. Strategic agility: A state of the art introduction to the special section on strategic agility. *Calif. Manag. Rev.* **2014**, *56*, 5–12. [[CrossRef](#)]
2. Del Giudice, M.; Maggioni, V. Managerial practices and operative directions of knowledge management within inter-firm networks: A global view. *J. Knowl. Manag.* **2014**, *18*, 841–846. [[CrossRef](#)]
3. Lee, M.C. Knowledge management and innovation management: Best practices in knowledge sharing and knowledge value chain. *Int. J. Innov. Learn.* **2016**, *19*, 206–226. [[CrossRef](#)]
4. Hussain, G.; Nazir, M.S.; Rashid, M.A.; Sattar, M.A. From supply chain resilience to supply chain disruption orientation: The moderating role of supply chain complexity. *J. Enterp. Inf. Manag.* **2023**, *36*, 70–90. [[CrossRef](#)]
5. Pant, P.; Dutta, S.; Sarmah, S. Structural supply chain complexity index and construct validity: A data-driven empirical approach. *Int. J. Emerg. Markets*, **2023**, ahead-of-print. [[CrossRef](#)]

6. Al-Rawashdeh, O.M.; Jawabreh, O.; Ali, B.J. Supply Chain Management and Organizational Performance: The Moderating Effect of Supply Chain Complexity. *Inf. Sci. Lett.* **2023**, *12*, 1673–1684.
7. Hobday, M. Product complexity, innovation and industrial organisation. *Res. Policy* **1998**, *26*, 689–710. [[CrossRef](#)]
8. Closs, D.J.; Jacobs, M.A.; Swink, M.; Webb, G.S. Toward a theory of competencies for the management of product complexity: Six case studies. *J. Oper. Manag.* **2008**, *26*, 590–610. [[CrossRef](#)]
9. Closs, D.J.; Nyaga, G.N.; Voss, M.D. The differential impact of product complexity, inventory level, and configuration capacity on unit and order fill rate performance. *J. Oper. Manag.* **2010**, *28*, 47–57. [[CrossRef](#)]
10. Choi, T.Y.; Wu, Z. Triads in supply networks: Theorizing buyer–supplier–supplier relationships. *J. Supply Chain Manag.* **2009**, *45*, 8–25. [[CrossRef](#)]
11. Hearnshaw, E.J.; Wilson, M.M. A complex network approach to supply chain network theory. *Int. J. Oper. Prod. Manag.* **2013**, *33*, 442–469. [[CrossRef](#)]
12. Choi, T.Y.; Narayanan, S.; Novak, D.; Olhager, J.; Sheu, J.B.; Wiengarten, F. Managing extended supply chains. *J. Bus. Logist.* **2021**, *42*, 200–206. [[CrossRef](#)]
13. Chowdhury, P.; Paul, S.K.; Kaisar, S.; Moktadir, M.A. COVID-19 pandemic related supply chain studies: A systematic review. *Transp. Res. Part E Logist. Transp. Rev.* **2021**, *148*, 102271. [[CrossRef](#)] [[PubMed](#)]
14. Sabahi, S.; Parast, M.M. Firm innovation and supply chain resilience: A dynamic capability perspective. *Int. J. Logist. Res. Appl.* **2020**, *23*, 254–269. [[CrossRef](#)]
15. Jermstittiparsert, K.; Srisawat, S. Complexities in a flexible supply chain and the role of knowledge transfer. *Humanit. Soc. Sci. Rev.* **2019**, *7*, 531–538. [[CrossRef](#)]
16. Iftikhar, A.; Purvis, L.; Giannoccaro, I.; Wang, Y. The impact of supply chain complexities on supply chain resilience: The mediating effect of big data analytics. *Prod. Plan. Control.* **2022**, *34*, 1562–1582. [[CrossRef](#)]
17. Chand, P.; Kumar, A.; Thakkar, J.; Ghosh, K.K. Direct and mediation effect of supply chain complexity drivers on supply chain performance: An empirical evidence of organizational complexity theory. *Int. J. Oper. Prod. Manag.* **2022**, *42*, 797–825. [[CrossRef](#)]
18. Mariotti, J.L. *The Complexity Crisis: Why too Many Products, Markets, and Customers are Crippling Your Company—And What to Do about It*; Simon and Schuster: New York, NY, USA, 2007.
19. Lee, G. *Supply Chain Complexity and Supply Chain Resilience: A Literature Review*; EasyChair Preprint: Atlanta, GA, USA, 2023. [[CrossRef](#)]
20. Chand, P.; Thakkar, J.J.; Ghosh, K.K. Analysis of supply chain sustainability with supply chain complexity, inter-relationship study using delphi and interpretive structural modeling for Indian mining and earthmoving machinery industry. *Resour. Policy* **2020**, *68*, 101726. [[CrossRef](#)]
21. Wilding, R. The supply chain complexity triangle: Uncertainty generation in the supply chain. *Int. J. Phys. Distrib. Logist. Manag.* **1998**, *28*, 599–616. [[CrossRef](#)]
22. Milgate, M. Supply chain complexity and delivery performance: An international exploratory study. *Supply Chain Manag. Int. J.* **2001**, *6*, 106–118. [[CrossRef](#)]
23. Bozarth, C.C.; Warsing, D.; Flynn, B.B.; Flynn, E.J. The impact of supply chain complexity on manufacturing plant performance. *J. Oper. Manag.* **2009**, *27*, 78–93. [[CrossRef](#)]
24. Aitken, J.; Bozarth, C.; Garn, W. To eliminate or absorb supply chain complexity: A conceptual model and case study. *Supply Chain Manag. Int. J.* **2016**, *21*, 759–774. [[CrossRef](#)]
25. Christopher, M.; Lee, H. Mitigating supply chain risk through improved confidence. *Int. J. Phys. Distrib. Logist. Manag.* **2004**, *34*, 388–396. [[CrossRef](#)]
26. Soni, U.; Jain, V.; Kumar, S. Measuring supply chain resilience using a deterministic modeling approach. *Comput. Ind. Eng.* **2014**, *74*, 11–25. [[CrossRef](#)]
27. Soni, U.; Jain, V. Minimizing the vulnerabilities of supply chain: A new framework for enhancing the resilience. In Proceedings of the 2011 IEEE International Conference on Industrial Engineering and Engineering Management, Singapore, 6–9 December 2011; IEEE: Piscataway, NJ, USA, 2011; pp. 933–939. [[CrossRef](#)]
28. Janssen, J.I.; Nybakk, E. Inter-organizational networks and innovation in small, knowledge-intensive firms: A literature review. *Int. J. Innov. Manag.* **2013**, *17*, 1350008. [[CrossRef](#)]
29. Papa, A.; Chierici, R.; Ballestra, L.V.; Meissner, D.; Orhan, M.A. Harvesting reflective knowledge exchange for inbound open innovation in complex collaborative networks: An empirical verification in Europe. *J. Knowl. Manag.* **2021**, *25*, 669–692. [[CrossRef](#)]
30. Philip, J. An application of the dynamic knowledge creation model in big data. *Technol. Soc.* **2018**, *54*, 120–127. [[CrossRef](#)]
31. Paulin, D.; Suneson, K. Knowledge transfer, knowledge sharing and knowledge barriers—three blurry terms in KM. *Lead. Issues Knowl. Manag.* **2015**, *2*, 73.
32. Scholten, K.; Sharkey Scott, P.; Fynes, B. Building routines for non-routine events: Supply chain resilience learning mechanisms and their antecedents. *Supply Chain Manag. Int. J.* **2019**, *24*, 430–442. [[CrossRef](#)]
33. Day, J.M. Fostering emergent resilience: The complex adaptive supply network of disaster relief. *Int. J. Prod. Res.* **2014**, *52*, 1970–1988. [[CrossRef](#)]
34. Brandon-Jones, E.; Squire, B.; Van Rossenberg, Y.G. The impact of supply base complexity on disruptions and performance: The moderating effects of slack and visibility. *Int. J. Prod. Res.* **2015**, *53*, 6903–6918. [[CrossRef](#)]

35. Bode, C.; Wagner, S.M. Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions. *J. Oper. Manag.* **2015**, *36*, 215–228. [[CrossRef](#)]
36. Wiedmer, R.; Rogers, Z.S.; Polyviou, M.; Mena, C.; Chae, S. The dark and bright sides of complexity: A dual perspective on supply network resilience. *J. Bus. Logist.* **2021**, *42*, 336–359. [[CrossRef](#)]
37. Akin Ateş, M.; Suurmond, R.; Luzzini, D.; Krause, D. Order from chaos: A meta-analysis of supply chain complexity and firm performance. *J. Supply Chain Manag.* **2022**, *58*, 3–30. [[CrossRef](#)]
38. Ketokivi, M. Elaborating the contingency theory of organizations: The case of manufacturing flexibility strategies. *Prod. Oper. Manag.* **2006**, *15*, 215–228. [[CrossRef](#)]
39. Brandon-Jones, A.; Knoppen, D. The role of strategic purchasing in dynamic capability development and deployment: A contingency perspective. *Int. J. Oper. Prod. Manag.* **2018**, *38*, 446–473. [[CrossRef](#)]
40. Iftikhar, A.; Ali, I.; Shah, A. The Impact of Big Data Analytics on Firm's Operational Performance: Mediating Role of Knowledge Management Process. In Proceedings of the 2nd Asia Pacific International Conference on Industrial Engineering and Operations Management, Surakarta, Indonesia, 14–16 September 2021.
41. Gu, V.C.; Zhou, B.; Cao, Q.; Adams, J. Exploring the relationship between supplier development, big data analytics capability, and firm performance. *Ann. Oper. Res.* **2021**, *302*, 151–172. [[CrossRef](#)]
42. Pathak, S.D.; Day, J.M.; Nair, A.; Sawaya, W.J.; Kristal, M.M. Complexity and adaptivity in supply networks: Building supply network theory using a complex adaptive systems perspective. *Decis. Sci.* **2007**, *38*, 547–580. [[CrossRef](#)]
43. Anderson, P. Perspective: Complexity theory and organization science. *Organ. Sci.* **1999**, *10*, 216–232. [[CrossRef](#)]
44. Kim, Y.; Chen, Y.S.; Linderman, K. Supply network disruption and resilience: A network structural perspective. *J. Oper. Manag.* **2015**, *33*, 43–59. [[CrossRef](#)]
45. Speier, C.; Whipple, J.M.; Closs, D.J.; Voss, M.D. Global supply chain design considerations: Mitigating product safety and security risks. *J. Oper. Manag.* **2011**, *29*, 721–736. [[CrossRef](#)]
46. Perrow, C. The limits of safety: The enhancement of a theory of accidents. *J. Contingencies Crisis Manag.* **1994**, *2*, 212–220. [[CrossRef](#)]
47. Marley, K.A.; Ward, P.T.; Hill, J.A. Mitigating supply chain disruptions—a normal accident perspective. *Supply Chain Manag. Int. J.* **2014**, *19*, 142–152. [[CrossRef](#)]
48. Scheibe, K.; Blackhurst, J. Supply chain disruption propagation: A systemic risk and normal accident theory perspective. *Int. J. Prod. Res.* **2018**, *56*, 43–59. [[CrossRef](#)]
49. Janvier-James, A.M. A new introduction to supply chains and supply chain management: Definitions and theories perspective. *Int. Bus. Res.* **2012**, *5*, 194–207. [[CrossRef](#)]
50. Lai, C.H.; Huili Lin, S. Systems theory. In *the International Encyclopedia of Organizational Communication*; John Wiley & Sons: Hoboken, NJ, USA, 2017; pp. 1–18.
51. Farsi, M.; Hosseinian-Far, A.; Daneshkhah, A.; Sedighi, T. Mathematical and computational modelling frameworks for integrated sustainability assessment (ISA). In *Engineering for Cloud Computing and Big Data Analytics*; Springer: Cham, Switzerland, 2017; pp. 3–27. [[CrossRef](#)]
52. Serdarasan, S. A review of supply chain complexity drivers. *Comput. Ind. Eng.* **2013**, *66*, 533–540. [[CrossRef](#)]
53. Vogel, W.; Lasch, R. Complexity drivers in manufacturing companies: A literature review. *Logist. Res.* **2016**, *9*, 25. [[CrossRef](#)]
54. Wu, Y.; Frizelle, G.; Efstathiou, J. A study on the cost of operational complexity in customer–supplier systems. *Int. J. Prod. Econ.* **2007**, *106*, 217–229. [[CrossRef](#)]
55. Isik, F. Complexity in supply chains: A new approach to quantitative measurement of the supply-chain-complexity. *Supply Chain Manag.* **2011**, *21*, 417–432.
56. Dittfeld, H.; Scholten, K.; Van Donk, D. Burden or blessing in disguise: Interactions in supply chain complexity. *Int. J. Oper. Prod. Manag.* **2018**, *38*, 314–332. [[CrossRef](#)]
57. Chen, M.; Liu, H.; Wei, S.; Gu, J. Top managers' managerial ties, supply chain integration, and firm performance in China: A social capital perspective. *Ind. Mark. Manag.* **2018**, *74*, 205–214. [[CrossRef](#)]
58. de Leeuw, S.; Grotenhuis, R.; van Goor, A.R. Assessing complexity of supply chains: Evidence from wholesalers. *Int. J. Oper. Prod. Manag.* **2013**, *33*, 960–980. [[CrossRef](#)]
59. Lorentz, H.; Töyli, J.; Solakivi, T.; Hälinen, H.M.; Ojala, L. Effects of geographic dispersion on intra-firm supply chain performance. *Supply Chain Manag. Int. J.* **2012**, *17*, 611–626. [[CrossRef](#)]
60. Vachon, S.; Klassen, R.D. An exploratory investigation of the effects of supply chain complexity on delivery performance. *IEEE Trans. Eng. Manag.* **2002**, *49*, 218–230. [[CrossRef](#)]
61. Xiao, T.; Qi, X. Price competition, cost and demand disruptions and coordination of a supply chain with one manufacturer and two competing retailers. *Omega* **2008**, *36*, 741–753. [[CrossRef](#)]
62. Kanda, A.; Deshmukh, S.G. Supply chain coordination: Perspectives, empirical studies and research directions. *Int. J. Prod. Econ.* **2008**, *115*, 316–335. [[CrossRef](#)]
63. Shou, Y.; Kang, M.; Park, Y.W. Product complexity, variety and supply chain integration. In *Supply Chain Integration for Sustainable Advantages*; Springer: Singapore, 2022; pp. 31–48. [[CrossRef](#)]
64. Yin, W.; Ran, W. Utilizing blockchain technology to manage the dark and bright sides of supply network complexity to enhance supply chain sustainability. *Complexity* **2022**, *2022*, 7734580. [[CrossRef](#)]

65. Alabi, M.O.; Ngwenyama, O. Food security and disruptions of the global food supply chains during COVID-19: Building smarter food supply chains for post COVID-19 era. *Br. Food J.* **2023**, *125*, 167–185. [[CrossRef](#)]
66. Gružauskas, V.; Burinskienė, A. Managing supply chain complexity and sustainability: The case of the food Industry. *Processes* **2022**, *10*, 852. [[CrossRef](#)]
67. Hvam, L.; Hansen, C.L.; Forza, C.; Mortensen, N.H.; Haug, A. The reduction of product and process complexity based on the quantification of product complexity costs. *Int. J. Prod. Res.* **2020**, *58*, 350–366. [[CrossRef](#)]
68. Vidgof, M.; Wurm, B.; Mendling, J. September. The Impact of Process Complexity on Process Performance: A Study using Event Log Data. In *International Conference on Business Process Management*; Springer Nature: Cham, Switzerland, 2023; pp. 413–429. [[CrossRef](#)]
69. Trattner, A.; Hvam, L.; Forza, C.; Herbert-Hansen, Z.N.L. Product complexity and operational performance: A systematic literature review. *CIRP J. Manuf. Sci. Technol.* **2019**, *25*, 69–83. [[CrossRef](#)]
70. Fernández Campos, P.; Trucco, P.; Huaccho Huatuco, L. Managing structural and dynamic complexity in supply chains: Insights from four case studies. *Prod. Plan. Control* **2019**, *30*, 611–623. [[CrossRef](#)]
71. Zhao, K.; Zuo, Z.; Blackhurst, J.V. Modelling supply chain adaptation for disruptions: An empirically grounded complex adaptive systems approach. *J. Oper. Manag.* **2019**, *65*, 190–212. [[CrossRef](#)]
72. Ruslin, R.; Mashuri, S.; Rasak, M.S.A.; Alhabsyi, F.; Syam, H. Semi-structured Interview: A methodological reflection on the development of a qualitative research instrument in educational studies. *IOSR J. Res. Method Educ. IOSR-JRME* **2022**, *12*, 22–29.
73. Bearman, M. Focus on methodology: Eliciting rich data: A practical approach to writing semi-structured interview schedules. *Focus Health Prof. Educ. A Multi-Prof. J.* **2019**, *20*, 1–11. [[CrossRef](#)]
74. Panadero, E.; Alqassab, M. An empirical review of anonymity effects in peer assessment, peer feedback, peer review, peer evaluation and peer grading. *Assess. Eval. High. Educ.* **2019**, *44*, 1253–1278. [[CrossRef](#)]
75. Lester, J.N.; Cho, Y.; Lochmiller, C.R. Learning to do qualitative data analysis: A starting point. *Hum. Resour. Dev. Rev.* **2020**, *19*, 94–106. [[CrossRef](#)]
76. Adams, F.G.; Richey, R.G., Jr.; Autry, C.W.; Morgan, T.R.; Gabler, C.B. Supply chain collaboration, integration, and relational technology: How complex operant resources increase performance outcomes. *J. Bus. Logist.* **2014**, *35*, 299–317. [[CrossRef](#)]
77. De Bernardi, P.; Bertello, A.; Venuti, F. Online and on-site interactions within alternative food networks: Sustainability impact of knowledge-sharing practices. *Sustainability* **2019**, *11*, 1457. [[CrossRef](#)]
78. Huang, Y.; Han, W.; Macbeth, D.K. The complexity of collaboration in supply chain networks. *Supply Chain Manag. Int. J.* **2020**, *25*, 393–410. [[CrossRef](#)]
79. Ahmed, H.F.; Hosseinian-Far, A.; Khandan, R.; Sarwar, D.; E-Fatima, K. Knowledge sharing in the supply chain networks: A perspective of supply chain complexity drivers. *Logistics* **2022**, *6*, 66. [[CrossRef](#)]
80. Liu, J.; Yuan, C.; Hafeez, M.; Yuan, Q. The relationship between environment and logistics performance: Evidence from Asian countries. *J. Clean. Prod.* **2018**, *204*, 282–291. [[CrossRef](#)]
81. Trienekens, J.H.; Wognum, M.; Beulens, A.J.; van der Vorst, J.G. Transparency in complex dynamic food supply chains. *Adv. Eng. Inform.* **2012**, *26*, 55–65. [[CrossRef](#)]
82. Farooq, R. Developing a conceptual framework of knowledge management. *Int. J. Innov. Sci.* **2019**, *11*, 139–160. [[CrossRef](#)]
83. Krishnan, R.; Arshinder, K.; Agarwal, R. Robust optimization of sustainable food supply chain network considering food waste valorization and supply uncertainty. *Comput. Ind. Eng.* **2022**, *171*, 108499. [[CrossRef](#)]
84. Hou, Y.; Khokhar, M.; Sharma, A.; Sarkar, J.B.; Hossain, M.A. Converging concepts of sustainability and supply chain networks: A systematic literature review approach. *Environ. Sci. Pollut. Res.* **2023**, *30*, 46120–46130. [[CrossRef](#)]
85. Zhu, Z.; Chu, F.; Dolgui, A.; Chu, C.; Zhou, W.; Piramuthu, S. Recent advances and opportunities in sustainable food supply chain: A model-oriented review. *Int. J. Prod. Res.* **2018**, *56*, 5700–5722. [[CrossRef](#)]
86. Ruel, S.; Fritz, M.M. Gender diversity in supply chains: Towards more sustainable decisions? Evidence from interviews. In *Proceedings of the 13th International Meeting for Research in Logistics and Supply Chain Management (RIRL-SCM 2020)*, Le Havre, France, 7–9 October 2020; Volume 22, pp. 205–222. [[CrossRef](#)]
87. Silvestre, B.S.; Gong, Y.; Bessant, J.; Blome, C. From supply chain learning to the learning supply chain: Drivers, processes, complexity, trade-offs and challenges. *Int. J. Oper. Prod. Manag.* **2023**, *43*, 1177–1194. [[CrossRef](#)]
88. Hilal, A.H.; Alabri, S.S. Using NVivo for data analysis in qualitative research. *Int. Interdiscip. J. Educ.* **2013**, *2*, 181–186.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.