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Sustainable Food Supply Chains: Overcoming the Challenges with Digital Technologies

Purpose - The purpose of this paper is to offer a consolidative approach in exploring the potential contribution of digital technologies in sustainable supply chain management (SSCM) for the sustainable performance of food supply chains, through Circular Economy (CE) concepts.

Design/methodology/approach - As a single case study, this qualitative, interpretivist research was based on one of the largest food producers in the United Kingdom. The research utilises semi-structured interviews and applies thematic analysis to offer rich insights into SSCM challenges and their relationship with the business performance, through ten in-depth interviews.

Findings - Findings derived from thematic analysis of the interview transcripts suggest four main critical success factors underpinning SSCM practices and businesses performance – i.e. business continuity, waste reduction, performance measurement approach, and organisational learning, which could use the help of digital technologies to improve. This led to seven propositions to be addressed in the future research.

Originality/value - This research offers real, practical insights into SSCM challenges, within the context of food supply chain and explores the potential of digital technologies in overcoming them. Accordingly, the primary contribution of this work is grounded in the identification of critical success factors in SSCM for Food Supply Chains (FSC). Hence, this work contributes further to the literature on SSCM, as well as circular economy, by providing a study of a business in the context of the highly pertinent and valuable food industry.

Keywords Circular Economy; Sustainable Supply Chain; Food Supply Chain, Digital Technology

1.0 Background and Introduction

The concept of sustainable supply chain management (SSCM) continues to gain interest among the scholars especially in the awakening of the Circular Economy (CE) concepts in the early 1980s. CE, which implicates the modern economic system and processes in industry, intensely focus on optimising the full loop of economic cycle through the tenets of reduce, reuse, and recycle, providing clearer moral underpinnings of a policy of sustainability and its economic benefits. This understanding sheds light, precisely on the moral obligations of what must be sustained, and how, as well as its positive effect on sustainability of business performance. Studies have shown that SSCM have benefits businesses by developing their competitive advantages, beyond than just mitigating stakeholders' pressures and expectation. Hence, to enable the conversion of the competitive advantages to a sustainable business performance (SBP), an ethos of 'ethical' and 'sustainable' must underpin the business strategies rubric (Wolf, 2014). Although scholars have acknowledged the potential contribution of SSCM to SBP, the existence of conflicts between ethics, environmental and business profitability means the topic is susceptible to debate (Xiao et al., 2019). Working collaboratively and closely with the partners in supply chain network is said to foster sustainable competitive advantages (Seuring & Gold, 2013). However, empirical evidence

demonstrating the negative effect of SSCM on SBP still persists (Paulraj et al., 2017). Ni and Sun (2019) suggests that this negative complication is due to various reasons, including lack of rigorous methodology in research and the non-liner nature of the relationships held between the SSCM and SBP, thus calling for further investigation.

This research advocate that the reason for such link between SSCM and SBP to appear weak is the lack of holistic approach in rethinking the SSCM concept against the backdrop of CE tenets and incorporating the seamless potential of Artificial Intelligence (AI) to it for SBP. As opposed to conventional supply chain approach that focus merely on integrating the upstream suppliers and downstream customers to gain competitive advantage, the SSCM treats all entities in SC as independent players who deserves equal oversight (Ni & Sun, 2019). Due to this complex, intertwine nature, any actions performed by any of the players in the supply chain will implicate the others and affect the demand (de Sousa Jabbour et al., 2017). Therefore, a system that could warrant good governance practices becomes more pertinent in ensuring the sustainable economic performance of the business through optimisation of operational costs and maintenance of product integrity, while adhering to environmental, social, and moral conventions.

Despite the technological advancements of recent times, there remains a pressing need to find innovative solutions to the challenges faced within SSCM. Key challenges such as the projection that the world's population is expected to increase by one-third by 2050, as well as the supply chain disruptions caused by the recent Covid-19 pandemic, further highlights the need to understand modern supply chain challenges and their possible solutions. For instance, prior to the pandemic, a study suggested that food supply chain productivity needs to increase by 70%, in order to feed the projected growing population in 2050 (Vasconez et al., 2019). However, with the pandemic in 2020, the world is facing severe food insecurity, due to supply chain disruptions which have caused a shortage of manpower across the downstream and upstream supply chain (de Preneuf, 2020). This asserts the importance of having a sustainable approach to supply chain, demanding the re-evaluation of potential use of Digital Technology (DT) such as Artificial Intelligence (AI) and Big Data Analytics (BDA) in enhancing the supply chain integrity.

There is a plethora of studies investigating the role of DT within SSCM and its contribution to SBP. For instance, Tantalaki et al. (2019) who explore the potential of BDA in sustainable agriculture practices reveals the availability of real-time data helps to automate and optimise activities, reducing operational costs and optimising the economic performance of the business. Kazancoglu et al. (2021) also offer further insights into the role of DT in Food Supply Chains (FSC) by exploring the drivers of implementing BDA in food supply chains, as a means to transition towards CE and sustainable operations management. Findings highlighted the significance of governmental incentivisation in driving BDA applications to achieve CE related FSC. Meanwhile, Young (2020) suggests the use of AI in surveillance for agriculture can significantly reduce deforestation – an approach which is not just cost efficient to the farming business, but also friendly to the mother nature. Equally, Jha et al. (2019) confirm that the AI technology and BDA have managed enhance the safety of product, workers and environment, as the result of better control over pesticide use, which also contribute to lowering down the capital expenditure.

Given these benefits of the DT in supply chain, the traditional barriers to SSCM adoption which is rooted in CE concepts may be overcome. Limited availability of study on elucidating the relationships between SBP, CE, and DT, against the landscape of Covid-19

pandemic related challenges, has called for an investigation, which this research seeks to address. Hence, two-key questions that will be explored are as follows:

- **What are the key CE related challenges in establishing Sustainable Food Supply Chain (SFSC) ?**
- **What role can DT play in overcoming these challenges?**

With an aim to establish a better understanding on the relationship between those concepts, the research provides useful insights to both scholar and practitioners in this field. Hence, the paper is structured as the following: The Literature Review section provides introduction to the key concepts – i.e. CE, SSC, SFSC and DT. This is followed by the Research Methodology section outlining the research approaches, and then the Finding and Analysis section that highlights the empirical evidence and its synthesis. Lastly, the Discussion and Conclusion section provides the key findings, research contribution and avenue for future research on this topic.

2.0 Literature Review

2.1 Sustainable Supply Chain: The Role of Circular Economy

Sustainability has become a key priority in business to drive long-term success and value creation. In this light, many businesses have developed strategies to nurture sustainability across various business activities. In implementing the strategy, Dev et al. (2020) suggested organisations should focus on pursuing the aspect of economically doable business solutions that compensate the cost incurred in the chase of operational excellence. To attain this goal, businesses are urged to build a sustainable supply chain by addressing its flexibility, collaborative capability and innovation (Mangla et al., 2020).

The current context of Covid-19 pandemic has accelerated the reconfiguration of the drivers behind the SSC, amid the pre-existing challenges of rising material costs and preference over the greener supply chain. Businesses are forced to rethink of rebuilding the supply chain resilience by re-evaluating the players and processes involved in their supply to minimise the disruptions and shorten the chain. In the context of food supply chain, COVID-19 has implicated the overall process from farmers to the consumer, highlighting concern across various aspects – such as movement restrictions that halt the work on the fields, factories and distribution centres, increase of demands from the consumers side that escalate the need for speed in supply, as well as upsurge financial pressures in the company that challenge the suppliers' seamless operation (Aday & Aday, 2020).

Scholars argued that CE based production system could enhance the supply chain resilience, including in the food industry, through resources optimisation (Murray et al., 2017; Ghisellini et al., 2016; Emamisaleh & Rahmani, 2017; Tukker, 2015) – which is the integral input in supply chain, as well as creating a more profitable business model (Ghisellini et al., 2016). These advantages has promoted the introduction of policies to facilitate the CE adoption among their local businesses, by many governments across the globe (Winans et al., 2017).

Albeit missing a common definition, CE is described as 'system restorative and regenerative by design' (Ellen MacArthur Foundation, 2012) – a system that encourages the optimum

deployment and redeployment of resources and continuous search for value of the finished products throughout their life-cycle. Because the transition from liner to CE is a complex process, scholars agree that the process need an integrated support from all levels and angles external and internal to the business environment (Bauwens et al., 2020). ReSOLVE framework (**Error! Reference source not found.**) introduced by McKinsey Center for Business and environment (2016) helps to guide these actions.

Regenerate	Share	Optimise	Loop	Virtualise	Exchange
Reinvigorate and revitalise natural capital	Preserve the low speed of product cycle to enhance product utilisation.	Increase efficiency and performance	Maintain the close loops	Deliver virtually	Select resources input wisely

Figure 1: ReSOLVE Framework
Adapted from McKinsey Center for Business and Environment (2016)

However, a gap still exists between the concepts and the meaningful application of these concepts. This transition forces businesses to rethink of the whole steps and activities in the supply chain that underpins a sustainable production system – coined as the sustainable supply chain management (SSCM). However, SSCM practices lays a stream of complex challenges, on top of the existing challenges in the supply chain.

Based on the systematic review of 63 journals, Bressanelli et al. (2019) outlines 24 new challenges stemming from the implementation of CE concepts in supply chain and the traditional challenges that persists from the liner-economy concepts that are categorised into seven types. Four case studies were conducted to discover if these challenges were encountered and identify the potential solutions to overcome them. Findings were presented in a framework linking the challenges to the potential solutions – revealing challenges (and solutions) that have been overlooked by the literature (see). To ease understanding, challenges description was added to the framework.

Category	ID	Challenges	Description	Modular design	Upgradability	Access revenue model	Contractual agreements	Value added services	Supply chain integration	Partnership/ collaboration	skills and competence	Alternative financing	Asset remote monitoring	Lobbying	Track back incentives	Communication and awareness generation
Economic and Financial viability	1	Time mismatch between revenue and cost streams	Servitised Business Models (BMs) usually decouple-in-time the relation between costs incurred from manufacturing processes and revenue streams from customers. This, in turn, results in longer payback time for the manufacturer/supplier				L;C					C				
	2	Financial risk	In traditional sales-oriented BMs, the financial risk is shifted to the user when the product is sold. Conversely, in servitised BMs, this risk remains with the supplier even after the first transaction				L;C					C				
	3	Operational risk	In servitised BMs, also the operational risk (i.e. costs of product damages, maintenance, repair, etc.) remains with the supplier				L;C						L;C			

Market and competition	4	Cannibalisation	New 'circular' products (e.g. products designed to last longer) can cannibalise the existing ones, affecting the company revenue streams from traditional products and reducing the overall future sales of the company			L											
	5	IP and know-how access	Activities (e.g. remanufacturing) accomplished by a third party (independent from a manufacturer) may lead to a loss of control by the manufacturer of the Intellectual Property (IP) embedded in the products. For the same reasons, manufacturers may hinder an easy access to spare parts, repair manuals and tools for third-party actors							L;C							
	6	Brand Image	Activities (e.g. remanu-facturing) accomplished by a third-party (inde- pendent of OEM), if not performed properly, will have a negative impact on the OEM brand image							L;C							
Product characteristics challenges	7	Fashion change	Products designed-to-last are unable to respond to fashion changes	L;C	L;C												

	8	Product complexity	The proliferation of new materials as well as the growth of product complexity (e.g. Bill-of-Material) increase the difficulties in managing recovering and recycle processes.	L;C							L ; C					
	9	Product (mass) customisation	Mass customisation pushes towards personalised products, which leads to a higher complexity when products are disassembled for remanufacturing	L;C							L ; C					
Standards and regulation challenges	10	Taxation and incentives	Existing taxation systems, policies as well incentives, are not aligned with the adoption of the CE paradigm											C		
	11	Measures, metrics, indicators	Existing indicators were built around the concept of Lin- ear Economy, with the aim to maximise throughput. CE requires shifting the focus from a purely volume- driven economic perspective to a more comprehensive one, encompassing economic, environ- mental and social dimensions											C		L;C
	12	Lack of standards	Standards regarding CE processes, activities,											C		

			materials, etc. are generally missing														
Supply-chain	13	'Return-flows uncertainty'	Uncertainty about quantity, mix, quality, time and place of returns of end-of-use products decreases the probability of achieving an economic scale and creates difficulties in capacity planning. Illegal forms of disposal reduce the amount of products collected and treated at end-of-use, thus increasing this uncertainty.			L;C			L	L;C					L;C	
	14	'Transportation and infrastructure'	Due to the installed base geographical dispersion, CE would drastically increase transportation activities and costs if all the products have to be sent back to producers or specialised sites for refurbishing, remanufacturing,							L;C						
	15	Availability of suitable supply chain partners	Companies who decide to move towards CE often experience difficulty in finding appropriate supply chain partners, with appropriate skills and a CE approach							L;C						

	16	'Coordination and information sharing'	CE requires a close collaboration and information exchange among the different tiers of the supply chain, which may not be achieved especially within global configurations. This can be due to several reasons such as competition among supply chain tiers, information sensitivity, IT system integration, poor planning of activities, etc.										L;C			
	17	'Product traceability'	Product traceability improves collection and renovation processes, but often information systems provide an inadequate support. Several information should be available and easily accessible to the relevant supply chain partners in order to improve the efficiency of return flows and end-of-use activities, as well as to improve the capability to make accurate forecasts										L;C			
	18	Cultural issues (linear mind-set)	Internal resistance to change, especially given the prevailing linear mind-set and structures in industries													L;C

			(also referred to as the 'Linear lock-in'), limited awareness and commitment (from both top management and employees)														
Technology	19	Eco-efficiency of technological processes	Renovation processes (especially recycling) may be inefficient from a technological perspective, causing losses and cross-contamination of materials. Moreover, they can be very expensive compared to the linear production from raw materials														
	20	Product technology improvement	Products designed to last would be unable to participate in the continuous technology improvements processes		L;C												
	21	Data privacy and security Concerns	Concerns about privacy and data security inhibit collection of products when they reach the end-of-use. Appropriate data-clear activities must be guaranteed.					L;C									
Users' behaviour	22	Ownership value	Servitised BMs offer access to product instead of ownership. Consequently, users may not perceive intangible values such as					L;C									L

			self-esteem, sense of control, etc. This is particularly true in the B2C sector													
	23	Careless behaviour in product usage	Servitised BMs may lead to careless behaviour in product use and conservation by the users since they no longer feel responsible for the product correct conservation. This may reduce the product duration, or generate legal issues between the supplier and the user				L;C						L;C			
	24	Users' willingness to pay	During the acquisition process, users often only consider product price as one of the main factors influencing their choice. Circular products may be characterised by high selling price, due to enhanced quality (durability) or upgradability, thus constituting a barrier for the customer. On the other side, some customer segments may not accept to buy 'second hand' (renovated or refurbished) products, due to status or fashion design reasons, or since they have a perception of lower			L;C		L;C								L;C

			reliability. This reduces the market size for 'renovated' products compared to new ones.														

Key: L=solutions identified in the literature; C= solutions identified in the case

Table 1: The framework linking CE supply chain redesign challenges with potential levers to overcome them (Source: Brasenelli et al., 2019)

The supply chain management challenge in itself entails two further challenges – i.e. reverse logistic (RL) related (ID 13, 14 and 18), and value chain configuration related (15, 16 and 17). The framework signposts barriers in understanding the consequences of CE supply chain implementation, as some potential solutions are not suggested in the existing literatures. The research highlights seven key arguments that we have classified into two dimensions – i.e. digital-technology-led, and people-led, as listed in Table 2 as follows.

Digital-technology-led	1.	While "Contractual agreements and alternative financial solutions" could overcome the challenges of economic and financial viability, the Internet of Thing technology could mitigate operational risk through remote monitoring
	2.	The supply chain management challenges could be superseded by establishing closely knitted partnerships with the supply chain actors, using IoT for remote monitoring of assets and products, promoting 'take-back incentives', changing to the access revenue models, and generation of awareness.
	3.	Enhancing product upgradability and introduction of value-added services are useful in overcoming technology-related challenges.
People-led	4.	While cannibalisation could be overcome by adopting 'access' revenue model that monetises the increased life products, partnership with different suppliers across supply chain tiers help to win "market and competition challenges".
	5.	The design stage should incorporate the modular design and upgradable strategy to combat the issue of product characteristics. Workforce competency, however, underpin the success of this strategy.
	6.	In overcoming regulations barrier, lobbying has emerged to shape legislations to be implemented at adequate standards, thus prepare the businesses in embracing them
	7.	Behaviour-related challenges may be overcome through value-added services and awareness building to increase willingness to pay a higher price for the product.

Table 2: Key highlights of Challenges in SSCM (adopted from Brasenelli et al., 20219)

We argue that not all of these highlights are applicable to understand the challenge of building a sustainable food supply chain (SFSC) due to contextual differences, as outlined in the subsequent sub-section.

2.2 Challenges in Sustainable Food Supply Chain and Digital Technologies

It is envisaged that the future food supply chain produces nutritious food grown in an ethical way and safe environment, and seamlessly fulfil the needs of the exponentially increased global population regardless of the resource scarcity, climate change, socio-economy crisis, and consumer location – hence sustainable food supply chain (SFSC). This, of course, renders myriad of challenges, which makes FSC unique as compared to others. Comprehension on the FSC and consumer demands is pivotal to understand these challenges. Prior to arriving to shelves, food that was passed by the growers go through a long network of processers, producers, and retailers. This complex network encapsulate various actors with

different roles and location, thus may be governed by different processes and regulations too – entailing the first challenge. SFSC incorporates the 'value-chain', where different players at different stage (e.g. growers, manufacturers, distributors, and sellers) from raw material production until the final product reaches the consumers, play a significant role in shaping the value of such FSC. This remains a concern as each player has their own business model-led objectives, which potentially at the tangent of other players' objectives, where the resulting consequences of these actions determine the overall value and performance of the FSC (Nostratabadi et al, 2020; Higgins et al., 2010).

Second, unlike any other supply chain network, the FSC are highly sensitive to speed where the produces or harvested products must be ensured to reach consumers before the final due date (Zhong et al., 2017). Hence, where some of the FSC are horizontal, others are highly vertical to facilitate instant movement of products despite of being reliant on the greater organisation network. The large amount of food items are globally sources, forming a greater supply chain network. Thus, a single, vertically coordinated product will still become part of a large, globally coordinated supply chain network. Because of this, the access to information become complicated and stability of support functions is easily compromised. As the result of this great challenge, a FSC network is highly susceptible to failure (Garnett et al., 2020). Inefficient and ineffective FSC could resulted into various ramifications – one being food waste. It was reported that a huge portion of the 1.3 billion tons of the wasted food worth 1 trillion USD was contributed by the supply chain inefficiency (IFCO, 2020). Another setback of the inefficient and ineffective supply chain is inadequate food supply. This is evident by the fact that millions of people were reported at the rank of undernourished since 2015, and 690 million people went hungry in 2019 – an increase of 10 million from 2018; while the Covid-19 pandemic causes hundreds of millions more people in 2020 to be in the state of chronic hunger (World health Organization, 2020). Besides, FSC are highly susceptible to the environmental catastrophes such as droughts and green-house effects, as they may dramatically decrease agricultural production yields (Zhong et al., 2017).

On top of these, heavy reliance on a greater degree of temporal coordination with the stakeholders is also another threat to a SCM within an FSC. This coordination which is based on the principle of 'just in time' delivery (JiT), often started by the electronic point of sales (EPOS) generated algorithm before it is passed to the supplier. From this point forward, the coordination process relies intensely on the human efficiency. For instance, the EPOS generated algorithm in T supermarket in the UK placed an order for fresh fruit with the headquarter before noon. This order is then relayed to the tier 3 supplier in Spain who then instruct the sub-contractor to pick and pack the fruits before next day delivery to T supermarket. This example shows that FSC network is temporally vulnerable, as the business relies on the supply to be able to sell the product, and any impediment in the supply chain network could jeopardise the product usability – which is against the CE principle of maximising the product life cycle. Recently, study reveals that these challenges are further intensified by the Covid-19 pandemic, which also has caused the emergence of new sets of challenges in SSCM.

Prior to the business shutdown, many businesses thought that they have visibility and understood their supply chain by knowing the first-tier suppliers. Later, it was discovered that the granularity of the supply chain data understood was extremely inadequate, which limits the plan and action to overcome the depleting resources. Besides this, businesses faced interruption in productions due to the 'single-sourcing' strategy adopted. Although the lesson tends to suggest the businesses to adopt multi-sourcing to reduce vulnerability, the single

sourcing fosters a solid relationships and mutual trust between the company and supplier, encouraging long-run investment from the suppliers and allowing rather flexible contact re-negotiation as and when needed. Therefore, real-time oversight on supplier's activity is crucial in this sourcing type. Despite of its criticality, this capability is currently non-existence in most businesses, thus amplified the magnitude of risk in the supply chain. Study suggest that this situation entailed the decelerated of digital transformation in business operations.

Notwithstanding the richness of data hold by different departments, most of these departments work in silos. Thus, the flow of data within the business organisation has been limited, hampering the effectiveness of decision making. In relation to the shortfall of slowed digital transformation, there are businesses who persistently relied on traditional inventory strategy. This strategy, which counted on the past performance to plan the supply disregard the current needs and disentangled from reality, resulting into stock mismatch. The adoption of the traditional Enterprise Resource Planning (ERP) that is built on the historical transaction rather than prescriptive analytics provides narrow inputs for forward-planning, which again, degraded the accuracy of decision – thus compromise the integrity of supply chain management.

All of these challenges warrant a rethinking of the current activities and processes in FSC, urging CE-led business model innovations. Furthermore, Bresanelli et al. (2019) framework has highlighted that DT is central in providing solutions to build a CE led SSC. Research suggest that DT offer vast potential in facilitating the adoption of CE concepts in FSC (Rajput & Singh, 2019; Saberi et al., 2019; Yadav et al., 2020). The DT-led circular concept utilisation include the integration of the RL to optimise material life-cycle and use facilitated by artificial intelligence, AI (Yadav et al., 2020; Xing et al., 2020; Bibby & Dehe, 2018). Another example of material optimisation led by DT is the use of remote sensing technology in detecting plant disease to enable just right amount of pesticide application – which also reduce unnecessary material cost in supply chain and enhance quality of the product and its safety as it is not overly infested (Fatorachian and Kazemi, 2018; Moeuf et al., 2018). In addition, Dev et al. (2020) has confirmed the relationship between DT and CE in the context of a RL system within the background of operation management, in support of the research agenda suggested by Jabbour et al. (2018). Earlier, Jabbour et al. (2018) suggested the exploitation of 'sharing of information' concept underpinning CE using DT towards SSC, which is also advocated by Mangla et al. (2019). Interestingly, this signposts the potential usefulness of DT in overcoming the challenges to build a SFSC. Nonetheless, study on the potential of DT in overcoming the traditional, as well as the COVID-19 related challenges to implementing SFSC remain scarce. As the matter of fact, none of the four cases used in Bresanelli et al. (2019) is from food industry. This signposts a research need in this area, which this study has attempted to address.

2.3: The Significance of Sustainable Supply Chain Management for Business Performance

Carter and Rogers (2008) conceptualise a sustainable supply chain management (SSCM) as an achievement of a strategic and transparent integration of the social, environmental and economic objectives of a business, in the context of coordinated business process that enhance the long-term socio-economic and environmental performance of a business and its supply chains. This idea can be attained by developing capabilities that improve the business mechanisms (Wolf, 2014). SSCM is critical for many, especially for businesses that are vulnerable to stakeholder groups pressure, where they are held accountable for actions across

all stages of product cycle – from resourcing to consumption (Parmigiani et al., 2011). Paulraj et al. (2017) posits that there are two factors underpinning the SSCM: (i) the resources – i.e. anything valuable to the business and (ii) the business dependency on others for resources access – suggesting the resource owner has control over the resources needed by others. Therefore, to ensure availability of resources needed for the business operation in the long run, businesses are encouraged to develop strategies to reduce this dependency by harnessing and optimising the resources within their control (Koh et al., 2017), which is instrumental in warranting sustainable business performance.

Sustainability of supply chain is attributed by synchronous performance across the three indicators of economic, environmental, and social (Roy et al., 2018). Yet, in the pursuit of performance, some businesses often trade-offs between these indicators, depending on the business goals (Hahn et al., 2010; Van der Byl and Slawinski, 2015). Hence, most often, a business is said to have achieved SSCM when it has successfully performed economically (Liu et al., 2012). An investigation on this later rebut this argument by claiming that SSCM that conditions business performance is underpinned by a successful performance in all three indicators and this can be observed when customers are willing to pay more for environmental friendly or social responsible products or services (Ni and Sun, 2019). Although this has confirmed the link between SSCM and business performance, its relationship yet to be explored in this research.

The influence of stakeholders' pressure on the adoption of SSCM is undeniable. However, the motivation of attaining SBP also is also one of the key factors motivating businesses to adopt SSCM as practices (Wolf, 2014). This has long proven by history, especially in the food industry. In 1990s, Wal-Mart had decided to only buy fish from suppliers certified by Marine Stewardship Council as a strategy to ensure 'sustainability' of fish (resources) in the long run – as those suppliers abide the conducts of sustainable fishing practices (Sampson et al., 2015). Therefore, SSCM is also characterised by the successful coordination between partners, which is often a challenging process due to factors such as complexity of communication, high administration costs, and demand for a specific skillset (Seuring and Müller, 2008). Amidst this situation, businesses are prone into making a limited effort to integrate all players in the supply chain, especially the customers (de Souza et al., 2014; de Sousa Jabbour et al., 2017), impeding SSCM. Recently, many studies suggest that this integration issue in supply chain management could potentially being addressed through the use of DT such as blockchain (Saberi et al., 2019; Nica, 2019; Mangla et a. 2021). Research conducted by Mangla et al. (2021) highlights the significance Of Blockchain technology, in not only overcoming these issues, but in also achieving UN's Sustainable Developmental Goals (SDG). More specifically, their research investigates the impact of Blockchain within milk supply chain, concluding that its application offers the potential to provide safe food, promoting good health and better well-being for everyone. Moreover, others have also emphasised the role of DT such as, Internet of Things (IoT) (Manavalan & Jayakrishna 2019; Rose & Chilvers, 2018) which this research seeks to evidence, further for the support of SSCM.

3.0 Research Methodology

Given that the case context for this research is one of UK's largest food producers, a single case study approach was preferred and a highly suitable setting for the purposes of this research. Moreover, a single case study offers an in-depth description of the existence of phenomenon (Siggelkow 2007), which is also preferred, when studying a group of people (Yin 2003), such as supply chain professionals, as in this case. Additionally, the single case research is also recognised for its descriptive power and attention to context (Shakir 2002), with these elements being vital in the context of this research. Moreover, single case research can also offer a well-grounded indication of future research, at the same time as offering novel, deep and nuanced understanding of previously unexplored phenomena (Boddy 2016).

This research aims to explore the perceptions and challenges faced by Supply chain professionals and warehouse managers, within food production industry, as a result of the COVID-19 pandemic situation. While a growing number of studies are exploring COVID-19 related supply chain disruptions, there is need to understand the experiences of key workers, such as retailer and food producers, during this situation, and the potential role of technology in overcoming them. Accordingly, semi-structured interviews are utilised, given its role in offering insights into human behaviour, the perceptions of actors, as well as extracting people's interpretations of technologies and their actions around them (Orlikowski ö Gash, 1994).

In line with scarce, yet a growing numbering of qualitative supply chain studies (Mahroof 2018; Sachan and Datta 2005; Varoutsa and Scapens 2015; Wagner and Sutter 2012), this research takes a qualitative approach to explore the attitudes of supply chain professionals and their attitudes surrounding technology. In order to gain a holistic, yet in-depth insight into COVID-19 related challenges, the sample size of this research is 10 semi-structured interviews, with operational staff in a variety of roles and seniority, as highlighted in Table 3. These participants were selected specifically, given the close proximity to the FSC and more importantly given that they were considered as key workers during the pandemic situation. An exponential non-discriminative snowball sampling approach was taken (Etikan et al. 2016) to recruit the participants, whereby the initial research participant, who was recruited through the professional connections of the researcher, then assisted in recruiting further participants, with relevant experience for the purposes of this research. The interview protocol was made up of exploratory questions, framed through the sustainable food supply chain and DT literature, (Beitzen-Heineke et al. 2017; Belaud et al. 2019; Kayikci et al. 2020), which explored various dimensions of how technology may be a driver to overcome food supply chain. The semi-structured interviews consisted of 8, open-ended, exploratory questions gleaned from relevant academic sources.

Qualitative thematic analysis was conducted to analyse the data, with the intention of exploring the research questions, at the same time as allowing for unanticipated insights to also surface from the data (Klein and Myers, 1999). The research data was analysed thematically, through a manual process which was underpinned by Braun and Clarke (2006) six phase approach to thematic analysis, which consisted of transcribing the data, reading the transcribed data, familiarisation with the data, coding, converting the codes into themes, searching, reviewing and then finalising the themes. Firstly, the interviews were recorded and transcribed verbatim. Although transcribing can be a time consuming activity, it helps to establish an excellent opportunity to familiarise oneself with the data (Riessman 1993), thus enhancing the quality of the analysis. Thus, the interviews were manually transcribed and

sent to the research participants, to confirm the accuracy of the content. The findings were then summarised into a table in conjunction with the transcribed data. This allowed the interview content to be summarised into simplified paragraphs. This thematic process then continued, the summarised content was further shortened to key passages and themes. This method was repeated, which eventually led to various themes emerging from both the interviews. Following the data familiarisation phase, achieved through the transcribing process, initial codes had surfaced from the data. According to Boyatzis (1998) codes can be emergent and data driven, or more theory driven. For the purposes of this research, a more data driven approach was taken, whereby no pre-defined codes were used, thus an open coding approach was applied, whereby codes were developed and modified during the coding process. Thus, the codes emerged from the data nodes through inductive reasoning and reflective analysis was undertaken to establish the trustworthiness of the themes which emerged.

The research participants were interviewed in line with social distancing guidance, formally in the warehouse offices, on a one-to-one basis. Ethical approval was granted by the University of Bradford, School of Management. In upholding anonymisation, the participants' names were replaced with their initials in the study.

Table 3: Research Participant Profile

Participant initials	Role	Operational experience (Years)
S.C	Shift operational manager	15
R.H	Supply Chain Specialist (Head Office)	15
M.P	Team Manager	17
M.T	Team manager	7
A.H	Shift operational manager	8
R.B	Shift operational manager	4
T.C	Implementation manager	8
A.A	Project manager	3
K.S	Improvement coach	4
A.M	Team Manager	11

4.0 Findings and Analysis

This research set out to understand the role of SSCM, CE, and DT, and it's applicability and relevance within the ongoing COVID-19 pandemic situation to sustain the business performance. As such, the research uncovered a plethora of key issues, mainly centred on "Business continuity", "Data-driven performance management", "Minimising waste and operational losses", "Portfolio Management" and "Contingency planning". These key themes were derived during the thematic analysis process, as highlighted in *Table 4.* On top of these some challenges from Bresanelli et al's (2019) research also persists.

Table 4: Qualitative thematic analysis summary

Themes and Sub-themes	Brief description of themes and sub-themes	Frequency of reference

Business Continuity	This was a dominant theme identified from the data, which was predominately concerned with maintaining service to stores and eliminating any supply chain bottlenecks as well as maintaining staffing levels.	
a) **Servicing Stores**	This sub-theme linked to Business Continuity referred to ensuring stock and food produce arrived at stores, thus placing emphasis on the movement of good, from each aspect of the supply chain	21
b) **Maintaining Staffing**	In order to ensure business continuity, there was the need to maintain staffing levels, to support with picking orders and stock in distribution centres, ready for transportation to stores.	15
Minimising waste and loss	With all the challenges and pressures, resulting from panic buying, the participants placed emphasis on the need to minimise waste and food loss resulting from poor temperature control and spillages during warehouse transportation.	
a) Congested warehouses	During peak festive periods, or during times of high volume picking, it was identified that the warehouse aisle would get congested, leading to lack of productivity, spillages and even accidents in the warehouse.	11
Data driven KPI's: Performance measurement	The research findings highlighted the pandemic situation highlighted the need for more data-driven, performance management, for better management of new, agency staff, for existing colleagues as well as for fast-moving lines and products.	
a) New Starters performance	The need to understand shorter term recruitment cycles, approaches and performance of new starters	13
b) Colleague Performance	It was evident that managers placed emphasis on individual performances of colleagues, in order to deliver the picking targets. Thus, they felt more data points and creative ways in bringing the data together was key.	10
c) Portfolio management	The findings highlighted the increased focus on changing product lines and choices, from variety to volume and the role of data in identifying the trending and in-demand products.	16
Organisational learning	This theme referred to the need to learn from the experiences and to take more proactive steps in overcoming such "black swan" events in the future.	
a) Contingency Planning	The participants revealed, they were not prepared for this situation, therefore strongly highlighted the need for proactive rather than reactive planning.	8
b) Maintaining Relationships	The overall performance of the supply chain was underpinned by the relationships between key stakeholders across the supply network, therefore ensuring collegiate, transparent and positive relationships was essential for favourable and agile service level agreements.	5

4.1 Business continuity – *"The priority is bringing about as much normality as possible during such times"*

A dominant theme identified from the research data was that of 'Business Continuity', it was evident that the participants placed emphasis on maintaining their operations, be it supplying stores with goods or maintaining staffing levels. This was highlighted when M.P mentioned '*We have put all our efforts into servicing our stores and having maximum output*', further to this, R.B stated: '*I went from being in my office, onto the shop floor, picking stock and getting stuck in*". Further emphasis was placed on the movement of goods and the importance of those who facilitate during this process. Here, A.M states: *"Logistics can be complicated, it's not just about receiving stock, it is also about making sure you are picking it and moving it just as efficiently"*. Therefore, identifying ways in which business operations could resume, was a key priority for majority of the research participants. Another manager, S.C, remarked *"The key for us was to keep the operations running, even if it meant, we were focussing on fewer products, but ensuring higher volumes. The issue you will have is, in such challenging times, you may not always have the resources, such as operational staff, or the right skilled staff to deliver. Therefore, we had to be mindful of what we want to achieve and how realistic that would be"*.

4.2 Minimising waste and loss – *"Waste is bad, but exceptionally bad during peak demand"*

Despite there being some form of consensus between the participants regarding the importance of minimising waste, it seemed that many of the managers were of the view that on occasions, waste was unavoidable, particularly during peak time, demand such as that seen during the pandemic situation. Much of this was attributed by the managers, to the warehouse and to congested lines, which not only impacted productivity, through delays and extended warehouse travel time, but also due to damaged stock and items. This was emphasised further when K.S, stated: *"to be fair, minimising waste is probably the least of worries for those picking in the warehouse, as they would naturally focus on maximising their pick number, and on many occasions, at the expense of how pallets were stacked"* therefore it was evident through the data, that sustainability and in general and optimisation of the product life cycle in specific, may be disregarded, due to performance targets and pick rates.

This was further emphasised by S.C, who outlined '*if you are looking at reducing waste, you have to ask yourself what the root cause of wastage within the warehouse would be. You quickly realise, it is more often than not attributed to the individuals, rather than any processes. For example, orders are not be stacked correctly or safely, they may not be correctly dropped at the loading bay, when in transit, they may even topple over, due to poor stacking and weight distribution of pallets, all these issues lead to waste and are directly attributed to actions of individuals, rather than any particular process'*. It is evident here that although, commitment towards minimising waste was evident amongst managers, it was often seen as being unavoidable in busy, fast-paced environments. One of the managers highlighted the lack of cost effective initiatives or alternatives for waste management, he stated: "*It appears, that despite all the efforts, you will always have waste and achieving zero waste is not necessarily possible in busy, operational environments. Therefore, bringing in new approaches, the training and even new processes, can be as costly as the waste itself, if it isn't managed correctly"*.

4.3 Data-driven performance management – *"If you can't measure it, you can't manage it – seems to be more crucial now than ever before"*

Due to the pandemic situation, there was an urgent need to recruit agency staff and new starters, for shorter contracts and more frequently. Reliance on new agency staff, accompanies its own unique challenges, centred on uncertainty, lower productivity, high staff turnover amongst many others. Despite the uncertainty, participants highlighted the pivotal role the short-term contracts had, M.T posits: *'Agency staff played a pivotal role in helping with demand, however, usually we held contracts for longer periods of time, unfortunately, as demand fluctuated, the contracts were shorter and more frequent'*. This further emphasised by A.H, '*in hindsight, if we were able to use analytical techniques to better predict both the demand and subsequent staff turnover this would have allowed for better utilisation or should short-term contracts*. As new colleagues would require training, given moving and handling and other hazardous aspects in the warehouse operations, managers felt contract allocation, training and utilisation of agency staff could have been better applied. Moreover, in addition to having better predictive power when it comes to short-term staff retention and turnover, managers also felt being able to forecast or predict the performance of new colleagues more closely, would have allowed for a better utilisation of resources.

Another manager highlighted the role of data, when it came to making more informed decisions; he stated: '*without the data, you fail to make informed decisions and therefore often are not able understand the consequence of our actions, therefore, I honestly believe having access to data helps change behaviour'*.

Managers also highlighted the need for more accurate and reliable data for managing internal, as well as applying it to external factors, such as for predicting and forecasting product demand. R.H posits *'we really changed our operations and went from variety to volumes' but having more detailed intelligence around panic buying and consumer behaviour insight would been helpful'*. It is evident that the senior manager knows the importance of responding to customer needs. Supporting this further, T.C mentions *'we prioritised household supplies and other high-demand products, having to significantly put other product lines on hold'*. Despite this, there is still the need to procure, replenish and distribute the products to customers, hence having real-time, live data would add really add value from a supply chain context.

5.0 Discussion

A number of interesting insights were gleaned from the interview data, and despite there being a plethora of possible solutions to some of the challenges highlighted by the managers, the identified challenges can be reversed through technological and innovative solutions, which may be worthy of exploration in future research. Table 5 outlines the framework linking sustainable food supply chain challenges with potential DT solutions key challenges identified and maps them across DT enablers, worthy of exploration for future research. Challenges that are identified in the case are marked with 'NEW'.

Business continuity was highlighted as a key priority for the research participants, with emphasis placed specifically on increased volumes, continuation of service for stores, whilst also retaining resource to deliver these outputs. Given the uncertain and rather disruptive

nature of the pandemic, whereby large portions of the workforce were either furloughed or self-isolating, one can look towards the role of automation and automated order picking systems as a potential solution and enabler for business continuity. For instance, Mahroof (2019) highlights AI automation has potential to significantly improves, as well as standardise processes and operations across different shifts, therefore supporting and driving business continuation. Moreover, Caputo and Pelagagge (2006) also highlight automation can drive productivity and set reorder levels and maximum picking quantities for specific items, thus significantly assisting logistic managers. Accordingly, the following research proposition is put forward:

> ***Proposition 1****: The application of AI driven automation will drive business continuity during a pandemic situation and will allow for distribution centres to service stores and ultimately, their customers.*

The exponential rise in logistics businesses and the increasing requirements for larger warehouses, has led to discussions around the design of warehouses, and the need for a balance between flexibility, layout configuration, storage density and throughput capacity (Lerher et al. 2010). The present research findings allude to the general 'RL challenge' as highlighted by Bressanelli et al. (2019), or warehouse congestion and 'product traceability' challenges in specific, which in turn leads to reduced productivity and efficiency, as well as increase of unintended waste.

Digital twin solutions and simulation techniques may help overcome these challenges. For instance, Baruffaldi et al. (2019) propose a decision-support tool, which exploits optimization and simulation techniques acts and acts a digital twin of the warehouse management system, aimed at supporting logistics managers with warehouse customization and fulfilling required service levels. Similarly, Petković et al. (2019) also propose virtual reality digital warehouse twins, as a means to realistically simulate worker behaviour, thus allowing warehouse managers to plan ahead and put appropriate contingencies in place. A further example of simulation modelling for contingency planning purposes is put forward by Kogler and Rauch (2020), who propose a contingency planning toolbox involving an event simulation model setup to examine outcomes of decisions prior to real, costly, and more permanent changes are made. Accordingly, the following research propositions are put forward:

> ***Proposition 2:*** *Digital twin and simulation techniques can reduce warehouse waste and expenses.*

> ***Proposition 3:*** *Digital twin and simulation techniques can prepare warehouse managers for contingency planning.*

There is increasing hype around the use of data analytics within HR settings. This is unsurprising, given the large quantity of HR data which can be captured within HR environments through appraisals, performance metrics, training and development data, capability and disciplinary data as well as participation schemes and staff attitudes surveys (Angrave et al. 2016) However, much of this data has been collated and utilised disparately (Parry and Tyson 2011), but triangulating and bringing this data together has potential of unlocking previously untapped value. For instance, Kim et al. (2021) highlight how BDA can minimise bias HR decision-making and offer more objective and accurate decisions for HR professionals. The research participants highlighted the need for more objective and measurable metrics, when it came to recruitment of new starters, as well as when it came to analysing the performance of current staff. Thus, through applying HR

Analytics, organisations may be able to identify idea candidates, recognise top performers, as well as single out individuals at the risk of leaving the job. Accordingly, the following research proposition is put forward:

> ***Proposition 4****: Utilising HR Analytics will drive better performance KPIs and allow managers to manage the recruitment of new starters and existing staff more efficiently.*

It was evident from the research participants that a more proactive, rather than reactive approach to meeting customer expectations was imperative, especially during a pandemic situation whereby panic buying and disruptions were being experienced across the supply network. Sivarajah et al. (2019), highlight sentiment analysis enables one to understand what people feel about a certain topic, through sentiment detection, polarity classification, target identification and collection and aggregation processes and can significantly help drive sustainability. Similarly, Chen et al. (2017), highlight how textual sentiment analysis generates a better summary of customer opinions, which is utilised within periods of panic buying, will allow organisations and food producers alike, to offer products, which are most sought after and in high demand rather than stock piling other inventories, which implicate the cashflow of the business and its performance in general. Therefore, through the use of sentimental analysis, organisations may be able to gauge what is needed and instantly adjust product variations accordingly. Thus, the following research proposition is put forward:

> ***Proposition 5****: Portfolio Management and/or product line selection can be driven directly by customers, through the application of Sentiment analysis approaches.*

It is also evident that some of the challenges linked to reverse logistic and value chain configuration, as discussed by Bressanelli et al. (2019), still persists, which is not surprising. John et al. (2018) and Moghaddam et al. (2019) underlined the key strategic challenge of SSC is the design or reengineering of the supply chain network, while managing the flow of materials with minimum costs. From this point forth, organisations and researchers strive for closing the loop in the supply chain network by means of RL activities in order to achieve the desired SSCM environment. This being the case, the importance of logistics efficiency for the competitiveness of organisations becomes clearer (Kumar et al., 2020) and, thus, the critical role of RL in SSCM, more particularly in the food supply chain context, come to the forefront.

Generally speaking, supply chains are interconnected systems where multiple stakeholders are interrelated to each other. In this complex structure, RL activities are especially gaining more importance in recent years due to economic and environmental concerns in the CE (Kazancoglu et al., 2021), in which the environmental aspect remains as the focal point. Conceptually, RL incorporates a series of activities in common with the CE, such as recovery, repairing, and recycling. Yet, although RL plays a vital role in reducing environmental pollution and increasing economic and social benefits, particularly in the food SC domain, through these activities (Wei et al., 2018), the environmental impact of RL activities were largely neglected in the extant literature and this has also caused vagueness in business practices with regard to food waste and food loss operations (Kazancoglu et al., 2021). For addressing this lacunae in the food value chain, as Kumar et al. (2020) noted, it is crucial to maintain traceability, transparency, and coordination through modern information and communication technologies used in logistics. Indeed, since the latest exponential development of technology has accelerated the digital transformation (Kucukaltan et al., 2020), digitalisation-based Industry 4.0 initiatives offer a great potential to meet CE and sustainability needs (Cezarino et al., 2019;

Rossi et al., 2020). More specifically, since logistics undertakes an intermediary role among different stakeholders in the supply chain network, it remains as a key field to examine Industry 4.0 implementations. Thus, by implementing digitalisation to logistics operations, especially to RL activities to prevent food loss and waste, information and material flow carried out by logistics companies can be meaningfully and effectively disseminated to the entire supply chain network, which, in turn, can positively affect the food value chain.

Proposition 6: *Simulation can help to overcome challenges in RL.*

Proposition 7: *Artificial Intelligence can improve value chain configuration.*

Based on the suggested propositions, these challenges and their potential solutions are worth exploring in the future. It would also be useful to explore how DT can influence the RL and value chain configuration aspects of supply chain, and their impact on the FSC in more details.

Table 5: The framework linking sustainable food supply chain challenges with potential digital technologies solutions

L: Solutions identified in literature; C: Solutions identified in case

Theme	ID	Challenge	Digital Technologies Solutions								Non-technology solution (Bresanelli et al 2019)												
			AI Automation	Digital twin warehouse	HR Analytics	Sentiment analysis	Simulation	Ripple effect modelling	RFID	Blockchain technology	Modular design	Upgradability	Access revenue model	Contractual agreements	Value added services	Supply chain integration	Partnership/ collaboration	skills and competence	Alternative financing	Asset remote monitoring	Lobbying	Track back incentives	Communication and awareness generation
Economic and Financial viability	1	Time mismatch between revenue and cost streams					C	C							C	C		C					
	2	Financial risk				C	C								C	C							
	3	Operational risk		C		C	C	C							C	C							
Market and competition	4	Cannibalisation																					
	5	IP and know-how access																					
	6	Brand Image													C								
Product characteristics challenges	7	Fashion change																					
	8	Product complexity																					
	9	Product (mass) customisation																					
Standards and regulation challenges	10	Taxation and incentives																					
	11	Measures, metrics, indicators																					
	12	Lack of standards																					

Supply Chain: RL	**13**	'Return-flows uncertainty'			C	C				L			L;C			L	L;C					L; C	
	14	'Transportation and infrastructure'	C			C	C										L;C						
	18	Cultural issues (linear mind-set)																					C
Supply Chain: Value chain configuration	**15**	Availability of suitable supply chain partners								L							L;C						
	16	'Coordination and information sharing'	L				L													L;C			
	17	'Product traceability'							L	L										L;C			
Technology	19	Eco-efficiency of technological processes																					
	20	Product technology improvement																					
	21	Data privacy and security Concerns																					
Users' behaviour	22	Ownership value																					
	23	Careless behaviour in product usage																					
	24	Users' willingness to pay																					
NEW: Business Continuity	**25**	Servicing Stores	L																				
	26	Maintaining Staffing	C, L																				
NEW: Minimising waste	**27**	Congested warehouses	C	L			L																
NEW: Data driven KPIs	**28**	New Starters performance			L																		
	29	Colleague Performance			L																		

	30	Portfolio Product management				L																
NEW: Organisational learning	**31**	Contingency Planning		L			L	L														
	32	Stakeholders coordination							C, L	C, L												

5.1 Implications for theory

Implications for management science are desirable and must be aligned with research objectives and aims. In this case, while the theory and debates around the CE principles, SSCM, FSC and usability of DT in all areas of life are growing steadily, their integration remain scarce. The real-life evidence on SSCM challenges within the context of FSC and the potentials of DT in overcoming them are even more rarely debated. Consequently, the primary contribution of this work is a pioneering approach to understanding the critical success factors in SSCM for sustainable business performance by exploring the case of one of the giant food retailers in the UK. Hence, this work adds to the literature on the SSCM and FSC, as well as CE by providing a study of a business in the context of food industry. Thus far, this type of study has been infrequently presented in the literature, moreover against the backdrop of COVID-19 pandemic. Another major contribution is that this work develops seven research propositions for future study, derived from the empirical evidence and state of the art literature review in the topics discussed. Many of the main works on the SSCM neither discuss nor address such propositions.

Propositions 1, 2, 3, 5, 6 and 7 potentially adds to the literature, suggesting the use of DT could efficiently address the issue of integration of all players in the supply chain and having an oversight of their activities to boost business performance. This implies that DT could be the backbone of the ReSOLVE framework application in businesses, especially the ones in FSC, as time is the essence in mitigating the complexities and challenges. Meanwhile, proposition 4 suggests DT could effectively manage human performance, which is no doubt key to all aspects.

5.2 Practical implications

This research aimed to minimise the gap between theory and practice, by reporting and providing an in-depth insight into some of the real challenges faced on the ground by supply chain professionals within the food sector. As highlighted in great detail within section 4 and 5 of this paper, the findings and critical perspectives shared by the experienced research participants may hold much relevance for a diverse set of stakeholders, including supply chain professionals, warehouse managers, technology specialists, senior managers and talent management. The findings not only touched upon operational issues but also discussed the potential of DT for various stakeholders within organisations. For instance, the findings and particularly table 4, in which the DT enablers outlined, maybe of interest to human resources, given the emphasis placed on data driven management and the role of data analytics in potentially supporting with the recruitment activities for new staff, in particular third-party agency staff. Moreover, business process specialists and improvement managers may also find insights from this research useful, given discussions around ways in which waste can be reduced, and the role of DT, such as digital twin warehousing in supporting this. This research went beyond just highlighting challenges resulting from COVID-19, which are widely reported in academic literature, consultancy reports and mainstream media, rather this research also offers potential, innovative solutions, to these challenges, in line with the extant literature. Therefore, in addition to practitioners and professionals, research consultants and researchers can also benefit from the numerous research avenues on offer for exploration as a result of this research.

6.0 Conclusion

The practices of SSCM have emerged in the last decades to integrate CE principles advocating optimisation of resources use to conserve the environment and reduce negative societal implications of production and consumption processes. In support of environmental sustainability, CE emphasise the idea of running processes in a business in such a way that there are harmonious relationships between ecological systems and economic growth. The transition to CE-based supply chain has offered businesses myriad of challenges, which further amplified by the COVID-19 pandemic, which this research set out to identify, and explore how the concepts of CE and DT can assist and allow the businesses to achieve sustainable performance.

Accordingly, the contribution of this study is twofold. Firstly, it brings together the concepts of SSCM, CE, DT, and FSC and linking their challenges as SFSC against potential solutions that some are not identified in the existing literature, thus allowing for in-depth, real FSC issues to come to the forefront. Secondly, the research provides a number of future research agendas, through the lenses of DT, namely developed in line with the extant literature and generated as research propositions. Despite the practical insights resulting from this research, it is also worth noting that this research also has some limitations. Firstly, the research was based on 10 in-depth interviews, thus it is proposed that further research in this area should utilise a larger sample size, which will help enhance our knowledge in this area. Furthermore, one must also acknowledge that the present research is grounded in a single case study setting, therefore fails to offer broader generalisation. The approach taken in this research has helped offer an in-depth perspective of SSCM, CE, DT and SFSC, however this research can be taken forward and explored in more detail, through the generated propositions.

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