Digitalisation in Food Supply Chains to build resilience from disruptive events: A combined Dynamic Capabilities and Knowledge-based view

Abstract

Purpose- Building resilience in food supply chains is considered vital to tackle disruptions and ensure the availability of food. The study aims to empirically explore how firms operating in food supply chains can develop dynamic capabilities and utilise digital technologies to address disruption.

Design/methodology/approach- A multiple case study methodology was adopted to understand how the firms built resilience by developing dynamic capabilities. Twenty-five semi-structured interviews were conducted with four case companies to gather data across various functional areas (sourcing, operations, logistics).

Findings- Results show that knowledge management is a key antecedent to developing dynamic capabilities. The development of such dynamic capabilities - sensing, seizing, and transforming, along with the adoption of digital technologies enabled firms to address the disruptions and, hence, build resilience. Resilience is demonstrated in the form of maintaining or improving performance outcomes such as profit, waste reduction, food quality, lead time, efficiency, customer satisfaction, etc.

Originality – This is one of the earliest empirical studies that provide insights into how firms operating in food supply chains have built resilience by developing dynamic capabilities through knowledge management practices and, which required the implementation of digital technologies. The study extends Dynamic Capability Theory with the knowledge-based view and develops a novel framework along with a pathway to build resilience.

Keywords – Resilience, Dynamic capabilities, Knowledge management, Food Supply Chain, Artificial Intelligence, Blockchain, IoT

Paper type – Research paper

1. Introduction

Businesses have experienced significant supply chain disruptions caused by the COVID-19 pandemic and have faced difficulties reorganising distribution networks and supply chains (Mahajan and Tomar, 2021). To adapt to this ever-changing business environment, companies must build operational resilience in order to minimise the effects of supply chain (SC) disruptions (Remko, 2020). Thus, SC resilience (SCRES) has garnered substantial interest from academicians and practitioners alike (Durugbo *et al*., 2020). The agriculture food SC was crippled with supply-side and demand-side shocks due to the protracted lockdown and restriction on the movement of goods (Sharma *et al*., 2020). The perishable nature of the food further increases the need to develop SCRES (Ali *et al*., 2018). The food supply chain (FSC) in emerging economies is mainly unorganised and labour-intensive, in contrast to the mechanised, organised, highly interconnected, and resilient FSC in affluent economies (Kumar *et al*., 2021). The pandemic's devastating effects are significantly worse in developing nations, where there is a hunger crisis and a lack of access to nutritional food (Mangla *et al*., 2021). Hence, it is essential to address these concerns by critically analysing the current state of the FSC, the different FSC disruptions, and the FSC processes in the context of an emerging economy - India.

Firms must improve their capabilities to overcome SC shocks and to create resilience. Resilience enables a SC "to persist, adapt, or transform in the face of change" (Wieland and Durach, 2021, page 316). Dynamic capability is the organisational capability that enables firms to combat environmental unpredictability. The vulnerability of a company's SC will increase if it fails to demonstrate preparedness, reaction, and recovery capabilities (Chowdhury and Quaddus, 2017). A resilient SC is able to recover from unplanned business interruptions and return to normal operations, which can provide it with a competitive edge (Ali *et al*., 2017).

Previous studies have pointed out that the application of digital technologies improves resilience. Artificial Intelligence (AI) can expedite the decision-making process through the identification, testing, and evaluation of innovative ideas (Wamba *et al*., 2020) and is considered a key enabler of SCRES

(Modgil *et al*., 2022a). Blockchain can help businesses increase the traceability and transparency of their SCs (Pettit *et al*., 2019; Spieske and Birkel, 2021), lowering the risk of disruptions and lessening the adverse consequences of the COVID-19 pandemic. Internet of Things (IoT) applications positively impact organisations' integration, customer integration, and information sharing, which in turn improves SC performance and firm performance (Yadav *et al.,* 2023).

Some of the major blockchain application areas in FSCs include – real-time monitoring, traceability and transparency (Nestlé) (Nestlé, 2024), food safety and quality assurance (The Bumble Bee) (The Bumble Bee, 2019), smart contracts for automation (Queen Frozen Fruit) (The Phnom Penh Post, 2019), sustainable and ethical sourcing, and SC optimization (Walmart) (Harvard Business Review, 2022). Domino's Pizza, a leading quick service restaurant, has developed digital ordering channels (website and an app) registering 85% of its sales through online channels. It has implemented an AI-powered chatbot for customer service and incorporated Augmented Reality for virtual pizza building and customisation (Forbes, 2021a). Döhler, a global food and beverage producer, through digitalisation improved product quality, financial status, and customer service. Döhler was able to quickly react and re-route shipments through early visibility of suppliers and closure of ports during the COVID-19 lockdown (Forbes, 2021b).

The global food technology market was valued at 260.07 billion USD in 2022 and is expected to be worth over 360 billion USD by 2028 (Statista, 2023). In Europe alone, approximately 2.4 billion euros have been invested in food technology startups in 2020 (Statista, 2021). In India, the growth of several agri-based startups in the past decade has fuelled the development of innovative and digital products. Startups such as Agrostar, BigHaat, Khetinext and Gramophone have been providing farmers with digital solutions to maximise their utilisation and ensure the delivery of quality inputs (NABARD, 2022). Cropin provides integrated digital solutions that help to provide accurate weather forecasts, timely pests and disease alerts leading to health monitoring for crops, farm management solutions, and farm-to-fork traceability (Cropin, 2024). These startups have also helped to overcome the disruptions

in FSCs brought on by the pandemic and this strengthened their resilience, and at the same time, accelerated their growth amidst the pandemic (NABARD, 2022).

Though some preliminary suggestions exist on how firms can create a resilient SC (Ivanov, 2021), the capability development for the improvement of SCRES during the COVID-19 pandemic is underexplored and requires further inquiry (Ali *et al*., 2023). Despite some promising initial findings on the impact of SCRES through the adoption of various digital technologies, there is a call for additional research (Pettit *et al*., 2019; Ivanov, 2021). Prior research has indicated certain capabilities, which are dynamic in nature, to boost resilience. However, there is a very limited understanding regarding these dynamic capabilities and how firms can develop them to enhance resilience, specifically amidst COVID-19 disruptions. The present study is an effort to unveil such dynamic capabilities in the context of FSCs that will enable firms to build resilience.

Consequently, the research questions (RQs) addressed in this research are as follows:

1. Which dynamic capabilities are developed by firms operating in food supply chains to counter disruptions faced in their supply chains? How can such capabilities be developed?
2. How can the above capabilities be leveraged to mitigate the disruptions and build resilience in food supply chains?

This work contributes to the scholarly discussion on how firms can build dynamic capabilities and implement digital technologies to mitigate the disruptions faced in their food supply chains during catastrophic events and, as a result, develop resilience.

The paper is organised as follows. Section 2 presents the literature review. Section 3 covers the research methodology, followed by the findings in Section 4. Section 5 contains the discussion, and section 6, the implications of the study. Section 7 concludes the study.

2. Literature Review

2.1 Dynamic Capability Theory

Dynamic capability is defined as "*the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments*" (Teece *et al*., 1997, p. 516). The Dynamic Capability Theory (DCT) is considered an extension of the resource-based view (RBV) and addresses the static nature of RBV (Helfat and Peteraf, 2003). The DCT has frequently been recommended as a theoretical framework for dealing with changing environments by offering a way to expand, modify, and reconfigure current capabilities (Pavlou and El Sawy, 2011) to provide a long-term competitive edge (Teece *et al*., 1997; Eisenhardt and Martin, 2000).

Dynamic capabilities allow for consistent and reliable conduct of strategic change-related activities and as such are different from *ad-hoc problem solving* which entails a non-routine "response to novel challenges from the environment or other relatively unpredictable events" (Winter, 2003, p. 993). Since dynamic capabilities encompass the conduct of activities in a repeated and patterned manner, they are considered to stem from organisational routines (Eisenhardt and Martin, 2000; Winter, 2003; Teece, 2007) with varying degrees of routinisation for different dynamic capabilities (Schilke *et al*., 2018). Dynamic capabilities are context-specific and ingrained within organisations, requiring organisations to develop them over time (Helfat and Martin, 2015). Regarding heterogeneity of dynamic capabilities, some researchers assume dynamic capabilities to be idiosyncratic while others assume them to exhibit significant commonalities with respect to key features across firms (Barreto, 2010).

Teece (2007) classified dynamic capabilities into – 1. Sensing 2. Seizing and 3. Transforming or Reconfiguring capabilities. Sensing capability enables a firm to scan and monitor the business environment continually to identify opportunities and threats. Seizing capability enables a firm to act quickly and allocate resources to the identified opportunities and threats. Transforming refers to a firm's capability to recombine and reconfigure its resources and operational capabilities to ascertain that its resources and capabilities match the changes and opportunities that are sensed (Teece, 2007). The

success of dynamic capabilities depends on a firm's processes, which may be used to systematically change its capabilities and create new positions and avenues for maximising the use of its strategic assets (Helfat and Peteraf, 2009). As a result, it provides a theoretical foundation and a dynamic lens to assess how organisations' capacities are developing (Eisenhardt and Martin, 2000).

2.2 Antecedents of Dynamic Capabilities

Various researchers have shed some light on the antecedents of dynamic capabilities. Accordingly, these antecedents are classified under *Organisational* factors, *Individual/team* factors, and *Environmental* factors (Schilke *et al*., 2018). *Organisational* antecedents include organisational structure - polyarchy and social proofs (Felin and Powell, 2016); entrepreneurial orientation (Teece, 2007; Correia, 2022); and learning orientation (Correia, 2022). Studies (Aslam *et al*. 2020; Juan and Li, 2023) have revealed that knowledge management and learning capabilities are antecedents to dynamic SC capabilities. Digital technologies combined with big data analytics enable firms to sense customers' changing demands and reveal market trends preparing them to respond quickly to changing markets (Warner and Wäger, 2019) and are thus, considered as antecedents. *Individual/team* antecedents to dynamic capabilities include intellectual capital (Farzaneh *et al*., 2022); managerial cognitive skills such as social cognition, problem-solving and reasoning, perception and attention (Helfat and Peteraf, 2015), global vision, and agility thinking (Feng *et al*., 2023). *Environmental* antecedents comprise market dynamism (Wang and Ahmed, 2007); COVID-19 shocks (Ali *et al*., 2022), and their respective upstream and downstream impacts (Kähkönen *et al*., 2021).

2.3 Dynamic Capabilities and Supply Chain Resilience

SCRES is defined as "supply chain's ability to be prepared for unexpected risk events, responding and recovering quickly to potential disruptions to return to its original situation or grow by moving to a new, more desirable state in order to increase customer service, market share and financial performance"

(Hohenstein *et al*., 2015, p. 108). The traditional view of SCRES is based upon the concept of engineering resilience and is believed to have a single state of equilibrium (Holling, 1996), which advocates SCs to persistently "bounce back" as quickly as possible to the same status quo that existed prior to the disruption. However, the COVID-19 pandemic has taught us that the "new normal" will not be the same as the "old normal", and that in order to survive and thrive in a time especially pertinent to the volatile, uncertain, complex, and ambiguous world we currently live in, adjustments or even more radical transformations may be necessary (Wieland *et al*., 2023). Hence, this drives us to the modern conceptualisation of SCRES which is based upon the socio-ecological view that endorses SCs to adapt and transform ("bounce forward") as there can be multiple states of equilibrium in a radical business environment (Wieland, 2021).

A frequent misperception is that a SC has the autonomy and the capability to reconfigure itself both proactively and reactively in the face of disruption. The reality is that the dynamic capability of the focal firm adjudicates the development of the reconfiguring capability to counter disruptions leading to SCRES (Juan and Li, 2023). Hence, we confirm DCT to be an appropriate theoretical lens to study SCRES. The DCT has been one of the most pertinent theoretical frameworks to explain the SCRES phenomenon according to recent reviews of SCRES studies (Ali and Gölgeci, 2019; Rahman *et al*., 2022; Stadtfeld and Gruchmann, 2024).

Drawing upon DCT, Chowdhury and Quaddus (2017) empirically built the first integrated measurement scale for SCRES composed of proactive, reactive, and SC design quality capabilities that are dynamic in nature to sense, reconfigure, and transform resources in accordance with the business environment. The impact of COVID-19 on the firm's upstream SC influences firm's seizing capability while the impact of COVID-19 on its downstream SC influences the firm's reconfiguring capability. Seizing and reconfiguring capabilities positively impact SCRES (Kähkönen *et al.*, 2021). Juan and Li (2023) uncovered the role of knowledge-based dynamic capability in promoting sensing, seizing, and transforming dynamic capabilities and subsequently fostering SCRES.

A limited number of studies on SCRES utilising DCT have been conducted in the context of FSCs. Mishra *et al*. (2022) identify the supply, logistics, and demand-related capabilities required to build SCRES in Indian FSCs. Do *et al*. (2021) demonstrate how FSCs pursued agile responses to the COVID-19 crisis through sensing and seizing dynamic capabilities which enabled FSCs to quickly identify the relevant changes and acquire, combine, and modify resources in accordance with the identified changes. Ali *et al.* (2022) unveil that the various (supply, production, demand) shocks induced by COVID-19 triggered the development of readiness, response, and recovery dynamic capabilities that helped to build, integrate, and reconfigure the internal and external competencies and thereby maintain the competitiveness of global food value chains. Belhadi *et al*. (2024) illustrate how digital technologies enable firms in FSCs to develop sensing, seizing, and transforming capabilities required to build resilience.

2.4 Digital Technologies and Supply Chain Resilience

The adoption of digital technologies in SC enables real-time information acquisition and processing which accelerates decision-making, enhances SC visibility, and fosters cooperation to strengthen SCRES, particularly during periods of increased unpredictability (Ivanov *et al*., 2021). Büyüközkan and Göçer (2018) list factors such as speed, flexibility, transparency, global connectivity, innovativeness, intelligence, and eco-friendliness as some distinct characteristics associated with the application of digital technologies in SC that enable the development of SCRES. Birkel and Hartmann (2020) illustrate how IoT applications ensure data availability in businesses which enhances process velocity and transparency. The implementation of digital technologies for developing SCRES capabilities - collaboration, visibility, planning, agility, redundancy, flexibility, efficiency, and velocity has been echoed by several researchers (Birkel and Hartmann, 2020; Spieske and Birkel, 2021; Birkel *et al*., 2023).

The Digital SC twin model visualises the network state at any given time and provides end-to-end SC visibility which greatly aids in making both proactive and reactive decision making (Ivanov and Dolgui, 2020; Burgos and Ivanov, 2021). AI-powered information processing capabilities lead to enhanced

SCRES through adaptive capabilities, agility, and SC collaboration (Belhadi *et al*., 2024). AI equips SC to develop capabilities for analysing demand, reconfiguring resources, and activating contingency plans during extreme disruption (Modgil *et al*., 2022a). AI can offer personalized solutions, improve transparency, and facilitate agile procurement strategy thus, enhancing SCRES (Modgil *et al*., 2022b). Suali *et al*. (2024) investigate the advent of digital platforms as an enabler for process flexibility and system resource efficiency which facilitates quick reconfiguration of supply, processing, and go-to-market channels by food industry operators, allowing them to carry on operations with minimal interruptions.

Similarly, the benefits of blockchain and its relationship with SCRES have been explicated by several authors. Blockchain applications like smart contracts and tracking solution supports aggregation, visibility, and validation which enables agility and collaboration (Beck *et al*., 2023). Through real-time data exchange between the integrated parties, blockchain enhances visibility which aids SCs in planning ahead for interruptions and speedily recovering from them (Razak *et al*., 2023). Utilising open ledger data may assist in tracking material movement, verifying inventory levels, and understanding the whole order fulfilment process (Spieske and Birkel, 2021). Furthermore, Blockchain can prevent fraud and counterfeiting by protecting the SC's integrity through efficient monitoring, which improves the brand reputation and increases firms' competitiveness (Razak *et al*., 2023). Blockchain's decentralised, transparent, and cryptographic structure facilitates credibility and trust, promoting long-term collaborative relationships among SC actors and consumers (Spieske and Birkel, 2021; Razak *et al*., 2023).

Studies conducted on FSCs have indicated that digital technologies reduce the detrimental effects of supply-demand mismatch, and transportation, financial, and process risks associated with SC disruptions, influencing firm performance (Ali *et al*., 2021; Ali and Govindan, 2023). Belhadi *et al*. (2024) demonstrate how African agri-food upstream firms used mobile apps and cloud-based data analytics to develop sensing capabilities. The downstream companies utilised digital seizing and

transforming capabilities to create worst-case scenarios through blockchain and additive manufacturing. Sengupta *et al*. (2021) demonstrate how the integration of IoT and satellite imagery enabled providing weather-related data and the location of wild catch to inform and navigate fishermen quickly to the catch area. Blockchain ensures the authenticity of fish and enables quality monitoring of fish fetching better prices for the fisherfolk.

2.5 Gaps in the literature

The comprehensive review of the literature reveals that amidst a turbulent business environment, firms need to develop dynamic capabilities to mitigate disruptions and hence, build resilience in their SCs. Digital technologies have demonstrated the potential to enable firms to develop resilience capabilities. We argue that the adoption of digital technologies is a part of the dynamic capabilities that firms require to build resilience. Whether digital technologies enable firms operating in food supply chains to build resilience amidst the pandemic is a pertinent question that remains largely unanswered due to the lack of empirical studies (Ali and Govindan, 2023) especially in emerging economy nations. At the same time, there is a lacuna in understanding how dynamic capabilities can be developed, and how they can assist firms in developing resilience, especially for FSCs. The present study is a response to the call made by Ali *et al*. (2023) to empirically investigate how firms operating in food supply chains develop dynamic capabilities that enable them to achieve SCRES during a rapidly changing environment such as COVID-19.

3. Methodology

Case study research is especially suitable for investigating real-life complex issues with limited empirical knowledge, thus resulting in new and in-depth insights. The main aim of the study is to understand and explore how the firms operating in FSCs developed dynamic capabilities and implemented digital technologies to build resilience during COVID-19. Since the pandemic setting is

quite unique and contemporary, and there isn't sufficient understanding as to how firms build dynamic capabilities to exhibit resilience, our study used a qualitative multiple-case study technique (Yin, 2018), employing the theoretical lens of dynamic capabilities recommended in current literature (Do *et al*., 2021; Kähkönen *et al*., 2021). Our unit of analysis is a firm operating in FSC.

3.1 Case selection

The cases are chosen based on the purposive sampling technique. Purposive sampling for case studies, according to scholars, should consider variation as well as representativeness with regard to theoretical interests (Seawright and Gerring, 2008). Purposive sampling was used to gain diversity among different types of products belonging to the FSC category to qualify the data for a more generalisable result. Firms that deal in relatively higher-priced food items (e.g., dairy, poultry, fruits) are at a higher risk than firms that deal with low-priced staple foods. Hence, developing resilience is critical for such firms. Since building resilience is the goal of our study, the firms associated with high-priced food items were selected. We contacted the Foundation for Innovation & Entrepreneurship Development (FIED) to select cases by utilising their food industry associations. FIED is running projects of the Department of Science and Technology and the Ministry of Agriculture and Farmers' Welfare regulated by the Government of India.

For the generalisation of results, a sample size (number of cases) of four to ten works well (Eisenhardt, 1989; Yin, 2018). Accordingly, four focal firms operating in FSC based in India were selected for this research. To preserve anonymity and confidentiality, the participating case firms are alphabetically named as A, B, C, and D.

3.2 Data Collection

Data was gathered through in-depth face-to-face interviews with case firm practitioners. In certain cases where face-to-face interviews were not possible, telephonic interviews and online meetings through platforms like Zoom, Google Meet, etc. were conducted. The interview protocol is provided in the appendix. Respondent and corporate identities are hidden to ensure complete anonymity and

confidentiality. The interviewees were chosen based on their ability to give detailed information on the firm's strategic direction and general operation. To ensure that different viewpoints and a comprehensive picture emerged throughout the interviews, we conducted five to seven interviews of functional managers (e.g., sourcing, operations, logistics) in each firm at various management levels (Corley and Gioia, 2004). The details of the interviewees and the sources of secondary data are provided in appendix (Table A1). The respondents were provided with the questions beforehand to thoroughly inform them of the research objectives and goals before the interviews (Voss *et al*., 2002). A thorough assessment of the literature including impactful SCRES papers (e.g. Hohenstein *et al*., 2015; Tukamuhabwa *et al*., 2017; Stone and Rahimifard, 2018); papers on the nexus of DCT and SCRES (Chowdhury and Quaddus, 2017; Stadtfeld and Gruchmann, 2024); and previous questionnaires in FSC and SCRES case study research (e.g. Do *et al*., 2021; Mishra *et al*., 2022) served as the basis for developing the semi-structured questionnaire (see Table I). Additionally, two professors with extensive methodological and domain knowledge of SC management and three senior SC practitioners pre-tested the questionnaire to confirm that the questions are unambiguous and comprehensible.

The first section of the questionnaire was targeted to collect background information of the respondents and the case firms. In the second section, we asked open questions to get a detailed account of the impacts and the disruptions caused by the COVID-19 pandemic. In the following section, we collected information on how the case firms developed sensing capability i.e., identified the various threats and opportunities induced by the pandemic. The fourth section sought to explore how the firms responded to curb the negative impacts of the pandemic and subsequently, mitigated the disruptions. This section also sought to investigate how the firms seized new business opportunities and developed resilience capabilities. In the final section, we asked the respondents how the firms prepared themselves to transform and adapt to the changing business environment. In total, 25 interviews were conducted across four firms. The interviews lasted from 56 to 74 minutes. Each interview was audio recorded. The audiotape was transcribed by one of the researchers, while the other double-checked the transcription.

Inconsistencies in the replies of the participants were resolved in later sessions. One of the researchers oversaw conducting the interview; the other supplemented it with follow-up questions.

Section	Questions
The company and interviewee	Please provide a brief overview of your company.
	Please describe your role and responsibilities in the company
	Can you please describe the business model of the company, the product/s, the related business processes, and the SC stakeholders?
COVID-19 disruptions	What are the disruptions caused by the pandemic COVID-19 in your company? Which are the most significant disruptions? How are these disruptions similar or different from past disruptions that you faced?
	What are the various supply side, demand side, and operational uncertainties faced by your company and the SC amidst the pandemic? Please elaborate.
Sensing	What are the prime threats experienced amidst the pandemic? How did you gather knowledge to identify the potential threats posed by the pandemic? How did the stakeholders contribute in the due process? Please explain
	What are the opportunities experienced amidst the pandemic? How did you gather knowledge to identify the potential opportunities posed by the pandemic? How did the stakeholders contribute in the due process? Please explain
	How did you plan to mitigate the disruptions? Please explain.
Responding	How did you mitigate the disruptions in your SC? How far were the existing risk mitigation strategies successful in tackling the disruptions? How did you involve the stakeholders in the responding effort?
	Which digital technology did you adopt to curb the negative impacts of the pandemic? How did you plan and implement the digital technology? Did you have any plan to implement digital technology before the pandemic? Please elaborate
	How did the adoption of digital technology enable in tackling the disruptions? Please explain
	How did the adoption of digital technology enable in seizing the identified business opportunities? Please elaborate
	What are the benefits associated with the adoption of digital technology? How do these benefits enable in building resilience capabilities? How do these benefits translate to performance outcomes?
Transforming	Are you going to continue using digital technologies in your business when the pandemic subsides? If so, how are you preparing for that?
	What changes will be there (if any) in your business processes in the post pandemic period? Are you anticipating any significant alterations to the way you and your SC conduct business?
	What is your take on the way business in shaping in the food industry in India? How are you preparing for that? Please elaborate

Table I: Semi-structured questionnaire

3.3 Data Analysis

The interview transcriptions were analysed by two researchers in two stages: first, a within-case analysis, followed by a cross-case analysis (Eisenhardt, 1989). The data analysis evolved in three stages, leading to the data structure presented in Table A2 of the appendix. Each researcher used the informants' own language and words to openly code the interviews in the first phase (Strauss and Corbin, 1990; Gioia *et al*., 2013). The codes were improved by comparing the interviews, and we then started collecting and classifying related ones to get the first-order codes (Gioia *et al*., 2013). We consolidated the first-order codes into second-order categories by comparing them to the theoretical concepts from the DCT and knowledge management literature (Gioia *et al*., 2013). The second-order categories were aggregated into six broader dimensions (Strauss and Corbin, 1990; Gioia *et al*., 2013) including SCRES capabilities and knowledge capability. Triangulation and enrichment of synthesised interview results were performed by employing a summary of observations as well as secondary data. In certain instances, the secondary data provided information that was missing from the interviews, like the details of the digital technologies that were implemented by the firms. It also provided data on various performance outcomes of the firms, like profit, lead time, waste, etc.

3.4 Reliability and Validity

Table II provides a summary of the steps taken to resolve concerns about the reliability and validity of the case study research in the design, data collection, and data analysis phases.

Dimension	**Research phase**		
	Design	**Data Collection**	**Data Analysis**
Reliability	Development of case study protocol	Common interview questions following the semi-structured interview protocol	Multi-perspective data coding and verification involving multiple researchers

	Development of interview guidelines	Careful documentation of data collection	Rigorous coding process
	Development and use of case study database	Updated transcripts and recordings of interviews for the case study database	
Internal Validity	Research model based on SCRES and DCT literature	Multiple respondents	Consensus among researchers on coding
		Experienced, knowledgeable key persons interviewed	Data triangulation using multiple sources, e.g. company website, online articles, newspaper articles, archival records, etc.
		Interview transcripts were sent to interviewees for checking.	
Construct Validity	Questions adapted from extant literature on SCRES and DCT	Multiple sources of information- interviews, observation, secondary data	Describe and clarify the coding approach
		The case study procedure and interview questions were given to the interviewees	Case study findings validated by interviewees to avoid researchers' bias
		Multiple interviewers for each interview	Data triangulation, including additional data sources
External Validity	Multiple case study	Collecting data on case contexts	Within-case and cross-case analysis for generalisability
	A description of the case's context and situation	Comparison of available secondary data	

Table II: Reliability and Validity

4. Findings

4.1 Within-Case Analysis

The various knowledge management (KM) practices (knowledge accumulation, knowledge sharing, knowledge creation) enabled the case firms to develop dynamic capabilities (sensing, seizing, and transforming). The KM practices and the associated KM activities undertaken by the case companies are discussed hereafter and summarised in Table III. The adoption of digital technologies for mitigating disruptions and seizing new business opportunities are also elaborated henceforth.

4.1.1 KM practices for developing sensing capability

4.1.1.1 Tacit KM for sensing threats:

i) Internal threats: The case companies conducted regular meetings with the various functional departments (operations, quality control, logistics) for internal *knowledge accumulation* and *knowledge sharing.* Through such meetings, case firms identified the bottlenecks, inefficient, and outdated processes that were considered potential threats. *Knowledge sharing*- The employees used social media such as WhatsApp to discuss potential threats and their effect on performance. For *knowledge creation*, the managers (middle and top-level) along with the experienced employees discussed the nuances of the potential threats and subsequently, identified the internal threats. For case B, the significant internal threats were the low efficiency of hatcheries, the dependence on traditional and manual processes, and the unavailability of labour. Case C witnessed threat due to the shortage of labour for harvesting. Managing manual records – milk quantity and quality for the milk farmers at the collection centres was considered a threat for case D.

ii) External threats: *Knowledge accumulation* - The case companies held meetings with the stakeholders (suppliers, wholesalers, and retailers) and knowledge sessions with food industry experts to accumulate knowledge regarding external threats arising from the changing business environment. For cases B and C, *knowledge sharing* occurred mostly in an informal manner during lunch and break

time when the employees interacted with each other. *Knowledge creation* -The case firms consulted with industry experts, technology experts, and government health officials to get a glimpse of how business is reshaping in the current state of affairs.

For Case A, the prime external threats identified were the closure of test labs for quality testing, high turnaround time (TAT), and inaccurate quality grading. For case B, a prominent threat was the demand evaporation caused by the closure of HORECA (Hotel, Restaurant, Catering) which in normal times, used to generate a major portion of the overall demand. "*The demand from the restaurant and catering business almost vanished during that (lockdown) period*" (B4). The household demand for raw poultry meat was reduced by 76%. The most significant threat for C was the closure of wholesale markets ('mandis') due to the lockdown. This resulted in a drastic decrease in demand. For case D, the foremost threat was the shortage of milk and irregular milk supply as many farmers who contracted the coronavirus either supplied less quantity or were unable to supply. The demand for clarified butter and cottage cheese also decreased due to the closure of HORECA. Also, firm D's competitor in the nearby region was planning to implement a traceability system in its SC to cater to the customer demand for traceability.

4.1.1.2 Tacit KM for sensing opportunities:

Knowledge accumulation - Managers of case A participated in conferences and webinars targeted at the food & beverage industry where they discovered the use of AI devices for food quality testing and the associated implications. Case C conducted brainstorming sessions with its employees and major stakeholders to generate new business ideas. Social media monitoring of the competitors enabled firms to uncover customer needs revealing new business opportunities. Case A discovered customers' propensity for flavoured and immunity-boosting tea from Facebook. Similarly, case B discovered the application of IoT in the poultry industry from a YouTube success story. Case D realised the customer demand for traceability through its competitor's Facebook business profile. *Knowledge sharing* was carried out through formal and informal meetings with stakeholders and the use of social media which enabled instant sharing of thoughts, ideas, and experiences to targeted groups. *Knowledge creation* -

The case firms A, C, and D conducted surveys with retailers and customers to recognise latent demand for new products and capture customer needs and preferences.

4.1.2 KM practices for developing seizing capability

4.1.2.1 Tacit KM: For *knowledge accumulation*, firms B and C consulted with agri-based startups and entrepreneurs to gain knowledge regarding the various threat mitigation strategies, new business opportunities, and recent technological advancements. Two firms (A and D) reached out to their suppliers and retailers to gain an understanding of how their competitors tackled the threats. *Knowledge sharing* comprised discussing the identified threat mitigation strategies and new business ideas and opportunities with the top-level management and stakeholders of the respective firms through formal meetings. *Knowledge creation* - The top-level managers along with the stakeholders consulted with business analysts and technology experts to find digital solutions for mitigating threats and seizing the identified opportunities. The feasibility (financial and technical) of such solutions was also discussed.

4.1.2.2 Explicit KM - Knowledge accumulation: Training and knowledge sessions were conducted for employees and SC partners across all the cases to impart knowledge on digital technologies. The departmental managers of firms (A, B, and D) and the various stakeholders together prepared the business requirement document detailing the business goals, tasks and actions, and cost-benefit analysis for the digitalisation process. *Knowledge sharing*: The business requirement document was shared with the outsourced technology team. The outsourced team shared documents with the case firms detailing the resources (financial and human) and infrastructure required for the implementation of digital technologies. Firm C implemented digital platform with the help of young IT professionals who also prepared the business requirement document. *Knowledge creation*: The firm managers prepared a document providing an overview of the digital technology to be implemented and the expected outcomes. A blueprint for the digitalisation process was also developed.

4.1.3 KM practices for developing transforming capability

4.1.3.1 Tacit KM: Knowledge accumulation - Company A conducted various skill development programs and workshops with the support of Tea Board India, a statutory body of the Government of India. Cases B and C arranged workshops on digital literacy for their employees through local NGOs. The employees of firm D were provided training on data security and cyber threats through the outsourcing team. *Knowledge sharing* – Through informal meetings at the canteen and cafeteria, the young tech-savvy employees educated their older counterparts and managers on the functional and business values of digital technologies across all cases. Outsourcing technology teams conducted knowledge transfer sessions with the managers and employees. *Knowledge creation* – The employees who participated in the knowledge transfer process trained the other staff members.

4.1.3.2 Explicit KM: Knowledge accumulation: The managers collected various documents, demo videos, and newspaper articles on digital technologies and circulated them among the employees. *Knowledge sharing*: The employees were provided access to the knowledge repository of their firms. The outsourced team shared documents on the various troubleshooting techniques related to digital technologies. *Knowledge creation* – The information generated from digital technologies was utilised to create new knowledge through data analytics capabilities. The case firms hired data analysts and business analysts to perform data analytics tasks. The new knowledge provided critical insights for quality control and quality management in the case of A, for monitoring the growth of chicks in the case of B, for estimating demand and recognising demand patterns in the case of C, and for efficient supplier management in the case of D.

KM Practices	Activities
Knowledge accumulation	Meetings with functional departments, formal & informal meetings with stakeholders, knowledge sessions with industry experts, consultation with market analysts and technology experts, social media monitoring, workshops, skill development programs, participating in webinars & conferences, brainstorming sessions, consultation with startups and entrepreneurs
Knowledge sharing	Use of social media, informal discussions, formal & informal meetings with stakeholders, meetings with top-level management, meetings with functional departments, sharing business requirement documents, access to knowledge repository, circulating documents on digital technologies & troubleshooting techniques
Knowledge creation	Validation from top-level management, consultation with government health officials and business analysts, surveys with retailers & customers, training sessions, performing data analytics, creating a blueprint for digitalisation of business processes

Table III: KM practices and associated activities

4.1.4 Digitalisation as Seizing capability

i) Disruption Mitigation: Case A implemented a device based on AI and spectroscopy for quality testing. Accurate quality tests were performed within seconds and that too without the requirement of a dedicated lab and testing personnel. Hence, firm A mitigated the disruption caused due to the closure of testing labs. Case B implemented IoT devices and used a digital platform that provides a) real-time information on environmental conditions like temperature, humidity, and light intensity b) live notifications and c) control of environmental parameters from the mobile app. This enabled the firm to eliminate dependency on manual interventions and consequently, mitigate labour-induced disruption. Case C developed a website and an app with the help of young IT professionals for the creation of a virtual marketplace. The university students performed marketing activities for the cooperative through social media outlets (Facebook, Whatsapp). Thus, the firm was able to market and sell the produce in spite of a disrupted physical marketplace. The implementation of blockchain in the SC network enabled end-to-end traceability which empowered firm D to mitigate disruptions caused by supply failures. On account of the visibility of daily supplies, firm D could arrange for procurement from alternate suppliers in case of supply shortage or failure.

ii) Seizing new business opportunities - With improved quality management and quality control provided by the AI device, firm A extended its portfolio of products with the addition of flavoured tea and immunity-boosting tea which were in high demand. IoT enabled firm B to realise high efficiency. The firm was able to cater to the growing demand for eggs. The high efficiency also enabled the firm to secure contracts with frozen food companies for supplying raw meat. With the help of a digital platform, firm C was able to aggregate demand from far-off places which was not possible with the presence of only a physical market. The firm partnered with nearby farmers which improved the product variety and availability resulting in improved sales. The virtual marketplace assured good prices for the produce and at the same time minimised wastage. Blockchain enabled firm D to capture new customer segments who demanded traceability and quality information and thus, provided the firm with a competitive edge. The robust supply management enabled through blockchain equipped the firm to

expand its supplier network. Firm D expanded its product portfolio by introducing flavoured milk and milk-based health drinks.

4.1.5 KM post-digitalisation

Knowledge creation & utilisation: Data analytics capability enabled the case firms to generate new knowledge from the digital information which was effectively utilised for developing resilience capabilities. The resilience capabilities and the associated performance outcomes are elaborated in cross-case analysis (section 4.2).

4.2 Cross-case analysis

4.2.1. Visibility: IoT enabled firm B to create visibility through real-time monitoring of environmental parameters within the hatcheries and during the growth phases of the chicks. Visibility enabled timely control of environmental conditions which resulted in higher efficiency, reduced mortality rate (reduced waste), and increased number of healthy chickens at the farm gate resulting in improved food quality. Blockchain enabled firm D to track the suppliers thus, improving the visibility of its supplier network. Immutable data records of the supply (quality and quantity) at the milk collection centres assist in ensuring food quality and better inventory management leading to increased profits. Smart contracts enabled the firm to recognise the default suppliers and impose penalties. Visibility assisted the firm in procuring from alternate suppliers in case of supply shortage improving - supplier management, capacity planning, and contingency planning.

4.2.2. Transparency: Blockchain implementation enabled case D in tracking and tracing, creating transparency which allowed for easy resolution of quality concerns by identifying the product's source ensuring that there is no adulteration of milk in its journey from farm to glass. Immutability promotes credibility and induces trust among suppliers and customers. Transparency helped the firm to gain a competitive advantage and capture new markets. Overall, transparency resulted in increased food quality, increased sales and profits, product immutability, provenance, and customer satisfaction.

4.2.3. Efficiency: With the help of AI, firm A was able to accurately grade the quality of its products and considerably reduce the lead time. AI-enabled testing also significantly reduced the wastage previously associated with lab testing. For firm B, IoT enabled the elimination of manual intervention in monitoring the environmental parameters and improved production efficiency from 75-80% to around 94%. The use of a digital platform enabled case C to fetch higher prices for its produce and sell the produce which was mostly either not harvested or thrown away due to the lack of a physical marketplace thus, improving sales and profit, and reducing waste.

4.2.4. Agility: All four cases improved their capability to quickly react to the changes in the business environment on account of the usage of digital technologies. With the in-house testing facility, firm A promptly responded to demand changes, improved order fulfilment, and lowered TAT. Firm B implemented IoT and sensor networks through which it could collect and process real-time data, detect changes in the environmental parameters, immediately respond to the detected changes, and make evidence-based decisions thus, enhancing agility and reducing cost and wastage. Case C used digital platforms wherein they could take orders 24/7, which enabled C to appropriately plan for harvesting, and efficiently manage inventory to quickly cater to customer demand. This enabled the firm to improve capacity planning and realise increased sales, increased profits, and reduced waste. Case D implemented Blockchain which enabled agility of the firm's supply network amidst supply shortage, assisting the firm in swiftly procuring from alternate suppliers leading to improved order fulfilment and robust contingency plans. Catering to the customer demand for traceability resulted in increased sales, increased profit, and customer satisfaction.

4.2.5. Flexibility: With the help of an AI-powered device, case A could perform quality tests accurately within seconds at any time thus, providing the firm with flexibility in quality management. Consequently, case A was able to decrease the lead time, improve the order fulfilment rate, and improve food quality and profit. Case C, through the implementation of digital platforms, was able to aggregate customer demand and source from different suppliers as per the demand which enabled the firm to

develop flexibility. For case C this yielded increased sales and profit. Case D adopted Blockchain for providing traceability information to its customers responding to their demand for traceability. Hence, Blockchain adoption resulted in developing flexibility for case D to realise increased sales, profit, and customer satisfaction.

The details of cross-case analysis are summarised in Figure. 1.

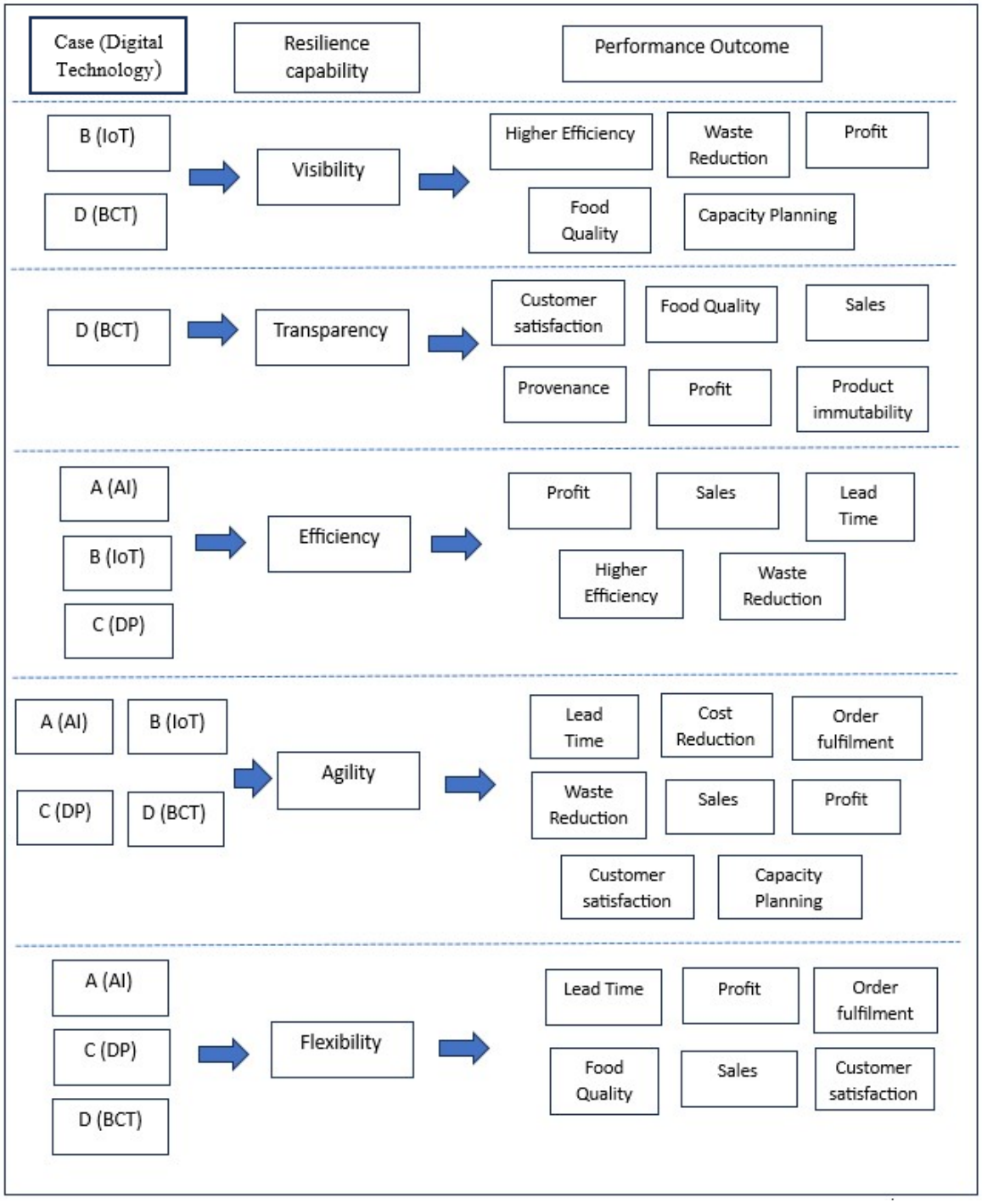

Figure 1: Cross-case analysis (IoT = Internet of Things; AI = Artificial Intelligence; BCT = Blockchain; DP = Digital Platform).

5. Discussion

Considering the dynamic nature of the business environment, the risk factors may vary across industry sectors, thus demanding independent research on the emanating threats and their remedial measures (Ali *et al*., 2021). Researchers have emphasized the importance of dynamic capabilities to build SCRES (Do *et al*., 2021; Ali *et al*., 2023; Juan and Li, 2023) nevertheless, there is a lack of research that empirically demonstrates how such capabilities can be developed, especially in FSCs. This research work analysed multiple cases to uncover how dynamic capabilities were forged, and how these dynamic capabilities fostered the development of resilience capabilities along with the associated performance outcomes in FSCs amidst the COVID-19 outbreak.

All four cases exhibited KM routines involving their stakeholders (suppliers, wholesalers, retailers) much before the onset of the pandemic. After the pandemic inflicted disruptions, the firms sought ways to mitigate those disruptions. In an attempt to do so, the firms accumulated experience, expertise, intuition, and wisdom (tacit knowledge) internally through the managers and employees and externally through the engagement with various stakeholders such as suppliers, retailers, and customers, and with food industry experts. The managers also gained knowledge about how their competitors tackled the disruptions through social media monitoring and surveying retailers and customers. By these mechanisms, knowledge is raised from the individual to the group and eventually to the organisational level (Heimeriks *et al.*, 2007).

The knowledge gained in due course provided the management with a vision as to how things are likely to unfold in the post-disruption "new normal" phase, which the experts predicted to stay for some time (Wieland *et al*., 2023). This knowledge enabled the firms to develop sensing capability – the capability

to identify the various threats (internal and external) and recognise new opportunities that lie ahead. Our study lends empirical support to the fact that managers' knowledge and learning capacities enable them to recognise new opportunities (Teece, 2007).

This leads us to the following propositions-

P1a: Tacit knowledge accumulation, sharing, and creation involving the various functional departments of the firm lead to the identification of internal threats, which positively influences the development of sensing capability.

P1b: Tacit knowledge accumulation, sharing, and creation involving the various stakeholders and industry experts lead to the identification of external threats and new business opportunities, which positively influences the development of sensing capability.

After sensing, the firms developed seizing capability by implementing digital technologies – AI, IoT, digital platform, and Blockchain which is in line with the recommendation provided by Burgos and Ivanov (2021). The explicit and tacit knowledge received from the outsourced team and technology experts guided the technology implementation process. Through our study, we explain how the adoption of digital technologies enabled firms not only to mitigate the disruptions caused by the pandemic but also seize new business opportunities which is equally important for firms to survive in a highly uncertain business environment. The various resilience capabilities developed by the cases and the associated performance outcomes are shown in Figure 1. In all the cases, we witness the involvement and support of the top management and decision-makers for the investment in digital technologies to improve SCRES (Sawyerr and Harrison, 2019).

Consequently, we propose:

P2: Disruption caused by the unavailability of quality testing labs can be mitigated by performing food quality tests using AI device which provides flexibility in quality management, improves the accuracy of tests, reduces food wastage, and reduces the turnaround time, enhancing efficiency.

P3: Disruption caused by irregular manual monitoring of environmental conditions (light intensity, temperature, humidity) can be mitigated by adopting IoT, which enables seamless monitoring and remote control of requisite environmental parameters, improving visibility and enhancing efficiency.

P4: Disruption caused by the limited availability of physical marketplace can be mitigated by creating a virtual marketplace through the adoption of a digital platform, enhancing flexibility and improving agility.

P5: Disruption caused by poor visibility of the supplier network can be mitigated by implementing Blockchain, improving visibility and transparency, and facilitating alternate supplier selection.

Thus, building on the above specific propositions, we can generalise the findings and propose P6.

P6: Adoption of digital technologies by firms operating in food supply chains enhances the continuity of business operations amidst disruption and simultaneously enables the seizing of new business opportunities, thereby ensuring their survivability during prolonged disruption.

In the transformation stage, the managers made provisions for training the staff on the newly implemented technologies, and the existing operational routines were modified in consultation with the outsourced technology team and technology experts. The transformation capability provided experiential learning for the firm regarding the associated changes made to the business operations to tackle disruptions. The knowledge gained on how competitor firms in the industry mitigated COVID-19 disruptions through the industry experts and the various SC members based on their reflections and experiences led to vicarious learning (Scholten *et al*., 2019). Digital technologies helped firms to create,

share, and utilise knowledge. The three knowledge sources, i.e., experiential learning, vicarious learning, and knowledge created from digital technologies lead to the formation of SC memory. Previous research has shown that creating, preserving, and accessing information on how to handle disruptions is essential to preventing future ones (Ponomarov and Holcomb, 2009; Scholten *et al*., 2019). Thus, we conceptualise that SC memory will provide the firm with the necessary knowledge and experience to respond to similar future disruptions with agility.

An important point to note here is that although three firms (A, B, D) knew about the financial benefits that digital technologies can bring with them, they were sceptical regarding the business value of those technologies. COVID-19 disruptions acted as a catalyst for the firms to realise the business value of digital technologies, which eventually led to their adoption. By providing real-time accurate information to the right person at the right time and right place, digital technologies enhance a company's decision-making ability, which enables the firm to handle uncertainty and disruptions (Qader *et al*., 2022). However, the lack of knowledge regarding their business value is a major impediment to the adoption of digital technologies (Ali and Govindan, 2023), particularly in the case of developing nations where the value of digital technologies is gauged only in terms of their potential to boost profitability (Bogoviz *et al*., 2019). The present study helps to address this shortcoming by highlighting the significance of digitalisation in ensuring business continuity and firms' survivability in turbulent business environments, assuring food security, which is a prime concern for FSC resilience (Stone and Rahimifard, 2018). This is a significant contribution of our study. Hence, despite their barriers to adoption (Chauhan *et al*., 2021), efforts to implement digital technologies to deal with disruptions are recommended, as the present study provides empirical support to the fact that digital technologies significantly influence in building SCRES.

Previous studies have endorsed the fact that dynamic capabilities play a substantial role in the development of resilience (Kähkönen *et al*., 2021; Ali *et al*., 2022). However, the literature does not provide a clear understanding regarding how to develop dynamic capabilities amidst a severe disruption. This is a crucial omission, in our opinion, since managers would be better equipped to appreciate the

value of these capabilities and reap the benefits that come with them if we could provide them with more specific guidance on how to foster the development of dynamic capabilities inside their organisations (Felin and Powell, 2016). Our study contributes to this end by elucidating how dynamic capabilities are developed in the backdrop of COVID-19 through KM practices – knowledge accumulation, sharing, and creation, embedded as organisational routines. Also, the present study demonstrates the connection between KM and SCRES (Kamalahmadi and Mellat Parast, 2016; Ali *et al*., 2023) by revealing KM as an antecedent to dynamic capabilities that enable firms to build SCRES. We extend DCT in the context of FSCs, which require prompt response to severe disruptions by incorporating KM as a necessary antecedent to developing dynamic capabilities.

Based on our findings, we develop a novel framework depicting a pathway to build resilience (Figure 2).

Pathway: The experience, expertise, intuition, and wisdom (tacit knowledge) from the various functional departments, stakeholders, and food industry experts equip firms operating in FSCs to develop sensing capability. After sensing threats and opportunities, firms mitigate the threats and seize the opportunities by implementing digital technologies. The tacit and explicit knowledge gained from the industry and technology experts together pave the way for the successful adoption of digital technologies. Post-implementation of digital technologies, the information generated enables the creation of new knowledge. Utilising this knowledge, firms develop capabilities such as visibility, transparency, efficiency, agility, and flexibility to counter the disruptions in their SCs, thereby building resilience and enhancing performance outcomes.

All the cases developed resilience following this pathway.

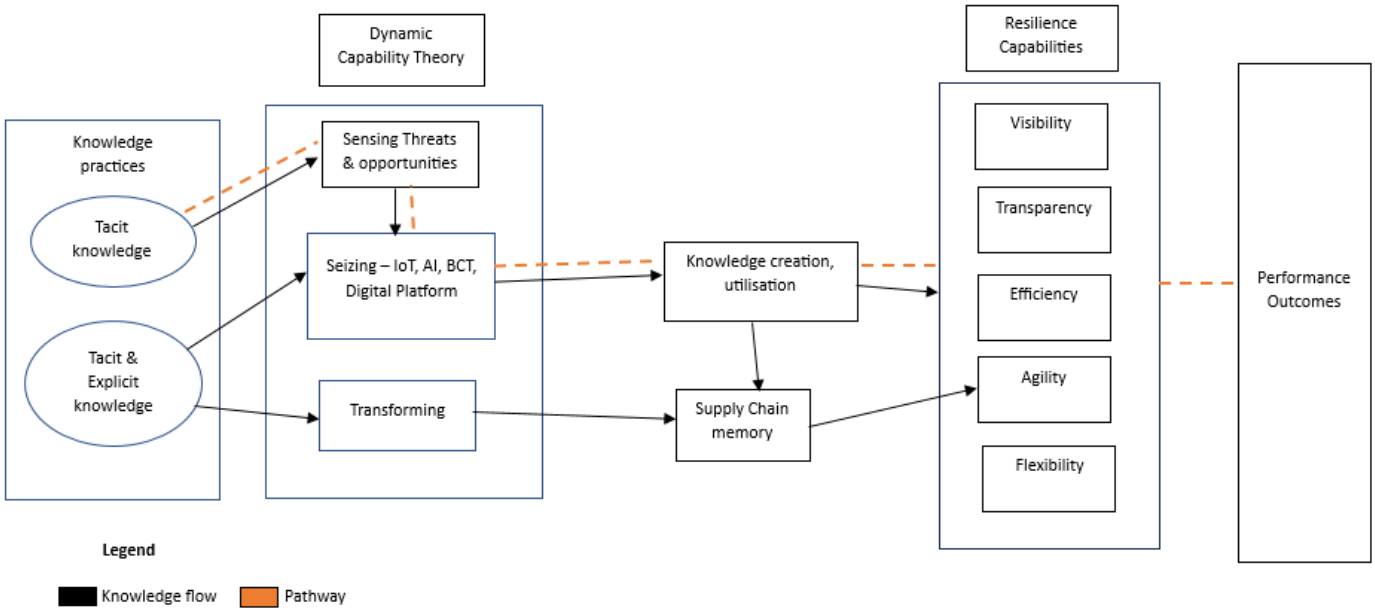

Figure 2: Framework for developing resilience

The pathway is indicated by dashed lines and knowledge flow by solid arrows as shown in Figure 2.

6. Implications

6.1 Theoretical contributions

Our study makes some noteworthy contributions to the theoretical discourse on dynamic capabilities and SCRES literature. *First*, there is a lack of empirical research that explores the impact of digital technologies on SCRES (Spieske and Birkel, 2021; Ali and Govindan, 2023) amidst COVID-19; and sparse empirical research on SCRES in the context of FSCs (Stone and Rahimifard, 2018; Do *et al*., 2021; Ali *et al*., 2023). The present study attempts to fill these voids and reveals that the adoption of digital technologies enabled firms operating in FSCs to build resilience capabilities and improve performance outcomes amidst the pandemic, which to the best of the authors' knowledge, has been largely unexplored. This way, our study significantly contributes to the maturity of SCRES literature. *Second*, we contribute to the literature on DCT by empirically investigating the much-needed understanding of the process by which the case firms developed dynamic capabilities – sensing, seizing, and transforming capabilities through KM practices - knowledge accumulation, knowledge sharing, and knowledge creation. The study also portrays the various activities undertaken by the firms for performing the KM practices. *Third*, we offer theoretical richness to DCT by extending it with KBV in

the context of FSC disruptions caused by COVID-19, recognising knowledge as a rare, valuable, inimitable, and non-substitutable resource in times of an unpredictable and rapidly changing business environment which enables the formation of dynamic capabilities.

Fourth, the findings of our study lend empirical support to the fact that dynamic capabilities originate from organisational routines (Eisenhardt and Martin, 2000; Winter, 2003; Teece, 2007). KM routines involving the firms' employees and managers, stakeholders, and industry experts enabled the accumulation, sharing, and creation of critical knowledge needed for the formation of dynamic capabilities. KM routines allow firms to promptly identify the changes in the business environment and quickly respond and adapt to those changes which is extremely important in the case of FSCs considering their perishability aspect (Stone and Rahimifard, 2018). *Fifth*, the present study makes a significant contribution by highlighting two lesser-researched yet crucial perspectives on the business value of digital technologies – i) to assure firms with continuity of business operations through disruption mitigation and ii) to enable firms to seize new business opportunities presented by the current business environment. These perspectives ensure the survivability of firms amidst prolonged disruptions and consequently, safeguard food security, which has a profound societal impact on the masses, especially in emerging economy nations. *Lastly*, we developed seven propositions related to the development of dynamic capabilities and resilience in firms operating in FSCs. These propositions provide a foundation for further research.

6.2 Managerial Implications

This research reveals that KM practices encompassing knowledge accumulation, knowledge sharing, and knowledge creation involving the firms' employees and managers, stakeholders, and industry experts provide firms with invaluable knowledge regarding threats, new business opportunities, competitors' actions, and technological advances in the food industry which enable them to develop sensing, seizing, and transforming dynamic capabilities. Hence, managers need to realise the role of KM in developing dynamic capabilities. Managers need to build a climate of mutual trust, compassion,

sharing and respect for others in an organisation as this facilitates effective KM practices (Nonaka and Konno, 1998; Holsapple and Joshi, 2000). This research also showed that seizing capabilities can be developed by adopting digital technologies which enable them to mitigate threats and disruptions and seize new business opportunities to build resilience. In case firms do not possess adequate competency to implement digital technologies on their own, they can outsource the deployment of technologies to service providers. Thus, FSC managers need to assess digital technologies considering aspects like business continuity amidst disruptive events, survivability, gaining competitive advantage, reducing food waste, and ensuring food security apart from improving profitability.

The managers need to conduct training and knowledge sessions for the employees to impart knowledge regarding the industry's best practices and digital advancements. This would equip the firm with a competent workforce required to sustain the adoption of digital technologies and consequently, transform business processes. Findings reveal that informal meetings with the stakeholders and the use of social media are important activities that promote KM practices. Informal meetings with the stakeholders possessing different disciplinary expertise helped in building interpersonal trust and relational bonding, which enabled them to socialise and build rapport, allowing longer and deeper discussions promoting knowledge accumulation and knowledge sharing. The suppliers and retailers shared their experiences and learnings on how similar firms resorted to adopting digital technologies to mitigate the disruptions in their SCs during the post-meet snacks break. The informal setting provided the environment, opportunity, and time required to share experiences, stories, and thoughts, fostering the development of new ideas. The younger, technophile employees narrated success stories of digitalisation to their senior colleagues and managers, demonstrating the practical and commercial benefits of digitalisation through informal meetings. KM practices can be supported by conducting informal meetings like lunch events and coffee talks post-formal meetings, which would stimulate stakeholders to further discuss and share ideas beyond the formal context.

Finally, we recommend managers build capabilities on data and social media analytics through training and workshops. This would enable managers to gain a better understanding of their customers' evolving

preferences, competitors' actions, and stakeholders' information through social media monitoring which can be beneficial for formulating resilience strategies.

7. Conclusion

The present study empirically investigates how the firms operating in FSCs developed dynamic capabilities to mitigate disruptions caused by the COVID-19 pandemic and, hence, build resilience. To answer the first RQ, the study reveals that firms developed dynamic capabilities - sensing, seizing, and transforming to counter disruptions faced in their supply chains. KM practices comprising knowledge accumulation, knowledge sharing, and knowledge creation involving various stakeholders, industry experts, and technology experts enabled the development of dynamic capabilities. To answer our second RQ, the sensing capability enabled the firm to recognise the threats and opportunities that lie ahead. The firms developed seizing capability by implementing digital technologies - AI, IoT, Digital platform, and Blockchain which enabled them to mitigate disruptions and simultaneously seize new business opportunities. Following the implementation of digital technologies, the knowledge created was effectively utilised, leading to the development of capabilities - visibility, transparency, efficiency, agility, and flexibility that enabled the firms to build resilience. The present study confirms the role of KM as a key antecedent to the development of dynamic capabilities. Our study reveals the importance of digital technologies to ensure firms' survivability and enhance food security during severe disruptions. Through our study, we continue to support the socio-ecological view of resilience (Wieland and Durach, 2021) wherein firms operating in FSCs need to adapt and transform to the changing business environment in order to build resilience.

The present study is not devoid of limitations. The study considers cases specific to one country - India. The extent of disruptions and mitigation solutions may differ from one country to the other depending on the existing infrastructure and country-specific policies of the food industry. In this research, we couldn't explore the behavioural challenges such as resistance to change and trust-related issues associated with the adoption of digital technologies faced by the firms. Future studies can explore such

behavioural challenges and how KM can play a role in overcoming such challenges. Future studies may concentrate on the contingent factors such as absorptive capability and national culture that influence KM practices amidst an uncertain and volatile business environment across multiple geographies. Previous researchers have indicated that dynamic capabilities can be specific to the industry sectors (Ali *et al*., 2021). Hence, future studies may be undertaken to unveil how dynamic capabilities can be developed in other industry settings. Future studies can also empirically investigate how digitalisation enables firms to build resilience in the readiness (pre - disruption) phase. Currently, there has been an increasing interest in social media by operations and SC management researchers (Huang *et al*., 2020), however, the use of social media to improve FSC management is in its infancy (Singh *et al*., 2018). Consequently, researchers can explore the role of social media in developing resilience in FSCs. Since the recognition of new business opportunities is contingent on the cognitive capabilities of the manager, it would be worth investigating the role of managers' cognitive capabilities on the development of dynamic capabilities and consequently, the impact on SCRES.

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Appendix

Interview protocol

Research ethics terms:

(1) With your permission, we would want to record the interview and transcribe it to increase the validity of our study. Your identity will not be disclosed in the research work.

(2) After analysing the data and drawing conclusions, we will email you our findings, along with the quotes we want to use in our research article, for your approval.

Introduction to the study, its aims, and the researcher.

Interview Guide

Date:

Place:

Name of the interviewee (anonymous):

Title/role in the organisation:

Work Experience (in years)

Duration:

Case	Code	Designation	Experience (years)	Medium of interview	Interview Length (mins)	Secondary data source
A	A1	Operations Manager	10	Face-to-face	58	Corporate website, social media sites, online articles, newspaper articles, archival records
	A2	SC Manager	9	Face-to-face	63	
	A3	Procurement Manager	6	Telephone	67	
	A4	Quality Manager	6	Face-to-face	74	
	A5	Project Manager	7	Face-to-face	61	
	A6	Technical Manager	5	Online	71	
	A7	SC Manager	8	Face-to-face	65	
B	B1	SC Manager	8	Online	61	Corporate website, social media sites, online articles, YouTube videos, archival records
	B2	Operations Manager	8	Online	63	
	B3	Procurement Manager	7	Online	60	
	B4	COO	10	Telephone	59	
	B5	Quality Manager	6	Online	70	
	B6	Technical Manager	5	Online	64	
C	C1	SC Manager	9	Face-to-face	71	Social media sites, online articles, community blog
	C2	Technical Manager	6	Face-to-face	74	
	C3	Farmer	12	Face-to-face	68	

	C4	Store Manager	8	Face-to-face	69	
	C5	Farmer	15	Face-to-face	62	
D	D1	Procurement Manager	7	Online	70	Corporate website, social media sites, online articles, YouTube videos, archival records, online user reviews
	D2	Quality Manager	8	Online	72	
	D3	SC Manager	10	Online	67	
	D4	Operations Head	10	Online	61	
	D5	Vice President	10	Telephone	60	
	D6	SC Manager	9	Online	68	
	D7	MD /Founder	12	Telephone	56	

Table A1: Details of interviewees and secondary data

Aggregate Dimension (Capability)	**Second Order categories**	**First Order codes**	**Interview Excerpts**
Visibility	Sensing (Threats)	Analysing impact of demand uncertainty	*"Cafeterias and coffee shops are all closed. It will impact milk consumption" (D3)*
		Understanding customer preferences	*"The demand for raw poultry meat has declined significantly…" (B5)*
		Manual processes	*"We have to manually check the environmental parameters from time to time" (B4)*
	Sensing (Opportunities)	Need to improve efficiency	*"We definitely need to improve efficiency if we want to increase profits" (B1)*

		Need for information sharing	*"We need seamless information sharing within the various departments so that we can plan more effectively." (D2)*
		Need for provenance	*"Customers want to know the source of their milk." (D4)*
	Seizing	Adoption of Blockchain	*"Blockchain provided details of milk at our collection centres" (D1)*
		Adoption of IoT	*"With the IoT, we could know the temperature and humidity of all the hatcheries in our farm at a given point of time." (B2)*
	Transforming	Investment	*" IoT was a substantial investment at that point of time [during the pandemic], but we were certain to reap the benefits of it in future." (B5)*
		Outsourcing	*"The operations managers provided the requirements – types of reports to be generated and the environmental parameters to be monitored" (B6)*
Transparency	Sensing (Threats)	Market Change	*"We had 80% B2B and 20% B2C before [the pandemic]. Within a week after the pandemic, it's now settled at around 50% B2B and 50% B2C." (D1)*
		Less Demand	*"The demand for milk and cheese dropped suddenly. The restaurants and sweet shops were closed." (D3)*

	Sensing (Opportunities)	Emphasis on food safety	*"We gained a deeper understanding of the significance of food safety and traceability." (D4)*
		Need for provenance	*"Traceability of milk is rarely available today." (D6)*
	Seizing	Adoption of Blockchain	*"Blockchain provides a transparent and reliable base for provenance." (D3)*
	Transforming	Process Management	*"The manual process of maintaining records was totally automated." (D2)*
		Outsourcing	*"We [operations and supply chain managers] provided the details of the supply and distribution networks, the plant locations, and all the associated processes required..." (D6)*
Efficiency	Sensing (Threats)	Labour Shortage	"*Many of the workers travelled back to their homes…At that time, we were working with around 50% of our workforce." (B2)*
		Unavailability of Markets	*"Closure of markets was a nightmare for us […]. Some of the fruits and vegetables got wasted in the fields as we could not afford to spend money on labour for harvesting." (C4)*
		High Turnaround Time (TAT)	"*The lab tests were delayed by weeks." (A2)*

		Manual Processes	*"The operator has to manually check the temperature and humidity in the hatchery from time to time." (B5)*
	Sensing (Opportunities)	Lower TAT	*"If we can decrease the time spent at testing labs, we can decrease the lead time" (A1)*
		Minimise waste	*"We could reduce the wastage if we could showcase the produce to our customers." (Website, C)*
		Improve order fulfilment rate	*"In certain cases, the order is cancelled by the customer when we are unable to deliver within the time window." (A6)*
	Seizing	Adoption of AI	*"…Quality testing, which proved to be a bottleneck, was a cakewalk using the AI-powered testing device. The quality test results were accurate and were available within a few seconds." (A4)*
		Adoption of IoT	*"The implementation of IoT, a single operator could handle multiple hatcheries and control the requisite parameters by a simple tap on his mobile." (B3)*
		Development of Digital Platform	*"Creating a virtual market was the most important step in protecting the livelihood of hundreds of farmers and their families…" (C3)*
	Transforming	Outsourcing	*"The operations team provided all the details of the various parameters and the processes to the outsourced technology team." (B2)*
		Process Change	*"The quality test was performed in the house through the help of the AI enabled device." (A7)*

		Social media marketing	*"We used social media like Facebook, Instagram, and WhatsApp to showcase our products." (C5)*
		Inventory Management	*"We dedicated four people to physically check the inventory and update the status in the app on an hourly basis." (C2)*
Agility	Sensing (Threats)	Demand uncertainty	*"The demand for poultry meat also declined in the retail market.. In the rural areas, people are buying less meat and switching to affordable source of nutrition like eggs […]" (B1)*
		Labour shortage	*"…It was harvesting season, and we struggled to find labours for harvesting." (C5)*
		Market Change	*"People were buying more staples than expensive fruits and vegetables…" (C3)*
	Sensing (Opportunities)	Competitive Advantage	"*We have supply …what we lack is the access to markets" (C1)*
		Provenance	*"If we knew how many farmers sold what quantity of milk instantaneously, we could plan the daily operations in a better way." (D7)*
		Information sharing	*"The more we can showcase our products [fruits and vegetables], the more the opportunity for sales." (C1)*
	Seizing	Adoption of AI	*"The AI-enabled device empowered us to test quality in-house 24/7. We can plan and schedule delivery of orders well before time." (A5)*
		Adoption of IoT	*"IoT can monitor the requisite parameters and provide alerts and notification ..We have better control of our hatch now." (B4)*
		Development of Digital Platform	*"Through digital platform we can track the inventory and the order requests. This way, we*

			could plan the harvest or source from another farmer when required." (C4)
		Adoption of Blockchain	*"...In a rare case, if something goes wrong, we can easily cancel the entire batch and track the source." (D1)*
	Transforming	Process change	*"Previously [before using digital platforms], we made procurement and harvest decisions intuitively on a daily basis, now we do it in a well-informed way on an hourly basis." (C2)*
		Training	*"We trained our operators how to use the app and control the parameters.." (B6)*
Flexibility	Sensing (Threats)	Manual processes	*"The manual testing at the labs was out of our control.." (A3)*
		High TAT	*"Food also gets wasted because of long turnaround time." (Website, A)*
		Market Change	*"Demand evaporated due to closure of HORECA.. " (D4).*
	Sensing (Opportunities)	Inventory management	*"We can procure when we are out of stock ...we can sell off the inventory whose shelf life is less at a lower price." (C3)*
		Multiple sourcing	*"We can source from other farmers; in case a particular farmer falls ill and is unable to deliver." (D2)*
		Addressing Customer preference	*"Customers are preferring home delivery, that too within a specific time window." (C4)*
	Seizing	Adoption of AI	*"AI testing device provided quick and accurate results... We were able to process more orders" (A6)*

		Development of Digital Platform	*"Digital platform enabled us to better match the demand and supply." (C1)*
		Adoption of Blockchain	*"Blockchain-enabled us to trace all the source nodes [collection centres] together with the collection quantities." (D4)*
	Transforming	Process change	*"We can now procure as per our order, hence minimising losses and maximising profits." (C5)*
Knowledge capability	Knowledge accumulation	Meetings with functional department	*".. we used to have weekly meetings with the various functional departments like operations, quality control, logistics to discuss the various potential threats..." (A1)*
		Social media monitoring	*"We used to monitor social media accounts of our competitor firms to know what they are upto.."(D4)*
		Participating in webinars & conferences	*"We got to know how AI can be used to perform food quality test in the conference which was not known to us before" (A3)*
	Knowledge creation	Performing data analytics	*"We could monitor the growth of chicks, predict their growth, and plan for their selling" (B2)*
		Surveys with retailers & customers	*"We conducted surveys with our retailers to identify the latest trends, customers' preferences.. " (A2)*
		Consultation with business analysts	*"We got in touch with some business analysts to seek their advice on digital solution to our problem.."(D3)*
	Knowledge sharing	Use of social media	*"We used to be in touch with our farmers and retailers through Whatsapp and Facebook." (C5)*

		Informal meeting with stakeholders	*"We had informal discussions during snacks after regular meetings with stakeholders.. This helped to strengthen our relationship ..we also got a lot of updates on the industry trends "(A4)*
		Meetings with top-level management	*"Through meetings with top level managers we shared the various strategies and new business ideas.." (D2)*

Table A2: Coding Structure

About the authors

Tapabrata Pal is a research scholar pursuing his PhD in Operations Management & Decision Sciences at the Indian Institute of Management Kashipur. He has done B. Tech in Electronics & Communications Engineering from Heritage Institute of Technology affiliated to West Bengal University of Technology. He has more than 3 years of professional experience in one of the leading Indian IT giants - Infosys Ltd. His research interests include supply chain resilience, sustainable supply chain management, and cold chain management. Tapabrata Pal is the corresponding author and can be contacted at: tapabrata.fpm1813@iimkashipur.ac.in

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