Technological Forecasting & Social Change 178 (2022) 121603

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

The impact of intellectual capital on supply chain agility and collaborative knowledge creation in responding to unprecedented pandemic crises

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ARTICLE INFO

Keywords:
Intellectual capital
Supply chain agility
Collaborative knowledge creation
Corporate sustainability
COVID-19

ABSTRACT

This study explores the relationships between intellectual capital, supply chain agility, collaborative knowledge creation, and corporate sustainability during unprecedented crises such as the COVID-19 epidemic. Data were collected from food and beverages firms and analyzed using Smart-Partial Least Squares (Smart-PLS) structural equation modeling software. The sample consisted of 289 managers, directors, and heads of department. The results reveal that intellectual capital significantly impacts supply chain agility, collaborative knowledge creation, and corporate sustainability. Furthermore, the findings confirm that collaborative knowledge creation and supply chain agility significantly impact corporate sustainability during the COVID-19 crises. This study contributes to the literature on intellectual capital, dynamic capabilities, supply chain management, and knowledge management, and the role of these capabilities in preserving corporate sustainability during unprecedented crises.

1. Introduction

Covid-19 was like a worldwide earthquake that inflicted severe damage, direct and indirect, on many aspects of human and organizational life. The frequent closures of borders and lockdown measures exposed local and global supply chains to massive disturbance and disruption, threatening the survivability and sustainability of large numbers of firms (Guan et al., 2020; Sarkis, 2020). The pandemic has forced organizations to act as much more adaptive systems than before, looking to their basic need for survival (Lo et al., 2021) Starik and Rands (1995). describe sustainability as the adaptive entity's ability to exist and grow, emphasizing long-term continuity.

Research has been conducted for over twenty years on what firms need to support the sustainability of their supply chains. Intellectual capital theory has offered us valuable insights into various issues of supply chain management. In recent decades, constant irregular changes in economic, political, social, and technological structures have forced business organizations to develop their intangible dynamic capabilities, including investment in knowledge resources. Intellectual capital is considered a pivotal determinant of active supply chain management (Tooranloo et al., 2018; Dabić et al., 2021). Firms with more resilient supply chains were in a much better position during the COVID-19 crisis (Guan et al., 2020; Sarkis, 2020). According to Mubarik et al. (2021), intellectual capital assets—meaning the sum of knowledge rooted in employees, structures, and the relationship with partners—have provided valuable support to supply chain resiliency during the epidemic crisis.

Intellectual capital plays a pivotal role in improving dynamic organizational capabilities (Shou et al., 2018; Tooranloo et al., 2018). Supply chain agility is considered a valuable dynamic capability that reflects adaptive intelligence through sensing and responding quickly to disruptive events. Organizations with an agile supply chain have displayed the ability to bounce back from the disastrous effects of COVID-19 (Ivanov, 2020; Do et al., 2021). Supply chain agility describes organizations' ability to adjust their supply chain strategies and processes swiftly in response to a turbulent, volatile environment (Naughton et al., 2020). The impact of the COVID-19 shock on the business environment has provided a new impetus to the value of supply chain agility in dealing with crises that bring unprecedented risks and uncertainty.

Intellectual capital represents a warehouse of learning and innovation that constantly creates new knowledge for dealing with emergencies and crises. Collaboration is the jugular vein of survival for firms and their supply chains when crises strike. In crises, firms need to move

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https://doi.org/10.1016/j.techfore.2022.121603
Received 9 October 2021; Received in revised form 22 February 2022; Accepted 2 March 2022
Available online 7 March 2022

quickly to collaborate with their supply chain members and coordinate their collective capabilities, learning from each other, to create new knowledge in responding to unpredictable changes in market supply and demand (Pinto, 2020). Collaborative knowledge creation has become urgently needed to deal with the unfolding effects of the epidemic. Intellectual capital management is a primary determinant of the spirit of creating knowledge from the collaboration with business partners, increasing the cohesion and integrity of the supply chain.

The literature review yields no exploration of the link between intellectual capital and supply chain agility during unprecedented crises. Despite their close relationship, a review of prior research also reveals no work associating intellectual capital with collaborative knowledge creation. An analysis of the COVID-19 research reveals that no prior studies have explored the impact of supply chain agility on corporate sustainability in responding to the pandemic crisis. Discussions surrounding COVID-19 have not paid sufficient attention to the role of this dynamic capability in sensing, seizing, and responding to the consumer's needs and satisfying the market demand. The literature also lacks empirical studies exploring, in a unified research model, the causal relationships between intellectual capital, supply chain agility, collaborative knowledge creation, and corporate sustainability.

This study aims to deploy the framework of intellectual capital to examine empirically the determinants of supply chain agility, collaborative knowledge creation, and corporate sustainability, taking into consideration the impact of the COVID-19 epidemic. It explores the impact of supply chain agility and collaborative knowledge creation on corporate sustainability. The findings contribute to the development of supply chain management and knowledge management in the context of shocking global crises.

2. Theoretical framework

2.1. Literature review

The COVID-19 outbreak caused uncertainties of various kinds and at various levels for citizens, businesses, societies, and governments worldwide. In today's dynamic, turbulent business environment, it has become very challenging to maintain simple survival, let alone superiority. Intellectual capital, the repository of intangible knowledge, has always been closely connected with uncertain environments, where organizational knowledge assets are turned into innovative and agile responses to opportunities and threats (Raymond et al., 2015; Mubarik et al., 2021). The literature reveals that financial assets have been superseded by less tangible capital forms as the main drivers of organizational success and value creation (Khan, 2014; Han and Li, 2015; Tooranloo et al., 2018) Raymond et al. (2015). emphasize that growing the company's intangible resources and capabilities is one of the best business strategies for survival and sustainable development.

The evolution of the field of intellectual capital has coincided with the rise of the knowledge-based economy (Namvar and Khalilzadeh, 2013; Yaseen et al., 2016). This intangible capital captures the tacit and explicit knowledge embedded in humans, in organizations, and in relationships with business partners (Mubarik et al., 2021). Organizational knowledge improves performance, entrepreneurial orientation, innovation, learning, customer satisfaction, and competitiveness; it can also be directed to improving supply chain management (Tuan, 2016; Shiranifar et al., 2019). Prior research emphasizes that intangible knowledge resources have become a vital source of effective supply chain management (Inkinen, 2015; Tooranloo et al., 2018; Pinto, 2020). However, the literature indicates that prior research in this field has focused on predicting organizational performance, competitive advantage, stock values, or economic trends to improve investments profitability, but not predicting sustainability, particularly during unprecedented crises.

There is a broad consensus in the literature that intellectual capital comprises human capital, structural capital, and social capital (e.g., Bontis et al., 1999; Han and Li, 2015). Human capital represents the collective capabilities and intelligence of the organization's members. It is an organization's 'thinking asset' and includes education, experience, skills, judgment, and the application of leadership skills to make the best use of all its individuals' knowledge (Bontis et al., 2001). Structural capital represents the codified knowledge accumulated in databases, files, manuals, information systems, structures, procedures, routines, trademarks, and organizational culture. It gives a firm's human capital the capacity to learn and innovate (Bontis et al., al.,1999). Social capital is relational: it describes the knowledge rooted in relationships and networks of organizations, including internal and external stakeholders (Han and Li, 2015). It is one of the main sources of information and knowledge gathering for innovation and learning (Hsu and Sabherwal, 2012). Supply chain agility is the ability to sense and respond to turbulence fluctuations, dynamic requirements, and unpredictable changes in the market environment, reactively or proactively, adjusting functions and operations flexibly and rapidly (Al Humdan et al., 2020). A wide range of studies has identified and analyzed the drivers, critical success factors and enablers of supply chain agility, attempting to understand what makes a supply chain agile. Authors have investigated the impact of continuous learning, top management support, operational capabilities, and process integration on supply chain agility (Al-Shboul, 2017; Irfan et al., 2019). Considerable attention (e.g., Yang, 2014; Um, 2017; Haq et al., 2020) has been paid to the role of collaborative relationships between partners in forming supply chain agility. Studies have also focused on the role of logistics and distribution capabilities (Gligor and Holcomb, 2014; Shi et al., 2017). Information Technology (IT) and its role in embracing supply chain agility have gained considerable attention (Ngai et al., 2011; Alzoubi and Yanamandra, 2020). However, despite the steady momentum of the growing importance of intellectual capital in today's organizations, little consideration has been given to its impact on supply chain agility during an unprecedented crisis.

Dynamic capabilities theory implies that a firm needs to constantly renew or create new knowledge if it is to keep pace with the changes it faces and to manage uncertainties effectively. Creating new knowledge requires exploring external resources and learning in collaboration with business partners and other actors in the firm's environment Nonaka (1994). described this collaboration as the pivotal point of organizational knowledge creation. Intellectual capital development—renewing or creating new knowledge—is essential for collaborative knowledge creation. Despite its logical role in creating new knowledge, the literature contains little work on the impact of intellectual capital on collaborative knowledge creation. Moreover, although a consensus has grown on the impact of collaborative knowledge creation on supply chain management and performance (e.g., Chen et al., 2016; Tuan, 2016; Alzoubi and Yanamandra, 2020), its impact on supply chain agility has given little attention.

As with other organizational capabilities, scholars have recognized that a broad understanding of dynamic capabilities requires an examination of expected outcomes and performance measurement. COVID-19 has posed unprecedented survival challenges for organizations. Corporate sustainability is about how organizations can sustain themselves in their society (Lo et al., 2021). Special attention (e.g., Forcadell et al., 2020; Hernández et al., 2020; Kraus et al., 2020; Barchiesi and Colladon, 2021) has been paid recently to the role of corporate social responsibility in the maintenance of corporate sustainability. The literature (e.g., Gligor and Holcomb, 2014; Fritz et al., 2021; Siltori et al., 2021) is unanimous on the importance of firms' ability to change and to adapt to change on their survival and sustainability. Despite this, no work has studied the role of intellectual capital, supply chain agility, and collaborative knowledge creation in corporate sustainability in unprecedented crises and environments threatening its survival.

In summary, the COVID-19 shock confirms the importance of reinvestigating many concepts, practices, and strategies that have always been studied under normal conditions. Despite the growing interest in studying business sustainability in light of the pandemic crisis, a

review of COVID-19 literature indicates a lack of empirical research on the relationships between intellectual capital, supply chain agility, collaborative knowledge creation, and corporate sustainability during novel crises. Therefore, the current study examines the impact of intellectual capital on supply chain agility, collaborative knowledge creation, and corporate sustainability during pandemic crises. It also examines the role played by collaborative knowledge creation and supply chain agility in corporate sustainability.

2.1. Research model and hypotheses

This study proposes that intellectual capital significantly impacts collaborative knowledge creation, supply chain agility, and corporate sustainability during unprecedented pandemic crises. The research model also suggests that collaborative knowledge creation significantly impacts supply chain agility and corporate sustainability, and that supply chain agility significantly impacts corporate sustainability. These relationships and related hypotheses are discussed below.

2.1.1. Intellectual capital and collaborative knowledge creation

Intellectual capital includes three components that complement and support each other (Bontis et al., 1999; Subramaniam and Youndt, 2005; Hsu and Sabherwal, 2012). Hence, insufficiency in one of the components leads to an ineffective intellectual capital asset as a whole (Shou et al., 2018). According to Mubarik et al. (2021), organizations with more intellectual capital not only have better human capital and structural capital, but also have excellent social capital, which enables them to collaborate and learn from their business partners. Likewise, Shou et al. (2018) assert that firms with more intellectual capital are better able to conduct collaborative activities with supply chain partners.

Organizations with higher levels of outstanding intellectual capital have better knowledge management, including its creation and acquisition (Nickerson and Zenger, 2004; Shiranifar et al., 2019). The structuring of intellectual capital plays a pivotal role in developing the knowledge of individual members into explicit organizational knowledge. Structural capital also represents the processes and systems that accumulate internal knowledge via promoting learning and acquiring external knowledge from supply chain partners (Hsu and Sabherwal, 2012). Employees with higher levels of education, creativity, experience, and skills are more eager to communicate and collaborate with supply chain members to create new knowledge (e.g., Mandal, 2018; Yusoff et al., 2019). Social capital pools different networks and resources that enhance novel knowledge creation (Weber and Tarba, 2014; Faccin and Balestrin, 2018).

Inter-firm collaborative arrangements are pivotal mechanisms by which the supply chain members can create collaborative knowledge across the firm's boundaries. Rather than relying on internal knowledge assets, a firm needs to access external knowledge resources through inter-organizational collaboration with supply chain members (Shiranifar et al., 2019). Intellectual capital is the primary intangible asset providing the framework of collaboration-based strategies. It creates the foundations for firms to communicate with their supply chain members. The knowledge and experience held by each company help to create new knowledge through internal and external collaboration (Tooranloo et al., 2018). The repository of internal knowledge is the basis for managing collaboration with supply chain partners, and this external collaboration, in return, updates and enriches existing knowledge (Shou et al., 2018). Organizations with large reserves of intellectual capital are more likely to search, integrate, and support the flow of novel knowledge throughout the supply chain parties (Cegarra-Navarro and Martelo-Landroguez, 2020). According to Mubarik et al. (2021), intellectual capital capabilities increase integrity and cohesion among supply chain members by generating the spirit of knowledge creation. This background leads to hypothesis 1:

H1: Intellectual capital significantly impacts collaborative knowledge creation during unprecedented pandemic crises.

2.1.2. Intellectual capital and supply chain agility

Any firm's attempts to be agile must support its intellectual capital (Nissen and von Rennenkampff, 2017; Tooranloo et al., 2018). In highly turbulent environments, intellectual capital critical enables organizations to draw rapidly upon prior knowledge and to learn, create new knowledge, and innovate novel solutions (Gligor et al., 2013; Pinto, 2020). According to Dabić et al. (2021), agility is the ability to sense business environments and respond rapidly. Other scholars have argued that agility incorporates scanning and employing intellectual capital effectively in responding to environmental uncertainties (Nissen and von Rennenkampff, 2017). Many scholars (e.g., Weber and Tarba, 2014; Dabić et al., 2021) have also argued that intellectual agility is a primary ingredient of intellectual capital. Intellectual agility makes people and organizations ready to adjust their structures and activities and to think innovatively in response to unpredictable environmental changes. Dabić et al. (2021) regard intellectual agility as a dynamic aspect of intellectual capital, often seen as a synonym for the broader notion of organizational agility.

Active sharing of intellectual assets with members of the supply chain improves its agility significantly (Tooranloo et al., 2018). Supply chain agility is demonstrated by an organization's use of its intellectual assets, swiftly detecting fluctuations, opportunities, and threats (Gligor et al., 2013). Today's businesses need the behavioral and mental agility of human capital to sense, respond, and perform work quickly and correctly (Tooranloo et al., 2018). A higher level of human capital helps an organization respond to unpredictable changes quickly and adapt and renew its organizational strategies and values more flexibly (Subramaniam and Youndt, 2005). Structural capital also facilitates the flow of knowledge across the supply chain, thereby enabling members to make agile decisions to deal with the effects of disruptions (Mubarik et al., 2021) Bontis et al. (2001). found that this organizational capital, which provides flexible communication and collaboration with supply chain members, helps the firm manage material procurement, production schedules, and manufacturing issues effectively and efficiently, leading to an agile supply chain and customer responsiveness. The organization's agility is also facilitated by social capital, which supports the incorporation and integration of internal and external knowledge, helping the organization to develop its response quickly (Weber and Tarba, 2014; Tooranloo et al., 2018). The internal and external collaboration through an organization's social networks in dynamically complex domains optimize the collective awareness and fast response to turbulent and uncertain markets via supply chain agility. Accordingly, this study proposes:

H2: Intellectual capital significantly impacts supply chain agility during unprecedented pandemic crises.

2.1.3. Intellectual capital and corporate sustainability

Firms' sustainability in the current unstable knowledge economy depends increasingly on knowledge resources (Raymond et al., 2015). With the increasing pressures caused by uncertainty and disruption of the business environment, intangible assets make a central contribution to the fate and performance of firms. This pivotal role has inspired academics and practitioners to focus more on developing and exploiting these assets to generate renewal values in terms of long-term sustainability. Bontis et al. (1999) claim that intellectual capital is the most essential and most intangible of a firm's resources Wasiluk (2013). emphasized the consistency between intellectual capital and sustainability as both emphasize the organization's need to develop its understanding and knowledge of how to generate and improve its nonfinancial resources. The resource-based view (RBV) implies that intellectual capital, including knowledge, experience, judgment, IT, intelligence, and relationships with business partners, can preserve sustainability during environmental uncertainty (Tseng et al., 2019; Lo and Liao, 2021). Firms' long-term sustainable development and growth, particularly small and medium-sized enterprises (SMEs), need robust

intellectual capital (Gölgeci and Kuivalainen, 2020; Srikalimah et al., 2020). According to Shou et al. (2018), intellectual capital has become an essential source of sustainable economic growth.

Mubarik et al. (2021) claimed that firms with excellent social capital, well-integrated structural capital, and knowledgeable human capital are more likely to mitigate the negative impacts of the massive disruption caused by COVID-19. Social capital is widely acknowledged as one of the strategic corporate assets for achieving superior sustainable performance (Shakina and Barajas, 2014) Gölgeci and Kuivalainen (2020). claimed that social capital empowers businesses to survive during crises and economic instability Lo et al. (2021). and Lo and Liao (2021) have explained how human capital plays a significant role in obtaining the sustainability of competitive advantage. Furthermore, achieving a high level of structural capital—with codified knowledge and developed processes, routines, IT, and database—is fundamental for keeping the business alive in complex and uncertain environments (Bontis et al., 1999; Hsu and Sabherwal, 2012; Mubarik et al., 2021). Against this background, this study hypothesizes:

H3: Intellectual capital significantly impacts corporate sustainability during unprecedented pandemic crises.

2.1.4. Collaborative knowledge creation and supply chain agility

In high-velocity and unpredictable markets, dynamic capabilities rely on the organization's readiness to work with supply chain members as a single entity in order to create new knowledge rapidly (Baah et al., 2021) Shiranifar et al. (2019). found that the appropriate integration of internal and external knowledge resources and processes is a prerequisite of organizational agility. The dynamic capability view posits that a firm can gain the essential internal and external competencies and perform better if it can create and integrate new knowledge, capitalizing on its partners' resources and capabilities through effective collaboration (Wu et al., 2017). According to this view, acquiring new knowledge and assimilating it into a firm's functions and processes is crucial to its ability to strengthen its agility and capitalize on market trends.

The firm's flexibility and ability to adapt to uncertainties rely mainly on new knowledge creation (Nafei, 2016; Irfan et al., 2019). Agility can be regarded as the organization's ability to redeploy existing knowledge or create new knowledge and translate it into quick action and early responses to business disturbances and unpredictable market changes (Nafei, 2016). Collaborative learning that builds on current knowledge to create new knowledge reinforces a firm's ability to sense business irregularities and achieve continuous alignment with its environment (Shiranifa et al., 2019). Collaborative knowledge creation means those dynamic social and organizational activities and practices that help firms create and acquire the requisite knowledge from diverse fields in order to resolve complicated and unique problems or exploit new opportunities. It is embodied in continuous sensing, learning, and adapting to swift fluctuations in market demand (Faccin and Balestrin, 2018).

Supply chain agility results from the successful implementation of the competition rules of the entire supply chain, including speed, flexibility, and innovation through the integration of resources and collaborative restructuring of best practices in a rich knowledge environment. Supply chain collaborative activities resulting in mutual knowledge creation facilitate supply chain integrity, speed, and flexibility. According to this view, acquiring and assimilating new knowledge of a firm's functions and processes is crucial to capitalizing on market trends and enhancing supply chain agility Alzoubi and Yanamandra (2020). emphasize that a critical dimension of supply chain agility is the pivotal impact of collaborative knowledge management on the firm's alertness to fluctuations and business environmental changes. Chen et al. (2016) concluded that there is a significant association between supply chain flexibility and collaborative creation of knowledge in highly uncertain market environments. This background leads to hypothesis 4:

H4: Collaborative knowledge creation significantly impacts supply chain agility during unprecedented pandemic crises.

2.1.5. Collaborative knowledge creation and corporate sustainability

Knowledge creation has been broadly considered the main prerequisite for organizations remaining competitive, surviving, and growing in increasingly volatile environments Dabić et al. (2021). claimed that knowledge creation distinguishes successful from unsuccessful firms. Knowledge creation is considered a major driving force behind enterprises' continuous growth (Tuan, 2016; Zhao et al., 2019). Creating and applying knowledge facilitates not only survival but also, potentially, prosperity in an unpredictable and dynamic environment (Nafei, 2016). According to Pinto (2020), knowledge creation is fundamental for supply chain management and has become an essential process for the survival of firms.

The knowledge-based view (KBV) holds that organizations exist to create knowledge and transform it into a sustainable competitive advantage (Sangari and Razmi, 2015). This view underlines the value of knowledge creation capabilities as fundamental sources of improving performance and long-term success, i.e., survival (Gligor and Holcomb, 2014; Lo et al., 2021). Knowledge also represents the essence of innovation. Continuous innovation is a function of constantly creating new knowledge. Innovation is considered crucial for business survival and competitiveness, particularly in complex environments. Recent studies on COVID-19 (e.g., Sarkis, 2020; Nandi et al., 2021) confirm the role of innovative solutions in responding rapidly and working on novel strategies to alleviate the pandemic effects on supply chains.

Nowadays, a business's success relies on its strategic ability to sustain inter-organizational knowledge creation (Tuan, 2016; Zhao et al., 2019). Leveraging inter-firm knowledge creation is related with the role of collaboration between supply chain members in gaining sustained competitive advantage (Baah et al., 2021). Collaborative knowledge creation among firms has become increasingly common during crises as a survival strategy for all business partners at risk in uncertain environments. Collaborative and collective knowledge creation allows the emergence of a great chain of ideas and solutions to survival threats during pandemic crises, such as COVID-19 (Pinto, 2020). Accordingly, this study proposes:

H5: Collaborative knowledge creation significantly impacts corporate sustainability during unprecedented pandemic crises.

2.1.6. Supply chain agility and corporate sustainability

The absolute need for sustainability forces a firm to be highly sensitive and to think quickly, respond dynamically, and recreate itself vis-a-vis the current and expected future state of its environment. Organization agility is a source of superior performance and a winning strategy for surviving in environments with high levels of uncertainty, where firms can realign strategies and re-engineer their processes to absorb threats and exploit opportunities (Sambamurthy et al., 2003; Wu et al., 2017; Siltori et al., 2021). According to Gunasekaran (1999), organizational agility represents the ability to survive and grow through rapid responses to changing needs and customer demand in changing markets and turbulent environments.

In today's constantly changing markets, agility is a survival requirement: under the pressures of COVID-19, it enables entire supply chains to deliver production inputs, finished goods, and services. Supply chain agility is perceived as a fast acclimatization capability that reduces the pressures caused by unpredicted and accelerated environmental changes. Naughton et al. (2020) describe acclimatization as a fundamental mechanism by which organizational resources and behaviors are adjusted efficiently, promptly, and beneficially to fast-changing environments, preserving the firm's survival.

The sustainable enhancement of supply chain performance is vital for corporate survivability and growth (Shou et al., 2018; Tooranloo et al., 2018; Fritz et al., 2021). Supply chain agility is one of the most

effective strategies in highly uncertain environments for managing and mitigating supply chain disruption risks threatening firms' survival and sustainability (Braunscheidel and Suresh, 2009; Shiranifa et al., 2019; Kraus et al., 2020). Supply chain agility is an essential ingredient for helping firms and supply chain members to survive in turbulent and changing situations (Ngai et al., 2011; Alzoubi and Yanamandra, 2020). Rapid, active actions or reactions are essential, but also the ability to think and move rapidly and intelligently. Building supply chain agility ensures that the chain can speedily recover from disruptive situations (Mubarik et al., 2021). In the context of the COVID-19 crisis, Sarkis (2020) confirms that a firm with an agile supply chain has previously exhibited a readiness to recover faster from disastrous consequences. According to this background, this study hypothesizes:

H6: Supply chain agility significantly impacts corporate sustainability during unprecedented pandemic crises.

Fig. 1 summarizes the proposed relationships as discussed in the earlier subsections.

3. Methodology

3.1. Development of the measurement instrument

An electronic questionnaire was developed for the empirical side of the study, to measure the research constructs. In the face of the unprecedented situations caused by COVID-19 and the preventive measures enacted against it, particularly the restrictions on movement and access to companies, the electronic questionnaire was an appropriate choice for collecting data. Items of measurement have been derived from studies (Table 1) on intellectual capital, collaborative knowledge creation, supply chain agility, and corporate sustainability.

To provide preliminary validation of the items measuring research constructs in the survey instrument, two experts in knowledge management and three in supply chain management gave feedback on their logical consistency, context relevance, and clarity. Drawing on the feedback, the items were refined to ensure that the instrument was understandable and suitably validated. The questionnaire has 30 items (Appendix 1). The items were measured on a five-point Likert scale from "strongly disagree = 1″ to "strongly agree = 5".

Table 1
The source of measures.

Research constructs	No. of items	References
Intellectual capital	9	Shou et al., 2018; Tooranloo et al., 2018; Mubarik et al., 2021.
Collaborative knowledge creation	8	Nonaka and Takeuchi, 1995; Al-Omoush et al., 2020; Rusland et al., 2020.
Supply chain agility	6	Blome et al., 2013; Gligor et al., 2015; Naughton et al., 2020.
Corporate sustainability	9	Tseng et al., 2019; Arianpoor and Salehi, 2020; Lo et al., 2021.

3.2. Sampling and data collection

COVID-19 impacted in most industries forcing to reduce their activity, following government restrictions to combat the spread of the pandemic. One of the most important sectors that had to keep working is the food and beverages industry. As in other industries, food and beverage firms have faced enormous uncertainties and risks, particularly in unprecedented supply chain disruption and having to deal with highly uncertain market demand. Lockdown policy has shocked supply chain partners in the food and beverage industry, making them deploy their knowledge and dynamic capabilities to continue to operate and thus ensure their survival. This makes the food and beverages industry an attractive one for this study.

The sample was obtained from Jordanian food manufacturing firms. The food manufactured in Jordan meets about 60% of the country's total needs, contributing significantly to food security. This sector represents 23% of Jordan's total industrial output. The industry's adherence to global standards and specifications, and its implementation of the international frameworks for food safety, led to a 9% growth in Jordanian exports in 2020, doubling its exports to reach more than 70 countries (Al-Jitan, 2021).

The distribution of the questionnaire took more than a month, from 5 March 2021 to 11 April 2021 Table 2. displays the characteristics of firms and participants.

The sampling approach assumed that respondents are actively engaged in, or well-informed about, the operations of the upstream and downstream supply chains. The sample included people in the roles of president, vice president, chief officer, manager, director, and head of

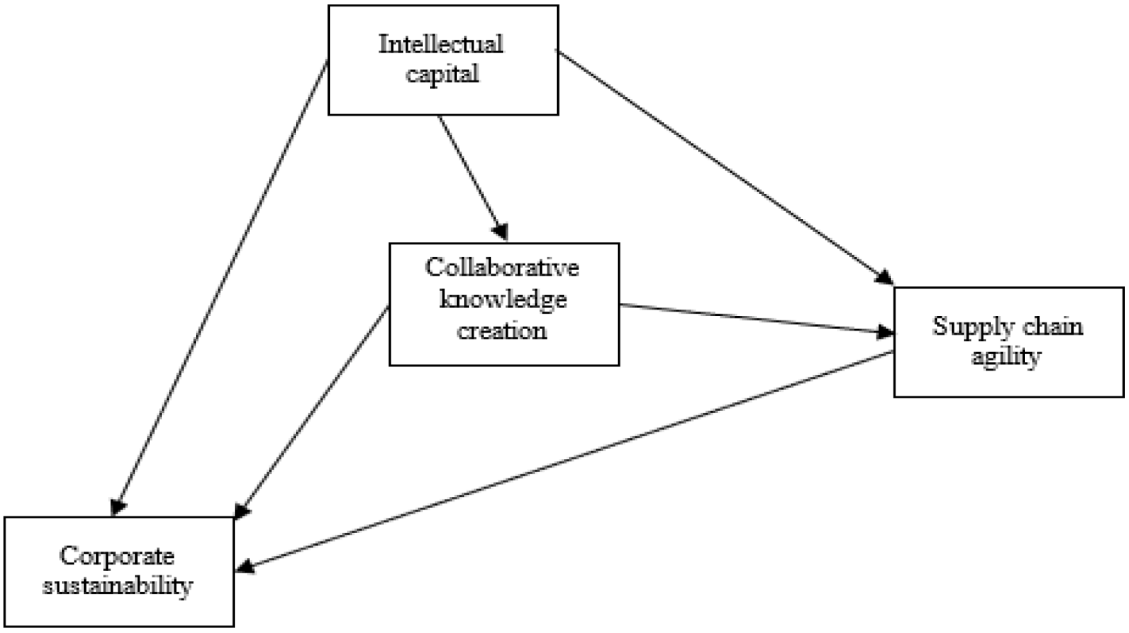

Fig. 1. Research model.

Table 2
Characteristics of firms and participants.

Firms	No	%	Participants	No	%
Ownership			Experience		
Public limited	3	0.12	>10 years	46	0.16
Joint venture	6	0.23	10–15 years	138	0.48
Private	14	0.54	16–20 years	72	0.25
Foreign funded	3	0.12	<20	33	0.11
Firm age			*Education*		
>10	9	0.35	Diploma or less	63	0.22
10–20	11	0.42	Bachelor	179	0.62
<20	6	0.23	Postgraduate	47	0.16
Firm size			*Position*		
>500 employees	13	0.50	Top management	54	0.19
500–1000 employees	9	0.35	Middle management	149	0.52
<1000 employees	4	0.15	Operational management	86	0.30
Total	**26**	**100**	**Total**	**289**	**100**

department. Titles varied from one firm to another, but the sample included participants from units and departments of supply chain and logistics, procurement and purchasing, Research and Development (R&D), sales and marketing, IT, quality, manufacturing, and production.

The questionnaire was typically distributed by e-mail, through firms' managements, or sent directly to respondents, using the respondents' information on the firms' websites. The authors also distributed paper-based questionnaires as much as was possible under the preventive measures against the pandemic. After one month of distribution and communications work, 289 usable responses were received.

3.3. Data analysis

Smart PLS software was employed to analyze the collected data. PLS is a powerful tool for examining and studying new causal models that include multiple variables and measurements. It can assess the measurement and the structural model in the same transaction. According to Garson (2016), along with its robustness, PLS' ability to handle small samples is another reason why it is sometimes preferred over structural equation modeling approaches. PLS can be computed even for very small samples, including even when there are fewer cases than the number of indicator variables Fornell and Larcker (1981). also asserted that the PLS method does not need a large sample or normally distributed multivariate data.

3.3.1. The measurement models

Factor loading estimation was implemented to improve the instrument and refine its measures Hair et al. (2014). confirmed that a factor loading of > 0.70 indicates a distinct factor structure. Therefore, 0.70 was considered a cutoff value; the results show that the factor loading of most items is more than 0.70. One item from intellectual capital (IC3) and two from corporate sustainability (VCC3, VCC8) were removed from the scale.

Table 3 reveals that Cronbach's α is greater than 0.80 for all constructs. Composite Reliability (CR) and rho_A also is greater than 0.80, indicating good scale reliability. The results also show that the average variance extracted (AVE) for all constructs is more than 0.5, confirming adequate convergence validity.

Table 4 shows that the square roots of the AVE of the four constructs are higher than the squared correlation values of the latent constructs, confirming an acceptable discrimination validity (Fornell and Larcker, 1981).

Table 3
Validity and reliability.

Constructs	Cronbach's α	CR	rho_A	AVE
Intellectual capital	0.835	0.839	0.872	0.558
Collaborative knowledge creation	0.917	0.917	0.909	0.623
Supply chain agility	0.891	0.914	0.910	0.640
Corporate sustainability	0.822	0.831	0.854	0.599

Table 4
Discriminant Validity.

No.	Constructs	1	2	3	4
1	Intellectual capital	**0.811**			
2	Collaborative knowledge creation	0.637	**0.789**		
3	Supply chain agility	0.570	0.665	**0.800**	
4	Corporate sustainability	0.699	0.649	0.614	**0.812**

3.3.2. The structural model

The outcome of the PLS path analysis is summarized in Fig. 2. The results indicate that intellectual capital and collaborative knowledge creation account for 47.8% of the variances of supply chain agility. The model also shows that intellectual capital accounts for 40.6% of the variances of collaborative knowledge creation. Finally, PLS path analysis indicates that intellectual capital, collaborative knowledge creation, and supply chain agility account for 58.3% of the variances of corporate sustainability.

However, the results (Table 5) reveal that intellectual capital significantly impacts collaborative knowledge creation (H1), supply chain agility (H2), and corporate sustainability (H3).

The findings indicate that collaborative knowledge creation significantly impacts supply chain agility (H4) and corporate sustainability (H5). Furthermore, the findings show a significant impact of supply chain agility on corporate sustainability (H6).

4. Discussion

This study confirms that intellectual capital significantly impacts collaborative knowledge creation. These results support prior studies' view (e.g., Nickerson and Zenger, 2004; Shiranifar et al., 2019) that organizations with higher levels of outstanding intellectual capital have better knowledge management, including the ability to create and acquire it, than those with lower levels of intellectual capital. Previous studies (e.g., Mandal, 2018; Yusoff et al., 2019) had also confirmed that employees with a high level of education, creativity, experience, and skills are more eager to contribute to communication and collaboration with supply chain members to create new knowledge. Firms that hire experts and highly skilled employees and have more social and structural capital are more likely to encourage knowledge-sharing, best practices, and the creation of new knowledge, ideas, and solutions in collaboration with supply chain partners. Such firms have multiple transmission channels for transferring and exchanging knowledge and constantly collaborate with supply chain partners to capture, integrate, and classify new knowledge.

The results show that intellectual capital significantly impacts supply chain agility. Such results are compatible with prior studies (e.g., Tooranloo et al., 2018; Dabić et al., 2021), confirming the pivotal role of intellectual capital in organizational agility. They also agree with earlier findings that supply chain agility is demonstrated through an organization's intellectual assets, which enable it to detect fluctuations, opportunities, and threats swiftly (Gligor et al., 2013; Pinto, 2020). The findings reveal that intellectual capital contributes significantly to the speed of making and implementing decisions in response to sudden market changes, particularly responding more quickly than competitors to changes in product availability and demand during unique global crises. A high level of intellectual capital enhances supply chain agility by enabling rapid reconfiguration of supply chain resources during uncertainties in market supply and demand and excluding non-value-added activities. It also enhances the adaptability of supply chain processes to shorter manufacturing lead times and delivery cycle times.

The findings show that intellectual capital significantly impacts

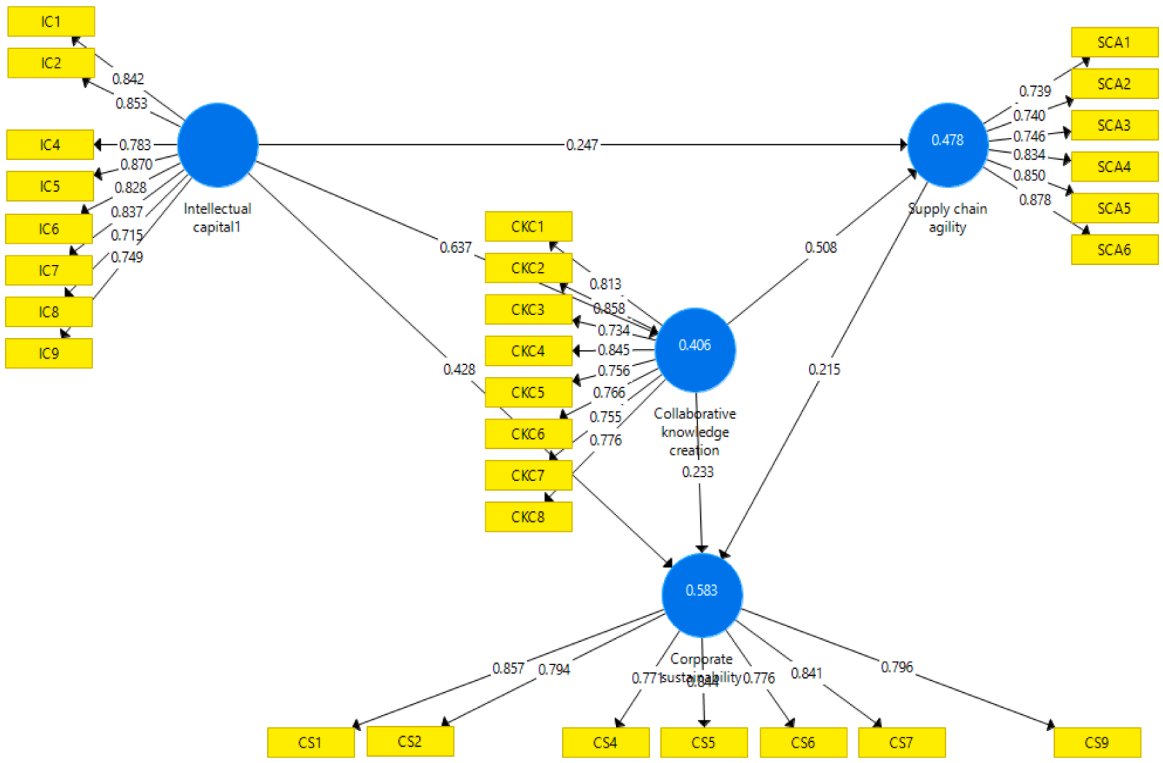

Fig. 2. The results of path analysis.

Table 5
Testing hypotheses.

H	Path	β	T value	P value	Results
1	IC → CKC	0.637	14.748	0.000	Supported
2	IC → SCA	0.247	3.130	0.002	Supported
3	IC → CS	0.428	4.823	0.000	Supported
4	CKC → SCA	0.508	5.846	0.000	Supported
5	CKC → CS	0.233	2.388	0.017	Supported
6	SCA → CS	0.215	2.505	0.013	Supported

corporate sustainability during unprecedented crises. They accord with those of previous studies (e.g., Tooranloo et al., 2018; Srikalimah et al., 2020; Mubarik et al., 2021), confirming that the continued survival and success of today's firms depends mainly on their intellectual capital capabilities. The literature also emphasizes that the sustainable development and growth of firms require robust intellectual capital (Alvino et al., 2020; Srikalimah et al., 2020). Firms with outstanding social capital, well-integrated structural capital, and knowledgeable human capital can legitimize their social acceptance and existence through effective responsiveness to customers' emerging needs and build long-term relationships with supply chain members. These intangible assets play a central role in gaining sustainable competitive advantage through promoting firms' social responsibility in protecting the health and safety of employees, customers, and society during pandemic crises.

The current findings provide support for a significant role for collaborative knowledge creation in developing supply chain agility. They are compatible with studies (e.g., Nafei, 2016; Shiranifa et al., 2019) that described agility as the organization's ability to redeploy its existing knowledge or create new knowledge and translate it into quick action and early response to business disturbances and inconstant market changes. They also fit with the dynamic capability view that acquiring new knowledge and assimilating it into a firm's functions and processes are crucial to its ability to capitalize on market trends and empower agility capabilities (Wu et al., 2017). Collaborative knowledge creation is an agility mechanism in responding to unprecedented crises, such as global pandemics. It enables a firm to respond to changes in the market and adapt its supply chain operations and capabilities to shortened manufacturing and delivery cycle times. Collaborative innovation also plays a central role in developing a firm's supply chain agility in response to short-term and unpredictable events through improving its tactics and operations, and excluding non-value-added activities, more quickly than competitors and without shortages or overstocking.

This study supports the significant impact of collaborative knowledge creation on corporate sustainability in the current epidemic crisis. The results accord with studies (e.g., Nafei, 2016; Baah et al., 2021) that showed that developing collective knowledge, creating new knowledge, and using it competently when required are essential for an organization's sustainability. The literature (Gligor and Holcomb, 2014; Lo et al., 2021) has emphasized the value of knowledge creation capabilities as fundamental requisites of improved performance and long-term successes, and thus survival. These findings confirm collaborative knowledge creation as a main driving force behind the survival of firms in unpredictable and dynamic environments. It enables supply chain partners to know how to utilize the emerging IT tools both for communication and collaboration and doing business in dealing with the COVID-19 pandemic. Collaborative knowledge creation is essential for maintaining customer satisfaction through effective responsiveness to their emerging needs and wants. It enables firms to respond rapidly and mitigate pandemic effects on supply chains, enhancing social cohesion, and thus preserving their survival and sustainability. This study underlines the value of collaborative knowledge creation as one of the primary sources of improving profits and achieving sustainable competitive advantage as long as there is renewed collaboration in creating new knowledge.

The results also show that supply chain agility significantly impacts corporate sustainability in the COVID-19 crisis, agreeing with Gunasekaran (1999), who characterized organizational agility as the ability to survive and grow through rapid responses to the changing needs and desires of customers in changing markets and turbulent environments. These results also agree with prior studies that recognized supply chain agility as an effective strategy in high-risk environments for managing

and mitigating risks and, in particular, supply chain disruption risks that threaten firms' survival and sustainability (Gligor and Holcomb, 2014; Shiranifa et al., 2019). This is consistent with the idea that agility is a primary reason for firms' survival and sustainability through rapid responses to customers' changing needs in changing markets and turbulent environments. The necessity of corporate sustainability forces a firm to be highly sensitive and to think quickly and make and implement decisions faster than competitors in response to sudden market changes. Supply chain agility allows the rapid reconfiguration of supply chain resources and capabilities in response to risky short-term changes and market uncertainties. Under pressure from unprecedented crises, corporate sustainability requires firms to increase their supply chain agility in order to re-organize the streamlining of their supply chain processes, modify the tactics and operations of partners, and thus coordinate and adjust their resources and behaviors to the fast-changing environment.

4.1. Theoretical contributions and implications

This study provides many important contributions. The worldwide spread of COVID-19 has brought real risks, threatening the survival and sustainability of firms and their local and global supply chains. These threats call for new studies re-examining the supply chain environments and their resilience factors that enable business partners to sustain the flow of procurement processes and logistics, manufacturing, production, and product delivery. Before the current paper, no empirical studies had examined the causal relationships between intellectual capital, collaborative knowledge creation, supply chain agility, and corporate sustainability during global pandemic crises. There were no empirical studies about the impact of collaborative knowledge creation or knowledge management on supply chain agility in the COVID-19 literature. This study has examined how intellectual capital and supply chain collaboration help to maintain corporate sustainability during unprecedented global crises. It provides valuable insights into the causal relationships between intellectual capital, collaborative knowledge creation, supply chain agility, and corporate sustainability. The findings enrich the supply chain management literature by examining the role intellectual capital and collaborative knowledge creation play in supply chain agility and the impact of such agility on maintaining corporate sustainability. It also enriches the literature on knowledge management by investigating the relationship between intellectual capital and collaborative knowledge creation and the contribution of this new knowledge to preserving corporate sustainability.

4.2. Implications for practice

This study has some significant contributions for practitioners. It provides firms with powerful mechanisms for responding to such crises in the future and ensuring their survival and sustainability. It contributes to improved management of supply chains, highlighting valuable opportunities to survive and recover from the COVID-19 crisis quicker than competitors. Firms need to invest in intellectual capital, collaborative knowledge creation, and supply chain agility to preserve their sustainability. In food and other essential industries, it is necessary to collaborate and integrate the intellectual capitals of supply chain members to support the collaborative knowledge creation that enables them to address threats of chain disruption. Focusing on the significance of intangible assets for supply chains induces members to collaborate and coordinate their intellectual capitals to promote better supply chain agility. The research model provides managers with a paradigm of how to attain co-value creation in exceptionally turbulent environments. It thus offers guidance for firms on how to employ their intellectual capital in collaboratively creating new knowledge and the supply chain agility required to manage unprecedented crises. The research model can be viewed as a paradigm that explains how to preserve corporate sustainability in a turbulent environment. It provides valuable guidance for managers on employing e-supply chain collaboration in generating novel innovations and developing the improved supply chain agility needed.

4.3. Limitations and future research direction

Notwithstanding its academic and practical contributions, this study has some limitations, mostly connected with new horizons for future research. This study was focused on local manufacturing food firms in one country. Therefore, if the results are to be generalizable, the research model must be applied in other places in the world, in different industries and supply chains. The study did not account for the size of firms, especially SMEs, and size might be a critical factor in firms' reactions and survival chances during unprecedented crises. Future research is suggested to focus more on studying intellectual capital, collaborative knowledge creation, and supply chain agility in SMEs' use of these dynamic capabilities to preserve their sustainability during unprecedented crises. Also, since the study explores the dynamic capabilities of firms and their supply chains, future research may focus on the status and development of these capabilities in relation to the characteristics of the crisis itself: its beginning, severity, ending, recovery steps taken, and aftermath. Thus, longitudinal research could provide valuable understanding of how to develop the dynamic capabilities that can preserve corporate sustainability in future crises.

5. Conclusions

The unprecedented crisis of the COVID-19 has highlighted the importance of supply chains for firms continuing ability to produce and distribute what the market needs in such a challenging period. With the frequent closings of borders and lockdown measures, local and global supply chains came under increasing pressure, threatening the sustainability of these chains and the survival of all their members. Accordingly, this study aimed to explore the associations between intellectual capital, collaborative knowledge creation, supply chain agility, and corporate sustainability.

The pandemic has provided further evidence that intellectual capital is an essential driver of critical organizational dynamic capabilities such as collaborative knowledge creation and supply chain agility. This study also confirms that the continued survival and success of firms in such crises depends primarily on intellectual capital assets. Supply chain agility is also a lifeline for companies to continue producing and distributing what the market needs in such a challenging period. Finally, for supply chain agility and organization sustainability, inter-organizational collaboration in new knowledge creation and learning how to use it more cleverly when required are essential.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. Questionnaire items

Constructs	Code	Measures
Intellectual capital		*Human capital*
	IC1	My firm hires highly experienced employees.
	IC2	Employees in my firm are specialists in their jobs.
	IC3	The firm is keen to employ well-educated and clever people.
		Social capital
	IC4	Our firm has long-term relationships with supply chain members.
	IC5	Communication and collaboration between our firm's departments and employees run smoothly and openly.
	IC6	Our firm encourages sharing knowledge and collaborating with others.
		Structural capital
	IC7	We have active documented policies, instructions, standard procedures, and rules to support business operations.
	IC8	Much of our information and knowledge is embedded in the firm's structure, manuals, archives, and databases.
	IC9	Our firm provides all the necessary tools, technologies, and facilities to support access to existing documents and information.
Collaborative knowledge creation	CKC1	Our firm constantly gets novel ideas and solutions from its collaboration with supply chain partners.
	CKC2	Our top management believes that collaboration with partners enables the creation of new knowledge.
	CKC3	Our firm constantly launches and discusses creative ideas and disruptive thoughts with supply chain members.
	CKC4	Our firm encourages sharing knowledge and best practice with supply chain members.
	CKC5	Our firm constantly collaborates with supply chain partners in capturing, integrating, and classifying new information and knowledge.
	CKC6	My firm has accessible databases and resources of best practice and experience, self-learning, and lessons learned.
	CKC7	Our firm has multiple transmission channels for transferring and exchanging knowledge with business partners.
	CKC8	My firm collaborates with supply chain members to share and use newly learned knowledge.
Supply chain agility	*In responding to COVID-19, our firm was able to:*	
	SCA1	Respond quicker than competitors to changes in product availability and orders.
	SCA2	Quickly make and implement decisions in response to sudden market changes.
	SCA3	Rapidly reconfigure supply chain resources in responding to uncertainties in market supply and demand.
	SCA4	Exclude non-value-added operations.
	SCA5	Constantly adapt supply chain operations to decrease manufacturing and delivery cycle time.
	SCA6	Modify quicker than competitors its tactics and operations supply chain in responding to short-term changes in market demand.
Corporate sustainability	*To what degree do you agree that the firm was able to conduct the following during the COVID-19:*	
	CS1	Enhance the investment in new emerging technologies.
	CS2	Lengthen a firm's lifetime and enhance social acceptance.
	CS3	Enhance the firm's image.
	CS4	Reinforce customer satisfaction through effective responsiveness to their emerging needs and wants.
	CS5	Empower long-term relationships with business partners.
	CS6	Promote the firm's social responsibility through protecting the health and safety of employees, customers, and society.
	CS7	Achieve competitive advantage.
	CS8	Increase productivity.
	CS9	Improve profits.

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