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Accepted for publication in International Journal of Logistics Management.

Supply chain agility as the antecedent to firm sustainability in the post COVID-19

Abstract

Purpose: COVID-19 has caused critical supply chain problems, especially in sustainable supply chain management, but very few empirical studies have been explored how to improve the firm sustainability through supply chain endeavours such as supply chain agility to manage the impacts of COVID-19. This paper aims to develop a model to incorporate supply chain agility and supply chain relationships that link firm sustainability to mitigate the impacts of the pandemic.

Design/ methodology/approach: We conducted an online survey and collected 203 valid responses from businesses in the United Arab Emirates, and employed an exploratory factor analysis, mediated regression analysis and structural equation modelling methodology to test the models and hypotheses.

Findings: We find that the adoption of supply chain agility can improve supply chain relationships and positively impact sustainability. Meanwhile, supply chain relationships partially mediate the relationship between supply chain agility and sustainability. In addition, sustainability mitigates the impacts of COVID-19 pandemic on supply chains.

Originality: The results provide fruitful insights and implications for the challenges and uncertainties caused by the pandemic post COVID-19, and provide several directions for further research.

Keywords: agility, sustainability, supply chain relationship, COVID-19

1. Introduction

COVID-19 pandemic has caused uncertainties and challenges in business supply chain operations (Velayutham et al., 2021, Chowdhury et al., 2021, Dente and Hashimoto, 2020). Moreover, new variants of the coronavirus such as the Delta variant and the Omicron variant keep appearing. Since many countries have abandoned their 'Zero-COVID' strategy, for a long time in the future, we may need to adapt this 'new normal', and organisations must face

‘sustainability transformations’ and continuously deal with these COVID-19 uncertainties and challenges to enable a sustainability post COVID-19 (Dente and Hashimoto, 2020, Chambers et al., 2022). Sarkis (2021) stress that there are unprecedented opportunities for this transition to a sustainable post-COVID-19 environment. Therefore, it is significant to rethink about how we can address these uncertainties and challenges, and leverage the opportunities for developing sustainability in business supply chain operations post COVID-19.

Based on the resource-based view, John Elkington’s triple bottom line, and contingency theory, in this study, we develop a model incorporates supply chain agility and supply chain relationships that link firm sustainability in supply chains to mitigate the impacts of COVID-19 pandemic. Supply chain agility is the firm’s ability to quickly adjust its supply chain tactics and operations (Gligor et al., 2015a). It is a critical dynamic capability to counter supply chain risks and disruptions. The impact of COVID-19 pandemic could be viewed as unexpected fluctuations and uncertainties in supply chains (Velayutham et al., 2021). The firm sustainability focuses on the profits, social responsibility, and environmental responsibility (Sarkis, 2021). Supply chain agility plays a vital role to tackle these supply chain risk and uncertainties (Christopher, 2000), and building sustainability (Sarkis, 2021).

In addition, a modern supply chain is a complex network, which contains multiple stakeholders and relationships (Wang et al., 2020b). It is essential to embrace all members in a supply chain to resolve the problems. Supply chain relationships is considered as a mediator of the relationship between supply chain agility and sustainability in this research model. Besides, the concept of supply chain relationships contains supply chain partners, enables the supply chain integration and collaborations, and facilitates the supply chain flows (Wang et al., 2021). Patrucco and Kähkönen (2021) stress that researchers should revisit and focus on the critical capabilities and concepts of supply chains in the post-COVID-19 business environment.

Teece et al. (1997) developed the resource-based view one step further by formulating the dynamic capabilities perspective, the term ‘dynamic’ refers to the capacity to renew competencies to achieve congruence with a changing environment. The term ‘capability’ reflects the major role of strategic management in adapting, integrating and reconfiguring resources, organisational skills and functional competencies to respond to the challenges of the external environment (Helfat et al., 2009). According to the dynamic capability theory, agility is viewed as a dynamic capability and it is almost a synonym for flexibility (Teece et al., 2016, Wang, 2016), and supply chain relationships may be viewed as an important corporate asset / resource in modern logistics and supply chains (Wang et al., 2021). The sustainability refer to

the triple bottom line from a corporate's perspective, as companies should commit to focusing as much on social and environmental concerns as they do on profits (Sarkis, 2021).

Although supply chain agility and sustainability are recognized as important concepts in the post COVID-19 research, little research exists which addresses how an organization can interact with supply chain agility, supply chain relationships, and sustainability to mitigate the impacts of COVID-19 on supply chains. There is a lack of empirical study that investigates this phenomenon from a holistic perspective that could be used as a foundation for both theory building and theory testing post COVID-19. This paper provides empirical investigations about the role of supply chain agility in the firm sustainability post COVID-19. This study examines the relationships among the supply chain agility, supply chain relationships, sustainability and impact of COVID-19 on supply chains and attempts to answer the following research questions to fill conceptual gaps and provide valuable insights for managing the COVID-19 pandemic in supply chains and the development of firm sustainability post COVID-19.

RQ1: How does supply chain agility affect sustainability post COVID-19?

RQ2: How does supply chain agility affect supply chain relationships post COVID-19?

RQ3: How does supply chain relationships affect sustainability post COVID-19?

RQ4: How does sustainability affect impacts of COVID-19 pandemic on supply chains?

This paper contributes to the supply chain management post COVID-19 literature by incorporating newly developed constructs in a research model and providing early empirical evidence concerning the efficacy of the model. The remainder of the paper is organized as follow. Section 2 introduces the theoretical background and literature review. Section 3 presents the research framework and hypotheses development. Section 4 describes the research methodology. Section 5 illustrates the research results. Last section concludes the paper.

2. Theoretical background

2.1 Supply chain agility

Christopher (2000) define agility as the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety. Supply chain agility enables organisations to become competitive in today's dynamic and turbulent business environment (Patel and Sambasivan, 2022). According to the dynamic capabilities approach, supply chain

agility also can be viewed as a dynamic capability which can help companies gain the competitive advantage and against uncertainties in supply chains (Teece et al., 2016), and reconfigure firm level and supply chain level resources (Gligor and Holcomb, 2012a). Christopher and Towill (2001) suggest that agility is a business-wide capability that embraces organisational structures, information systems, logistics processes and in particular, mindsets. And the agility was identified as one of the most salient issues of contemporary supply chain management (Gligor and Holcomb, 2012b). Blome et al. (2013) argue that supply chain agility is a central component of the organisation's competitive strategy in an uncertain environment. Furthermore, supply chain agility is considered as an important term to help organisations to create value in a turbulent and unpredictable environment (Shams et al., 2021).

In the contingency theory, companies must find an appropriate way to resolve the supply chain uncertainties upon the internal and external situation (Grötsch et al., 2013). Further, supply chain agility does not only relate to customers, but also suppliers. Gligor et al. (2015b) defined supply chain agility as the firm's ability to quickly adjust its supply chain tactics and operations including production and/or service capacity. Braunscheidel and Suresh (2009) conceptualised supply chain agility as a second-order construct that includes the four factors joint planning, demand response, visibility, and customer responsiveness. Although the concept of supply chain agility has been widely discussed in supply chain literature (Christopher and Towill, 2001, Dubey et al., 2018), the environment and marketplace are constantly changing. Especially, COVID-19 pandemic has caused a huge impact on supply chains (Velayutham et al., 2021). In additions, Industry 4.0 technologies have been widely applied in modern logistics and supply chain operations, it is significant to revisit the logistics and supply chain capabilities and explore the impacts those capabilities in the industry 4.0 era (Wang et al., 2020a).

The agility is also viewed as the firm's dynamic ability to efficiently change operating states in response to uncertain and changing market conditions (Braunscheidel and Suresh, 2018, Narasimhan et al., 2006). According to the contingency theory, companies must find a suitable way to resolve the supply chain risks upon the internal and external situation (Grötsch et al., 2013). Further, supply chain agility does not only relate to customers, but also should respond suppliers' requests. Gligor et al. (2015b) defined supply chain agility as the firm's ability to quickly adjust its supply chain tactics and operations including production and/or service capacity. It also includes strategic agility, which allows organisations to remain flexible in facing new developments, and to reconfigure operations process to adapt the changes (Shams et al., 2021).

2.2 Supply chain relationships

Supply chain relationship is an important concept in supply chain management. Based on the resource based view, the supply chain relationship is viewed as an important corporate asset, and may be influenced by a firm capability (Wang, 2020). The supply chain is a network of multiple businesses and relationships, offering the opportunity to capture the synergy of inter-organisational management (Lambert et al., 1998, Lai et al., 2004). Managing supply chain relationships is a complex business managerial task, the priority is to understand the situations, know how to manage in a knowledge-based supply chain and embrace uncertainty (Braunscheidel and Suresh, 2009, Wang et al., 2021). Supply chain agility may help to address the complexity of change, while supply chain relationship can be viewed as a kind of strategic asset to achieve long-term supply chain cooperation and ensure the achievement of sustainable development.

Supply chain relationships include a personal channel to connect and communicate each other (Tsang, 1998, Park and Luo, 2001, Luo et al., 2012, Gold et al., 2004). Dunning and Kim (2007) assert that the nature of the relationships depends on the lifelong experience of those involved in building the relationships, and interpersonal relationship implies reciprocity in exchange for favours. Luo et al. (2012) argue that social ties and networks formed by managers with other managers and government officials bring social capital to the organizations to which they belong. Besides, the supply chain relationships promoting trust and credibility that will definitely facilitate the collaboration and information sharing in supply chains. Based on the long-term relationships, the supply chain business partners can achieve a higher level of collaboration and promote the trust in supply chains (Wang et al., 2021). Supply chain relationship can be considered as a strategic tool to integrate the supply chains and facilitate the supply chain activities during the sustainability transformations (Wang and Abareshi, 2019).

2.3 Sustainability

Sustainability is widely known as fulfilling the present needs of people without compromise on the needs of people in future, this can be viewed through multiple lenses (Seuring and Müller, 2008). We adopted one of the most popular views - John Elkington's

triple bottom line in this study. Sustainability is an important topic in supply chain management (Seuring, 2008, Govindan et al., 2014, Fahimnia et al., 2015). With increased demands on economic performance of the supply chains, firms are also held responsible for the environmental and social performance of their supply chains. (Seuring et al., 2008). Such as supplier evaluation schemes may integrate environmental and social criteria (Seuring, 2008). Carter and Rogers (2008) argue that the concept of sustainability includes the integration of environmental, social, and economic criteria that allow an organization to achieve long-term business success. Green Jr et al. (2012) suggest that the broad view of sustainability incorporates the concepts of economic, social, and environmental performance in green supply chain management. Miceli et al. (2021) emphasise that the pandemic crisis of the COVID-19 has changed the paradigm of business performance evaluation, stakeholders want to know how the profits were generated. It is significant to develop sustainable supply chain to respond external pressure and incentives set by different groups (Seuring and Müller, 2008). Sarkis (2021) argue that the COVID-19 pandemic provides additional evidence that the three sustainability dimensions are inextricably linked. Environmental, social, and economic sustainability should be measured in the firm sustainability.

2.4 Impacts of COVID-19 pandemic on supply chains

As we discussed before, COVID-19 pandemic has become a new normal (Velayutham et al., 2021). We need to manage these impacts of COVID-19 pandemic post COVID-19. It is significant to measure the impacts of COVID-19 pandemic on supply chains in order to manage them. If we cannot measure it, we cannot manage it (Wang et al., 2018). COVID-19 pandemic has caused serious impacts on global supply chains. We develop a new construct to measure the impacts of COVID-19. To assess the impacts of COVID-19 is not a simple task, as the impacts of COVID-19 pandemic can be assessed from several perspectives, companies may experience a wide variety of effects during COVID-19 pandemic (Chopra et al., 2021, Paul et al., 2021). Besides, companies in different country or region may face different challenges.

In this study, COVID-19 pandemic is treated as a type of supply chain uncertainty in a supply chain system (Sodhi and Tang, 2021, Velayutham et al., 2021). The impacts of COVID-19 pandemic on supply chains are assessed in terms of the supply chain risks and uncertainties including markets / customers, internal business operations, supply / suppliers, logistics and transportation, and finance (Christopher and Peck, 2004, Christopher, 2005). Supply chain

uncertainties may cause both positive and negative impacts on logistics and supply chain operations (Wang, 2018). For example, the environmental uncertainties would positively impact SCM performance if the uncertainties can align with SC strategies (Sun et al., 2009). This study focuses on the negative impacts on supply chain operations from a corporate's perspective.

3. Research Framework and Hypotheses Development

This section presents the conceptual framework and proposes hypotheses in the study as follows.

3.1 Supply chain agility and sustainability

Supply chain agility plays a vital role in the supply chains, it is a critical supply chain capability to respond in a speedy manner to both internal and external changes (Christopher and Towill, 2001). According to the dynamic capability theory and contingency theory, supply chain agility allows organisations to adapt and respond rapidly to the immediate contingent circumstances (Morgan, 2006, Teece et al., 1997). Besides, it is an important capability to address the sustainability, such as Govindan et al. (2014) found that lean, resilient, and green supply chain practices could influence sustainability. Recent studies Geyi et al. (2020) suggest that agile capabilities can increase the sustainability performance. Nath and Agrawal (2020) suggest that supply chain agility and lean management practices are antecedents of social sustainability orientation as well as social sustainability performance. Shams et al. (2021) stress that agility may include the combination of principles of lean and flexibility, which can lead to sustainability. Sarkis (2021) find that one pharmaceutical company attempts to build supply chain agility and resilience to against COVID-19, this effort can also be used to improve sustainability. In this study, firm sustainability was represented by the social, environmental, and economic performance. Blome et al. (2013) posit that supply chain agility is a central component of the organisation's competitive strategy in an uncertain environment. Moreover, Ur Rehman et al. (2020) argue that agility is a capability that drives competitiveness to foster sustainability aspects. Therefore, we argue that supply chain agility can facilitate sustainability post COVID-19, and hypothesize that

H1. Supply chain agility is positively related to firm sustainability.

3.2 Supply chain agility and supply chain relationships

As we discussed above, supply chain agility is a dynamic capability, which can reconfigure firm level and supply chain level resources (Gligor and Holcomb, 2012a). Supply chain relationships including interpersonal relationship, inter-organisations relationship and long term business partnership can be considered as an important firm resource to enhance supply chain network performance, integrate supply chain and deliver value to customers (Wang et al., 2021). According to dynamic capability theory, supply chain agility can reconfigure, build, and integrate the organization's resources and other capabilities (Wang, 2016). Supply chain relationships can be viewed as superior resources, the dynamic capability (i.e. supply chain agility) can purposefully adapt an organization's resource base (Helfat et al., 2009, Teece et al., 1997). In additions, supply chain agility can help companies gain the competitive advantage and against risk and uncertainty in supply chains (Teece et al., 2016, Christopher and Towill, 2001). Agility can be viewed as responsiveness, which is the ability of an organisation to adjust to both internal and external changes in the supply chains and respond rapidly to both customers and suppliers in supply chains. This would enable companies quickly respond the challenges and uncertainties in the post COVID-19 environment. Supply chain agility may facilitate the supply chain relationships. Therefore, we hypothesize that:

H2. Supply chain agility is positively related to supply chain relationships.

3.3 Supply chain relationships and sustainability

Supply chain relationships is one of important components in supply chain management, they are superior resources, as companies require collaborative relationships with their supply chain partners (Nyaga et al., 2010). Supply chain relationships is related to the sustainability. Carter and Jennings (2002) investigates the impact of corporate social responsibility on the decision making of supply chain, and suggests that purchasing social responsibility has impacts

on supply chain relationships. Purchasing social responsibility (PSR) is regarded as an organizational-level business characteristic, indicating that a firm's purchasing activities need to meet the ethical and discretionary responsibilities expected by society (Griffis et al., 2014). Thus, buyer-supplier relationships in the upstream supply chain are enhanced through purchasing social responsibility. Oyedijo et al. (2021) argues that fairness is an important component of an organisation's sustainability, and supply chain relationship development plays a critical role in the fairness of sustainable multi-tier supply chain. Besides, Stranieri et al. (2019) confirms corporate social responsibility is positively related to supply chain relationships through an augmented vertical coordination and to integrate environmental policy. In sum, supply chain relationships bring collaboration with supply chain partners, and this could improve the overall firm sustainability. Therefore, we argue that supply chain relationship plays an important role in firm sustainability in the post COVID-19 business environment, and hypothesize that

H3. Supply chain relationship is positively related to firm sustainability

3.4 Sustainability and impacts of COVID-19

A sustainable supply chain practice may mitigate the impacts of COVID-19 pandemic on supply chains, as sustainability is often defined holistically, the required balance and the interplay of the economic, social and environmental values help optimise overall organization performance. Giannakis and Papadopoulos (2016) argue that the pursuit of sustainability is increasingly recognised as an effective strategy to deal with some of the contemporary challenges facing global supply chains. COVID-19 pandemic could be viewed as a special case of supply chain uncertainty and risk (Velayutham et al., 2021, Ivanov, 2020, Miceli et al., 2021). According to the contingency theory, organisations must satisfy and balance internal needs and to adapt to environmental uncertainties, and there is no one best way of manage (Morgan, 2006), sustainability may allow organisations to satisfy and balance the stakeholders' interest and to adapt the impacts of COVID-19 pandemic on supply chains. Furthermore, Sarkis (2021) argue that there is a close association between the COVID-19 crisis and sustainability, the role of sustainability should be considered in the supply chains post COVID-19. So far, we have not found any empirical study on the sustainability and impacts of COVID-19 on supply chains. In literature, the firm sustainability may enhance competitiveness and mitigate the

consequences of business risks (Godfrey et al., 2009, Giannakis and Papadopoulos, 2016). Therefore, we argue that good firm sustainability is critical to mitigate the impacts of COVID-19 on supply chains in the post COVID-19 business environment, and hypothesize that

H4. Firm sustainability is negatively related to impact of COVID-19 on supply chains

3.5 Supply chain agility and impacts of COVID-19 & supply chain relationship and impacts of COVID-19

Supply chain agility has been widely considered as an important capability to address the supply chain risks (Braunscheidel and Suresh, 2009). Müller et al. (2022) posit that supply chain agility enables companies building ad hoc supply chains in response to the impacts of COVID-19. In addition, supply chain agility is a dynamic capability, which can avoid disruptions caused by pandemics such as COVID-19 (Kazancoglu et al., 2022). Furthermore, supply chain agility can improve supply chain resilience (Patel and Sambasivan, 2022, Brandon-Jones et al., 2014). Therefore, we posit that supply chain agility may mitigate the impacts of COVID-19 on supply chains.

Companies' emphasis on supply chain relationship may lead to greater value and better collaboration in supply chains (Liao et al., 2017, Wang et al., 2021). Supply chain relationship allows companies to build trust and improve the supply chain integration (Wang et al., 2021). The supply chain relationship plays a significant role to increase supply chain connectivity and information sharing. Brandon-Jones et al. (2014) suggest that supply chain connectivity and information sharing resources lead to a supply chain visibility capability which enhances resilience and robustness. All this suggest that supply chain relationship may help companies to overcome the the impacts of COVID-19 on supply chains.

H5. Supply chain agility is negatively related to impacts of COVID-19 on supply chains

H6. Supply chain relationship is negatively related to impacts of COVID-19 on supply chains

Figure 1 illustrates the conceptual framework. Multiple theories are often adopted in the modern business research to tackle complex research questions, and provide a better understanding of the phenomenon from multiple angles (Bryman and Bell, 2011). Two important theories have been adopted in this study, they are dynamic capability theory and contingency theory. They do not only explain the interactive effects between supply chain agility, supply chain relationships, sustainability, and impacts of COVID-19 on supply chains, but also offer valuable insights into mitigation strategies in the post COVID-19.

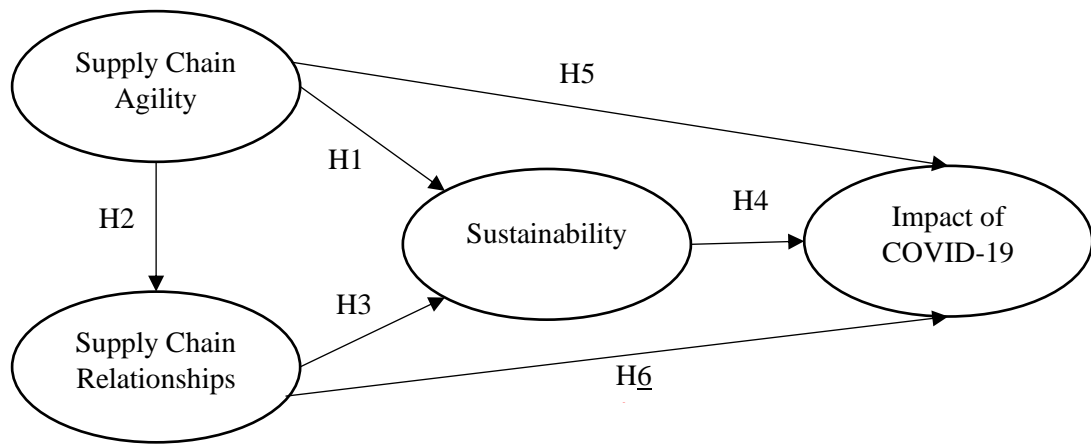


Figure 1. Conceptual Framework

4. Research Methodology

4.1 Sample

We collected the data in collaboration with the Chartered Institute of Procurement and Supply (CIPS) in UAE. The COVID-19 pandemic provides a very unique empirical research opportunity to revisit the critical supply chain capabilities for managing supply chain risks and uncertainties during the pandemic (Ivanov, 2021). This study does not focus on any particular industry or sector, as we attempt to investigate the relationships among the constructs: supply chain agility, supply chain relationships, sustainability and impact of COVID-19. Besides,

COVID-19 pandemic may cause different impacts on industries and/or countries. It would be useful to investigate the multiple industries in this empirical study to better capture and understand the phenomenon. We invited the participants who have been working in UAE organisations to participate in an online survey. Approximately 900 questionnaires were distributed to the different UAE organisations; all major UAE's industries have been included in the survey. Then we sent a follow-up email after 2 weeks, and total 203 valid responses were used for the data analysis. The response rate of the study is above 20%.

Table 1 indicates that the industries are represented in this study. Over 60% of the respondents hold managerial positions. Over 70% of the respondents have been working in their organisations for more than 2 years. According to UAE government report, small and medium enterprises account for 94% of all businesses in the UAE, supporting SMEs is a priority of the UAE federal government, as part of its policy to diversify the national economy and generate employment opportunities. The company sizes are classified by the company annual revenue. This study includes all company sizes from micro company to large companies, according to the UAE government company classification. For example: Micro companies' revenues approximately below AED 3 million (approx. USD 0.8 million); Small companies' revenues approximately between AED 3 million (approx. USD 0.8 million) and AED 50 million (approx. USD 13.6 million); Medium companies' revenues approximately between AED 50 million (approx. USD 13.6 million) and AED 250 million (approx. USD 68 million); Large companies' revenues approximately above AED 250 million (approx. USD 13.6 million) in UAE.

4.2 Non-response bias

Respondents were mainly from the seven emirates in UAE. Non-response bias was tested. The method tested for significant differences between early respondents and late respondents, these late respondents were considered as a surrogate for non-respondents (Armstrong and Overton, 1977). We compared responses of the first 30 received surveys to responses of the last 30 received surveys. t-Tests were conducted using company size, and type of industries along with three randomly selected measures. The results show that no significant difference between early respondents and late respondents. Non-response bias was not present in this study.

Table 1. Survey respondents' profile (n=203)

Metric	Number	Percentage
<i>Industry</i>		
Oil & Gas	28	13.8
Construction	14	6.9
Manufacturing	18	8.9
Trading	22	10.8
Tourism and hospitality	12	5.9
Educational services	13	6.4
Healthcare and pharmaceuticals	9	4.4
Transportation and warehousing	14	6.9
Finance and Insurance	12	5.9
Public Administration	2	1.0
Other services	59	29.1
<i>Position</i>		
CEO, Director / Senior Manager	48	23.6
Manager / supervisor	90	44.3
Staff	57	28.1
Others	8	3.9
<i>Working years in organization</i>		
Less than 2 years	50	24.6
2-5 years	54	26.6
More than 5 years	99	48.8
<i>Company size</i>		
Revenues below AED 3 million	38	18.7
Revenues between AED 3 million and AED 50 million	56	27.6
Revenues between AED 50 million and AED 250 million	47	23.2
Revenues above AED 250 million	62	30.5
<i>Location</i>		

Abu Dhabi	42	20.7
Ajman	6	3.0
Dubai	106	52.2
Fujairah	2	1.0
Ras Al Khaimah	2	1.0
Sharjah	6	3.0
Umm Al Quwain	2	1.0
Others	37	18.2

4.3 Instrument development

To ensure the constructive validity, the measurement items for supply chain agility, supply chain relationships were initially developed based on the existing literature. In this study, we introduced new constructs including sustainability, impacts of COVID-19 on supply chains. In the pilot study, five purchasing and supply chain managers and three business management academics in Dubai were invited to further validate the questionnaire. All these invitees were from both private and public sectors and had extensive experience with UAE businesses. After that, a minor modification was conducted to refine the questions. Two types of scales were applied in this study. A 7-point Likert-type scale (rating scale where 1=strongly disagree, and 7=strongly agree) is used in the survey for supply chain agility, supply chain relationships and sustainability. We asked participants to answer the supply chain agility and supply chain relationships questions based on the major supplier of their companies as the responding target. Sustainability was measured by the firm's sustainable performance; we asked participants to answer the questions related to their firm's performance compared to their major competitors.

As impacts of COVID-19 on supply chains construct is new, Ivanov and Das (2020) suggest that COVID-19 is a special case of supply chain risk. Besides, COVID-19 is a supply chain uncertainty (Velayutham et al., 2021). We developed a new measurement scale based on the supply chain uncertainty and risk instruments (Wang et al., 2014). We asked participants to rate the importance of each uncertainty / Covid-19 variable with reference to severity of impact in your company based on the explained seven-point severity scale where 1= no problem, and 7= critical problem. The scale was tested and validated in previous studies (Wang, 2018, Wang et al., 2020a, Wang et al., 2014). Five measurement items were newly

created to assess the impacts of COVID-19 on supply chains. A total of 19 questionnaire items (for details on each item in the model, see Table 2) were adopted to measure the constructs in this study.

Table 2. The measurement items with reliability (n=203)

<i>Construct</i>	<i>Measurement Items</i>	<i>Cronbach's alpha</i>	<i>Average extracted variance (AVE)</i>	<i>Composite reliability (CR)</i>
<i>Supply Chain Agility (SCA)</i>	(SCA1) Our company is capable of Joint planning with suppliers in purchasing, production and logistics.	0.91	0.70	0.93
	(SCA2) Our company is capable of responding suppliers and customer's request at a fast speed			
	(SCA3) Our company is capable of adjusting production / service capacity/capability			
	(SCA4) When unexpected situation arises, our company and the supplier would solve problems adequately.			
	(SCA5) When unexpected situation arises, our company is capable of reconfiguring operations process to adapt the changes			
	(SCA6) When disagreement arises in transaction process, our company and the supplier would re-evaluate the ongoing situation to achieve mutual-satisfied solution.			
<i>Supply chain Relationships (SCR)</i>	(SCR1) In our company, we believe interpersonal relationship is very important in doing business	0.82	0.72	0.89
	(SCR2) In our company, we believe inter-firms' relationship is very important in doing business			
	(SCR3) In our company, we believe long term relationship is very important in doing business			
<i>Sustainability (S)</i>	(S1) Our company has a strong profitability	0.86	0.65	0.90
	(S2) Our company has a high level of employee job satisfaction			
	(S3) Our company has reputation in the industry			
	(S4) Our company is a socially responsible business			
	(S5) Our company is an environmentally friendly business			
	(IC1) Impacts of Covid-19 Pandemic in your organization - Covid-19	0.90	0.70	0.92

Impacts of COVID-19 (IC)	pandemic affects our markets / customers			
	(IC2) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our internal business operations			
	(IC3) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our supply / suppliers			
	(IC4) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our logistics operations			
	(IC5) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our company financial performance			
Acceptable level		≥ 0.70	≥ 0.50	≥ 0.70

4.4 Factor Analysis

Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are performed in the study. Prior to performing the exploratory factor analysis (EFA), we have used SPSS to determine the KMO measure of sampling adequacy and conduct the Bartlett Test for Sphericity. Table 3 shows the results for KMO and Bartlett's Test. Kaiser-Meyer-Olkin value was 0.872, greater than the threshold of 0.6 and statistical significance value of 0.000 for Bartlett's Test of Sphericity (Fabrigar, 2012).

Table 3 KMO and Bartlett's Test (n=203)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.878
Bartlett's Test of Sphericity	Approx. Chi-Square	2527.932
	df	171
	Sig.	.000

EFA was performed to explore and ensure the underlying factors in line with the theoretical constructs (Hair, 2010), so EFA can enhance the reliability and validity of the study. The four scales were analysed in this study. Principal component analysis and varimax rotation

is used to examine their construct validity (Fabrigar, 2012). Items with poor factor loadings or cross loadings have been removed. The number of underlying factors is determined by Kaiser's criterion, which suggests retaining the factors that are above the eigenvalue of 1. All remaining factors explain 70.4% of variance in the data. Then, CFA using the partial least squares (PLS) technique is employed to test reliability and validity (Table 2). Table 4 illustrates the factor analysis results with the factor loadings of all measurement items. The factor analysis results show that all measurement items of constructs including supply chain agility, supply chain relationships, sustainability, and impact of COVID-19 on supply chain are nicely grouped to their own constructs. In sum, Table 4 presents those 6 measurement items of supply chain agility (SCA), including the Joint planning, responsiveness, flexibility, adaptation, reconfiguration and problem solving capability; 3 measurement items of supply chain relationships (SCR), including interpersonal, inter-firms and long term relationship; 5 measurement items of sustainability (S), assessing the sustainability from the triple bottom line: financial (profitability), social and environmental impacts; 5 measurement items of the impacts of COVID-19 on supply chains (IC), measuring the impacts of Covid-19 Pandemic in the organization in terms of demand (markets / customers), control (internal business operations), supply / suppliers, logistics operations and financial performance.

Table 4. Exploratory Factor Analysis

	Construct			
	SCA	IC	S	SCR
SCA5	.824			
SCA2	.762			
SCA4	.760			
SCA3	.754			
SCA6	.754			
SCA1	.736			
IC3		.873		
IC4		.871		
IC2		.843		
IC5		.822		
IC1		.811		
S4			.775	
S3			.726	
S1			.683	
S2			.680	
S5			.671	

SCR1	.842
SCR2	.805
SCR3	.670

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

- a. Rotation converged in 5 iterations.

5. Model testing

5.1 Validity and reliability

Convergent validity is a type of construct validity. It represents the measures relate to each other with respect to a common concept, and is established by having significant factor loadings (Anderson, 1984). Some results were presented in the previous factor analysis. Item measures with poor loadings and insignificant factor loadings in the model testing were removed from the scales. We used the SmartPLS software to test the first order latent construct validity and reliability in the structural model. All constructs' validity and reliability were established based on Cronbach's Alpha above the threshold of 0.7. Average Variance Extracted (AVE) above the threshold of 0.5, Composite Reliability (CR) greater than the threshold of 0.7. Factor loadings above the threshold of 0.7. Figure 2 shows all factors loading for the constructs in the research model.

Discriminant validity is established if the square root of the AVE is higher than the pairwise correlations for each construct of the measurement model (Hair et al., 2020, Fornell and Larcker, 1981). Table 5 indicates the discriminant validity results of the constructs and shows that discriminant validity was established. We also tested common method bias in the process of the factor analysis; the Harman single-factor test, which is a most widely used techniques to address the common method bias, was conducted for this study (Podsakoff et al., 2003). The result show that the total variance extracted by a single factor is 32.720% and it is less than the threshold of 50%. We didn't find any common method bias in the study.

Table 5 Discriminant validity

	COVID-19	SCA	SCR	Sustainability
COVID-19	0.841			
Supply Chain Agility	-0.055	0.836		
Supply Chain Relationships	-0.018	0.573	0.851	
Sustainability	-0.196	0.689	0.528	0.803

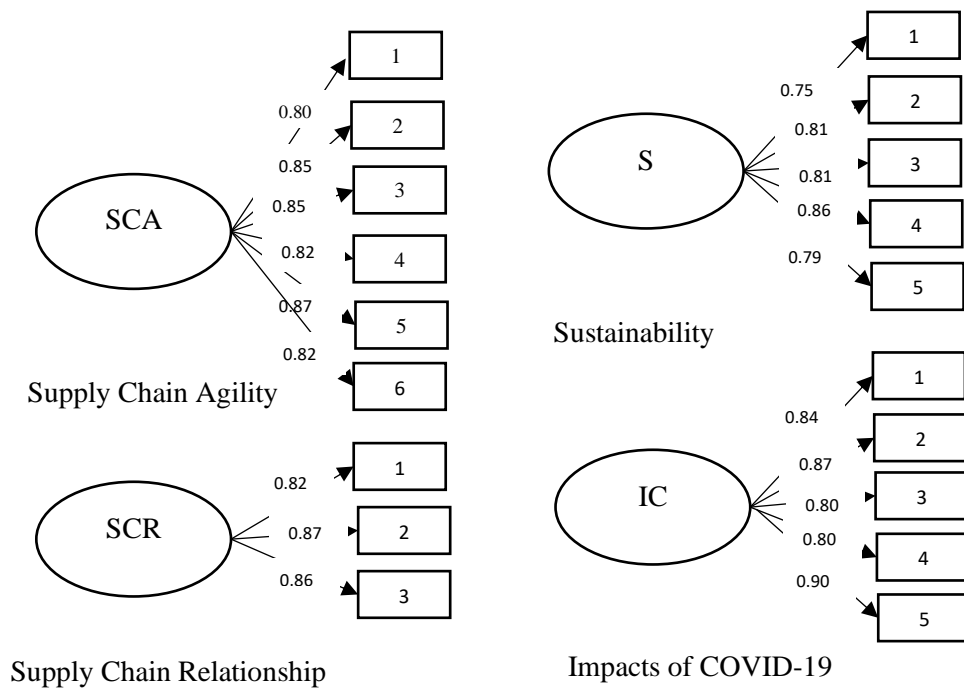


Figure 2. Measurement Models

Note: Standardized factor loadings are shown in the measurement models.

5.2 Mediation analysis

Mediation analysis is conducted to better understand a relationship between an independent variable and a dependent variable by investigating the underlying mechanism through a mediator. Table 6 presents the results of the mediated regression analysis in this study. In model 1, the dependent variable, supply chain relationships, was regressed as the mediator on the antecedent, supply chain agility. The model 1 was statistically significant,

supply chain agility accounting for 31.3% of the variance in supply chain relationships. Coefficients for supply chain agility ($\beta=0.560$) was statistically significant ($p\text{-value} < 0.05$) and in the predicted positive directions. In model 2, sustainability was regressed on the predicted antecedent, supply chain agility. This independent variable accounted for 47.3% of the variance in sustainability. Regression coefficients for supply chain agility ($\beta=0.688$) was statistically significant and in the expected positive direction. We added the mediator supply chain relationships construct to the regression model 3, the variance explained by the data increased to 50.2%. The revised model and the supply chain relationships coefficient ($\beta=0.204$) were both statistically significant ($p\text{-value} < 0.05$). Not surprisingly, the coefficient for supply chain agility decreased (from 0.688 to 0.574) because of the mediation effect of supply chain relationships. This implies that supply chain relationships partially mediate the relationship between supply chain agility and sustainability performance. The results also support hypotheses H1, H2 and H3.

The Sobel test is used to determine whether a variable mediates the effect of an independent variable to the dependent variable. The Sobel test was conducted to confirm whether or not supply chain relationships mediates the effect of supply chain agility to sustainability. In the model, unstandardized coefficients direct effect between supply chain agility and supply chain relationships $a = 0.58$ std. error = 0.061; unstandardized coefficients direct effect between supply chain relationships and sustainability $b = 0.21$ std. error = 0.062; unstandardized coefficients direct effect between supply chain agility and sustainability $c = 0.615$ std. error = 0.065, indirect effect between supply chain agility and sustainability via the mediator $a * b = 0.122$. Sobel test results show the indirect effect of the supply chain agility on the sustainability via the mediator supply chain relationship is statistically significant (Test statistic = 3.19 $p\text{-value} < 0.05$, std. error = 0.038). We can conclude the presence of partial mediation effect with supply chain relationships as a mediating variable in the model. Table 7 presents the results of Sobel test.

Table 6. Mediated regression analysis

	Model 1	Model 2	Model 3
	Supply chain	Sustainability	Sustainability
	relationships		
<i>Predicted antecedent</i>			
Supply chain agility	0.560*	0.688*	0.574*

<i>Mediator</i>			
Supply chain relationships			0.204*
F	91.748*	180.702*	100.755*
R ²	0.313	0.473	0.502
Adjusted R ²	0.310	0.471	0.497

* Coefficients statistically significant at $p \leq 5\%$.

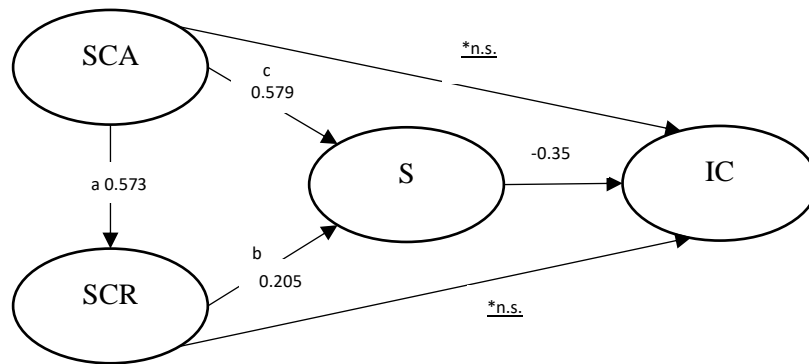
Table 7. Sobel test

Parameter	Value	Note	Results
a	0.58	The unstandardized regression coefficient for the relationship between the independent variable and the mediator	<i>Sobel test statistic:</i> <u>3.19069</u> <i>One-tailed probability:</i> <u>0.00070</u> <i>Two-tailed probability:</i> <u>0.00142</u>
b	0.21	The unstandardized regression coefficient for the relationship between the mediator and the dependent variable.	
SE _a	0.061	The standard error of the relationship between the independent variable and the mediator.	
SE _b	0.062	The standard error of the relationship between the mediator variable and the dependent variable.	

5.3 Path model

The path analysis is conducted to test the hypotheses and estimate the path model. We tested all possible paths in the initial model. The results show that not all relationship paths were statistically significant. This is understandable, as this was an exploratory study to investigate and understand the relationships between supply chain agility, supply chain relationship, sustainability and impacts of COVID-19 on supply chain in the post COVID-19 world. The insignificant paths were removed from the research model. The overall goodness-of-fit indices indicate that the path model is acceptable, this was done by checking the estimated coefficient (Hair et al., 2012). Figure 3 presents a path model **with standardized path coefficients in this research**.

The hypotheses testing was performed in the path model validating. All proposed hypotheses were tested in this empirical study. Table 8 present **standardized** path coefficients and hypotheses testing results. Supply chain agility has a significant relationship with supply chain relationships, besides both supply chain agility and supply chain relationships are significantly linked to sustainability including economic, social, and environmental performance, while sustainability shows a significant relationship with impacts of COVID-19 on supply chains. Thus, the empirical results from the Emirates' organisations support hypotheses, H1, H2, H3, and H4. However, insignificant relationships were found between the supply chain agility and the impacts of COVID-19 on supply chains (H5); and between the supply chain relationships and the impacts of COVID-19 on supply chains (H6) in this study. The research was conducted in 2021 during the COVID-19 pandemic, perhaps many companies were still exploring ways to deal with the pandemic, or the empirical data did not well reflect the phenomenon. Having said that, these insignificant relationships may provide directions for future post COVID-19 research. Researchers may test the constructs to validate the models in different contexts.



Notes: standardized path coefficients are shown in the path model, *n.s. = not significant

Figure 3. Path model results

Note: Standardized coefficients are shown in the path model.

Table 8 Path coefficients

<i>Path</i>	<i>Hypothesis</i>	<i>Sample mean</i>	<i>St. Dev.</i>	<i>T-Value</i>	<i>P Value</i>	<i>Notes</i>
<i>Supply Chain Agility -> Sustainability</i>	<i>H1</i>	0.579	0.077	7.426	0.000	<i>Support</i>
<i>Supply Chain Agility -> Supply Chain Relationships</i>	<i>H2</i>	0.573	0.067	8.564	0.000	<i>Support</i>
<i>Supply Chain Relationships -> Sustainability</i>	<i>H3</i>	0.205	0.075	2.652	0.008	<i>Support</i>
<i>Sustainability -> Impacts of COVID-19</i>	<i>H4</i>	-0.350	0.089	3.868	0.000	<i>Support</i>
<i>Supply Chain Agility -> Impacts of COVID-19</i>	<i>H5</i>	0.106	1.015	1.015	0.311	<i>Not Support</i>
<i>Supply Chain Relationships -> Impacts of COVID-19</i>	<i>H6</i>	0.146	0.082	1.791	0.074	<i>Not support</i>

5.4 Multigroup analysis

We conducted a multigroup analysis to better understand and verify the relationships in the model. According to industry classification, we divided the sample into two groups, service industry companies (n=121) and non-service industry companies (n=82), the service industries

including tourism and hospitality, educational services, healthcare and pharmaceuticals, transportation and warehousing, finance and insurance, public administration and other services, the non-service industries including oil & gas, construction, manufacturing, and trading. The first group contains 121 service industry companies, and the second group contains 82 non-service industry companies. Bootstrapping was applied to test the differences in the multigroup analysis. Table 9 shows the multigroup analysis results. We could not identify any significant difference between service industry companies and non-service industry companies in this model.

Table 9: The multigroup analysis results

Path	Path Coefficients - diff (service – non-service)	P-value (service vs non-service)	Notes
Supply Chain Agility ->	0.157	0.325	Insignificant
Sustainability Supply Chain Agility ->	-0.025	0.838	Insignificant
Supply Chain Relationships Supply Chain Relationships ->	-0.165	0.283	Insignificant
Sustainability Sustainability -> Impacts of COVID-19	0.188	0.553	Insignificant
Supply Chain Agility -> Impacts of COVID-19	0.013	0.925	Insignificant
Supply Chain Relationships -> Impacts of COVID-19	-0.063	0.739	Insignificant

6. Discussion and Conclusion

This paper presents an empirical study about the interactive effects between supply chain agility, sustainability, supply chain relationships and impacts of COVID-19 in the post COVID-19 environment on CIPS members in the UAE. Most likely, COVID-19 virus will not go away easily, while our society may still need to face new virus in the future. The COVID-19 crisis provides empirical research opportunities to understand the phenomenon and revisit concepts and mitigation strategies for supply chain management. Although many supply chain studies addressed COVID-19 problems, very few empirical studies have been carried out on managing the impacts of COVID-19 pandemic on supply chains post COVID-19. Besides, companies must find and understand some feasible strategies to respond similar situations in the future. This study is both exploratory and confirmatory. It attempts to develop novel insights about the role of firm sustainability in the post COVID-19 era and test supply chain agility as antecedent of firm sustainability. A structural equation modelling technique is used to explore and confirm the structural relationships.

Supply chain agility is a critical supply chain capability to enable agile supply chains strategy, which is considered strategic for supply chain competitiveness (Christopher and Towill, 2001). Supply chain agility offers a set of supply chain activities to gain value and achieve agility in the turbulent international business environment (Shams et al., 2021). Sustainability is important to the supply chain management, as it does not only improve productivity or save money, but also respond to pressure from various stakeholders in a long run (Seuring et al., 2008). More importantly, the pursuit of sustainability is increasingly recognised as an effective strategy to deal with the contemporary challenges facing global supply chains (Giannakis and Papadopoulos, 2016). Supply chain often contains multiple stakeholders and parties, and the supply chain relationship is a key component in supply chain management to facilitate the physical goods, information, and financial flows between the supply chain partners and integrate the supply chain systems.

Since the first COVID-19 breakout, COVID-19 pandemic has become the new normal, based on the contingency theory, we considered COVID-19 pandemic as a supply chain uncertainty in this study. To measure the impacts of COVID-19 is not an easy task, as researchers may assess the impacts of COVID-19 from different perspectives, the supply chain literature provides a variety of effects that company may experience during COVID-19

pandemic (Chopra et al., 2021; Paul et al., 2021). Each region may face different challenges. This study introduces a new construct for assessing the impacts of COVID-19 on supply chains across industries. Five items were developed to measure the impacts of COVID-19 on supply chains. (IC1) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our markets / customers; (IC2) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our internal business operations; (IC3) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our supply / suppliers; (IC4) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our logistics operations; (IC5) Impacts of Covid-19 Pandemic in your organization - Covid-19 pandemic affects our company financial performance. Supply chain agility construct and supply chain relationships were measured by adopting the previous measurements (Kim and Chai, 2017, Swafford et al., 2006, Wang et al., 2021). Sustainability scale was developed and measured by the five validated performance items, such as profitability, employee job satisfaction, reputation, social responsibility, and environment friendly. All the measurement models have been validated by rigorous research procedures in this study.

6.1 Theoretical implications

Based on the dynamic capability theory and contingency theory, the model incorporates supply chain agility and supply chain relationships that link firm sustainability in supply chains to mitigate the impacts of COVID-19 pandemic. Although supply chain agility, supply chain relationships and sustainability has been extensively studied at the firm level, the empirical evidence of the impact of COVID-19 at the firm level is limited and inconclusive. The impact of COVID-19 is viewed as an environmental uncertainty, according to the contingency theory, organisations must adapt and respond to environmental circumstances (i.e. COVID-19 pandemic) (Morgan, 2006). This study revisits the concepts of supply chain agility, supply chain relationships and sustainability in the post COVID-19 era. The findings support that the superior resources (i.e. supply chain relationships) and dynamic capability (i.e. supply chain agility) can be adopted to adapt to environmental circumstances. Path model results reveal that supply chain agility does not only enhance sustainability, but also facilitate the supply chain relationships including interpersonal, inter-firm, and long-term business partnership, while sustainability mitigates the impacts of COVID-19 on supply chains. This may extend dynamic capability theory into the contingency theory, the dynamic capability approach is not only

applicable to the COVID-19 pandemic, but it can also be used if there is similar situation (i.e. supply chain disruptions) in the future. The mediated regression analysis results show the indirect effect of the supply chain agility on the sustainability via the mediator supply chain relationship is statistically significant.

The aforementioned discussion shows that investing in supply chain agility could add value to sustainability transformations. However, more agility is not always better. Sarkis (2021) argue that agility in supply networks will likely mean building redundant capacity and capabilities. Redundancy results in wasted resources and energy. This study finds that building supply chain relationships may also help the sustainability transformations in supply chains. This may provide alternative directions for managing sustainability in the post COVID-19 era.

6.2 Managerial implications

Conventionally, forming collaborative supply chain relationships and improving supply chain agility can be viewed as strategies for improving resilience (Tukamuhabwa et al., 2015). Resilience is one of the important components for achieving the wider sustainability (Miceli et al., 2021). The study confirms that companies need to improve supply chain agility and build sustainability to mitigate the impacts of COVID-19 on supply chains in the post COVID-19 environment. Since collaborative decision-making can positively impact the company's performance (Lai et al., 2020), managers may pay attention to building collaborative supply chain relationships to enhance the sustainability, which may also help companies to mitigate the impacts of COVID-19 on supply chains. The collaborative supply chain relationships may include interpersonal, informal inter-firm and long-term relationships. According to our empirical results, the supply chain agility does not only refer to the responsiveness and flexibility with both suppliers and customers, but also contain problem-solving ability, for example: when unexpected situation arises, our company and the supplier would solve problems adequately (SCA4). Quick responsiveness flexibility and problem-solving ability may be applied for supplier selection criteria post COVID-19. Moreover, we found that supply chain relationships partially mediated the relationship between supply chain agility and sustainability performance. This implies that managers could utilise supply chain relationships as a tool to mediate the relationship between supply chain agility and sustainability. Adding supply chain agility is costly, managers also must consider how much agility their companies and supply chains need to be helpful for businesses, and their supply chain strategies must

support overall business objectives. The service industry companies, and non-service industry companies were tested in the multigroup analysis, the results show there is no significant difference between groups. This may affirm that the COVID-19 has caused similar supply chain disruptions across industries, and the research findings can be applied to both service industry companies, and non-service industry companies.

6.3 Limitations and Future research

This study contains the limitations. The proposed model does not focus on specific industry or sector, the empirical data was collected from the organisations in the UAE. This may limit the generalisation; the model could be validated in different contexts. This study explores the relationships among the constructs in post COVID-19 business environment, and firstly assess the impacts of COVID-19 on supply chains in the UAE. Because the direct impact of supply chain agility and supply chain relationships on the impacts of COVID-19 was insignificant in this study, the two factors may be unable to mitigate the impacts of COVID-19 on supply chains directly. Since serious consequences from COVID-19 on different supply chains have not yet been fully reflected in the company's operations, managers may still seek the ways to deal with the impact of COVID-19 on their supply chains. However, we find that the companies with better firm sustainability may lead to weaker impacts of COVID-19 on their supply chains. These limitations may provide directions for future research. Such as the new measurement models can be validated in different industries or sectors to further understand the phenomenon. Moreover, future research needs to explore additional supply chain capabilities, and revisit more concepts, such as a model that uses changes in antecedents (dynamic capabilities) and/or changes in consequence (performance) may yield more interesting results post COVID-19.

Acknowledgements

The authors would like to express their gratitude to all survey participants in this project. We would also like to thank the anonymous reviewers for their constructive comments and suggestions towards improving the manuscript.

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