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Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19

Ipek Kazancoglu [a], Melisa Ozbiltekin-Pala [b,*], Sachin Kumar Mangla [c], Yigit Kazancoglu [b], Fauzia Jabeen [d]

[a] Ege University, Faculty of Economics and Administrative Sciences, Department of Business Administration, Izmir, Turkey
[b] Yasar University, Logistics Management Department, Yasar University, İzmir, Turkey
[c] Research Centre on Digital Circular Economy for Sustainable Development Goals (DCE-SDG), Jindal Global Business School, O P Jindal Global University, Haryana, India
[d] College of Business, Abu Dhabi University, Abu Dhabi, United Arab Emirates

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ABSTRACT

Supply chains are gradually transforming into more global structures. To ensure sustainability and resilience in face of the problems that arise in globalizing supply chains, it is becoming an important issue today; a supply chain must be flexible, agile and responsive. Therefore, the aim of the study is to focus on resilience in sustainable global supply chains (GSC) to avoid disruptions caused by pandemics such as COVID-19; it is also conducted research on responsiveness of sustainable global supply chains during COVID-19. In this study, dynamic capability perspective and contingency theory are used to conceptualize theoretical models for COVID-19. Moreover, a partial least squares (PLS) model is used to analyse the research hypotheses with 200 responses collected from companies which have complex supply chain structures. As a novel result, the relationship between flexibility, agility and responsiveness of global supply chain is revealed. Supply chain agility is found to be directly affected by supply chain flexibility. Moreover, supply chain flexibility and supply chain agility directly affect the responsiveness of the global supply chain. In addition, the agility of the supply chain acts as a partial mediator variable in the effect of supply chain flexibility on responsiveness.

1. Introduction

The world has had to cope with various disasters such as natural disasters, epidemics and chemical explosions over the years (Kumar and Chandra, 2010). These disasters disrupt human life and the functioning of countries (Ivanov, 2020a; Mitręga and Choi, 2021). Nowadays, the whole world, faced with COVID-19, has seen this disaster causing many problems in the context of operations management in supply chains (Tirkolaee et al., 2022). According to research, it is revealed that COVID-19 (Lee and Trimi, 2021), which started in the Chinese city of Wuhan, is one of the biggest global health epidemics that human beings face (Deloitte et al., 2020).

In order to stop the pandemic, measures such as closing factories and banning travel between countries have been taken (Ivanov, 2020a). With the size of the pandemic and all the measures taken, disruptions occur at each stage of global supply chains (GSCs), from production to consumption worldwide (Sarkis et al., 2020). Problems have arisen such as raw material delays, increases in logistics costs (Golroudbary et al., 2019), stoppage of production, decrease in demand in markets (Hossain et al., 2021), problems in import and export processes and changes in customer demands (Chakraborty and Maity, 2020). All these problems that arise negatively affect the resilience (Bak et al., 2020) and sustainability of the GSCs of companies (Chowdhury et al., 2021). However, there are three important concepts, which are responsiveness, flexibility and agility that need to be addressed if GSCs are to be resilient and sustainable.

The responsiveness of companies in their GSC structures shows how they can react to sudden disruptions and cope with the situation (Azaron et al., 2021). GSCs are accepted as the backbone of a country's economy throughout the world (Edwin Cheng et al., 2021). Therefore, firms have to develop responses to problems that occur in GSC structures. The resources of the firm, the strategy followed and the firm's flexibility

* Corresponding author.
E-mail addresses: ipek.savasci@ege.edu.tr (I. Kazancoglu), melisa.ozbiltekin@yasar.edu.tr (M. Ozbiltekin-Pala), sachinmangl@gmail.com, smangla@jgu.edu.in (S. Kumar Mangla), yigit.kazancoglu@yasar.edu.tr (Y. Kazancoglu), fauzia.jabeen@adu.ac.ae (F. Jabeen).

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structure must maintain its survival and ensure long term sustainability (Sarkis et al., 2020; Awan et al., 2021). Responsiveness in GSCs is considered as one of the main issues to ensure resilience of the GSC (Rajesh, 2021). Moreover, in these days, sustainability concerns became extremely important in GSCs (Thakur and Mangla, 2019; Anser et al., 2020a). Sustainability of GSCs is now accepted as directly linked with responsiveness and resilience of GSCs (Burgos & Ivanov, 2021; Fatorachian and Smith, 2022). Therefore, it is essential to discuss the importance of GSC responsiveness to preserve resilient and sustainable GSCs against unexpected disruptions.

Agility in a GSC enables the adoption of different policies in the face of sudden changes. In cases where agility is present in the GSC, improvements in GSC performance occur (Li et al., 2022). In addition, flexibility in GSCs makes it easier to find new solutions to preserve the resilience and sustainability of GSCs in the face of events such as COVID-19 (Sriyanto et al., 2021). Since technological innovations increase flexibility in a GSC, these can keep the problems that companies will experience in the face of sudden disruptions to a minimum level (Anser et al., 2020b).

Hence, research questions are given as follow:

- ***Research Question 1:*** **What is the relation between flexibility and agility in companies' sustainable GSCs during COVID-19?**
- ***Research Question 2:*** **What is the impact of agility and flexibility on responsiveness in firms' sustainable GSCs during COVID-19?**
- ***Research Question 3:*** **Is agility a mediator variable in the relationship between flexibility and responsiveness during COVID-19?**

This study aims to focus on the ability of resilience in sustainable GSCs to avoid or cope with the disruptions faced during pandemics such as COVID-19; it is also aimed to conduct research on the responsiveness of sustainable GSCs during COVID-19. The study is based on the dynamic capability perspective and contingency theory. Dynamic capabilities are defined as the external and internal capabilities to deal with the rapidly changing environment of the company (Best et al., 2021; Chatterjee et al., 2022); this also provides competitive advantage for a company (Weaven et al., 2021; Bhupendra and Sangle, 2022). The contingency theory advocates that the risks in institutions should be distributed, structures should become more flexible (Liang et al., 2022) allowing decisions to be made more quickly in unexpected situations (Brandon-Jones et al., 2014). Hence, implementation of these theories can provide more resilient and sustainable GSCs (Weaven et al., 2021).

As previously mentioned, especially in times of disruption, to provide a resilient and sustainable GSC, it is essential to have an agile (Awan et al., 2021), flexible and responsive GSC structure (Nayeri et al., 2021; Oliveira-Dias et al., 2022). Therefore, the main motivation of the study is to identify relationships between sustainable GSC flexibility, sustainable GSC agility and sustainable GSC responsiveness to ensure resilient GSCs against unexpected disruptions such as COVID-19. An examination of these concepts in GSCs will make a theoretical contribution to contingency theory and dynamic capability perspective. One of the main contributions of the study to existing literature is to be able to define which concepts, such as agility, flexibility and responsiveness, affect each other and directly affect sustainability in GSCs and to reveal the relationships between these concepts in the context of dynamic capability and contingency theory. In order to have sustainable and resilient GSCs, it is necessary to focus on the concepts of "flexibility" and "agility" within the concept of "responsiveness" from the perspective of dynamic capabilities and contingency theory. Unlike other studies, examining the resilience, agility and responsiveness concepts of GSCs together to maintain their resilience and sustainability is a unique contribution, filling a research gap in existing literature.

In order to provide answers to the research questions, one of the objectives of the study is to analyse the relationship between flexibility and agility in companies' sustainable GSCs during COVID-19. A second objective of the study is to analyse the impacts of agility and flexibility on responsiveness in firms' sustainable GSCs during COVID-19. The last objective is to answer the question of whether it is variable agility that mediates the relationship between flexibility and responsiveness during the COVID-19 pandemic from the perspective of dynamic capability and contingency theory. In order to answer these research questions, a detailed literature review about sustainable GSC flexibility, agility and responsiveness and the relationships between resilience of sustainable GSCs was completed. A hypothesis is developed in line with these terms. Exploratory factor analysis and Structural Equation Modelling are implemented to answer these research questions. It is aimed to analyse the relationships between the methods applied in the study on flexibility, agility and responsiveness and the relationships to each other. bib_Kumar_and_Kumar_Singh_2021.

In Section 2, a detailed literature review on dynamic capability and contingency theory, the relationships between resilience and responsiveness of GSCs, sustainable GSC flexibility, sustainable GSC agility and sustainable GSC responsiveness is conducted. Section 3 includes hypothesis development with Section 4 covering research methodology. This is followed by the findings and results, discussion and implications, and finally conclusion.

2. Theoretical background

The literature review consists of dynamic capability and contingency theory, resilience in sustainable GSC, sustainable GSC flexibility, sustainable GSC agility and sustainable GSC responsiveness. Firstly, dynamic capability and contingency theory are explained.

2.1. Dynamic capability and contingency theory

Dynamic capabilities represent the high-level, strategic capabilities of enterprises, institutions and organizations related to innovation and change beyond their ordinary skills necessary to carry out their routine activities (Bahrami and Shokouhyar, 2021). Dynamic capability theory provides agility and flexibility in the face of sudden disruptions, especially for global companies and GSC structures (Chatterjee and Chaudhuri, 2021). When supply chain operations or company processes need to change suddenly in the face of disruptions, learning and developing new processes increases the resilience of supply chains (Ramos et al., 2021).

Contingency theory argues that everything, supply chain processes and organizations, has uncertainty (Dubey et al., 2021a). For this reason, the theory accepts that the best changes are made according to each situation (Chatterjee and Chaudhuri, 2021). Therefore, in the face of sudden disruptions such as COVID-19, the state of being the best in terms of processes and operations suddenly changes (Parajuli et al., 2020). Applying contingency theory provides an understanding of how and when innovation can be achieved in GSCs (Chatterjee and Chaudhuri, 2021). In this way, it ensures that improvements or changes can be made in operations according to existing processes and conditions; this makes GSCs agile, flexible and responsive (Dubey et al., 2021a; Thakur, 2021).

In summary, these theories ensure that supply chains are resilient and sustainable, especially in the face of sudden disruptions such as COVID-19 (Abdelilah et al., 2021). In addition, dynamic capability and contingency theory are the basis of supply chains being flexible, agile and responsive (Manzoor et al., 2021). For this reason, this study is based on dynamic capability and contingency theory as a theoretical basis. In the following section, resilience in sustainable GSCs is explained in detail.

2.2. Resilience in sustainable GSCs

Recently, GSCs have become more complex in the globalizing world (Schniederjans et al., 2020). In this complex environment, ensuring the

resilience and sustainability of GSCs has become one of the most important issues (Kumar and Kumar Singh, 2021). There are many factors that affect sustainability and resilience of GSCs, such as suppliers, capacity and manufacturing processes (Gölgeci and Kuivalainen, 2020; Wong et al., 2020; Liu et al., 2021). Sudden changes or unexpected events, such as COVID-19, occurring in global GSCs affect the sustainability and resilience of GSCs (Majumdar et al., 2020; Fan et al., 2021). Issues arising during COVID-19 have revealed the importance of the resilience of GSCs (Singh et al., 2021). The resilience of GSCs determines how flexible, agile and responsive GSCs can be in the face of sudden disruptions (Singh et al., 2021).

According to research, flexibility in GSCs also affects GSC resilience (Pettit et al., 2013). Alternative supplier choices and flexibility in operations affect the sustainability and resilience of GSCs in a complex environment (Tukamuhabwa et al., 2015; Awan, 2019). It is also one of the factors that enable GSCs to respond quickly, an indicator of responsiveness of GSCs (Pettit et al., 2013) in the context of the dynamic capability perspective and contingency theory. From another point of view, flexibility and speed come to the fore in order to ensure agility in GSCs (Chiang et al., 2012; Gligor and Holcomb, 2012; Li et al., 2022). Flexibility is one of the most important requirements for agility (Ivanov, 2020b). Swafford et al. (2008) stated positive relations between GSC flexibility and GSC agility in their experimental studies.

As a result of these explanations, responsiveness and resilience of GSCs are related with each other (Kahiluoto et al., 2020) from the perspective of dynamic capability and contingency theory. The responsiveness of the GSC enables the company to prepare recovery plans in the face of sudden events and to respond quickly to changes (Khan, 2020). Effective management of the process in global GSCs, rapid decision-making and rapid response in operations increase resilience in GSCs (Raut et al., 2021). Therefore, it can be stated that the more responsive the GSC structure of an organization, the more resilient is the GSC (Sabahi and Parast, 2020). Hence, having a resilient GSC is crucial to analyse the responsiveness of the GSC (Wong et al., 2020).

When the concepts of flexibility, responsiveness and agility discussed in the study are integrated with each other, it is thought that they have an impact on the resilience and sustainability of the GSC. Although the integration of the three concepts has been discussed in literature, these concepts should be examined together in order to assess the resilience and sustainability of a GSC. To sum up, it is necessary to examine the concepts of "flexibility" and "agility" within the concept of "responsiveness" (Sukati et al., 2012) to have sustainable and resilient GSCs from the perspective of dynamic capability and contingency theory; this is a gap in current literature. This point of view constitutes the uniqueness of the study. In other words, responsiveness directly affects resilience of sustainable GSCs. Therefore, the literature review of the study is explained under three headings - "sustainable GSC flexibility", "sustainable GSC agility" and "sustainable GSC responsiveness". Firstly, sustainable GSC flexibility is discussed.

2.3. Sustainable GSC flexibility

Change is inevitable in today's risky business environments with volatile GSCs (Dey et al., 2022; Khan et al., 2022). This situation threatens the sustainability of GSCs (Yang et al., 2021). Flexibility is a concept that arises from the need to decrease the adverse effects of uncertainty and risks in GSCs (Liao, 2020). Flexibility in the GSC is identified as the capability of a GSC to be resilient, to react and to change in order to meet changes in market demand (Delic and Eyers, 2020).

Flexibility in the GSC provides benefits such as responding to and meeting demand changes such as seasonality, poor production periods, poor supplier performance, poor delivery performance and responding to new products, new markets or new markets (Katsaliaki et al., 2021). Chirra et al. (2020) defined the biggest obstacle in ensuring the flexibility of GSCs as the purchasing function of the GSC.

Sustainable GSC flexibility enables GSCs to be responsive to sudden disruptions and changes in GSCs (Qrunfleh and Tarafdar, 2013; Sundgren, 2022) by considering dynamic capability and contingency theory. As more flexible GSCs can react quickly to unexpected disruptions, they are also increasingly agile, sustainable and resilient (Katsaliaki et al., 2021). For these reasons, it is essential to handle "sustainable GSC flexibility" when considering "sustainable GSC responsiveness" (Kim et al., 2013).

2.4. Sustainable GSC agility

Another important concept for investigating responsiveness in GSCs is "agility". The role of a GSC is not only to ensure that the business has the appropriate supply of raw materials to produce the final product, but also to ensure that the broader business is agile enough to meet customer demands (Naughton et al., 2020). Agility in GSCs means how quickly a GSC reacts to changes in customer preferences, environment and competitiveness (Kumar et al., 2018). Agility is a measure of how firms adapt their GSCs to these changes and then how quickly they can do it (Gligor et al., 2020).

According to another definition, GSC agility is the capability of a firm to respond smoothly and profitably to foreign market changes (Nandi et al., 2021) in the context of dynamic capability and contingency theory. Shekarian et al. (2020) found that when there are changes in flexibility and agility against sudden disruptions, GSCs will lead to a development in the responsiveness of GSCs. Moreover, an agile, sustainable GSC is a response to rapidly changing segmented markets (Mukhsin et al., 2022). Therefore, this term is also related with the responsiveness of sustainable GSCs (Nandi et al., 2021). Sustaining GSC agility depends on companies proactively responding to risks (Rehman et al., 2020).

Integration enables business stakeholders to participate in the competencies needed to be able to deliver. In order to be resilient and sustainable against the problems occurring in GSCs, the responsiveness, flexibility and agility of the GSC must be analysed together (Carvalho et al., 2012). As stated earlier, the COVID-19 pandemic has led to sudden changes in GSCs. When the responsiveness, flexibility and agility of GSCs can be integrated with each other, companies can ensure their sustainability. Therefore, in this study, sustainable GSCs of companies are discussed in order to determine the responsiveness dimensions of those companies affected during the COVID-19 period.

2.5. Sustainable GSC responsiveness

Responsiveness of GSCs belonging to different sectors to sudden disruptions/events has become an issue that needs to be investigated given the epidemic that the world faces today (Belhadia et al., 2020). The definition of "responsiveness" continues to change over time in literature. Kritchanchai and McCarthy (1999) defined the concept of "responsiveness" as the use of firm information and stimuli to cope with market conditions, to meet customer needs and to prevent environmental uncertainties and to respond to requests. From another point of view, "responsiveness" is identified as the ability to understand market conditions in advance and respond on time (Catalan and Kotzab, 2003; Huo et al., 2021). Garrett et al. (2009) made the definition of being able to adapt rapidly to a competitive environment in line with changing market needs. According to Zhou et al. (2019), "responsiveness" is the capability to define and respond to fluctuations in market opportunities. According to Khan (2020), "responsiveness" in companies is defined as the ability to produce answers to the problems or situations faced by enterprises.

Due to the COVID-19 pandemic, the responsiveness of company SCs has become an important issue. It is seen that companies that can react quickly and keep up with sudden changes can maintain their continuity, while others face difficulties (Wong et al., 2020; Shou et al., 2021). Moreover, given the definition of "responsiveness", it is necessary to examine the concept of "responsiveness of the GSC", the main subject of

the study. From the perspective of dynamic capability and contingency theory, the "responsiveness of the GSC" is defined by the supplier's ability to quickly respond to needs of the purchasing party (Handfield and Bechtel, 2002). From another point of view, it is considered as the capability of a firm's SC to respond quickly to fluctuations in the habits of customers (Qrunfleh and Tarafdar, 2013).

According to the research of Shekarian et al. (2020), it is necessary to gauge the flexibility and agility of the GSC in order to ensure responsiveness in GSCs. They argue that increasing flexibility and agility in GSCs will increase responsiveness. Similarly, Sukati et al. (2012) discuss the effect of GSC integration with GSC responsiveness and competitive advantage of a company. As a result of the research, it has been revealed that GSC integration positively affects GSC responsiveness and competitive advantage. In addition, Sachdeva et al. (2015) defined top management commitment, technology use (Cheung et al., 2021), resource development and strategy development as factors crucial to GSC responsiveness. They aimed to develop a roadmap to increase the responsiveness of GSCs by developing structural relationships between different factors. Handfield and Bechtel (2002) investigated how to establish trust-based relationships with managers in order to avoid time losses between GSC processes. As a result of their model, they have found that buyer dependency, supplier's human asset investments and trust are positively related with GSC responsiveness. Recently, the responsiveness of the GSC has become even more important for the sustainability of a company. With the COVID-19 pandemic, production and logistics activities in companies have come to a standstill (Ivanov, 2020a). The high responsiveness of a GSC enables a company to tackle the sudden changes and disruptions due to COVID-19 and adapt to new orders in a short time (Deloitte et al., 2020). To sum up, sustainable GSC flexibility and sustainable GSC agility are related with sustainable GSC responsiveness.

Considering the literature review, the flexibility, agility and responsiveness of GSCs should be analysed in an integrated way in order to ensure resilience and sustainability. Integrating the concepts with resilience and sustainability alone gives insufficient results for highly vulnerable GSCs in the face of complex disruptions.

3. Hypothesis development

In the study, the following hypotheses are developed to investigate the mutual relationships between variables.

3.1. Relationship between GSC flexibility and agility

Global markets and GSCs are becoming more diverse and more complex day by day (Bayraktar et al., 2020; Wong et al., 2020). The situation has revealed the necessity for GSCs to be more flexible (Katsaliaki et al., 2021). Flexibility in the GSC provides the company with the capability to respond to environmental changes and contributes to the improvement of high-quality products and services (Liao, 2020). From another point of view, flexibility in GSCs provides more agility in operations in the context of dynamic capability and contingency theory (Chirra et al., 2020). Therefore, the concept of "agility" emerges in GSCs and symbolizes the ability to manoeuvre in the face of disruptions that may occur in flexible GSCs (Al Humdan et al., 2020). By considering the literature, one of the crucial characteristics of the agile GSC has been stated as its focus on "speed and flexibility" (Shekarian et al., 2020).

Therefore, the hypothesis is proposed as below:

H1. GSC flexibility positively affects GSC agility.

3.2. Relationship between GSC agility and GSC responsiveness

Agility in the GSC covers factors such as the speed of the firm's launch of new products to the market, the ability to reduce production times, reducing product development cycle time and improving customer service level (Naughton et al., 2020). GSC agility provides rapid response change (Sharma et al., 2021). GSC agility depends on companies proactively responding to risks (Nandi et al., 2021; Rehman et al., 2020). Moreover, GSC agility provides an increase in the level of GSC responsiveness. Some studies conclude that there is a positive relationship between agility and responsiveness (Sharma et al., 2021). Hence, the following hypothesis is proposed:

H2. GSC agility positively and significantly affects GSC responsiveness.

3.3. Relationship between GSC flexibility and responsiveness

GSC flexibility is a measure of GSCs' ability to adapt to changing markets and customer demands. GSCs who wish to increase and maintain GSC competitiveness need to increase their level of flexibility. Moreover, GSC flexibility enables GSCs to be more responsive to sudden disruptions and fluctuations (Shekarian et al., 2020). GSC responsiveness is defined as quick responses made to changing needs in GSCs (Kahiluoto et al., 2020). In some studies, GSC responsiveness is positively correlated with GSC flexibility and supports efforts to increase resilience through purchasing or planning strategies (Shekarian et al., 2020). Hence the hypothesis is proposed as below:

H3. GSC flexibility positively and significantly affects GSC responsiveness.

3.4. The mediating role of GSC agility

GSC flexibility, GSC agility and responsiveness are related to each other (Shekarian et al., 2020). A lack of one of these characteristics affects sustainability and resilience in GSCs (Kahiluoto et al., 2020). Furthermore, flexibility in GSCs enables the GSC to be agile (Nandi et al., 2021). At the same time, GSCs that are not agile cannot be expected to be responsive (Rehman et al., 2020). While responsiveness in GSCs depends on flexibility and agility, as mentioned in some studies (Sukati et al., 2012), agility is present where there is flexibility and responsiveness. Therefore, the hypothesis is proposed as below:

H4. GSC agility mediates the relations between GSC flexibility and responsiveness.

4. Research methodology

The research methodology consists of research instrument, data collection and data analysis. First of all, to ensure understanding of the methodology, a flowchart is given in Fig. 1.

As shown in Fig. 1, after a detailed literature review on responsiveness, agility, flexibility and sustainability of GSCs, a questionnaire is developed based on three scales and 15 items. Then, the validity and reliability of survey statements are approved. After this, a survey is completed by online mail. For hypothesis testing to investigate the mutual relationships between variables, EFA (Exploratory Factor Analysis) and SEM (Structural Equation Model) are applied. After analysing data and discussions, implications are given based on these analyses. In the following section, the research instrument is explained in detail.

4.1. Research instrument

The questionnaire is generated with three scales and 15 items. Measurements for flexibility, agility and responsiveness are taken from previous studies as shown in Table 2. The statements obtained from literature have been adapted due to the Covid-19 pandemic. All items are measured with a 5-point Likert scale (5 = strongly agree and 1 = strongly disagree). The questions are adapted into Turkish from the original scales developed in English. The question items of the constructs are adapted from previous studies to ensure reliability and validity of measurement instrument.

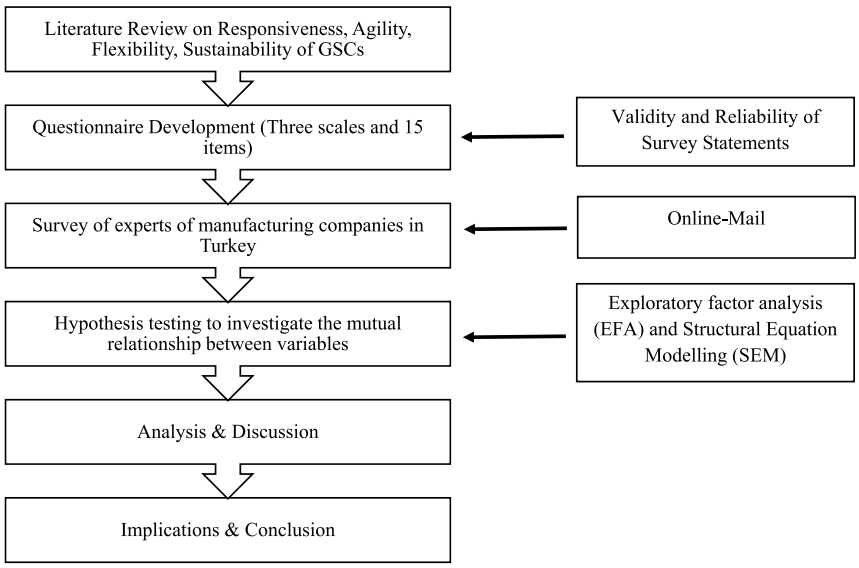

Fig. 1. Flowchart of the methodology.

To ensure validity and reliability of the survey statements, previous studies have been utilized. The flexibility construct is comprised of four statements adapted from Carvalho et al. (2012); Chirra et al. (2020) and Shekarian et al. (2020). The agility construct consists of six statements and is taken from Qrunfleh & Tarafdar (2013); Al Humdan et al. (2020); Khan (2020) and Shekarian et al. (2020). The responsiveness constructs include five statements adapted from Gunasekaran et al. (2008); Sukati et al. (2012); Qrunfleh & Tarafdar (2013) and Sachdeva et al. (2015).

4.2. Data collection

Data collection is completed through an online mail survey sent to companies. The questionnaire was self-administered and the survey was conducted online via Google form. The online questionnaire consists of two parts. In the first part, respondents were asked about the sector they worked in, the number of years of experience and job positions. In this section, the rate of impact of the COVID-19 pandemic on their sectors was also explored. (5 = very high and 1 = very little). In the second part, the impact of COVID-19 on the supply chain was questioned in terms of flexibility, agility and responsiveness. A 5-point Likert scale was used to assess the answers to the items regarding these variables. (5 = strongly agree and 1 = strongly disagree)

4.2.1. The profile of respondents and non-response bias

Non-response bias analysis was performed to check the validity of the data in the questionnaire. For this analysis, the sample was divided into two groups in order to compare early respondents and late respondents according to the date the answers were received (Armstrong and Overton, 1977; Mentzer and Lambert, 2015). The early response group consisted of 80 responses with the late response group consisting of 120 responses. A *t*-test was performed to detect differences between the early respondents (March–May 2021) and the late respondents (June–August 2021). According to the *t*-test results between the mean of the two groups, there was no statistically significant difference in terms of flexibility, agility or responsiveness variables ($t = 0.108$; $p = 0.382$; $t = 0.623$; $p = 0.231$ and $t = 0.206$; $p = 0.345$) at the confidence level of 0.05. Accordingly, it was concluded that the non-response bias did not affect the model.

The main population consists of 103,187 manufacturing companies registered at Union of Chambers and Commodity Exchanges of Turkey (TOBB, 2021). 500 companies from the food, automotive, textile and energy sectors are selected for the survey. By considering the literature review, food (Hobbs, 2020; Barman et al., 2021; Davari et al., 2022), automotive (Spieske and Birkel, 2021; Zhurova and Moshkova, 2022; Sudan and Taggar, 2022), textile (Majumdar et al., 2020; Rani et al., 2022; Santos and Castanho, 2022) and energy (Hasan et al., 2021; Samara et al., 2022; Gollakota and Shu, 2022) are the sectors most affected by COVID-19. All of these studies are conducted on specific sectors, concluding that these sectors are most affected in a negative way within the context of GSC operations by COVID-19. According to the Deloitte et al. (2020) Report, the GSCs of these sectors were relatively more affected by the COVID-19 pandemic. Due to the restrictions experienced in the COVID-19 pandemic, production breakdowns and shortages interrupted the supply chain; demand could not be met due to the uncertainty caused by supply and logistics disruptions. Hence, some manufacturing industry sectors were more affected - the automotive, food, electronics, machinery and pharmaceutical industries (Cai and Luo, 2020; Chamola et al., 2020). In another study, it is emphasized that clothing, mining, jewellery and automotive were the sectors most affected by the pandemic (Magableh, 2021). According to Sethi et al. (2021), the most affected sectors in the Indian economy are clothing and textiles, automobiles, aviation, tourism, construction, chemistry, education, retail and finance. In the study of Gupta (2022), the sectors that are most affected by the pandemic are energy, retail, textile, chemistry, construction, transportation and logistics, metals and mining, automotive, airlines and hotels. Although every manufacturing industry is different and face different challenges in any pandemic, as mentioned in the studies and reports in literature, the sectors discussed are the sectors that form the backbone of a country's economy. For this reason, food, automotive, textile and energy sectors were selected for the survey.

As mentioned before, the questionnaire was sent via e-mail to the sector representatives in the food, automotive, textile and energy sectors. The questionnaire was sent to employees in the supply chain, logistics, marketing, sales and production departments of the companies in these sectors. The return rate from the surveys was 40%, with 200 companies responding. The reason for the low return rate in the survey is the reluctance of companies to complete a survey due to the difficult economic conditions during the COVID-19 pandemic. For this reason, the questionnaire was designed to be short and easy to complete.

According to Nunnally (1978) and Rahi (2017), the sample size should be 10 times the sample size. There are 15 items in total in this study; therefore, the mandatory number of preorder sizes is 150. Despite this, 500 companies were invited to participate; the return rate from the surveys was 40% with 200 participants completing the survey. The

sample of the study was 200 industrial companies. 50 companies from each of the following sectors - food, automotive, textile and energy - have participated in the research. In general, the use of SmartPLS is recommended when there are a limited number of samples. Therefore, while this software is used for small sample data, it is not useful for large sample data (Purwanto et al., 2019). A sample size of 200 companies is sufficient to analyse data using Smart PLS (Henseler et al., 2016).

Table 1 shows a profile of respondents in this survey. Most respondents are GSC specialists/managers or logistics planning specialists/staff. Most of the respondents have been working in these sectors for more than eleven years.

4.3. Data analysis

In this study, the SPSS version 21.0 is firstly used to analyse internal consistency of the scale structures. Then, Partial Least Squares (PLS) analysis was performed with SmartPLS 3.0 software to analyse the research model. In the analysis of this research model, firstly, the reliability and validity of the model is tested, and then the Structural Equation Model (SEM) is used to test the research hypotheses (Hair et al., 2016; Awan et al., 2018).

SEM is a technique that tests predictive causal relationships for direct and indirect effects (Hair et al., 2016). SEM is a multivariate statistical analysis technique consisting of factor analysis and multiple regression analysis. It is also used to examine and understand the relationships between latent variables. SEM techniques are divided into two groups as covariance-based techniques and variance-based techniques (Henseler et al., 2009). Partial least squares (PLS) method, a variance-based SEM technique, has also been frequently used in supply chain management (SCM) studies (Hartmann and Grahl, 2011; Kaufmann and Gaeckler, 2015; Hazen et al., 2015; Malesios et al., 2020; Chandak et al., 2019; Mardani et al., 2020). The reason for choosing PLS for this research model analysis is that it is a very useful technique with high predictive power when the sample size is small and the data does not require normal distribution assumption (Hair et al., 2013; Hair et al., 2013; Peng and Lai, 2012). The advantage of the PLS method, based on multiple regression analysis, is that it can predict complex relationships between reflective and formative structures.

5. Findings of research hypotheses

The findings of each research hypothesis consist of measurement and structural models. First of all, the measurement model is explained in detail.

Table 1
The profile of respondents.

Category	Frequency	Percentage (100%)
Job position		
Manufacturing Engineer/Quality Engineer	32	16
Sales and Marketing Specialist/Representative/ Employee/Export Specialist	20	10
Purchasing Specialist/Manager	20	10
R&D Specialist/Engineer/Manager	24	12
Product Development Specialist/Manager/ Production Planning Engineer/Specialist	8	4
Global supply chain Specialist/Manager	60	30
Logistics Planning Specialist/Staff	28	14
Other	8	4
Total	200	100
Experience (years)		
Less than 5 years	17	8.5
5–10	33	17
11–16	128	64
More than 17 years	22	22
Total	200	100

5.1. Measurement model

Exploratory factor analysis (EFA) is performed using the Varimax rotation method. The questionnaire items in the scales were adapted into Turkish by using the scales prepared in English. It is more beneficial to use EFA and DFA together to test the validity and reliability of scales when the scales are adapted by different languages (Sousa and Rojjanasrirat, 2011). While preparing the questionnaire items, adaptations are made by using the existing scales. Translation errors may occur due to these adaptations. As a result of this semantic shift, it is possible to form a different structure from the original scale structure. In the absence of EFA, a second model will not be tested as the first tested model fits the data (Orçan, 2018). Depending on this, the model may be misleading (Hayton, Allen & Scarpello, 2004). For this reason, it would be appropriate to make an EFA in order to adapt the questionnaire items in a more logical way by considering the possible differences between cultures and languages. Therefore, in this study, EFA was performed to identify possible errors. EFA was applied to all constructs (flexibility, agility and responsiveness) to determine the number of common factors. Then, CFA was performed to test the validity of the scales for the sample and to verify the structure of the adapted scale (Brown, 2015). In this way, EFA could determine the nature of latent dimensions among observed variables reflected in the items of an instrument (Tomé-Fernández et al., 2020). Therefore, EFA was conducted to generate empirical evidence for validity and reliability. Also, two items were deleted due to low loadings of less than 0.40 (Hair et al., 2013). These items are “F4 - A new product or service has been developed in accordance with the pandemic conditions.” and “A1 - There was a decrease in demand in terms of the market.” Table 2 shows the validity and reliability for constructs.

Discriminant validity is analysed as the relationship between correlations among the square roots of Average Variance Extracted (AVE) and constructs (Hair et al., 2013). Table 3 shows which square root of AVE for each construct is bigger than the correlation of a construct with all other constructs.

Common method bias was statistically tested via two methods. These are Harman’s single factor test and full Collinearity Variance Inflation Factor (VIF). According to the results of principal component analysis (PCA) in SPSS version 21.0 using Harman’s (1960) single factor test suggested by Podsakoff et al. (2003), each value of the total variance explained should be less than 50%. Accordingly, when 13 items consisting of three constructs were analysed in the study, it explained 68.549% of the total variance. The first factor explains 26.83% of the total explained variance, less than 50 percent. Accordingly, the first factor did not account for most of the variance; it was thus confirmed that there was no common method bias. The second method is based on examining the internal VIF values as proposed by Kock (2015). VIF is used to detect multicollinearity between the constructs via SmartPLS. Inner VIF values ranging from 1.000 to 1.622 are shown in Table 4; outer VIF values ranging from 1.271 to 2.551 are shown in Table 2. All three-construct values were less than 3.3 (Hair et al., 2013); there was no collinearity problem and no common method bias.

The average block VIF (AVIF) value of 1.648 is less than 5 ($1.238 < 5$). The result revealed that there is no multicollinearity problem between exogenous variables. The model was a good fit to the data.

5.2. Structural model

Partial least squares (PLS) path modelling (Henseler et al., 2016), is used to test the hypotheses in this study. A bootstrapping technique has been used in Smart PLS to analyse the path relationships of the structural model. The results of structural model obtained from the PLS-SEM analysis are shown in Table 6 and Fig. 2. According to this analysis, all t values above 1.96 are significant at the 0.05 level (Hair et al., 2013). In the study, predictive power of the endogenous variables in the structural model by the model is calculated by blindfolding analysis. The

Table 2
Validity and reliability for constructs.

Constructs		Items	Loadings	Outer VIF	AVE	CR	Cronbach's α
Flexibility	F1	Different cost policies were applied.	0.706	2.259	0.697	0.813	0.87
	F2	Changes in production planning (lengthened or shortened) were applied.	0.816	1.629			
	F3	Raw material variety was enhanced.	0.872	2.551			
Agility	A2	Effective solutions have been produced for sudden increases in demand.	0.852	2.082	0.656	0.904	0.88
	A3	Effective solutions have been produced for sudden decreases in demand.	0.798	1.907			
	A4	A logistics system that can quickly respond to dynamic demands was established.	0.876	1.522			
	A5	Efficient information sharing was achieved between customers and suppliers.	0.823	1.785			
	A6	The inventory policy was adapted to avoid stock problems.	0.783	1.271			
Responsiveness	R1	Innovative products or services suitable for pandemic conditions were launched.	0.736	1.556	0.628	0.845	0.86
	R2	Transportation modes and methods were changed.	0.702	1.254			
	R3	Delivery times were changed.	0.799	1.806			
	R4	Collaboration was established between supply chain members.	0.831	1.852			
	R5	New technological investments were made.	0.718	1.632			

Table 3
Discriminant validity.

Constructs	1	2	3
Flexibility	0.773		
Agility	0.630	0.810	
Responsiveness	0.643	0.660	0.726

Table 4
Inner VIF test.

Constructs	Flexibility	Agility	Responsiveness
Flexibility		1.000	1.622
Agility			1.622
Responsiveness			

Table 5
R^2, Effect size (f^2), cross-validated redundancy (Q^2).

Construct	R^2	Effect Size (f^2)	Q^2
Flexibility		0.159	
Agility	0.482	0.615	0.174
Responsiveness	0.657		0.238

Table 6
Hypotheses testing (Direct and Indirect Effects).

Hypotheses	Path coefficients	t value	p value	Results
H1: Flexibility→Agility	0.530	9.471	0.000	Supported
H2: Agility→Responsiveness	0.529	7.310	0.000	Supported
H3: Flexibility→Responsiveness	0.260	3.244	0.000	Supported
Indirect Effect Path H4: Flexibility→Agility→ Responsiveness	Indirect Effect value 0.280	5.128	0.000	Supported/ Partial

Notes: Critical t-values. *1.96 ($P < 0.05$).

coefficient of Q^2 (cross-validate redundancy) greater than 0 indicates that the model has the power to predict endogenous variables. Q^2 values of GSC agility and responsiveness are 0.174 and 0.238, respectively. As seen in Table 5 and Fig. 2, the acceptable predictive relevance of the structural model is provided due to the Q^2 values being above zero. In the structural model, f^2 is calculated for each independent variable and gives size of effects of each independent variable on dependent variable (Chin et al., 2008). Effect sizes are classified as 0.02 small, 0.15 medium and 0.35 large, respectively. According to the classification, f^2 values of flexibility and agility variables were 0.159 and 0. 615, indicating that the effects of independent variables are medium and high, respectively. The tests of model fit are evaluated by normed fit index, NFI values, and Standardized Root Mean Square Residual, (SRMR). The value is expected to be below 0.08 and the NFI value is expected to be above 0.90 (Garson, 2016). The structural model fit index is SRMR = 0.072 and NFI = 0.885, meaning that this model is acceptable (Hair et al., 2013).

5.3. Hypotheses testing

PLS model analysis was used to test hypotheses in this research. Table 6 shows the hypothesis test result, path coefficients, p-value and t-value. According to the results of the hypothesis test, all hypotheses are supported. Fig. 2 also shows the results of the hypotheses.

In this study, the flexibility of the GSC directly affects the responsiveness of GSC ($\beta = 0.554$; $t = 10.952$; $p < 0.05$). The flexibility of the GSC explains 48.2% of variance in agility of GSC ($R^2 = 0.482$). In addition, the flexibility of GSC ($\beta = 0.267$; $t = 3.469$; $p < 0.05$) and the agility of the GSC ($\beta = 0.529$; $t = 7.774$; $p < 0.05$) affect responsiveness of the GSC. In the case where GSC agility enters the model, the flexibility and agility of the GSC explain 65.7% ($R^2 = 0.657$) of variance in the responsiveness of the GSC. When the changes in the R^2 value are examined, R^2 values indicate an important model as 0.482 and 0.657, higher than the 0.26 value proposed by Cohen (1988). As a result of this analysis, H1, H2, and H3 are supported.

6. Robustness of the model

The robustness of the model expresses the power of a statistical model, tests and procedures, even if the model does not meet all the assumptions (Cassel et al., 2000; Taylor, 2019). PLS was used in the study. Cassel et al. (1999, 2000) stated that PLS is robust against different problems and many types of data. PLS-SEM generally creates flexibility, robustness and precision in models by using similar conceptual models with different analyses (Taylor, 2019). To test the robustness of the model, a *t*-Test was performed using the bootstrapping method. For it to have a perfectly significant value, all t values greater than 1.96 are significant at the 0.05 level (Hair et al., 2013). As seen in Table 6, t values are 9.471, 7.310, 3.244 and 5.128. In addition, the positive result of the reflective measurement model in the study indicates the value and robustness of the model (Sander and Teh, 2014). These values are shown in Table 6 and Fig. 2. The reliability testing of the SEM determines Cronbach alpha values and Composite Reliability (CR), as seen in Table 2. These values > 0.7 are acceptable; values > 0.8 are very satisfactory. Three constructs are found to be quite reliable by showing values greater than 0.70 (Hair et al., 2013; Purwanto, 2021). As three variables - agility (0.88), responsiveness (0.86) and flexibility (0.87) - have values higher than 0.800, this is considered very satisfactory. CR and AVE values are examined in order to test convergent validity of the measurement model. Accordingly, it was found that all item loadings were above 0.6 (Chin et al., 2008). CR values are found to be above 0.7 with AVE values found to be above 0.5 (Hair et al., 2013).

The structural mediation model is shown in Fig. 2 and the results of

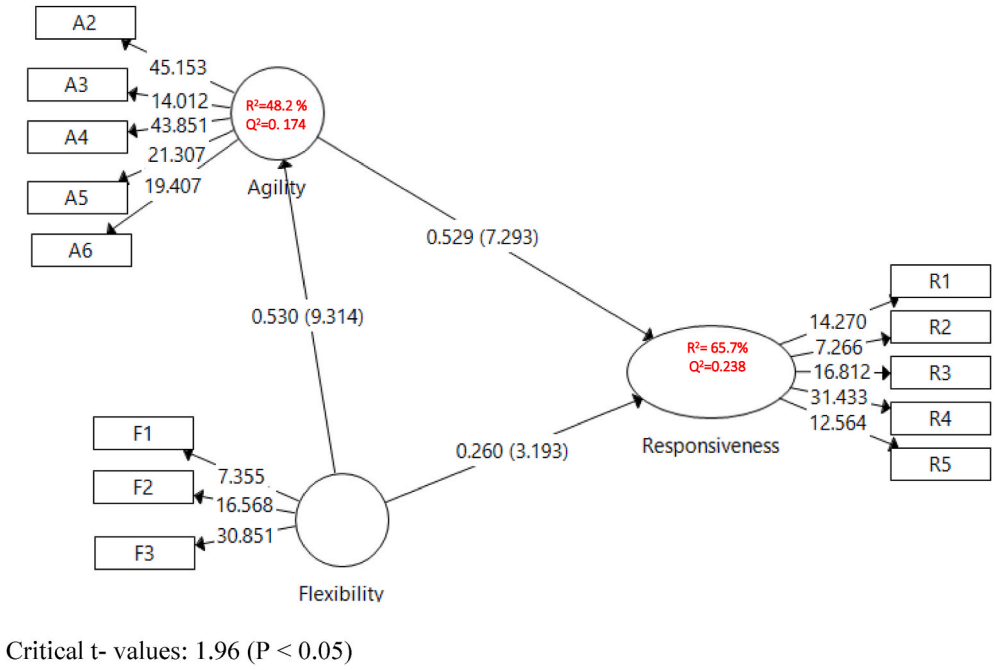

Fig. 2. Structural model

the mediation effect are shown in Table 6. The mediation effect of supply chain agility was tested. Using a bootstrapping (5000 resampling) method, the path coefficients, standard errors and t values of indirect effects are shown in Table 6. Dependent, independent and mediator variables are included in the same structural model and the relationships among them are examined. The proposed tree suggested by Zhao et al. (2010) is used to test the mediation effect. As this method suggests, if the indirect effect (a * b) and the direct effect (c) are significant and have the same direction (a*b*c), the mediation effect is complementary partial mediation (Zhao et al., 2010). According to the results of this analysis, the agility of the GSC acts as a complementary partial mediator variable effecting GSC flexibility on responsiveness. Based on the result, a portion of the effect of GSC flexibility on responsiveness is mediated via agility; a portion directly affects GSC responsiveness independent of GSC agility. Therefore, H4 is supported.

7. Discussions

As GSCs become more complex, the resilience and sustainability of GSCs is threatened (Singh, 2015). Especially in the face of sudden disruptions, being more flexible, agile and responsive increases the resilience and sustainability of GSCs (Gunessee and Subramanian, 2020). Due to COVID-19, GSCs have made changes such as strategy and new plans in order to maintain resilience in the face of disruptions (Nandi et al., 2021). However, the resilience of global supply chains in the face of disruptions depends on supply chains being agile, flexible and responsive (Sharma et al., 2021). Despite COVID-19, highly responsive GSCs have been able to overcome disruptions (Sarkis et al., 2020).

By considering the most relevant literature, the results of the study are compared as shown in Table 7.

The hypotheses in this study are compared with studies conducted in the same field; this is demonstrated in Table 7. According to findings of the study, when compared with other studies, the results obtained are significant in real world conditions. In accordance with Table 7, Delic and Eyers (2020) state that GSC flexibility is the capability to adapt to fluctuations in low flow loss in time, cost and performance. According to Nandi et al. (2021), GSC agility enables companies to fight against sudden adversities, stand up against threats in the market environment and use these changes to their advantage as a result of the variations that

Table 7
Comparison of results with past literature.

Hypothesis	In agreement with	In contrast with	Links with Research Questions and Hypothesis
H1: GSC flexibility positively affects GSC agility.	Katsaliaki et al. (2021)		Research Question 1
H2: GSC agility positively significantly affects GSC responsiveness.	Sharma et al. (2021); Nandi et al. (2021)		Research Question 2
H3: GSC flexibility positively significantly affects GSC responsiveness.	Qrunfleh and Tarafdar (2013); Kim et al. (2013)		Research Question 2
H4: GSC agility mediates the relations between flexibility and GSC responsiveness.	Sukati et al. (2012)	Um (2017)	Research Question 3

arise. Similar to this study, according to Dubey et al. (2021b), resilience is related with GSC flexibility. Furthermore, Gligor et al. (2019) stated that although GSC agility and resilience seem to have the same meaning, GSC agility is a concept that affects GSC resilience. In a similar manner, GSC resilience depends on GSC agility in this study. Moreover, according to Sukati et al. (2012), GSC responsiveness affects GSC resilience and sustainability of GSCs. Furthermore, Puriwat & Hoonsopon (2021) determined the relation between agility and flexibility of GSCs and state that GSC flexibility and agility can cope with disruptions from the resilience perspective.

From the perspective of the research questions, a novel finding of the study is revealing the relationship between flexibility and agility in companies' sustainable GSCs during COVID-19; deciding whether agility is the mediator variable in the relationship between flexibility and responsiveness during COVID-19 addresses the third research question. Based on novel findings, as mentioned in Table 6, flexibility of the GSC directly affects the responsiveness of the GSC; the agility of the GSC affects responsiveness of the GSC. This addresses the second research question. There are some studies which support this hypothesis in

existing literature. According to Sharma et al. (2021) and Nandi et al. (2021), GSC agility positively and significantly affects GSC responsiveness; this is supported in this study. Furthermore, GSC flexibility positively affects GSC agility, especially in disruption such as COVID-10 according to Katsaliaki et al. (2021). This addresses the first research question in this study.

7.1. Theoretical implications

By considering the COVID-19 period, Ivanov (2020b) stated that GSC agility affects not only resilience but also sustainability of GSCs. Nandi et al. (2021) determined that emerging technologies are essential to be responsive and agile in GSCs (Chung, 2021). In a similar light to this study, Kamalahmadi et al. (2021) state that flexibility affects resilience in GSCs. Although most previous studies examine flexibility, agility and responsiveness of GSCs, the uniqueness of the study is covering flexibility (Kamalahmadi et al., 2021), agility (Ivanov, 2020b) and responsiveness (Nandi et al., 2021) to improve resilience and sustainability of GSCs.

GSCs have more complex structures and are more vulnerable against disruptions such as COVID-19. These GSCs have many problems such as inventory management, production process, demand management etc. In times of disruption, these problems are doubled. These disruptions directly affect resilience and sustainability of GSCs. Therefore, to be resilient and sustainable, GSCs should be flexible, agile and responsive. As mentioned in the research questions, GSC flexibility has a relationship with GSC agility and GSC agility has a relationship with GSC responsiveness. As suggested in research question 3, GSC agility is a mediator between GSC flexibility and GSC responsiveness. These terms are directly related to each other and to be resilient, GSCs should have the aforementioned characteristics.

Regarding theoretical implications, the study is deals with the GSC. SCs have many multi-tiers and multi-stakeholders due to their structure; they are dynamic structures where uncertainty exists and continuous interruptions and disruptions occur. Therefore, the combination of dynamic capability and contingency theory can be used as a theoretical basis in studies that examine digital transformation on resilience. Thus, dynamic capabilities and contingency theory can be integrated in any type of resilience studies.

7.2. Managerial implications

With regard to managerial implications, in order to ensure resilience during disruptions experienced in GSCs, the current resilience efforts of companies are not enough; they can only be resilient with better continuous systems. In this way, companies can be agile, flexible and responsive. Hence, companies have to provide these characteristics throughout their entire GSC, leading them to digital transformation.

As mentioned before, emerging technologies (Industry 4.0, Blockchain, AI, IoT etc.) are essential to cope with GSC disruptions during the COVID-19 pandemic. Industry 4.0 ensures the integration of all stages of GSCs with AI, IoT etc. These emerging technologies provide more resilient and sustainable GSCs against disruptions by increasing traceability, automation and visibility. It is necessary to integrate these emerging technologies into companies' GSC operations to increase flexibility and agility in sustainable GSCs during the COVID-19 pandemic; this addresses research question 1. Conducting new approaches to the development and adoption of new cleaner production technologies also contributes to improving sustainability in GSCs in terms of environmental sustainability. This will directly affect the flexibility, agility and responsiveness of supply chains and contribute to being more resilient against sudden disruptions.

Considering emerging technologies is essential for being resilient and sustainable against disruptions in GSCs. Therefore, by using emerging technologies, managers can find strategies to cope with disruptions and manage their GSCs more effectively. In addition, managers can decide new solutions and can make quick evaluations around resilience of GSCs. These evaluations provide more effective and planned risk management strategies. Another managerial implication is about performance management. Firms need to focus on how to be resilient in their GSC. First of all, to ensure resilience in GSCs, they need to assess their performance in terms of their flexibility, agile and responsiveness. Therefore, this performance assessment will lead them to continuous improvement from the performance management perspective. Performance management provides the relation between GSC flexibility, agility and responsiveness as mentioned in research questions 1 and 2.

In terms of the organizational structure, the competencies mentioned for resilience are interdisciplinary; therefore, organizational structures should be planned and implemented as suitable for the structure. In this respect, matrix organization charts allow interdisciplinary teams to work together for both the specified performance assisters and for the sustainability of these competitors. Although companies' SCs may be flexible, being more agile as a mediator, as mentioned in research question 3, makes them more responsive.

For policy makers, in order to increase the resilience of GSCs, solutions are offered concerning developing technologies to the problems that may occur. The structure set out in this study can be considered not only for companies, but also for public institutions and even non-profit organizations to increase resilience in their GSCs. Since the competitive advantages of countries are actually based on the competitiveness of the private sector, policymakers should always favour the control and improvement of resilience of companies. Firms need to be agile, flexible, responsive and provide core competencies. To this end, policymakers can adjust regulations and new policies to increase the resilience of GSCs of companies. Policymakers can make various arrangements according to the competencies of the companies, especially in terms of policies, incentives and support. In the case of GSCs, policymakers can develop solutions by analysing possible disruptions within the country or abroad, and by carrying out scenario analysis in cooperation with particular sectors e.g. raw material supply problems, logistics problems.

In order to ensure resilience and sustainability in the food industry, logistics operations in the supply chain need to be improved. In order to adopt flexibility and agility in food supply chains, all stakeholders in the supply chain should be supported financially and morally. Similarly, in the energy sector, the supply chain is considered to be the area most affected by COVID-19. Due to the worldwide effects of the COVID-19 fluctuation, it has been inevitable for energy services and renewable energy companies to adopt the concepts of flexibility, agility and responsiveness in their supply chain processes. In general, energy demand in industrial areas is particularly challenging for manufacturing companies, so companies need to implement the use of spare capacity and be prepared to take different actions in order to adopt the concepts discussed in the face of sudden disruptions such as COVID-19.

The fact that the most important manufacturers of the automotive industry are located in China causes problems in terms of supply chain. Automotive manufacturers have had to restrict production in their facilities outside of China due to disruptions in the supply of parts. In order to avoid problems in terms of production and supply and to ensure resilience and sustainability in supply chain processes, policies that will reduce foreign dependency or new agreements that can cooperate with more than one supplier should be adopted. From the textile industry perspective, in order to ensure resilience and sustainability in the textile industry supply chain, managers should support the identification of vulnerabilities in their supply chains; these are more evident as a result of similar risk factors such as the COVID-19 pandemic. Action plans should be created with a holistic perspective and financial support should be provided by the state.

In terms of academic implications, resilience and sustainability in GSCs have become important issues recently. In this study, discussing the concepts of flexibility, agility and responsiveness for the resilience and sustainability of GSC contributes to academic knowledge. In addition, this study can be applied in different sectors with different methods

in future academic research.

8. Conclusion

Nowadays, within the framework of the conditions brought on by globalization, SCs have turned into global structures consisting of numerous links through complex networks of different companies in different countries. However, this growth comes with risks and challenges. The globalization of SCs makes GSCs vulnerable to sudden disruption such as COVID-19. COVID-19 is a global problem. Although the current COVID-19 disruption is discussed extensively in the study, the flexibility, agility and responsiveness of supply chains are important to ensure resilience and sustainability against any disruption. Firms will be able to provide resilience and sustainability against disruptions in GSCs with a flexible, agile and responsive approach. GSC flexibility, agility and responsiveness are successive concepts. The lack of one of these features affects the flexibility of GSCs in any disruption, not only COVID-19. Therefore, the main contribution of the study is to be able to define which concepts - agility, flexibility and responsiveness - affect each other and directly affect sustainability in GSCs; it is revealed the relationships between these concepts in the context of dynamic capability and contingency theory, especially in times of disruption. It is aimed to examine the results of this study and make them applicable in different disruptive times. For the analysis of the study, 200 responses collected from companies with complex GSC structures are used with a PLS model used for the analyses of hypotheses.

According to results, GSC agility is directly affected by GSC flexibility; this addresses research question 1. As GSC flexibility explains 48.2% variance of GSC agility, the results support H1. GSC flexibility and GSC agility directly affect the responsiveness of the GSC; this addresses research question 2. When GSC agility enters the model, the rate of explanation is increased to 65.7% of variance in the responsiveness of the GSC; this result supports H2. The agility of the GSC acts as a complementary partial mediator variable in the effect of GSC flexibility on responsiveness; research question 3 is thus addressed. Based on this result, a portion of the effect of GSC flexibility on the responsiveness is mediated through agility, and a portion directly affects GSC responsiveness independent of GSC agility. As stated in H3, part of the impact of GSC flexibility on responsiveness is mediated by GSC agility and part of it directly affects the responsiveness of the GSC, regardless of GSC agility. Therefore, H1, H2, H3 and H4 are supported.

As a limitation, the sample of the study is restricted to Turkey. With COVID-19, there is continual change throughout the world. For this reason, literature needs to be constantly renewed, making it difficult to keep abreast of the changing environment. Although it is a limitation, the study can be implemented in other emerging economies as a future study. For future studies, research can be improved with new parameters besides flexibility, agility and responsiveness. The sector dealt with in the study can be privatized and work on a single specific sector can be done. In addition, from an academic perspective, by extending this study, future research can include variables with more relationships. Moreover, a comparative study can be made with a different method to make a further contribution to the existing body of literature.

CRediT authorship contribution statement

Ipek Kazancoglu: Methodology, Writing – review & editing. **Melisa Ozbiltekin-Pala:** Data curation, Writing – original draft, Writing – review & editing. **Sachin Kumar Mangla:** Supervision, Writing – original draft, Writing – review & editing. **Yigit Kazancoglu:** Conceptualization. **Fauzia Jabeen:** Writing – review & editing.

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

Survey

Which sector do you work in?
How has the COVID-19 pandemic affected your sector? (5 = very high and 1 = very little).
How many years have you been working in this sector?
Which department do you work at?
Which position do you work in?
Answer the following statements in accordance with the changes in your firm's supply chain structure during the COVID-19 period.

Statements	1	2	3	4	5
Different cost policies were applied during Covid-19 pandemic.					
Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic.					
Raw material variety was enhanced during Covid-19 pandemic.					
There was a decrease in demand in terms of the market during Covid-19 pandemic.					
Effective solutions have been produced for sudden increases in demand during Covid-19 pandemic.					
Effective solutions have been produced for sudden decreases in demand during Covid-19 pandemic.					
A logistics system that can quickly respond to dynamic demands was established during Covid-19 pandemic.					
Efficient information sharing was achieved between customers and suppliers during Covid-19 pandemic.					
The inventory policy was adapted to avoid stock problems during Covid-19 pandemic.					
A new product or service has been developed in accordance with the pandemic conditions during Covid-19 pandemic.					
Innovative products or services suitable for pandemic conditions were launched during Covid-19 pandemic.					
Transportation modes and methods were changed during Covid-19 pandemic.					
Delivery times were changed during Covid-19 pandemic.					
Collaboration was established between supply chain members during Covid-19 pandemic.					
New technological investments were made during Covid-19 pandemic.					

(5 = strongly agree and 1 = strongly disagree).

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