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Transition to a sustainable food supply chain during disruptions: A study on the Brazilian food companies in the Covid-19 era

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ABSTRACT

The COVID-19 pandemic has brought negative impacts to global supply chains, in particular to the agricultural sector. Although these companies have been developing programs to mitigate the impacts caused by COVID-19, researchers have been worried about a possible weakening of the adoption of sustainable initiatives due to a focus on dealing with the consequences of the pandemic. Grounded on the Resource Orchestration Theory, the goal of this study was to assess the effects of the COVID-19 outbreak on sustainable (environmental, social, and economic) performance in the context of agri-food supply chains. To do so, a questionnaire survey was used to collect data from 349 different medium and large agri-food companies in Brazil. Data were analyzed using Structural Equation Modeling-Partial Least Squares technique. This study has found out that, under the impacts arising from COVID-19 pandemic (1) supply management and transportation and logistics management had a positive impact on food supply chains' sustainable performance; (2) the effects of relationship management and supply chain wide impact management were found to be negative on sustainable performance; and (3) the effects of demand and production management on sustainable performance were not considered significant. We propose a framework that clearly represents the relationship between the disrupted supply chain areas and sustainable performance through the development of orchestration capabilities. By knowing which kinds of impacts produce the most significant effects on sustainable performance, policy makers and managers will be able to make decisions and take actions to avoid negative effects and to improve firms' sustainable performance.

1. Introduction

The COVID-19 pandemic has brought negative impacts to global supply chains (Ladeira et al., 2021). Since they are naturally fragmented and geographically dispersed, they are more vulnerable to disruptions (Ibn-Mohammed et al., 2021). So, supply chains disruption has been one of the most frequent topics in the context of the pandemic. In doing so, Chowdhury et al. (2021) identified four frequently studied themes on this subject: impacts caused by COVID-19, resilience strategies, the contribution of technology to face disruptions, and sustainable supply chain management (SSCM).

One industry that has been greatly impacted by this outbreak is the agricultural sector (Ma et al., 2021). Consequently, agri-food supply chains (AFSCs) have been severely disrupted (Workie et al., 2020). In this context, some negative effects have been seen, such as, the increasing demand for some products, increased prices (Gurbuz and Ozkan, 2020), and food shortages (Boyacı-Gündüz et al., 2021). An increasing pressure for assuring higher levels of supply chains' robustness has been seen. Agnusdei and Coluccia (2022) identified that one of the challenges the agri-food industry currently faces is the improvement of AFSC systems. In fact, recent research has reported impacts of the pandemic related to different supply chain areas such as demand, production, supply, transportation, and relationship management (Chowdhury et al., 2021).

Although agricultural companies have been developing programs to combat COVID-19 (Djekic et al., 2021), researchers have been worried

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by a possible weakening of the adoption of sustainable initiatives due to the challenges imposed by the pandemic (Vale et al., 2021). Despite the increasing interest on AFSCs' sustainability, previous studies have found a limited number of publications dealing with sustainable performance of companies (Luo et al., 2018). The particularities of AFSCs together with the increasing social and ecological challenges involved in their operations, make a focus on the different sustainability dimensions necessary (Trivellas et al., 2020).

Even though some companies kept their attention on responsible production and adequate working conditions (Perrin and Martin, 2021), the COVID-19 crisis could have had several impacts on the sustainability initiatives of several companies. In fact, firms have been struggling to remain sustainable despite the great impacts caused by the pandemic (Alraja et al., 2022). Researchers have been investigating the relationship between the pandemic and firms' sustainable performance. Lu et al. (2022), for instance, found out that, during the outbreak, companies with higher sustainability performance have been more resilient, with lower decreases in their financial performance. Bose et al. (2022) found out that the negative impact of the pandemic on firms' value is lower in firms with greater sustainability performance. Kholaif and Ming (2022) observed that fear and uncertainty due to COVID-19 positively affected the adoption of green supply chain management practices, with higher impacts on firms' environmental and social performance. However, to the best of our knowledge, empirical research that assesses the extent to which the effects of the pandemic on different supply chain areas affected agricultural companies' sustainable performance has not been carried out so far.

Therefore, researchers have been calling for more studies on SSCM in the agricultural industry under the COVID-19 pandemic conditions. Ivanov (2020a) stated that investigating the impacts of epidemic outbreaks on supply chains is a new but robust research stream. Singh et al. (2021) affirmed that the impact of the pandemic on supply chains activities are still not discussed enough, especially in the context of AFSCs. Among the research themes proposed by these authors, they call for more research on the transition opportunities in the wake of COVID-19 and the expansion of quantitative research. Finally, they pointed out that most previous studies have focused only on a specific subject area or considered just one dimension of sustainability during the pandemic, calling for a more holistic view of sustainability. Luo et al. (2018) corroborate this by stating that quantitative analyses are rather restricted in this field. Moreover, Chowdhury et al. (2021) identified a lack of empirically designed and theoretically grounded studies in the field. Finally, previous studies on SSCM have not performed a thorough analysis of supply chain areas, sometimes excluding areas like transport, logistics or reverse logistics (Seuring et al., 2022; Seuring and Müller, 2008).

In order to fill in these research gaps, the goal of this research was to assess the effects of the COVID-19 outbreak on sustainable (environmental, social and economic) performance of AFSCs. To do so, the impacts of the pandemic on supply chains were described based on some of the dimensions identified by Chowdhury et al. (2021) as well as in other studies. Then, a survey questionnaire was used to collect data from strategic informants in 349 different medium and large Brazilian agri-food companies. Data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) technique.

During the COVID-19 pandemic, the international pressure for better environmental performance in Brazil has increased. Besides, Brazil has been one of the countries most affected by the pandemic, whose numbers of cases and deaths are only surpassed by the USA and India (Marinho et al., 2020). In general, emerging countries have been more affected by the pandemic than the developed economies since they are more vulnerable to economic restrictions and display a lower resilience capacity to deal with disruptions (Joshi et al., 2021). Researchers have been calling for more studies in countries like Brazil (Jia et al., 2018). South countries require a real transition towards sustainability in their AFSCs to achieve some of the goals of the 2030 Agenda for Sustainable Development of the United Nations (El Bilali, 2019) In addition to the sustainability concerns presented previously, Brazilian companies were invited to participate in this study since the country is considered one of the largest producers and exporters of vegetable foods in the world (de Paulo Farias and de Araújo, 2020).

This study is based on the Resource orchestration theory (ROT), an extension of the Resource-based view (RBV) (Barney, 1991) and Dynamic capabilities (DC) (Teece, 2007) theories. The ROT explains the role managers have in transforming resources into capabilities (Kristoffersen et al., 2021). ROT stresses that managers structure a firm's set of resources and bundles them to build capabilities to maximize the likelihood of achieving a competitive advantage (Burin et al., 2020; Sirmon et al., 2011). In the current competitive business environment, firms must be constantly updating the means used to deliver value, especially with the increasing pressure from different stakeholders to transition to more sustainable business models and operations. In times of severe and long disruptions, being able to develop capabilities that can deal with the impacts of these outbreaks and, at the same time, being able to keep sustainable initiatives and outcomes, is a key competence for managers and companies. Few studies have investigated how resources can be better orchestrated to plan for future waves of COVID-19 or similar pandemics and disruptions. Hence, future research should explore how to use resources to develop resilience capabilities to improve supply chains and operations (Baltas et al., 2022).

This study has contributions to scholars and practitioners. The study was carried out in an emerging economy context, Brazil, a country that faces several sustainability challenges and strong pressures from countries all over the world to increase the adoption of sustainable initiatives. Especially in the agri-food sector in the country, there is great concern with implementing this kind of action. This study also identified the main impacts caused by the pandemic that had significant effects over firms' sustainable performance. By understanding these effects better, firms can design and implement initiatives to prevent risks and keep sustainable initiatives working. This study also extends the Resource Orchestration Theory, answering calls for its adoption on the operations management research area.

2. Theoretical background and research hypotheses

While the COVID-19 pandemic is unprecedented, global supply chains have been disrupted in other situations since different kinds and magnitudes of crisis that affect businesses occur periodically around the globe (Krammer, 2022). For example, the world has witnessed several epidemics (SARS, swine flu/H1N1, MERS, and Ebola) (Park et al., 2022), natural disasters (wildfires, volcanic eruptions, floods, earthquakes, and tsunamis) (El Korchi, 2022), and financial crisis (Chang et al., 2022). However, these historical events did not have similar impacts on the economy and society similar to the recent outbreak (Bai et al., 2020).

As a result of the COVID-19 pandemic, supply chains have been disrupted in a way never seen before. This pandemic demonstrated that the classical resilience capacities developed so far were not sufficient to deal with the long-term disruptions caused by the pandemic (El Korchi, 2022). Therefore, the covid-19 outbreak can be considered a much more intense event due to the following characteristics: (1) its duration since new variants and infection waves continuously emerged, (2) it was an unexpected disruption, different from other events such as hurricanes and floods, so companies, citizens, and governments were not prepared for it (Chang et al., 2022), (3) it had a global reach that vastly exceeded the spatial extent of other disaster and health events, (4) strong and extensive policy measures like lockdowns and border closures were implemented, and (5) massive disruption to labor availability and supply chains impeded businesses to operate (Chang et al., 2022).

A unique outbreak, like the COVID-19 pandemic, requires specific sets of resources and capabilities to deal with its impacts. In this sense, a theory that describes how these resources and capabilities can be managed and structured is necessary. The ROT, which possesses these characteristics, is described in the next section.

2.1. Resource Orchestration Theory

The pandemic impacts promoted more discussions around sustainability, especially in developing countries. Sustainability is usually seen as a multidimensional concept, that comprises economic, environmental, and social dimensions. In agri-food systems, the economic dimensions involve value-addition, economic development, efficiency, and resilience. The environmental dimension refers to the natural environment's ecological integrity in a way that it keeps being productive and resilient to support human life. Social sustainability comprises producer-consumer interactions and relationships, food security, human rights, gender equity and equality, and labor (Agnusdei and Coluccia, 2022). Several studies identified that the environmental dimension has received greater attention from scholars, when compared to the economic and social dimensions of sustainability (Agnusdei and Coluccia, 2022; Barbosa and Oliveira, 2021; Rajeev et al., 2017). However, researchers call for a more holistic approach in the AFSC management that takes into account all stakeholders in order to develop more efficient and sustainable supply chains (Agnusdei and Coluccia, 2022).

Sustainable performance is difficult to achieve due to the relationships between its three dimensions (Seuring and Müller, 2008). In fact, effectively managing all sustainable performance dimensions simultaneously is not a simple task (Chavez et al., 2020), so we suggest the ROT as a possible theoretical framework to explain how sustainable performance could be achieved in this context.

The ROT establishes that a company can completely extract value from its resources only when they are structured, bundled, and leveraged effectively (Asiaei et al., 2021; Sirmon et al., 2011). Structuring is related to acquiring, accumulating, and divesting the company' set of resources. Bundling refers to stabilizing, enriching, and pioneering, that is, the firm integrates specific resources to develop a capability that is intended to generate value for clients. Leveraging is related to mobilizing, coordinating, and deploying the set of bundled resources to create value for the company's stakeholders (Sirmon et al., 2011; Wang et al., 2021). Literature on operations and supply chain management related to disruptions is primarily focused on resources and their allocation optimization (Dasaklis et al., 2012). So, ROT is a suitable theory to understand how firms respond to mobilize their resources in response to external events like disruptions (Giunipero et al., 2021).

We consider that the adequate management of the several dimensions of supply chain management is a plausible way in which managers can foster resource mobilization to face the impacts caused by the pandemic and achieve positive organizational outcomes. In this way, the use of appropriate supply chain management systems to face disruptions can play an effective role in orchestrating a firm's set of resources which, in turn, may lead to higher sustainable performance. As the capability of combining complementary capabilities is difficult to imitate, it contributes to a sustained competitive advantage (Sirmon et al., 2011) and synergistic performance (Malik et al., 2021).

The disruptions caused by the pandemic in the relationships management could also have impacts on the environmental, economic, and social performance of firms. Based on ROT, the firm and its suppliers orchestrate different types of resources, which complement each other. Thus, while individually these resources might not be able to affect environmental, social, and financial performance, however, collectively they could make a firm more sustainable (Wong et al., 2018). In this regard, by increasing communication and collaboration, food companies design alternative plans and supply allocations, minimizing disruption's effects on supply chain performance. Collaboration with key partners help preventing stockouts and enhance visibility (Burgos & Ivanov, 2021). Moreover, collaboration enables risk minimization, cost reduction, and workload sharing for mutual reward (Prosser et al., 2021). Also, extensive financial support from supply chain partners improves the processes related to sustainability (Karmaker et al., 2021). As so, relationship management is a way organizational resources are orchestrated among firms to achieve more sustainable outcomes.

The COVID-19 pandemic has caused disruptions in several supply chain areas, which could have affected firms' sustainable initiatives. In order to assess whether the adequate management of these dimensions of supply chain areas could have impacted the sustainable performance of firms, we present the following research hypotheses.

2.2. Research hypotheses

The COVID-19 pandemic has changed agricultural systems through its effects on demand, food supply, and the production and distribution capacity (Boyacı-Gündüz et al., 2021). As an attempt to reduce the propagation of the virus, many countries have imposed lockdowns, closures of ports, and travel restrictions, disrupting the global food supply chains, which led to a cascading effect on producers (Fan et al., 2021). As so, the disruptions provoked by the COVID-19 outbreak impacted the management of demand, supply, and production of agri-food products that could have led to effects on the environmental, economic, and social performance of firms. For example, customers modified their consumer behavior, increasing their home consumption reducing food waste, and returning to local products (Blazy et al., 2021). Thus, the increase demand for food introduced significant pressures on the AFSCs (Burgos & Ivanov, 2021). Additionally, mitigation measures negatively impacted agricultural production and reduced income and food (Iese et al., 2021), putting food security at risk (Roubík et al., 2022), increasing food prices and decreasing food availability (Moosavi et al., 2022). Also, reduced agricultural production and incomes were observed due to a decline in local markets and access restrictions to international markets. So, a reorientation from export channels towards satisfying domestic demand for food was observed (Blazy et al., 2021). Moreover, the pandemic has exposed some countries' vulnerability to dependency on other countries' inputs (e.g., chemical fertilizers) required to produce crops and livestock, which led to a decline in production (Adhikari et al., 2021).

The pandemic also led to price spikes and panic buying due to the increased demand, slower food supply chains (Galanakis et al., 2021), and the fear of food shortages during this period. Product shortages have made customers to look for alternative sources of supply, probably buying items in larger amounts, leading to even severer demand uncertainty (Zhu and Krikke, 2020). These changes in customers' behaviors have caused great variability in demand (Zhu et al., 2020).

Other identified impacts of the pandemic comprise an increase in the number of social conflicts such as land disputes and thefts and a reduced availability required materials, equipment, and labor (Iese et al., 2021) since agricultural production systems were affected due to restriction measures (Nundy et al., 2021). In order to deal with these impacts, farmers implemented some adaptations such as the reduction of the size of cultivated areas, the use of short marketing channels, diversification of production, and collaboration among farmers (Blazy et al., 2021).

Demand planning practices significantly contribute to mitigating disruptions since they allow companies to understand clients' demands and ensures that the supply response is given according to the demand (Swierczek, 2020). However, the pandemic makes demand planning very challenging. Sharma et al. (2020a, 2020b, 2020c) found out that demand uncertainty is one of the key challenges observed. This uncertainty reflects a decline in demand, as well as sudden spikes. Demand shocks have exposed supply chain vulnerabilities and raised concerns about resilience. Also, demand and supply have drastically dropped resulting in production stops (Ivanov, 2020b), major effects in manufacturing, processing, and significant changes in demand (Xu et al., 2020). The pandemic has caused fluctuations on demand, supply, and production, but it is still unclear whether those variations have impacted the sustainable performance of companies. This issue leads to our first hypotheses:

Under the impacts arising from COVID-19 pandemic.

H1. Demand management has a significant impact on food supply chains' sustainable performance.

H2. Supply management has a significant impact on food supply chains' sustainable performance.

H3. Production management has a significant impact on food supply chain' sustainable performance.

The pandemic seriously restricted the access to food due to mobility, trade and transport restrictions (Tittonell et al., 2021). The international logistics, either through maritime, air, and terrestrial routes, experienced delays, cancellations, and obstructions because of the travel restrictions and the closing of international borders (Xu et al., 2020). The logistic sector has had to focus more on local orders, and transport companies delivered orders made through internet while adapting to the ''new normal''. The pandemic has also provoked a scarcity of people for food transportation (Sharma et al., 2020a, 2020b, 2020c).

The disruptions caused by the pandemic in the logistics and transportation management could also have impacts on the environmental, economic, and social performance of firms. From the environmental perspective, a significant reduction in energy and carbon monoxide pollution was observed due to the reduction in individuals' transportation to point of sales (Adelodun et al., 2021). In an economic context, transportation costs increased because of the chaos and inefficiencies in ordering and storing systems, which led to irregular shipments and delays (Burgos & Ivanov, 2021). The sector may try to overcome the financial losses with investments in the development of a more sustainable transportation systems, using for example, electric vehicles (Nundy et al., 2021). Finally, it has been observed that logistics networking and transportation have a strong impact on sustainable performance (Trivellas et al., 2020).

Even before the beginning of the pandemic, some advances and improvements have been planned for logistics worldwide (Gurbuz and Ozkan, 2020). Technological advances, like drones, were used to get to customers located in severely infected areas (Singh et al., 2021). In fact, more technology-based solutions, for example, using blockchain-based applications and alternative modes of transportation have been investigated to reduce the negative effects of these disruptions and maintain transportation continuously working (Sharma et al., 2020a, 2020b, 2020c). The use of alternative modes of transportation and the measures companies implemented to face disruptions could have influenced the sustainable performance of firms. This context leads to our fourth hypothesis.

H4. Under the impacts arising from COVID-19 pandemic, transportation and logistics management have a significant impact on food supply chains' sustainable performance.

In order to deal with complex sustainability requirements and demands in AFSCs, interorganizational collaboration is essential to achieve a competitive advantage for better environmental, business and societal outcomes (Dania et al., 2018). Previous studies have demonstrated that sharing within other agribusiness companies is beneficial in terms of risk and investment management, access to previously unaffordable resources, efficient use of time and labor costs, and scaling up operations when resources are limited (Asian et al., 2019). When focused on environmental outcomes, collaboration comprises joint environmental goal-setting, shared environmental planning, and working together to reduce pollution or other environmental impacts (Vachon and Klassen, 2008).

As so, collaboration is an important characteristic of a resilient supply chain. Also, sharing information is the best way to increase visibility and reduce risks in a supply chain (Jabbour et al., 2020). In order to face the latest disruptions, companies could have intensified or started to develop their relationships with supply chain partners. Previous researchers found out that the implementation of supply chain collaboration strategies improves supply chains' sustainable performance by enhancing capacity building and resource usage (Chauhan et al., 2022). Barbosa et al. (2022) found out a positive relationship between environmental collaboration and all three dimensions of sustainable performance, however, with a lower effect observed on the economic dimension. Lockdowns and uncertainties caused by the pandemic gave rise to collaborative behaviors such as information sharing, which positively impacts agricultural productivity and sustainability (Kumari et al., 2021). Trivellas et al. (2020) corroborates it by stating that information sharing is one the main factors that impact sustainable supply chain performance. However, whether those changes in these relationships have affected the companies' sustainable performance remains unclear. This context leads to our fifth hypothesis.

H5. Under the impacts arising from COVID-19 pandemic, relationship management has a significant impact on food supply chains' sustainable performance.

As COVID-19 challenges the entire value chain, firms have been discussing how to create a resilient supply chain (Sharma et al., 2020a). The supply chain-wide impact management refers to the impacts in internal, upstream, and downstream operations, which generate more specific impacts such as the ripple effect on all the operations involved in supply chains and the closure of facilities. Due to displacement restrictions and quarantines, there has been sometimes a reduction, other times an increase in the shopping of some products, which has generated a unique bullwhip effect (Handfield et al., 2020). The bullwhip effect refers to the effects small changes in consumer demand have on fluctuations in upstream supply chain, which is amplified as orders pass through its different echelons, causing instability in production and distribution systems (Bamakan et al., 2021; Ponte et al., 2020). The pandemic has caused simultaneous severe disruptions in logistics infrastructure and on product supply and demand that led to both forward and backward disruption propagations (Ivanov and Dolgui, 2021). Managing the bullwhip effects caused by COVID-19 requires reducing the geographical distances between the companies and supply chain partners, the adoption of just-in-time inventory, and supply chain digitalization (Zighan, 2021).

The disruptions caused by the pandemic in the supply chain-wide impact management could also have effects on the environmental, economic, and social performance of firms. The pandemic has reduced global efforts to mitigate threats to natural resources with adverse effects on agriculture and food. In terms of social impacts, disruptions caused by the pandemic affected the poor and other marginalized groups due to food shortages. Lockdowns also undermined gender equality due to excessive workload stress on females (Rai et al., 2022). The pandemic made laborers, indigenous people, and women more vulnerable to food security and malnutrition (Adhikari et al., 2021). Finally, while the intense digitalization observed during this period can improve companies' performance, it can also reduce the need of foreign workers (Roubík et al., 2022).

Another wide impact observed along supply chains was that more local food products were introduced to supermarkets. Favoring local food helps creating a more sustainable food system (Nemes et al., 2021). An increase in community marketing schemes was also observed. As benefits, they can facilitate a smooth and continuous food supply during crises, produce less environmental footprint than conventional distribution channels, as well as foster social sustainability (Lioutas and Charatsari, 2021; Schmutz et al., 2018).

Changes observed throughout the supply chains and the bullwhip effect phenomenon are potential sources of sustainable impacts. For instance, it is considered the most important source of waste in supply chains of most industries (Ponte et al., 2022). As so, these wide impact in all echelons of the supply chain might have impacts on the sustainable performance of firms. This context leads to our final hypothesis.

H6. Under the impacts arising from COVID-19 pandemic, supply chain-wide impact management has a significant impact on food supply chains' sustainable performance.

According to the hypotheses presented, Fig. 1 illustrates our research model.

3. Methodology

This section presents the study's methodology, which is composed of the following steps: (1) instruments, (2) participants, (3), procedures, and (4) data anlysis.

3.1. Instruments

For this study, all measurement items were taken from the extant literature. The methodology for identifying items was based on previous published studies (Elangovan and Sundaravel, 2021; Yamada et al., 2010) that define a deductive method for scale development (Papadas et al., 2017). The deductive method is carried out through literature reviews and assessment of existing scales (Boateng et al., 2018). Since the magnitude of the disruptions provoked by Covid-19 has not been seen before, no previous scale has been proposed in the supply chain literature (Mirbagheri and Najmi, 2019). So, based on the items identified in the systematic literature review (SLR) performed by Chowdhury et al. (2021), the impacts of the pandemic on supply chains areas were identified. This type of review is considered more reliable and reproducible, allowing the objective appraisal of primary studies (Ruiz et al., 2020). The use of SLR findings to support the identification of impact of the pandemic on supply chain areas supports the idea that these items are applicable to the research context and theoretical framework.

Chowdhury et al. (2021) followed the strict and widely-accepted SLR procedures defined by Tranfield et al. (2003) to identify which aspects of the Covid-19 disruption have been studied so far. The authors searched several scientific databases to retrieve relevant articles and considered different types of articles. Authors found that exploring and reporting the several impacts of the pandemic on supply chains was the most frequently discussed topic. The reviewed articles reported several impacts of the outbreak related to six supply chain areas. In our study, we considered the same supply chain disrupted areas identified by Chowdhury et al. (2021). This item identification procedure from SLRs has been adopted in previous studies (Chi et al., 2021). Then, the proposed scale was validated by three PhD experts in sustainability and supply chain management to determine the items' relevance and readability (Salas-Zapata and Cardona-Arias, 2021). The dimensions of sustainable performance were described based on the studies published by Agyabeng-Mensah et al. (2020), Gölgeci et al. (2019), and Belhadi et al. (2020). The scales were translated by researchers fluent in both Portuguese and English, besides being experts in the SCM research field.

Table 1 presents the constructs assessed in this study and how they were defined from the existing literature. The six disrupted supply chain areas are demand management (Handfield et al., 2020; Ivanov and Dolgui, 2021), supply management (Baveja et al., 2020; Nikolopoulos et al., 2021), production management (Ivanov and Das, 2020; Paul and Chowdhury, 2020), transportation and logistics management (Chiaramonti and Maniatis, 2020; Deaton and Deaton, 2020), relationship management (Baveja et al., 2020; Gunessee and Subramanian, 2020), and supply chain wide impact management (Ivanov, 2020a; Queiroz et al., 2020). Measurement items for these constructs can be found in Appendix A. Items were measured with a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree, as used in previous research. Moreover, scales using 5 points are common (Hartley, 2014). Previous researchers recommend 5-point Likert scales because they enhance reliability and validity (Lietz, 2010).

Sustainable performance is usually described using the Triple bottom line (TBL) structure, which considers social, environmental, and economic aspects of sustainability (Kinnunen et al., 2022). In this study, sustainable performance is defined as a reflective construct for the following reasons: (1) most researchers generally define and measure sustainable performance in a reflective way (Antwi et al., 2022; Barbosa et al., 2022; Foo et al., 2018; Kumar and Rahman, 2016; Larbi-Siaw et al., 2022); (2) in spite of its extensive representation in three dimensions, sustainable performance has also been defined using other dimensions, such as innovation and operational would form the construct; (3) these dimensions have some overlapping that prevents them to be assessed in isolation.

3.2. Participants

The study used a cross-sectional e-mail survey with Brazilian agri-food companies. The target population comprised agri-food companies

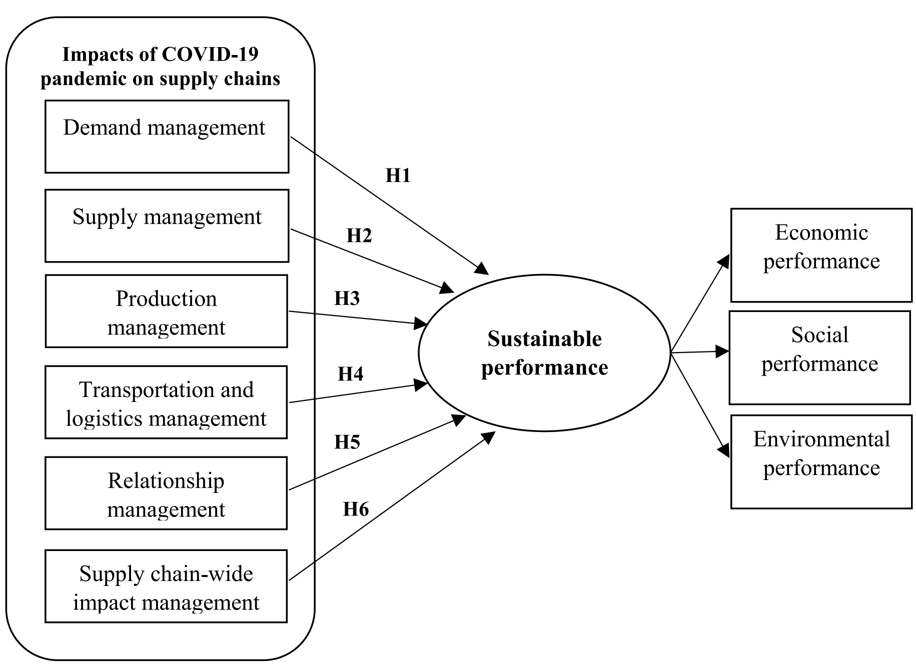

Fig. 1. Research model.

Table 1
Construct's definitions for the model's first order constructs.

Construct	Definition	Reference
Demand management	It includes the impacts the pandemic has caused on demand management: demand spikes for essential products, shortage of essential products, failure of on-time delivery, and ambiguity or difficulty in forecasting.	Chowdhury et al. (2021)
Supply management	It includes the impacts the pandemic has caused on supply management: shortage of material supply, supply-side shock, and supply disruption.	
Production management	It includes the impacts the pandemic has caused on production management: production disruption and backlog, reduced production capacity, and unavailability of workforce	
Transportation and logistics management	It includes the following kinds of impacts caused by the pandemic: delays in transportation and distribution, reduction of international transportation/trade, and loss/lack of physical distribution channels.	
Relationship management	It includes the following types of impacts caused by the pandemic: reduction of social interaction, lack of supplier engagement, and opportunistic behavior.	
Supply chain-wide impact management	It includes the impacts the pandemic has caused on supply chain-wide impact management such as ripple effects, closure of facilities (companies' and supply chain partners').	
Economic performance	It is the extent to which a firm is able to achieve financial goals (gain and retain customers, improve sales, profitability, and return on investment).	Agyabeng-mensah et al. (2020)
Social performance	It is related to an organization's responsibility for the impact of its business activities on society and the welfare of its employees.	Agyabeng-mensah et al. (2020)
Environmental performance	It is the set of a firm's strategic initiatives carried out to manage or reduce environmental accidents and the impact on the natural environment.	Agyabeng-mensah et al. (2020) Gölgeci et al. (2019) Belhadi et al. (2020)

related to Fundação Dom Cabral (FDC), which is among the top ten business schools in the world according to the British Financial Times newspaper (Times, 2020) and is the best positioned among all organizations in this sector in Latin America. In addition, FDC manages a research group dedicated to the agriculture industry. The survey was administered to company owners, Chief Executive Officers (CEOs), directors, managers, coordinators and supervisors in Brazilian medium and large-sized companies of the agriculture sector. The questionnaires were distributed to employees of 1272 different companies. At first, 385 responses were obtained. After eliminating incomplete and invalid questionnaires (36), 349 complete responses were obtained and were considered suitable for data analysis, yielding a response rate of 27.4%. Non-response bias was addressed by sending follow-up e-mails to respondents every 10 days, during the data collection stage of the research.

In order to identify the necessary sample size (n) to perform the structural equation analysis, we used the formula proposed by Westland (2010):

$$n \geq 50r^2 - 450r + 1.100$$

in which.

p = manifest variables = 37;
f = number of latent variables = 9;
$r = \frac{p}{f} = \frac{37}{9} \approx 4.11.$

Therefore, for this study, n should be greater than 95, a value by far exceeded by the number of valid questionnaires (349).

In terms of the hierarchical positions of respondents, the sample consisted mainly of high-level professionals: CEOs, General Directors, and Superintendents (124 cases), functional area directors and managers (148 cases), and functional area advisors/supervisors (54 cases). Twenty-three respondents declared to have other hierarchical position in their companies. The fact that almost 80% of the sample was constituted by high-level professionals is in line with the objective of this study. Table 2 represents the descriptive firm profiles.

The agricultural sector shows a strong dichotomy. Corporate agriculture is very dynamic and driven by the production of export commodities, mostly harvested in the South, Southeast and Central-West regions (de Castro, 2014). Family farming is concentrated in the Northeast and North regions (IFAD, 2021). As so, our sample follows a similar distribution compared to the whole population of agricultural companies in Brazil.

3.3. Procedures

The questionnaire pre-test was applied to a sample of 30 executives to check their comprehension of the survey questions (72 have been invited). They evaluated the measurement items' clarity with the aid of an appraisal sheet in which they reported the clarity of each item (how clear their wording was) and provided recommendations for improvement of each item, as recommended by Rodrigues et al. (2017). A 3-point Likert scale was used to assess items' clarity. The scale was composed of the following categories: 1 = not clear, 2 = item needs

Table 2
Firm descriptive characteristics.

Characteristic	Category	Number of Respondents	%
Revenue (millions of U$)	Less than 10	26	7.45
	10–20	15	4.30
	21–100	157	44.99
	101–200	72	20.63
	More than 200	79	22.64
Number of employees	Less than 50	24	6.88
	51–100	22	6.30
	101–200	49	14.04
	201–400	156	44.70
	More than 400	98	28.08
Employee's work experience in the company (years)	Less than 1	13	3.72
	1–3	27	7.74
	3–5	25	7.16
	More than 5	284	81.38
Firm Location	Central West	88	25.43
	North	7	2.02
	Northeast	11	3.18
	South	73	21.10
	Southeast	167	48.27

some revision; and 3 = very clear. Ratings of 1 and 2 were considered content invalid while the rating of 3 was considered content valid, as suggested by Souza et al. (2017). Respondents' recommendations to improve items' readability and clarity were followed. The team duly discussed suggestions, and necessary modifications were made to the survey questions. The final version of the questionnaire was obtained after considering the recommendations made by respondents that participated in the pilot study. Responses obtained in the pilot study were not considered for the analysis of the research model.

3.4. Data analysis

The model's hypothesized effects were analyzed using PLS-SEM (Hair et al., 2017) due to the characteristics and the objective of this study. The adoption of the PLS-SEM method demands that researchers transfer the constructs and their hypothesized relationships into a structural model (Benitez et al., 2020). The PLS model was assessed in two stages: evaluation of the measurement model and evaluation of the structural model. This first stage comprises unidimensionality, convergent validity and discriminant validity analysis. The second step involves testing the structural model and verifying the structural relationships represented by the model's hypotheses. In order to do so, path coefficients are determined for each relationship as well as the coefficient of determination (R^2). Data analysis was carried out using the LISREL 8.5 software.

3.5. Rigor analysis

In order to demonstrate that this study has followed a rigorous methodological research process, we have adopted several initiatives recommended by previous studies (Laher, 2016; Marquart, 2017). Appendix B shows the recommendations that need to be observed when carrying out quantitative studies based on thoroughness, accuracy, soundness, and precision in each of the study's phases (planning, data collection, analysis, and reporting). Some of the recommendations adopted include the carefully design of the survey instrument, the use of appropriate data collection and analysis techniques, and the use of goodness-of-fit indexes to assure the model's quality and prediction power. Appendix B also shows the initiatives and decisions taken in order to comply to these recommendations.

4. Results

4.1. Common method variance

Common method variance (CMV) occurs when variations in responses are caused by the measurement method rather than by the constructs the measures represent (Podsakoff et al., 2003). In order to detect CMV, the Harman's Single-Factor Test was adopted, since it is deemed as the most common test for this purpose. In this test, all measurement items for each construct are loaded into a factor analysis to assess if a single factor emerges, that is, if a single factor results in the majority of the covariance among the measures (Tehseen et al., 2017). In this study, the first unrotated factor captured only 19% of the variance in data, less than the acceptable threshold of 50% (Tehseen et al., 2017), thus, since no single factor emerged and it did not capture most of the variance, it can be concluded that CMV was not an issue.

4.2. Evaluation of the measurement and structural models

The evaluation of the measurement model comprised unidimensionality analysis, convergent validity analysis and discriminant validity analysis. Appendix A shows the results of the unidimensionality and convergent validity tests. It can be seen that all Cronbach's alpha values and all out loading values were greater than 0.7, the acceptable threshold established for this test (Hair et al., 2017). All composite reliability (CR) values were greater than 0.7, over the acceptable limit (Fornell and Larcker, 1981). Some of the indicators in the research model presented values between 0.4 and 0.7. They were kept due to content validity (Hair et al., 2017). All Average Variance Extracted (AVE) values were greater than 0.5, in accordance to the acceptable limits (Fornell and Larcker, 1981).

Discriminant validity assess how truly distinct a construct is from other constructs (Hair et al., 2017). The Fornell-Larcker criterion is a method used to evaluate discriminant validity. The values in the leading diagonal entry of Table 3, representing the square root of AVE, are greater than the inter-construct correlations. These methods demonstrate the discriminant validity of the model's constructs. Table 3 also shows the average and standard deviations (SD) for each construct.

In order to measure the quality of the model, we examined some Goodness-of-Fit (GoF) indeces. In our study, all GoF indeces exceed the cutoff values, which shows the good prediction power the model has. Table 4 shows the value of the GoF indices.

Table 5 shows path coefficients (β) and t-values for the proposed hypotheses. According to the results, supply management and transportation and logistics management have a positive and significant effect on sustainable performance, which confirms hypotheses H2 ($\beta = 0.36$; $t = 2.56$) and H4 ($\beta = 0.34$; $t = 2.76$). The effects of relationship management and supply chain wide impact management were found to be negative and significant on sustainable performance, confirming hypotheses H5 ($\beta = -0.46$; $t = -3.63$) and H6 ($\beta = -0.31$; $t = -2.66$). However, the positive effect of demand management on sustainable performance ($\beta = 0.11$; $t = 0.92$) was observed but it was considered non-significant, which led to the rejection of H1. Finally, the effect of production management on sustainable performance was not significant, which led to the rejection of H3 ($\beta = -0.10$; $t = -0.92$).

The coefficient of determination (R^2) was used to evaluate the structural model. According to Hair et al. (2017), the value of 0.51 observed in this study can be considered high. Fig. 2 shows the path coefficients and R^2 value obtained in this study for the structural model. Finally, our study showed that the three dimensions of sustainability (environmental, economic, and social) have respectively contributed as much as 0.50, 0.36 and 0.45 in explaining sustainable performance.

5. Discussions

The, COVID-19 has shown that sustainable goals are not resilient to shocks imposed by pandemic. In fact, some goals will not be accomplished by 2030 and some may become counterproductive (Ibn-Mohammed et al., 2021). Accordingly, supply chain managers have been facing difficulties in focusing on sustainability while focusing on and recovering from financial impacts (S. Kumar et al., 2021) (S. Kumar et al., 2021) (S. Kumar et al., 2021) (S. Kumar et al., 2021) (Kumar et al., 2021).

Namely, it has been a major challenge to keep the environmentally sustainable practices especially in the context of the pandemic. Although companies have been increasingly adopting environmental initiatives, there is a fear that those practices could be abandoned as soon as companies are confronted by new and difficult to predict challenges (Amankwah-Amoah, 2020) like the pandemic. Although some positive effects of the coronavirus outbreak have been observed such as the modest reductions in air pollution (Elleby et al., 2020), the implications of the pandemic on sustainability remain to be seen (Sarkis et al., 2020). Moreover, the COVID-19 pandemic has also impacted the sustainable performance of firms. Besides facing economic negative outcomes, organizations are facing challenges associated with social sustainability as well (Sharma2020). So, the social performance is one of the areas where firms needed to focus during pandemic. The coronavirus has created a new approach of working culture with flexible working hours and remote working (Sharma et al., 2020a, 2020b, 2020c), therefore companies need to assure the well-being of their employees under these conditions. Furthermore, issues of humanitarian logistics have been

Table 3
Descriptive items and correlations.

Construct	$\overline{X}$	SD	DM	SM	PM	TLM	RM	SWM	EN	EC	SC
DM	3.3761	.792	0.814								
SM	3.9850	.735	.579**	0.854							
PM	2.9427	.834	.510**	.486**	0.794						
TLM	3.7436	.752	.341**	.416**	.476**	0.806					
RM	3.1471	.753	.396**	.456**	.344**	.516**	0.773				
SWM	3.3639	.816	.402**	.457**	.524**	.487**	.504**	0.758			
EN	3.2808	.826	.108*	−.004	.120*	.038	−.122*	−.034	0.713		
EC	3.8135	.812	−.097	−.006	−.171**	.069	−.112*	−.091	−.116*	0.709	
SC	3.6784	.753	−.018	−.022	−.004	−.024	−.186**	−.084	.418**	.208**	0.794

Note. $1 \leq \overline{X} \leq 5$ and * $p < 0.05$; ** $p < 0.01$.

Table 4
Goodness-of-fit examination.

Fit indices	Estimated values	Cutoff values	Source
χ2/df	2.46	<3	Paswan (2009)
Root Mean Square Error of Approximation (RMSEA)	0.065	<0.08	Byrne (1998); Jöreskog and Sörbom (1993)
Akaike's Information Criterion (CAIC)	253.78	Acceptable (< saturated and independence)	
Saturated CAIC	305.69		
Independence CAIC	1176.67		
Comparative Fit Index (CFI)	0.98	≥0.95	Mulaik et al. (1989)
Standardized Root Mean Square Residual (SRMR)	0.030	<0.08	Hu and Bentler (1999)
Goodness-of-fit Index (GFI)	0.98	>0.90	
Adjusted Goodness-of-fit Index (AGFI)	0.93	≥0.90	Hooper et al. (2008)
Normed Fit Index (NFI)	0.97	>0.90	Hu and Bentler (1999)
Non-Normed Fit Index (NNFI)	0.95	>0.90	
Incremental Fit Index (IFI)	0.98	>0.90	

Table 5
Direct effects on Sustainable performance.

Hypothesis	Path	Direct effects		Hypothesis supported?
		β	t	
H1	DM → SUS	0.11	0.92^{ns}	No
H2	SM → SUS	0.36	2.56*	Yes
H3	PM → SUS	−0.10	-0.92^{ns}	No
H4	TLM → SUS	0.34	2.76*	Yes
H5	RM → SUS	- 0.46	- 3.63*	Yes
H6	SWM → SUS	- 0.31	- 2.66*	Yes

Note. ns = Not significant; *$p < 0.01$.

raised (Queiroz et al., 2020) as well as concerns with widespread unemployment and economic distress (Majumdar et al., 2020).

As the same way, the COVID-19 pandemic has severely impacted and continues to impact the ways production, distribution and consumptions of agri-food are being managed worldwide (Mishra et al., 2021). The pandemic has shown how dependent our society is on a well-functioning global food chain and how vulnerable agri-food chains are to disruptions (Elleby et al., 2020). Previous studies have identified different impacts caused by the COVID-19 pandemic in the agricultural sector: economic impacts (Ma et al., 2021), reduced incomes (Boyacı-Gündüz et al., 2021), shortage of capital flow to support companies along the supply chain (Deaton and Deaton, 2020), costs increase, financing difficulties, labor shortage, and order cancellations (Lin and Zhang, 2020).

This study assessed the effects different kinds of impacts caused by the COVID-19 pandemic had on the sustainable performance of agri-food supply chains. Evaluating these impacts is important since it remained unclear until now whether these kinds of impact caused by the COVID-19 pandemic positively or negatively influenced the adoption of sustainability initiatives.

The results of our study show that the impacts on the dimensions analyzed are able to explain 51% of the variance of sustainable performance, that is, a little more than half of the changes observed on sustainable performance have been caused by the impacts of the pandemic. This finding highlights the importance of this study due to the magnitude of the pandemic impacts on sustainable performance. By knowing which kinds of impacts produce the most significant effects on sustainable performance, managers will be able to make decisions to avoid these effects and to improve firms' sustainable performance.

It has been observed that, under the impacts arising from COVID-19 pandemic, supply management had a positive and significant impact on food supply chains' sustainable performance, confirming H2. In accordance to Hobbs (2020), the pandemic has caused supply-side disruptions to AFSCs, some of them caused by labor shortages due to worker illness, self-isolation, or movement restrictions. Supply side disruptions have also caused other impacts such as significant decreases in raw material supply (Paul and Chowdhury, 2020) and an increasing interest in locally sourced foods (Hobbs, 2020). In order to deal with supply disruptions, companies have implemented some initiatives that had a positive effect on their sustainable performance. This finding corroborates previous studies that found out that localization increases resilience of supply chains and make than more sustainable (Gupta et al., 2021; Ivanov and Dolgui, 2021).

The study has also shown that, under the impacts arising from COVID-19 pandemic, transportation and logistics management had a positive and significant effect on sustainable performance, which confirms H4. On the one hand, farm activities have been impeded to continue with their normal activities due to restricted movement of farm labor and their illness during quarantines (Goswami et al., 2021). On the other hand, transportation and distribution chains have shown to be vulnerable to disruptions (Hobbs, 2020). This current study considers that transportation-related impacts caused by the pandemic such as the loss of physical distribution channels, the shift to online or blended distribution modes, and the reduction of international trade have positively contribution to companies' sustainable performance in agri-food contexts. Previous research has identified a significant expansion of online food ordering (Music et al., 2022) and the use of digital technologies in transportation to maintain social distancing and reduce human interaction (Kumar et al., 2020). These actions are examples that might have contributed to an increase in firms' sustainable performance.

Furthermore, under the impacts arising from the pandemic, the effects of relationship management were found to be negative and significant on sustainable performance, confirming hypotheses H5. So, the disruptions the pandemic has caused on relationships among supply

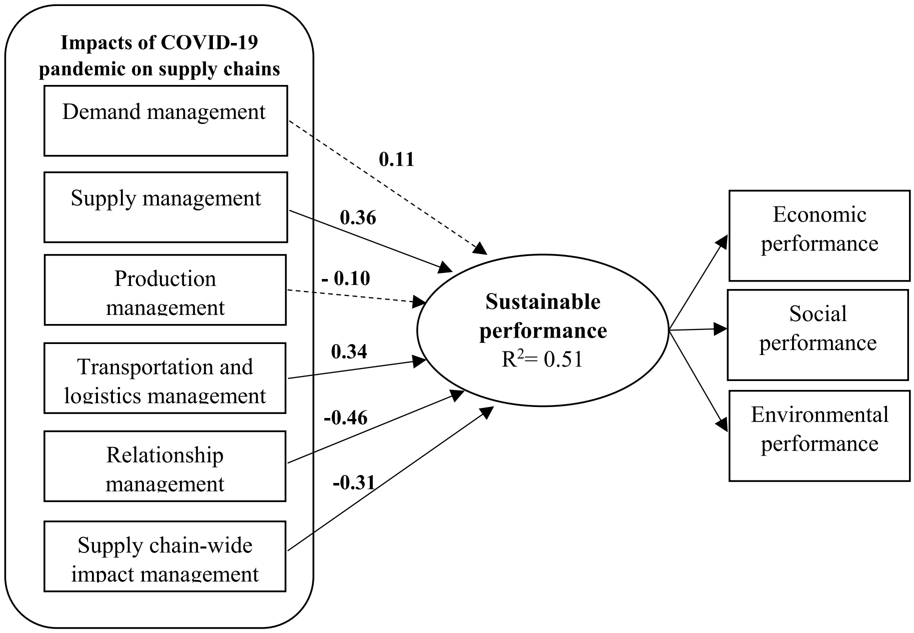

Fig. 2. Approved model.

chain partners have led to a decrease in companies' sustainable performance. This outcome is aligned with previous studies that state that the performance of the AFSC is partially dependent on the performance of each of the partners involved (Sufiyan et al., 2019) because these networks require joint efforts to meet the corresponding sustainable standards, reduce and share the high costs and risks of decisions on sustainability (Cao et al., 2020) to have a positive impact on environmental, social and economic performance (Esfahbodi et al., 2017; Li et al., 2017; Zhu et al., 2016).

In order to deal with sustainability requirements in AFSCs, collaboration among supply chain partners is essential to collectively achieve a competitive advantage for better environmental, business and societal outcomes (Dania et al., 2018). Previous studies have demonstrated that collaboration with other agribusiness partners is beneficial to optimize risk and investment management, to allow access to previously unaffordable resources, to promote efficient use of time and costs, and to scale up operations (Asian et al., 2019).

Additionally, under the impacts arising from the pandemic, the effects of supply chain wide impact management were found to be negative and significant on sustainable performance, confirming H6. The pandemic has disrupted food systems worldwide, affecting multiple systems interfaces in agriculture (Goswami et al., 2021). These results are in accordance with previous studies that have shown the pandemic has also caused negative effects on sustainability. For instance, the before-mentioned restrictive measures have increased online shopping, which has increased the use of paper and plastic waste (Sharma et al., 2020a, 2020b, 2020c). The pandemic has also increased the number of disposable face masks used, which has led to the challenge of coming up with solutions for a proper disposal (Maderuelo-Sanz et al., 2021). Moreover, it made some companies slow down their transition to renewable energy (Hosseini, 2020).

Our study has shown that, under the impacts arising from the pandemic, the effects of demand management on sustainable performance were not considered to be significant, which led to the rejection of H1. This finding contrasts with previous studies. The pandemic has caused a spike in demand for essential products (Frederico et al., 2021), specially healthcare products. In terms of agricultural products, demand spikes from panic buying have been seen specially when the pandemic started. Some demand shocks are due to changes in customers' behaviors, for example, an increase in the demand for ready-meals (Hobbs, 2020) or to a fall in consumer incomes. Some companies could experience a sharp drop in demand, which will lead them to cut back on production, expenses and investments (Baveja et al., 2020). All these effects could have impacted firms' sustainable performance; however, they were not considered significant in the present study.

This study has found out that, under the impacts arising from the pandemic, the effects of production management on sustainable performance were not significant, which led to the rejection of H3. The pandemic has caused disruptions of production processes as well as shifts in demand and supply (Okorie et al., 2020). Also, production has been stopped in different industries due to the non-availability of labor. The agriculture sector is strongly dependent on temporary workers for the harvest of crops. With restrictive measures, it was impossible for these workers to get to agricultural fields, which resulted in food losses (Dente and Hashimoto, 2020). Moreover, many products lost their shelf life and had to be returned to companies, requiring fast and effective reverse supply chains (Deshmukh and Haleem, 2020). Although some effects caused by production disruptions on companies' sustainable performance could have been predicted, our study demonstrated that they were not significant.

Finally, our study showed that the three dimensions of sustainability (environmental, economic, and social) have respectively contributed as much as 0.50, 0.36 and 0.45 in explaining sustainable performance.

5.1. Theoretical contributions

This paper contributes to the extant literature by investigating the effects the pandemic had on the sustainable (economic, environmental and social) performance of agri-food supply chains. This study offers some key theoretical contributions. First, we draw on the ROT to conceptualize constructs that reflect supply chain-related impacts caused by the COVID-19 pandemic. Second, the use of ROT in the context of the disruptions caused by the pandemic is quite relevant. Since ROT is derived from the dynamic capabilities, the capabilities managers need to deal with these kinds of impacts will be necessary to promote the sustainable transition of firms.

The ROT considers that resources alone are not enough to obtain competitive advantage because they need to be effectively managed to do so (Giunipero et al., 2021; Sirmon et al., 2011). In this context, managers should be able to orchestrate resources and transform them into capabilities aligned with corporate strategies (Queiroz et al., 2022). The authors believe this theory proposes a new approach to orchestrate different resources across firms and their supply chain partners in order to achieve sustainable performance, and therefore, it is an adequate theoretical underpinning for this research.

This study extends the ROT by adopting it under the context of the COVID-19 pandemic, whose unique characteristics force companies to review how their scarce resources should be managed (Giunipero et al., 2021). Moreover, researchers claim that this theory has been overlooked in the operations field (Hughes et al., 2018), with only few applications reported in this context (Kristoffersen et al., 2021; Queiroz et al., 2022). During the pandemic, as this study has reported, different kinds of resource scarcity were observed, such as the shortage of supply products and components and of the workforce. Under these circumstances, companies had to restructure their operations to keep their business running. At the same time, firms had to keep sustainable initiatives and goals, which forced the development of orchestration competences to deal with resource scarcity, support resilience and innovate.

By embedding the ROT in the management of supply chain areas required to face disruptions, this study contributes to the existing literature and sheds light on how companies need to synchronize their resources to improve their sustainable performance. Our study extends the adoption of ROT in contexts related to disruptions and alignment among supply chain partners. We also corroborate research that found out that coordinating related capabilities under ROT remains key to achieve sustainable and competitive advantages and that sustainability has been understudied in these contexts (Feizabadi et al., 2019). Our study's contributions answer calls made from other researchers for further theorizing in SSCM in order to elucidate and explain SCM phenomena toward economic, environmental, and social sustainability (Seuring et al., 2022).

Our study contributes to the extant literature by proposing that resources related to the disrupted supply chain areas need to be orchestrated to support identifying responses to deal with disruptions and promote resilient and sustainable operations. In this sense, we understand that, by orchestrating resources, firms create a better capability to improve their sustainable performance.

Scholars have criticized the operations research and operations management methods used so far in dealing with the complex impacts of disruptions because these methods do not provide an in-depth comprehension on the joint use of resources to address and plan for disruptions (Holguín-Veras et al., 2012; Kovács and Spens, 2011). Craighead et al. (2020) corroborates this line of thought by suggesting that ROT could support understanding how to deal with interruptions on product supply and demand and how resources can be reconfigured leading to different kinds of value during pandemics. As so, ROT can help in understanding the orchestration problems organizations experience during the outbreaks. Baltas el at. (2022) state that researchers should investigate what type of value they can create by bundling resources. Under ROT, we posit that resources are structured, bundled, and leveraged to improve firms' sustainable performance, dealing with the longer implications of this type of disruption.

In order to deal with the consequences of disruptions, firms had to obtain (acquire) new resources to face shortage of supply materials. Firms had to learn from others' experiences how to face disruptions and to keep running their sustainability programs. According to ROT, this can be done by accumulating resources, for example, by adding new knowledge to the firm's current knowledge set, which supports building the essential dynamic managerial capabilities required at disruption times. During the pandemic, firms also had to divest resources that no longer helped them achieving competitive advantages. This phenomenon was observed as less resources were dedicated to in-store buying, in-company work environments, and physical interactions. By divesting these resources, firms avoid that their capability weaknesses undermine the benefits provided by their strengths (Sirmon et al., 2011).

Following ROT, bundling refers to stabilizing (adding minor incremental improvements to existing capabilities), enriching (extending current capabilities); and pioneering (creating new capabilities) (Sirmon et al., 2011). With the pandemic, firms had to reconfigure resources to develop new distribution channels, with a clear shift to online or blended operations. Companies also had to develop new capabilities, for instance, those related to the use of technology (online shopping, accelerated digital transformation processes, faster adoption of Industry 4.0 technologies, and increased use of drones and robots). Firms that were able to update and enhance their capabilities could not only survive the outbreak but also increase their competitive advantages and performance.

Under ROT, leveraging processes are focused on coordinating and deploying resources to new locations as well as to existing markets. With the pandemic, firms had to strengthen their relationships with other partners to keep information exchange, to promote process integration and to avoid information ambiguity. Finally, firm resources had to be leveraged to face the consequences and to minimize the impacts of ripple effects and the closure of facilities, that caused great impacts on supply chains' operations. As suggested by Peterson et al. (2022), under a ROT perspective, managers and companies should look beyond their own role to achieve positive outcomes for themselves and their partners.

Based on the study's findings and on the previous discussion, we propose a framework that clearly represents the relationship between the disrupted supply chain areas and sustainable performance through the development of ROT capabilities. Fig. 3 depicts the proposed framework.

The proposed framework allows the identification of some insights, presented as follows.

Insight 1: The orchestration of resources among supply chain partners could facilitate supply forecasting and reduce shortage of supply material under disruptions

Insight 2: The orchestration of resources among supply chain partners could support the process of divesting physical distribution channels and shifting to online or blended modes of delivery and transportation under disruptions.

Insight 3: The orchestration of resources among supply chain partners could help coordinate operations in a context of reduced social interactions and reduce information ambiguity under disruptions.

Insight 4: The orchestration of resources among supply chain partners could support facing the negative consequences of ripple effects and closure of facilities under disruptions.

5.2. Practical implications

This paper also presents practical contributions to supply chain and sustainability professionals. This study is carried out in an emergent economy context, especially in a country (Brazil) that faces so many sustainability challenges, particularly during COVID-19 era. The country's economic growth and infrastructure development has also led to several undesirable social impacts (Waroux et al., 2019), which raises concerns with sustainability in this sector and the necessity to go beyond environmental performance and assess social and financial performance as well. This study answers calls for more research on the environmental, financial, and social impacts of agricultural supply chains, especially in emerging economies, in an integrated manner (Dung et al., 2020; Matzembacher and Meira, 2019; Seuring et al., 2022). Since sustainable SCM initiatives are context-specific, this study contributes to identifying pathways to achieve sustainability (Jia et al., 2018).

By showing that the disruptions caused by the pandemic on relationships among supply chain partners led to a decrease in companies' sustainable performance, this study extends previous studies on the relationship between interorganizational collaboration and sustainability (Gölgeci et al., 2019; Mishra et al., 2022). This study contributes to the extant literature by showing that, when interorganizational alignment and relationships are damaged, firms' sustainable

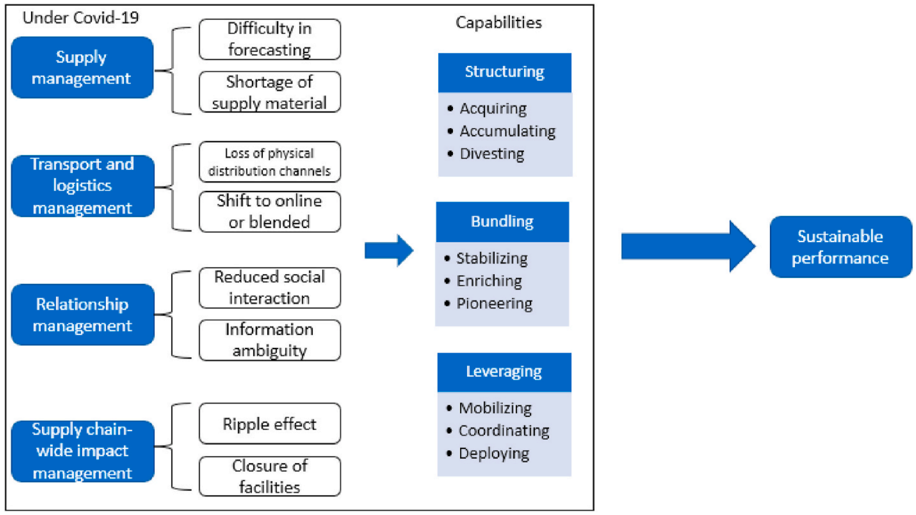

Fig. 3. Proposed framework.

performance is reduced. As so, our study showed that, even during outbreaks, companies should struggle to keep their collaborative relationships with supply chain partners in order to maintain their sustainable performance.

Our study also contributes to practitioners by showing that the disruptions caused by the outbreak in transportation and logistics managed, some of which related to the use of technology and digital channels, positively contributed to firms' sustainable performance. In this way, our study stimulates managers to accelerate the digital transformation of their transportation processes in order to achieve higher levels of sustainable performance. Change in shopping behavior and transportation modes will reduce greenhouse gas emissions, firms' carbon footprints, and energy use. Besides positive environmental effects, these changes will also contribute to companies' financial performance, due to costs reductions. When companies leverage their production and distribution networks, they might generate value for society by neutralizing threats to the environment.

Finally, our study contributes to scholars and managers by analyzing whether the impacts of the pandemic on managing different supply chain areas influenced firms' environmental, social and economic performance. The three dimensions were assessed together in the same model, as recommended by a previous study (Rajesh, 2020).

So, by understanding which supply chain dimensions have positive and negative significant impacts on sustainable performance, firms can design and implement initiatives to prevent threats and explore opportunities.

5.3. Limitations to this study

This study presents some limitations typical of this kind of research that open up possibilities for future work. First, this study employed only a quantitative method for data collection and analysis. Hence, examining these effects through qualitative methods could provide a deeper understanding of how the disturbances caused by the pandemic on supply chain dimensions have impacted sustainable performance. Second, this study only focused on Brazilian agricultural companies. Although the results of this study are applicable to other countries and regions, since the sector is global, this study can be expanded by including a broader sample of firms acting in different locations worldwide, because agricultural characteristics may vary across different regions according to the local economic, social, and institutional conditions. Due to the importance of each of the three dimensions of sustainable performance, further research could be dedicated to exploring how the impacts of the COVID-19 pandemic have affected each one of the three dimensions.

6. Conclusions

This study evaluated the impacts of the COVID-19 pandemic on sustainable (environmental, social, and economic) performance of agri-food supply chains. Data was collected with a questionnaire from 349 different medium and large Brazilian agri-food companies and analyzed using the SEM-PLS technique. Among the main findings of this study, we found out that, under the impacts arising from COVID-19 outbreak (1) supply management and transportation and logistics management positively and significantly impacted AFSCs' sustainable performance; (2) relationship management and supply chain wide impact management negatively and significantly impacted sustainable performance; and (3) the effects of demand and production management on sustainable performance were not considered significant.

We expect our study contribute to stimulate managers and policy makers to understand that the disturbances caused by the pandemic can offer a chance for a transition towards implementing sustainable management practices in agriculture.

The COVID-19 pandemic exposed the fragility of the supply chains, since production, distribution, and transportation systems have been majorly disrupted, either permanently or temporarily. In this study, we evaluated if the impacts the pandemic had on the different supply chain areas produced impacts on firms' sustainable performance. We are not aware of any previous study that has performed such an analysis before the pandemic. It is left as a suggestion for future work to evaluate if such effects would be different some years from now.

Data availability

Data will be made available on request.

Appendix A. Measurement items and model fit indices

Construct	Items	Item description	Loadings	t-value	α	CR	AVE
		I think that the Covid-19 pandemic has caused the following impacts on food supply chains					
Demand management	DEM1	… Demand spikes for essential products by the population.	0.88	–	0.774	0.898	0.649
	DEM2	… Shortage of products considered essential by the population.	0.91	14.33			
	DEM3	… Loss of food security with respect to essential items.	0.70	10.89			
	DEM4	… Failure of on-time delivery.	0.95	17.99			
	DEM5	… Declining demand for non-essential products.	0.50	7.14			
Supply management	SUP1	… Ambiguity or difficulty in forecasting.	0.61	–	0.772	0.852	0.597
	SUP2	… Shortage of supply material.	0.71	15.11			
	SUP3	… Supply side shock (Unforeseen change in supply of some items followed by change in price)	0.73	17.60			
	SUP4	… Supply disruption	0.99	21.92			
Production management	PRD1	… Production disruption	0.85	–	0.751	0.837	0.575
	PRD2	… Reduced production capacity.	0.93	15.59			
	PRD3	… Unavailability of workforce.	0.68	9.01			
	PRD4	… Obsolescence or impairment of machinery and capital assets.	0.50	8.82			
Transportation and logistics management	TRL1	… Delays in transportation and distribution.	0.98	–	0.722	0.795	0.509
	TRL2	… Lack of international transportation/trade.	0.70	11.68			
	TRL3	… Loss/lack of physical distribution channels usage.	0.51	7.31			
	TRL4	… Shift of distribution and logistics pattern (offline to online or blended).	0.57	7.38			
Relationship management	REL1	… Reduced social interaction among partners of food supply chains.	0.58	–	0.714	0.736	0.503
	REL2	… Information ambiguity (information incompleteness, lack of clarity and precision)	0.96	16.80			
	REL3	… Lack of supplier engagement/opportunistic behavior.	0.50	8.94			
Supply chain wide impact management	WID1	… Ripple effect on all the operations involved in supply chains (It is a phenomenon of low-frequency-high-impact disruptions propagations in the supply chain and their impact on output supply chain performance (e.g., sales, on-time delivery, and total profit)	0.89	–	0.788	0.834	0.630
	WID2	… Supply chain collapse (causing impacts in internal, upstream and downstream operations)	0.83	19.80			
	WID3	… Closure of facilities.	0.64	9.57			
		I think that the Covid-19 pandemic caused our company to …			0.870	0.907	0.663
Sustainable performance – Environmental performance	ENV1	… Decrease in wastewater and/or solid waste.	0.86	–			
	ENV2	… Decrease in use of hazardous/harmful/toxic materials.	0.86	23.87			
	ENV3	… Decrease in energy consumption	0.80	20.07			
	ENV4	… Decrease in industrial pollution and emission.	0.88	24.69			
	ENV5	… Improved reuse and recycle of materials and products.	0.65	13.34			
Sustainable performance – Economic performance	ECO1	… Increase in return on investment.	0.84	–	0.900	0.931	0.729
	ECO2	… Increase in gross profit margin.	0.89	25.95			
	ECO3	… Increase in net profit.	0.91	26.97			
	ECO4	… Increase in return on assets.	0.87	23.99			
	ECO5	… Increase in return on sales.	0.75	18.21			
Sustainable performance – Social performance	SOC1	… Improved employees' health and safety.	0.94	–	0.785	0.867	0.630
	SOC2	… Improved community health and safety.	0.77	16.86			
	SOC3	… Improved employees' skills.	0.88	18.49			
	SOC4	… Improved job satisfaction levels of employees.	0.52	10.36			

Appendix B. Methodological rigor analysis

Stage of the study	Items to assess*	Assessment results in this study
Planning	-Addressing instrument so that it captures the relevant underlying theoretical construct/framework to check construct validity (and then generalizability of the results) -Providing descriptions on the measures, format of response, scoring procedures, and adaptation of the measures -Addressing instrument to be piloted before application	-All constructs, descriptions and measures were taken from the literature (Table 1 and Appendix A). -Measures were assessed using a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree -Measures were adapted (to the local context and field of study) and validated by applying the parallel translation technique -Questionnaire pre-test was applied to a sample of 30 using a three-point Likert scale to assess items' clarity, readability and content validity
Data Collection	- Providing descriptions on the aspects of the research design and data collection methods - Control of coverage and sampling errors (to improve internal validity and generalizability) include: composition, representativeness and size of sample. - Control of nonresponse from potential participants (to improve generalizability) - How to consider ethical issues in the study	- A cross-sectional survey with Brazilian agri-food companies designed to collect data. - Hierarchical positions of respondents show the sample consisted mainly of different high-level professionals (80%) that is in line with the objective of the study (Table 2). - Westland (2010) formula was used to detect of sample size. - Conditions for representativeness of the sample was assessed. - Non-response bias was addressed by sending follow-up e-mails to respondents every 10 days.

(continued on next page)

(*continued*)

Stage of the study	Items to assess*	Assessment results in this study
		- Incomplete and invalid questionnaires (36) were excluded and 349 complete responses were considered for analysis, with response rate of 27.4% - Common method variance (CMV), Harman's Single-Factor Test, was applied to assess that variations in responses are caused by the constructs and measures. - In terms of ethical issues, providing report and feedback, consent, confidentiality and anonymity were addressed.
Analysis	- Providing descriptions on the applied analytical techniques - Control and cleaning of the data set before analysis in terms of appropriateness of scales, possible statistical errors and omissions, normality distribution of sample and homogeneity of variance, to maintain data integrity.	- The hypothesized effects were analyzed using PLS-SEM technique. - Data cleaning, integrity conditions, descriptive statistics and analysis assumptions were assessed.
	- Control of descriptive statistics before starting of inferential analyses	- Measurement model evaluated using the unidimensionality, convergent validity (include: composite reliability (CR), outer loadings and average variance extracted (AVE); see Appendix A) and discriminant validity (include: Fornell-Larcker criterion; see Table 3), and Cronbach's alpha (see Appendix A).
	- Fulfilling of assumptions needed for inferential analysis	- Some Goodness-of-Fit (GoF) indeces applied to assess the model quality (Table 4).
	– .	- The structural model was tested to verify the structural relationships (Table 5).
Reporting	- Providing clear and explicit descriptions about the findings and the statistical significance level	- This stage was explicitly completed using the literature sample on the topic and statistical issues about PLS-SEM modeling.

* Source: Marquart (2017), 2017; Laher (2016)

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