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Keeping key suppliers alive during the COVID-19 pandemic: artificial supply chain resilience and supplier crisis response strategies

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Abstract

Purpose – The study investigates supply chain leaders' initiatives to support their partners in the early stages of the coronavirus disease-2019 (COVID-19) pandemic, identifying measures taken to increase supply chain resilience and their impact on the quality of supply chain relationships.

Design/methodology/approach – Two complementary phases are employed. First, an exploratory approach is adopted, with the method of discourse analysis being employed in the identification of the supplier crisis response strategies by S&P500's top 30 firms. Second, two scenario-based experiments with 983 participants evaluated the impact of such strategies in two dimensions of supply chain relationships' quality (supplier satisfaction and supplier commitment).

Findings – Phase one revealed five initiatives' groups adopted: safety measures, innovative tools, information and knowledge sharing, supply chain finance and supply chain continuity. Phase two results indicate that supplier crisis response strategies have positive effects on both supplier satisfaction and commitment. Data also suggest that safety measures, innovative tools, and information and knowledge sharing strategies negatively impacted supplier satisfaction and commitment, when compared with strategies adopted by other buying firms competing for the same supplier. Supply chain continuity was negatively associated with both dimensions when other buying firms implemented innovative tools and information and knowledge sharing strategies with their suppliers, while supply chain finance yielded in no differences in comparison to strategies adopted by competing buying firms.

Originality/value – The authors offer a theoretical typology for supply chain resilience (i.e. natural and artificial), providing support for buying firms' decisions regarding supplier crisis response strategies through the strengthening of artificial supply chain resilience to increase the likelihood of vulnerable key suppliers' survival.

Keywords Artificial supply chain resilience, Natural supply chain resilience, Supply chain management, COVID-19, Supplier crisis response strategies, Crisis management

Paper type Research paper

Beyond a critical public health emergency (FDA, 2020), the COVID-19 crisis represented a stress test for the global economy (WTO, 2020). The very measures taken to curb the pandemic and avoid the saturation of health systems (WHO, 2020) left a legacy of economic side effects (Boissay and Rungcharoenkitkul, 2020). Restriction imposed on citizens' circulation and on the functioning of businesses (Reuters, 2021), for instance, led to a drastic interruption in the flow of goods (PwC, 2020), causing the greatest economic, financial and social shocks of the 21st century (OECD, 2020). As a result, companies found themselves struggling to deal with a series of immediate and often acute changes (Accenture, 2020). Among the many challenges faced by firms is the impact of the crisis on the structure of modern business models, particularly those anchored on global supply chains (Alfaro and Faia, 2020).

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In such an extreme scenario, the debate on supply chain resilience becomes even more complex, as the actions adopted considerably vary. At the same time the relocation or the substitution of suppliers were effective strategies for industries such as call centers (Jogani *et al.*, 2020), "keeping suppliers alive" was essential for many others. Depending on factors such as the level of differentiation of purchased items (Ellram *et al.*, 2013), the dependence of buying firms on suppliers (Elking *et al.*, 2017), buyer–supplier relationship tenures (Paulraj and Chen, 2007) and supply chain integration (Wiengarten *et al.*, 2019), the focus of many supply chain strategies shifted from speed and minimization of costs (Christopher, 2016) to survival (Ivanov and Dolgui, 2020). In this set, in addition to work for their own endurance, supply chain leaders were pushed to intervene in the operations of their partners in order to guarantee, or, at least, favor the continuation of their operations.

In light of the likelihood that the economic impacts of the COVID-19 crisis will last longer than the pandemic itself (UNCTAD, 2020), understanding the nature and effects of practices adopted by supply chain leaders early in the COVID-19 crisis should prove valuable. In times of uncertainty and economic hardship, effective actions on that regard may avoid a string of bankruptcies, increasing the chances that networks built over decades will withstand. In particular, the investigation of strategies to provide small, yet critical, suppliers assistance to weather the economic storm becomes urgent. Aiming to offer empirical evidence on that direction, the present study is composed of two paired phases. The first consists of an exploratory approach focused on the identification of the supplier crisis response strategies reported by large companies to support their partners during the early stages of the COVID-19 crisis.

Building on five categories of initiatives identified (supply chain finance, supply chain continuity, safety measures, innovative tools, and information and knowledge sharing), their effects on the quality of relationships with supply chain partners are evaluated in the second phase of the study. More specifically, through the conduction of two behavioral scenario-based experiments with a total sample of 983 participants, the impact of each strategy adopted is measured in terms of supplier satisfaction and supplier commitment. In addition, the influence of initiatives employed by competitors is analyzed. These objectives translate into the following research questions: (1) What measures have large companies adopted to support their supply chain partners during the early stages of the COVID-19 crisis? (phase one); and (2) what are the impacts of such measures in the quality of relationships between large firms and the supported partners? (phase two).

Based on our discussions and results, we develop the theoretical concept of artificial supply chain resilience, which comprises strategies for supplementing the natural resilience of a supply chain. The study is organized as follows: the section ahead presents a literature review on supply chain resilience, supply chain leadership, and supply chain relationship management. Next, the two hypotheses of the study are developed. The following section, in turn, details the method applied, continued by results, discussion, conclusion, and limitations and suggestion for future research.

Literature review

By bringing together the concerning literatures on supply chain resilience, supply chain leadership and supply chain relationship management, the following literature review supports the development of the two hypotheses of the study. Along with the presentation of the main arguments and debates issued from each of these sub-fields, the discussion is intended to contribute to the construction of a contextualized and integrated understanding of the topics addressed in the investigation.

Supply chain resilience

Despite common in the business literature, the concept of resilience derives from child behavior research (Garmezy, 1978), referring to the attributes of children who, regardless of

the exceptionally challenging environments they were exposed to (Gorman and Hoopes, 1999; Coutu, 2002), were capable to remain positive and proactive, while keeping their focus and flexibility (Reinmoeller and Van Baardwijk, 2005). Accordingly, the adaptation of this idea to business contexts evolved in the most varied forms, with authors associating it with corporate attributes, or bringing it closer to an overall search to reduce vulnerabilities (Starr *et al.*, 2003). In the strategic management literature, for example, resilience is typically seen as a process capability. Among other things, this means that for firms to reinvent themselves, they need to overwhelm barriers to change (Hamel and Välikangas, 2003).

In the supply chain management literature, in turn, the idea of resilience has been more often employed as the capacity of organizational schemes to absorb acute shocks. Coherently, Christopher and Peck (2004, p. 4) define it as "the ability of a system to return to its original state or move to a new, more desirable state after being disrupted". Within this view, scholars have concentrated on the most assorted themes. Kim *et al.* (2015a), for example, investigate the influence of different structural relationships in the level of resilience of supply networks, while Lotfi and Larmour (2021) concentrate on role of supply chain collaboration as a vector of supply chain resilience. Issues linking resilience to supply chain disruption are also frequent (e.g. Ambulkar *et al.*, 2015; Zhao *et al.*, 2019; El Baz and Ruel, 2020). From a broader perspective, Burnard and Bhamra (2019) define resilience as either active or passive. While active resilience would concern a system's pro-active engagements and adjustments in relation to change, passive resilience would comprise a system's resistance to impacts and the development of robustness within its elements. In this view, authors have stressed the importance of diligent measures to increase the resilience of both single organizations (e.g. Bell, 2019) and supply chains (e.g. Naghshineh and Lotfi, 2019).

Building on these developments, the present study proposes a theoretical typology for supply chain resilience, classifying it into *natural* and *artificial*. Natural supply chain resilience would result from the intrinsic supply chain characteristics that favor the absorption of impacts. This may include distinct levels of internationalization, institutional aspects, supply chain structures, the attributes of different industries, and country of origin, among others. In this way, natural supply chain resilience would provide a built-in defensive layer, akin to immunity, that prevents a supply chain disruption from having severe consequences. Because it is inherent, natural supply chain resilience functions without conscious activation, representing the outcomes of passive resilience strategies. On the other hand, artificial supply chain resilience refers to the results of the specific strategies that are intentionally activated to minimize the impact of a supply chain disruption (Chopra and Sodhi, 2004) or shock (i.e. active resilience). When effectively implemented, artificial supply chain resilience can compensate for lower levels of natural supply chain resilience. Noteworthy is the fact that, depending on their strategic orientations, companies may also damage the natural resilience of the supply chains they are inserted in. Cases in which buyers put excessive pressure on suppliers for cost reductions, more favorable payment conditions, faster outputs or for any other related issue may somehow alter the inherent characteristics of supply chain relationships, and thus, the original resilience of these arrangements. In this set, the use of bargaining power by buyers (Porter, 1980) must be more carefully analyzed, as beyond its immediate gains, they may cause long-term losses in natural resilience. Suppliers' demands must have similar effects.

An important element in the building of artificial supply chain resilience is provision, by a buying firm, of assistance to vulnerable key suppliers (DeSmet, 2018), which are often small and medium enterprises (SMEs) (Song *et al.*, 2018). SMEs are especially vulnerable to demand fluctuations because they typically lack deep reserves and may dedicate a substantial amount of their production to a reduced number of customers. Artificial supply chain resilience strategies for helping vulnerable partners survive a crisis include the maintenance of orders to suppliers (even if there is no immediate need) (Lekkakos and Serrano, 2016),

the intensification of information sharing (Kembro *et al.*, 2017), the provision of supply chain financing, the offering of technical assistance (Tong *et al.*, 2018) and the increase of buyer-supplier embeddedness (Kim *et al.*, 2015b). We refer to such strategies as *supplier crisis response strategies*. As anticipated, the employment of these strategies by supply chain leaders may impact the quality of supply chain relationships, as further discussed next.

Supply chain leadership and supply chain relationship management

The structuring of international supply networks brought inter-organizational management to the center of business debate, with the role played by leading firms in the administration of these schemes receiving growing attention (Mokhtar *et al.*, 2019a). Accordingly, globalization – and the reorganization of production resulting from it – increased the need for an enhanced coordination with suppliers, moving competition from individual firms to whole supply chains (Gosling *et al.*, 2017). Among other things, supply chain leaders are expected to disseminate sustainable practices among their partners (Jia *et al.*, 2019), help them improve their reverse flows (Mokhtar *et al.*, 2019b) and even directly finance their operations (Jiang *et al.*, 2021).

In investigating the relationship between supply chain leadership and firm performance, Chen *et al.* (2021) show that they are positively related, with the effect of leadership varying in face of factors such as region, industry and type of performance investigated. Upon acute crises it is possible, however, that the actions perpetrated by supply chain leaders come to be even more critical for the continuity of the operations of their upstream and downstream partners. In the specific case of the COVID-19 emergency, supply chain leaders' actions on restart support (e.g. loans) and inventory management are pointed out as essential for supply chain stabilization (D'Auria and De Smet, 2020). Beyond allowing for the continuity of suppliers' operations, these actions may have long-term impacts, particularly in the quality of supply chain relationships. It is possible, for instance, that the assistance provided upon difficult times comes to strengthen the ties between a leading company and its partners, with outcomes such as more intense collaboration or loyalty being expected.

As pointed out by Ahmed *et al.* (2017), however, supply chain relationships are not homogeneous, with companies using different metrics, processes, people and mentalities for managing distinct types of connections (Beth *et al.*, 2003). These differences would be basically due to the large number of relationships that organizations need to deal with, as the quantity of supply chain partners often surpasses the hundreds and even thousands. Still accordingly, the management of supply chain relationships would have important competitive implications for firms, with the growing level of specialization making the access to partners' resources and capabilities vital. In this sense, the development of metrics and standards allowing the comparison of the different sorts of relationships would be particularly useful. Adds to that the fact that procurement processes seem to have become particularly harsh on suppliers in the last decades, as time and cost-based competition became mainstream in many industries (Christopher, 2016). On that regard, Essig and Amann (2009) argue that the assessment of supplier satisfaction would be necessary for the management of buyer–supplier relationships, with the consideration of both interaction processes (e.g. exchange of information) and contexts (e.g. power dependence) being relevant. The authors define the construct as "a supplier's feeling of fairness with regard to buyer's incentives and supplier's contributions within an industrial buyer-seller relationship" (p. 103). Within this view, different levels of supplier satisfaction would denote different levels of buyer–supplier relationship quality.

Similarly, supplier commitment is associated with the stability of supply chain relationships (Lai *et al.*, 2005), being a requisite to increase performance from suppliers (Patrucco *et al.*, 2020). As stressed by the authors, supplier commitment would be preceded by factors such as buyer commitment, goals alignment and the collaboration initiatives adopted

by suppliers. In investigating both constructs in the context of the German automotive industry, Ghijsen *et al.* (2010) show that, while supplier commitment is influenced by the use of promises and by human and capital-specific supplier development, supplier satisfaction is affected by influence strategies and by capital-specific supplier development. We build on these views to employ the constructs as the dependent variables of the study, as argued in the development of our hypotheses.

Hypothesis development

In addition to directly supporting the survival of key suppliers, investing in supplier crisis response strategies may strengthen the bonds between a buying firm and its key partners. Enhanced inter-firm relationship quality should be expressed – among other factors – through higher levels of supplier satisfaction and commitment to the buying firm, valuable assets for unanticipated future crises. Differently put, the two constructs employed as dependent variables in the study are here considered to (partially) capture the extent to which the supply chain relationships investigated are perceived to be built in a purposeful, collaborative and mutually beneficial mindset, meaning that the value generated by the interactions is not excessively captured by the most powerful partner. This is proposed here to be a facet of the quality of inter-firm relationships.

The reasoning is translated in the first hypothesis of the study.

H1. The use of supplier crisis response strategies is expected to enhance inter-firm relationship quality.

During worker lockdowns and material shortages caused by the COVID-19 crisis, multiple buyers sometimes were forced to compete for the parts provided by a single supplier. For example, many Chinese suppliers were unable to operate, due to worker's lockdowns during the first few months of the crisis. Although establishing backup suppliers for critical parts is a typical resilience strategy, many buying firms discovered that their backup suppliers were also in China and, thus, were also in lockdown. This led to fierce competition for the services of suppliers located in parts of the world that had not yet been locked down. As the pandemic progressed and confinement orders shifted to different geographic areas, the competition for available suppliers continued. A buying firm's supplier crisis response strategies may be evaluated in light of the strategies that alternative buying firms implement to help their suppliers. Hence, it is also important to consider supplier crisis response strategies relative to the strategies used by other buying firms. These ideas are expressed in the second hypothesis of the study.

H2. The impact of a buyer's supplier crisis response strategies is evaluated by key suppliers relative to what other buyers are offering.

Phase one

Materials and methods

The situation embodied by the COVID-19 crisis calls for immediately responsive research methods, to tap into approaches used by supply chain leaders in real time. We propose a two-phase exploratory approach. In phase one, we used a discourse analysis (Forray and Woodilla, 2005; Grant and Iedema, 2005) approach. We selected the S&P 500's 30 top firms, and their websites were searched to identify whether they had adopted any supplier crisis response strategies to help their direct or indirect suppliers during the COVID-19 pandemic crisis. We found that 17 out of the 30 top firms did not indicate any information about how they dealt with suppliers, while two only provided generic statements, such as "remarkable efforts to restore our supply chain" (Apple, 2020) and "3 M North American respirator supply

chain running 24 h per day and seven days per week" (3M, 2020), without specifying concrete strategies. For the remaining 11 firms, we compiled a list of supplier crisis response strategies they applied during the COVID-19 crisis. We identified five broad categories: supply chain finance, supply chain continuity, safety measures, innovative tools, and information and knowledge sharing strategies. Table 1 summarizes the categories and supplier crisis response strategies by firm.

Results and discussion

The exploratory phase of the study revealed that the implementation of pro-active strategies to support suppliers did not figure among the priorities of all the 30 companies investigated. The fact that some of them did not mention such concern suggests that the role that supply chain leaders are expected to play is not yet fully understood, or, if so, it has not been adequately incorporated. Such inaction, however, may be explained by factors that have not been detected, such as the specific characteristics of the industries in question, or the sheer lack of need to do so. It is possible, for example, that these specific firms are not significantly dependent on their suppliers, with the resilience of their supply chains not representing an essential aspect in their business models. As discussed earlier, in some cases, the substitution of suppliers may be more attractive than the offering of support, at least from a pure economic perspective. In other situations, companies may not neglect their partners, as in case a critical supplier ceases to operate, the situation might have a detrimental impact for their own continuity.

This is probably the case for the companies that disclosed their supplier crisis response strategies in greater detail, with the five categories of pro-active actions identified being themselves revealing. The implementation of supply chain finance mechanisms, for instance, denotes a potentially high relevance of supply chain resilience for the leading firms, as the transfer of financial resources may be the fastest and most efficient way to guarantee suppliers' survival in the short-term. Actions classified as supply chain continuity may have a similar, yet more timely effect, mainly because the financial transfer is indirect (e.g. the non-interruption of orders placing). In turn, safety measures showed to be more associated with the combat to the immediate effects of the pandemic itself and not to its unpredicted side-effects. Depending on the exposition of suppliers to the direct risks issued from the COVID-19 crisis, the focus on such issues may prove essential to their endurance. This may be more evident to companies that are highly dependent on their workforce, where the use of robots and automation is low or non-existent. Finally, innovation and knowledge sharing may work both on the short and long-terms, possibly increasing the efficiency of suppliers' operations beyond the most acute moments of the crisis.

Building on these insights, phase two uses scenario-based experiments to assess the expected impact of supplier crisis support strategies. Two experiments were conducted with a total sample of 983 respondents, as further detailed ahead.

Phase two. Developing from the results pointed above, in phase two, we conducted two scenario-based experiments, both of which described Firm A, based in the US, operating in 22 countries, having over 160,000 employees, and annual revenues exceeding $76 billion. Respondents were asked to imagine they worked for Firm B, one of Firm A's suppliers, and were randomly assigned to manipulations in both studies. The first one carried six manipulations, reflected in six different vignettes: one in which Firm A did not apply any supplier crisis response strategy and five in which it applied a crisis response strategy corresponding to one of the five groups identified in Phase One (i.e. supply chain finance, supply chain continuity, safety measures, innovative tools, and information and knowledge sharing). Thus, the first experiment tested the perceived effectiveness of each crisis response strategy in isolation. In the second experiment, we examined the expected effect of various

Firm	Supplier crisis response strategies reported Supply chain finance	Supply chain continuity	Safety measures	Innovative tools	Information and knowledge sharing
American express	Accelerated payments				
Boeing			Provided safe facilities for visitors and suppliers Expected suppliers to comply with safety measures (e.g. wearing masks		Compiled informative documents on governmental measures and programs
Caterpillar		Monitored supply chain disruptions with protocols to diminish them	Provided safe facilities for visitors and suppliers		
Cisco					Provided guidance for suppliers' actions
Coca-Cola	Respected payment timing and supply chain financing program	Supported supply chain continuity	Expected suppliers to comply with safety measures (e.g. wearing masks) Provided safety equipment to suppliers if necessary	Simplified supplier compliance with remote technology	Helped suppliers getting back to business by engaging public authorities and regulators Shared information with suppliers
Home depot		Supported supply chain continuity			
Nike		Supported supply chain continuity			
Pfizer		Supported supply chain continuity			
United technologies		Created of supply chain focused team			Compiled informative documents on governmental measures and programs Shared information with suppliers and suppliers of suppliers

Table 1.
Supplier crisis response strategies during the COVID-19 pandemic crisis

(*continued*)

Firm	Supplier crisis response strategies reported Supply chain finance	Supply chain continuity	Safety measures	Innovative tools	Information and knowledge sharing
Verizon			Expected suppliers to comply with safety measures (e.g. wearing masks)		Shared information with suppliers
Walgreens		Supported supply chain continuity and safety measures expectations			

Table 1.

crisis response strategies, relative to crisis response strategies applied by other buying firms in the same industry. The base scenario remained the same, and the manipulations used groups of strategies employed by other buying firms. For each strategy used by Firm A, there were vignettes describing each of the other strategies used by other firms competing for the same supplier. The two-by-two combination of the five types of supplier crisis response strategies generated 20 different vignettes for the second study (see Tables 2 and 3).

Respondents and manipulation checks

The respondents comprised supply chain professionals in the US and the UK. US respondents were recruited from a professional's social media site (www.linkedin.com). LinkedIn profiles were searched for the terms "supply chain," "supply chain manager" and "supply chain analyst." Potential respondents were invited to participate, incentivized by a drawing for three Amazon gift cards valued at about $60 each. UK respondents were obtained from Prolific Academic, a crowdsourcing research platform providing respondents for online surveys (www.prolific.ac). They were rewarded at a rate of £0.53, equivalent to £6.36/hour, for successful completion. Out of the initial pool of 418 responses for the first experiment, 54 were incomplete, 20 were excluded for failing an attention check, and eight were provided by the same respondent, thus excluded. The final sample comprised 336 valid responses. The majority of participants ranged between 25 and 34 years old (39.29%) and between 35 and 44 years old (30.65%), with bachelor's (32.44%) and master's (34.52%) degrees, currently employed (70.54%) or self-employed (12.50%) and work in the private-for-profit companies (65.18%). Respondents rated the vignettes as realistic ($\overline{X} = 5.64$, $t = 24.379$, $p < 0.000$), believable ($\overline{X} = 5.66$, $t = 24.305$, $p < 0.000$) and likely ($\overline{X} = 5.63$, $t = 22.867$, $p < 0.000$). The manipulation checks indicated that respondents understood their role as Firm A's supplier ($\overline{X} = 5.87$, $t = 23.765$, $p < 0.000$) and Firm A's large size ($\overline{X} = 6.45$, $t = 60.782$, $p < 0.000$).

No significant disparities were found between respondents sourced from LinkedIn versus Prolific for either dependent variable (supplier satisfaction: $\overline{X}_L = 5.84$, $\overline{X}_P = 6.05$, $t = -0.768$, $p < 0.451$; supplier commitment: $\overline{X}_L = 5.88$, $\overline{X}_P = 5.94$, $t = -0.269$, $p < 0.791$). Thus, we relied solely on Prolific for the second experiment. An initial pool of 727 responses was collected, among which 25 were incomplete, 48 failed an attention check, and seven were duplicates, leaving a final sample of 647 valid responses. As in the first experiment's sample, most respondents ranged between 25 and 34 years old (41.42%) and between 35 and 44 years old (25.81%), with bachelor's (35.39%) and master's (29.37%) degrees, currently employed (63.99%) or self-employed (13.76%), and work in the private-for-profit companies (69.52%).

Common module		
Founded in 1916 and headquartered in Chicago, USA, firm a is one of the largest companies of the world, employing over 160,000 people in 22 countries and selling more than US$ 76 billion a year. The firm counts on more than 1,000 different suppliers, among which are individual entrepreneurs, small companies, medium companies, and large companies		
Manipulation modules		
No supplier crisis response strategy	Upon the 2020 COVID-19 pandemic crisis, firm a decided to concentrate on its own challenges, opting not to get involved with suppliers' eventual difficulties	
Supplier crisis response strategies	Upon the 2020 COVID-19 pandemic crisis, firm a offered help to its suppliers, among which firm B. In particular, the firm . . .	
	Supply chain finance	. . . sought to offer supplies financial support. That included the acceleration of their payments and the additional credit for those who needed the most
	Supply chain continuity	. . . took a series of measures to ensure the continuity of suppliers' operation. That included the uninterrupted placing of orders, and the creation of multi-skilled business continuity teams to identify and solve suppliers' problems
	Safety measures	. . . took a series of measures to improve the security of suppliers' operations. That included safety compliance programs followed by each of the firm's facilities, and the offering of safety equipment and material such as masks and alcohol when needed
	Innovative tools	. . . took a series of measures to improve the efficiency of suppliers' operations. That included the application of online methods and technologies, such as remote audits and assessment using virtual technology
	Information and knowledge sharing	. . . took a series of measures to improve the efficiency of suppliers' operations. That included the sharing of information such as safety measures and governmental aid programs with suppliers and suppliers of suppliers, and the provision of advice and guidance on the strategies to be adopted

Table 2.
Scenarios and manipulations for the first experiment

Participants also described the scenarios as realistic ($\overline{X} = 5.63$, $t = 33.740$, $p < 0.000$), believable ($\overline{X} = 5.59$, $t = 32.292$, $p < 0.000$) and likely ($\overline{X} = 5.51$, $t = 28.766$, $p < 0.000$). The manipulation checks indicated that the respondents understood their role as Firm A's supplier ($\overline{X} = 5.55$, $t = 26.193$, $p < 0.000$) and Firm A's large size ($\overline{X} = 6.00$, $t = 39.977$, $p < 0.000$).

Measurement of dependent variables

The two dependent variables for supplier satisfaction and supplier commitment were operationalized using seven-point Likert scales adapted from existing literature (Ghijsen *et al.*, 2010). The results of the confirmatory factor analysis (CFA) for construct validity are shown in Table 4. All items loaded on standardized factors above the acceptable limit in both experiments, and both measures had strong Cronbach's alpha and composite reliability values, demonstrating internal consistency. The average variance extracted (AVE) scores indicate that the greater portion of the variances were captured by the constructs rather than by errors in measurement. We assessed unidimensionality using CFA models, with both constructs linked through a covariance factor. Although the X^2 value for the model in the first experiment did not yield acceptable values ($X^2 = 27.061$, $p < 0.001$), X^2 per degrees of freedom was below the acceptable limit ($X^2/\text{df} = 3.383$). For the second experiment, X^2 was not

		Firm A's supplier crisis response strategy				
		Supply chain finance	Supply chain continuity	Safety measures	Innovative tools	Information and knowledge sharing
Other buying firms' Supplier crisis response strategy	*Supply chain finance*	–	Scenario 2,1	Scenario 3,1	Scenario 4,1	Scenario 5,1
	Supply chain continuity	Scenario 1,2	–	Scenario 3,2	Scenario 4,2	Scenario 5,2
	Safety measures	Scenario 1,3	Scenario 2,3	–	Scenario 4,3	Scenario 5,3
	Innovative tools	Scenario 1,4	Scenario 2,4	Scenario 3,4	–	Scenario 5,4
	Information and knowledge sharing	Scenario 1,5	Scenario 2,5	Scenario 3,5	Scenario 4,5	–

Note(s): *Example: Scenario 1,2*; Upon the 2020 COVID-19 pandemic crisis, Firm A offered help to its suppliers, among which is Firm B. In particular, Firm A sought to offer its suppliers financial support that included the acceleration of payments and additional credit for those who needed the most; You also know that other companies in the industry are helping suppliers with measures such as uninterrupted placing of orders, and the creation of multi-skilled business continuity teams to identify and solve suppliers' problems, which have not been offered by Firm A

Table 3.
Design of the second experiment

Measure	Factor loadings First experiment	Second experiment
Supplier satisfaction[a]		
Dealings with firm a benefit my firm	0.82	0.83
I would be satisfied with dealings with firm A	0.86	0.87
Firm a is good to do business with	0.89	0.90
$\overline{X}$ (Std. Dev.)	6.039 (0.878)	5.503 (1.087)
Cronbach's alpha	0.892	0.900
Composite reliability	0.892	0.900
AVE	0.734	0.751
Supplier commitment[a]		
I am interested in long-term alliances	0.83	0.85
I want to preserve the relationship with firm A	0.90	0.86
Buyers from firm a are considered partners	0.65	0.66
$\overline{X}$ (Std. Dev.)	5.939 (0.886)	5.597 (0.992)
Cronbach's alpha	0.820	0.828
Composite reliability	0.840	0.835
AVE	0.640	0.632

Note(s): [a]Adapted from Ghijsen *et al.* (2010), 1 = strongly disagree, 7 = strongly agree

Table 4.
Measurement analysis of dependent variables

significant (X^2 = 8.155, p = 0.422), with X^2/df of 1.014, indicating good fit. In both experiments, the incremental indexes exceeded threshold values (first experiment: NFI = 0.978, IFI = 0.985, CFI = 0.985; second experiment: NFI = 0.994, IFI = 1.000, CFI = 1.000).

Results and discussion

The results from the first experiment (Table 5) show statistically significant differences between the no strategy manipulation and each of the other five manipulations for both

Supplier crisis Response strategy	Supplier satisfaction $\overline{X}$(Std. dev.)	Sig. differences1	Supplier commitment $\overline{X}$(Std. dev.)	Sig. differences[1]
1. None	5.544 (1.075)	2, 4, 5, 6	5.316 (1.285)	2, 3, 4, 5, 6
2. Supply chain finance	6.140 (0.934)	1	6.128 (0.757)	1
3. Supply chain continuity	6.061 (0.985)	–	6.105 (0.740)	1
4. Safety measures	6.283 (0.651)	1	6.133 (0.721)	1
5. Innovative tools	6.144 (0.659)	1	5.983 (0.662)	1
6. Innovation and knowledge sharing	6.076 (0.641)	1	6.000 (0.644)	1
F	0.000***		0.000***	
Prob	5.398		8.304	

Table 5.
ANOVA results for first experiment

Note(s): ***$p < 0.001$; [1]Pairwise comparisons, using Tukey and Games–Howell tests, significant at $p < 0.05$ or less

supplier satisfaction and supplier commitment at the $p < 0.001$ significance level, indicating strong evidence in this direction. This indicates that respondents believe that implementing supplier crisis response strategies during the pandemic crisis will have a positive effect on both supplier satisfaction and supplier commitment, thus confirming Hypothesis 1.

Data from the second experiment (Tables 6 and 7) also confirm our Hypothesis 2, indicating that safety measures, innovative tools, and information and knowledge sharing strategies were negatively associated with supplier satisfaction and commitment, when compared with strategies adopted by other buying firms competing for the same supplier. For safety measures adopted by the company, supplier satisfaction scored $\overline{X}_{\text{no strategy}} = 6.28$ when competitors applied no strategy, while its difference with the remaining variables were statistically significant at $p < 0.05$ for $\overline{X}_{\text{supply chain finance}} = 5.66$, $\overline{X}_{\text{innovative tools}} = 5.63$, $\overline{X}_{\text{information and knowledge sharing}} = 5.40$, and at $p < 0.01$ for $\overline{X}_{\text{supply chain continuity}} = 5.43$, while supplier commitment scored $\overline{X}_{\text{no strategy}} = 6.13$ with significant differences at $p < 0.05$ for $\overline{X}_{\text{supply chain finance}} = 5.55$, $\overline{X}_{\text{supply chain continuity}} = 5.50$, $\overline{X}_{\text{innovative tools}} = 5.61$, $\overline{X}_{\text{information and knowledge sharing}} = 5.48$. Innovative tools, in turn, scored $\overline{X}_{\text{no strategy}} = 6.14$ for supplier satisfaction, being statistically different at $p < 0.01$ in comparison to $\overline{X}_{\text{supply chain continuity}} = 5.38$ and at $p < 0.05$ to $\overline{X}_{\text{supply chain finance}} = 5.53$, $\overline{X}_{\text{safety measures}} = 5.49$, and $\overline{X}_{\text{information and knowledge sharing}} = 5.58$, and $\overline{X}_{\text{no strategy}} = 6.13$ for supplier commitment, while statistically different from all other strategies ($\overline{X}_{\text{supply chain finance}} = 5.66$, $\overline{X}_{\text{supply chain continuity}} = 5.50$, $\overline{X}_{\text{safety measures}} = 5.61$, and $\overline{X}_{\text{information and knowledge sharing}} = 5.48$) at the $p < 0.05$ level. For information and knowledge sharing, differences in supplier satisfaction were detected at the $p < 0.001$ level between $\overline{X}_{\text{no strategy}} = 6.08$ and $\overline{X}_{\text{safety measures}} = 4.87$, and $\overline{X}_{\text{innovative tools}} = 5.49$, and at the $p < 0.05$ level for $\overline{X}_{\text{supply chain finance}} = 5.19$, and for supplier commitment, significant differences at $p < 0.01$ for $\overline{X}_{\text{safety measures}} = 5.08$, as well as at $p < 0.05$ for $\overline{X}_{\text{supply chain finance}} = 5.37$. Supply chain continuity was negatively associated with supplier satisfaction ($\overline{X}_{\text{no strategy}} = 6.06$) and commitment ($\overline{X}_{\text{no strategy}} = 6.20$) when other buying firms implemented information and knowledge sharing strategies with their suppliers also for both supplier satisfaction ($\overline{X}_{\text{information and knowledge sharing}} = 5.35$) and commitment ($\overline{X}_{\text{information and knowledge sharing}} = 5.45$) at the $p < 0.05$ significance level, while supply chain finance did not yield in significant differences when competitors applied different strategies.

While results of the analysis in the first experiment are relatively intuitive (any supplier crisis response strategy produces better outcomes than no strategy), the outcomes of experiment two call for further consideration. Contrary to what might be initially expected,

Firm A's supplier crisis response strategy	Other buying companies' supplier crisis response strategy	Supplier satisfaction $\overline{X}$ (Std. dev.)	Sig. Diff.1	Supplier commitment $\overline{X}$ (Std. dev.)	Sig. Diff.[1]
Supply chain finance	1 None	6.140 (0.934)	–	6.128 (0.757)	–
	2 supply chain continuity	5.696 (0.830)	–	5.787 (0.828)	–
	3 safety measures	5.656 (1.153)	–	5.656 (1.059)	–
	4 Innovative tools	5.616 (1.145)	–	5.808 (0.816)	–
	5 Information and knowledge sharing	5.813 (0.792)	–	5.882 (0.686)	–
		$F = 2.251$		$F = 2.034$	
Supply chain continuity	1 None	6.061 (0.975)	5	6.205 (0.740)	5
	2 supply chain finance	5.559 (0.982)	–	5.666 (1.125)	–
	3 safety measures	5.802 (0.732)	–	5.843 (0.733)	–
	4 Innovative tools	5.635 (1.360)	–	6.597 (1.158)	–
	5 Information and knowledge sharing	5.352* (1.072)	1	5.450* (1.171)	1
		$F = 2.978$*		$F = 2.827$*	
Safety measures	1 None	6.283 (0.651)	2, 3, 4, 5	6.133 (0.721)	2, 3, 4, 5
	2 supply chain finance	5.552** (0.989)	1	5.656* (0.730)	1
	3 supply chain continuity	5.436** (1.172)	1	5.505* (1.056)	1
	4 Innovative tools	5.636* (0.976)	1	5.616* (0.886)	1
	5 Information and knowledge sharing	5.400*** (1.081)	1	5.485* (1.103)	1
		$F = 7.251$***		$F = 4.395$**	
Innovative tools	1 None	6.144 (0.659)	2, 3, 4, 5	6.133 (0.721)	2, 3, 4, 5
	2 supply chain finance	5.526* (1.084)	1	5.656* (0.730)	1
	3 supply chain continuity	5.382** (1.018)	1	5.505* (1.056)	1
	4 safety measures	5.489* (1.176)	1	5.616* (0.886)	1
	5 Information and knowledge sharing	5.580* (0.788)	1	5.485* (1.103)	1
		$F = 7.251$***		$F = 4.385$**	
Information and knowledge sharing	1 None	6.076 (0.641)	2, 4	6.000 (0.644)	2, 4
	2 supply chain finance	5.198* (1.311)	1	5.374* (1.063)	1
	3 supply chain continuity	5.406 (1.217)	–	5.593 (1.073)	–
	4 safety measures	4.862*** (1.449)	1	5.088** (1.393)	1
	5 Innovative tools	5.494*** (0.999)	–	5.551 (0.818)	–
		$F = 5.541$***		$F = 3.918$**	

Note(s): *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; [1]Pairwise comparisons, using Tukey and Games–Howell tests, significant at $p < 0.05$ or less

Table 6. ANOVA results for second experiment

the provision of supply chain finance was not perceived to be any more effective than the other alternatives. This suggests that supply chain finance strategies are fundamentally important to suppliers, not just during an acute disruption. Some of the relative findings are also curious. For example, a supply chain continuity strategy is perceived as less important when other buying firms offer information and knowledge sharing strategies. This may underline the importance of supply chain leaders providing guidance to their suppliers. It was also intriguing that the offering of safety measures was perceived as inferior when any other supplier crisis response strategy was used by competing firms. This may reveal a greater supplier risk tolerance during the crisis. These and the other outcomes suggest the existence of a hierarchy of supplier crisis response strategies.

Still, the confirmation of hypotheses 1 and 2 may be particularly useful for managers, with results indicating the need for more adapted crisis management strategies in supply chain contexts. Regarding the evidence around the impacts of lead firms' support on the quality of

Firm A's supplier crisis response strategy	Other buying companies' supplier crisis response strategy	Supplier satisfaction			Supplier commitment		
		B	*t*	VIF	*β*	*t*	VIF
Supply chain finance	(Constant)		47.547***			55.963***	
	Supply chain continuity	−0.171	−2.079*	1.303	−0.155	−1.884	1.303
	Safety measures	−0.184	−2.248*	1.297	−0.213	−2.587**	1.297
	Innovative tools	−0.202	−2.458*	1.303	−0.13	−1.772	1.303
	Information and knowledge sharing	−0.127	−1.546	1.309	−0.114	−1.375	1.309
Supply chain continuity	(Constant)		45.360***			48.644***	
	Supply chain finance	−0.176	−2.193*	1.2368	−0.164	−2.041*	1.268
	Safety measures	−0.092	−1.143	1.274	−0.099	−1.230	1.274
	Innovative tools	−0.151	−1.879	1.274	−0.155	−1.915	1.274
	Information and knowledge sharing	−0.258	−3.187**	1.285	−0.254	−3.137**	1.285
Safety measures	(Constant)		51.529***			53.506***	
	Supply chain finance	−0.274	−3.537***	1.274	−0.195	−2.455*	1.274
	Supply chain continuity	−0.304	−3.963***	1.256	−0.247	−3.125**	1.256
	Innovative tools	−0.245	−3.160**	1.279	−0.214	−2.688**	1.279
	Information and knowledge sharing	−0.342	−4.397***	1.290	−0.274	−3.429***	0.290
Innovative tools	(Constant)		51.432***			53.762***	
	Supply chain finance	−0.238	−3.017**	1.267	−0.143	−1.774	1.267
	Supply chain continuity	−0.304	−3.836***	1.283	−0.280	−3.460***	1.283
	Safety measures	−0.255	−3.233***	1.272	−0.162	−2.009*	1.272
	Information and knowledge sharing	−0.217	−2.755**	1.267	−0.152	−1.886	1.267
Information and knowledge sharing	(Constant)		33.102***			36.616***	
	Supply chain finance	−0.287	−3.214*	1.474	−0.233	−2.561*	1.474
	Supply chain continuity	−0.219	−2.453*	1.474	−0.151	−1.664	1.474
	Safety measures	−0.405	−4.514***	1.493	−0.347	−3.797***	1.493
	Innovative tools	−0.188	−2.111*	1.464	−0.134	−1.485	1.464

Note(s): *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 7.
Regression results for second experiment

inter-firm relationship quality (H1), findings corroborate the idea that help offered upon extreme moments may be greatly valued by those receiving it, mainly when the aid is critical to the continuity of their operations. In increasingly competitive environments, the maintenance of stable and fruitful relationships with suppliers may represent an important source of differentiated performance, with the protection of supply chain networks possibly leading to abnormal returns in the long run (i.e. competitive advantage). This view also dialogues with the confirmation of the second hypothesis of the study, which stresses the need for the support offered to be more generous than those granted by competitors. Altogether, our results suggest that lead firms' managers may consider diminishing the use of bargaining power upon moments of acute crises, ideally substituting it (maybe proportionally to the level of their supply chain leadership) by supplier crisis response strategies.

It may be argued then that both the preservation of natural supply chain resilience and the development of an artificial one may be critical to lead companies' success. For natural

resilience this relates to powerful partners avoiding the use of their force upon periods of crisis, ceasing to exert additional pressure on the already weakened suppliers. For artificial resilience, in turn, the implementation of emergency measures may the expression of lead firms' determination to keep their supply chains alive and operating, regardless of the difficulties faced by their smaller partners. The expected result of both attitudes is the continuity of those in more sensitive situations and an enhanced resilience of the whole system.

Conclusion

As discussed throughout the text, supply chain resilience can be both natural and artificial, with objective measures being fundamental for the establishment of the latter. Despite logical, the reasoning lacks empirical evidence, not only regarding the recognition of which actions are taken by companies in this regard but also their effectiveness. In order to contribute to a better understanding of the dynamics of these factors, the present study sought to identify the initiatives effectively adopted by large companies to assist their supply chain partners in the early stages of the COVID-19 crisis. Thus, claims from the 30 largest companies composing the S&P 500 list were examined. This initial investigation revealed that while some companies do not even mention offering support to their weaker partners, others describe their initiatives in detail. Between these two extremes are the companies that addressed the issue in a generic way, without actually discussing the measures they implemented. The treatment of these data through the method of discourse analysis revealed five groups of supplier crisis response strategies: supply chain finance, supply chain continuity, safety measures, innovative tools, and information and knowledge sharing.

Based on this exploratory phase and on the discussion on the literature on supply chain resilience, supply chain leadership and supply chain relationship management, two vignette-based experiments were conducted in the testing of the hypothesis that (1) the use of supplier crisis response strategies is expected to enhance inter-firm relationship quality, and (2) the impact of a buyer's supplier crisis response strategies is evaluated by key suppliers relative to what other buyers are offering. In doing so, the effects of the five groups of supplier crisis response strategies identified on supplier satisfaction and supplier commitment were measured, as, together, the two constructs were considered to form a proxy of the quality of supply chain relationships. Likewise, the outcomes of a firms' actions in face of those of another one competing for the same supplier were evaluated.

As discussed in the previous section, the confirmation of both hypotheses of the study corroborates the view that supplier crisis response strategies indeed hold the potential to enhance inter-firm relationship quality. Among other entailments, the confirmation of the first hypothesis of the study suggests that pro-active measures constitute the building blocks of artificial supply chain resilience. Similarly, the ratification of our second hypothesis indicate that the power of the supplier crisis response strategies examined is relative, meaning that they depend on the offers made by competing firms. Along with adding to the understanding of the value of pro-active measures *per se*, finding contribute to the comprehension of corporate competition within business-to-business contexts (i.e. competition for the establishment of buyer–supplier relationships).

With the expectation that the economic effects of the COVID-19 crisis will be profound and probably last longer than the pandemic itself, this research is useful in several ways. First, it provides support for a buying firm's decisions regarding supplier crisis response strategies, enhancing artificial supply chain resilience and increasing the likelihood that vulnerable key suppliers will survive. Artificial supply chain resilience strategies are also beneficial in that they contribute to the maintenance of economic activity and job conservation. Our research supports the adoption of similar strategies in the advent of future severe and unpredictable

crises. Finally, by investigating the effectiveness of emergency measures taken during an extreme crisis, it adds to the study of supply chain configurations.

Limitations and suggestions for future research

Despite the rigor often applied in their conduct, scientific investigations do have limitations, with the present study not being exceptional in this regard. The first issue to be recognized refers to the relatively narrow scope applied in the identification of the supplier crisis response strategies adopted by large companies (phase one). While significant in terms of the economic power of companies publicly traded on American stock exchanges, the supplier crisis response strategies adopted by S&P500's top 30 firms may not adequately represent the conduct of large organizations in general. It is possible then that our study did not capture some actions or categories of actions employed during the crisis. Qualitative in-depth interviews might also be employed in order to gain more detailed perspectives on our results.

In order to treat this issues, future research should ideally extend the analysis, investigating the initiatives adopted by a larger group of companies. This may include firms operating in distinct regions, as well as smaller enterprises. Still on that matter, researchers should consider a wider range of information sources, expanding the types of secondary data considered (e.g. newspapers, magazines and institutional videos) and even adding primary data issued from direct interviews with those directly responsible for the concerned decisions. Likewise, scholars must profit from the investigation of more dependent variables, both in terms of the quality of supply chain relationships – as performed in this study – and other potentially relevant factors (e.g. suppliers' trust, word-of-mouth and corporate image). Research to come may also focus on more complex supply chain networks, investigating whether the position occupied by supply chain leaders affect the observed results.

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