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Supply Chain Context and its Impacts on Resilience

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Abstract

Purpose: This paper empirically investigates the influence of supply chain context on supply chain resilience, during an extreme climate event.

Design/methodology/approach: Based on 41 in-depth qualitative interviews in two Brazilian agri-food supply chains, this study explored how supply chain specificities influence the perceptions of environment and responses to an event at different nodes of the supply chain.

Findings: The results provided empirical evidence that the supply chain context (governance mechanisms and different resilience levels of firms) may underpin resilience capabilities. Resilience strategies are contingent on the supply chain and interfirm relationships.

Research limitations/implications: This study explores the context of two agri-food supply chains in Brazil during an extreme weather event. While the findings are relevant, future studies might explore different industries and countries.

Practical implications: To build supply chain resilience, organizations must leverage and align capabilities for a common purpose.

Social implications: The most vulnerable organizations in the chain are the least prone to build resilience. There is a need to intensify knowledge sharing to address the necessary adaptation.

Originality value: This study throws light on the contingency context as well as on the different perspectives at each node of the supply chain. Additionally, it covers two different phases of a disaster (longitudinal study).

Key Words: Resilience; Agri-food; Drought; Qualitative.

Article classification: Research paper

1 Introduction

The increasing frequency of events causing disruptions in supply chains has led researchers and practitioners to question the traditional approach of risk management that involves probabilistic measures of events (Jüttner and Maklan, 2011; Pettit et al., 2010, 2013). Disasters caused by extreme weather events and climate change have also increased in regularity and are still surrounded by uncertainty (George *et al.*, 2015). Therefore, firms need to build their resilience to as yet rare and uncertain events (Knemeyer *et al.*, 2009; Pettit et al., 2010).

Resilience is a multidimensional and multidisciplinary concept that is applied in several fields, such as ecology, psychology, economics, engineering, biology, sociology and organizations (Boin et al., 2010; Ponomarov and Holcomb, 2009). At the organizational level, resilience has been defined as the capacity to go beyond absorbing impact and recovery, thus incorporating the ability to adapt and build flexibility (Ponomarov and Holcomb, 2009). As organizations are interconnected in supply chain networks, their interdependence can magnify the consequences of disaster and disruption, and so resilience must be extended to the supply chain level in a cost-effective manner (Ponomarov and Holcomb, 2009; Tukamuhabwa *et al.*, 2015; Wieland and Wallenburg, 2013).

Supply chain resilience is a recent, growing and as yet unexplored area of research (Blackhurst *et al.*, 2011; Christopher and Peck, 2004). There is a growing body of literature on how to develop resilience at the supply chain level, but there is a need to understand how strategies should be implemented, how to choose between different strategies and if there are synergies or trade-offs between them (Tukamuhabwa *et al.*, 2015). For instance, one possible strategy for supply chain resilience is given in redundancy and multiple suppliers, as a way of limiting disruption and the ripple effect in the supply chain (Rice and Caniato, 2003; Tukamuhabwa *et al.*, 2015). Another possible strategy involves collaboration between buyers and suppliers with regard to shared resources for their mutual benefit (Pettit *et al.*, 2013; Zacharia *et al.*, 2009). While both strategies can be successful, they might not be feasible in all situations and not possible in all supply chain contexts.

Supply chain context (SCC) varies extensively in terms of relationship governance (Cao and Lumineau, 2015; Dyer and Singh, 1998; Williamson, 1979), uncertainty (Giunipero and Eltantawy, 2004; Mason-Jones *et al.*, 2000), and the capacity of management and the control of processes among partners (Lockamy and McCormack, 2004). Thus, some transactional and

arm's length relationships may not favor the development of cooperation, information exchange and partnerships, which are important in building resilience strategies (Kim et al., 2015; Liu et al., 2009; Poppo and Zenger, 2002). Organizations within a supply chain are also heterogeneous in their needs and processes (Lockamy and McCormack, 2004; Mortensen et al., 2008). Different cultures and management techniques between partners limit a systematic and strategic view that could result in joint efforts (Mentzer *et al*., 2001), especially during negative events. Since interfirm relationships are dependent on the SCC, this study poses the following research question:

How does supply chain context influence the capacity for building resilience to uncertain events?

The study investigates the influence of supply chain context on the process of building resilience to extreme weather events in food supply chains in Brazil. The study was conducted following the occurrence of a major drought, an extreme weather event that affected the sugarcane and orange supply chains in the Southeast (SE) region. With in-depth analysis of 28 firms representing agriculture producers, processors, manufacturers and relevant stakeholders, firms were grouped at each node in the supply chain, the node constituting the unit of analysis of this study.

In answering the research question, the contribution is threefold. First, this study investigates the contingency nature of resilience strategies in the supply chain. Second, it explores the context of a post-disruption disaster and how the affected supply chains developed resilience to future events. Third, it analyzes resilience at each supply chain node, thus presenting a broader perspective of the supply chain.

The remainder of this paper is organized as follows. The following section presents a literature review on supply chain risk management and resilience, as well as SCC. The sample, data collection and data analysis are described in the Method section. The Results are presented in terms of a within-case analysis and a cross-case analysis and in the Discussion section the findings were compared with extant literature and the propositions are formulated. Finally, the academic and managerial implications, the limitations and the possibilities for future research are presented in the Conclusions.

2 Literature review

This section has a review of the literature on supply chain risk and resilience for highlighting the difference between organizational and supply chain resilience and for emphasizing the importance of understanding the supply chain as a significant driver or inhibitor of SC resilience.

From Supply Chain Risk Management (SCRM) to Supply Chain Resilience (SCRES)

In the last decade, supply chain risk have become a new topic and one of utmost importance for both business and research (Manuj and Mentzer, 2008; Narasimhan and Talluri, 2009; Tang and Musa, 2011; Colicchia and Strozzi, 2012; Lavastre *et al*., 2012; Sodhi *et al.*, 2012; Heckmann *et al*., 2015). The interest in supply chain risk and vulnerability has increased in the operations and supply chain field as a consequence of many supply chain practices, such as global sourcing, postponement or the adoption of a lean approach (Jüttner, 2005).

Supply chain risk management (SCRM) requires that organizations identify and prepare for risks to their operations and to all other nodes and links, as they might suffer the impact of a disruption that affects their suppliers or customers (Christopher and Peck, 2004; Jüttner, 2005). An internal operational decision taken by individual firms may be part of their vulnerability to external risks and can worsen the effects of some disruptions (Jüttner, 2005; Tukamuhabwa *et al*., 2015).

More recently, some authors have been drawing attention to the fact that many risks faced by firms are unpredictable and unexpected, making it very difficult, if not impossible, to obtain data about them (Fiksel *et al*., 2015). Moreover, investing in strategies for mitigating each potential risk may be expensive and time-consuming. Therefore, supply chains should be designed to be more resilient (Christopher and Peck, 2004; Ponomarov and Holcomb, 2009; Tukamuhabwa *et al*., 2015).

Resilience is the ability that a system has for planning, responding to and recovering from disruptions in a timely and cost-effective way, and thereby returning to the original, or to a better state than prior to the disruption (Ponomarov and Holcomb, 2009; Tukamuhabwa *et al*., 2015; Wieland and Wallenburg, 2013). Resilient companies are less vulnerable to disturbances and more able to manage them when they occur (Ambulkar *et al*., 2015; Ponomarov and Holcomb, 2009).

Vargo and Seville (2011) classify organizations in terms of their resilience level in four groups: a) latent resilient, which neither plan nor adapt to risks; b) planned, which have a plan for events, but have low adaptability after the change in environment; c) ad-hoc, which do not plan, but have a high capacity to adapt to any new momentum; and d) dynamic, which have demonstrated both planning and adaptability capacities.

The concepts of resilience and risk management are interconnected and complementary (Pettit *et al*., 2010; Tukamuhabwa *et al*., 2015; Wieland and Wallenburg, 2013). Wieland and Wallenburg (2013) indicate that risk management is the most pronounced resilience driver (pp. 312). For Jüttner and Maklan (2011) risk management is an antecedent of resilience. Reducing risk occurrence probability may lead to reduced vulnerability, but it does not necessarily have an effect on increasing resilience (Jüttner and Maklan, 2011). The main difference is that resilience includes both proactive (planning and preparedness) and reactive (response and adaptive) strategies or capabilities (Tukamuhabwa *et al*., 2015; Vargo and Seville, 2011).

Several studies on resilience focus on resilience capabilities (Blackhurst *et al*., 2005; Blackhurst *et al*., 2011; Jüttner and Maklan, 2011; Scholten *et al.,* 2015, Hohenstein *et al.,* 2015). In their literature review, Tukamuhabwa *et al*. (2015) identified the core capabilities of resilient firms as being: flexibility, redundancy, collaboration and agility (visibility and velocity).

Flexibility refers to how easy it is for a supply chain to change due to its range of options (Stevenson and Spring, 2007). According to Rice and Caniato (2003), redundancy is concerned with maintaining idle response capacity to disruptions, largely through investments in capital and capacity prior to the point of need. Collaboration is related to the level of shared decisions between two or more members of the supply chain (Zacharia *et al*., 2009). Agility is defined as the capability to adapt or respond in a speedy manner (Braunscheidel and Suresh, 2009), and is sometimes represented as a combination of flexibility, visibility and velocity (Jüttner and Maklan, 2011; Wieland and Wallenburg, 2013). Velocity is associated with a speedy reaction to changes (Christopher and Peck, 2004), while visibility is the extent to which supply chain actors have access to, or share information about operations, or what they consider to be useful to their operations (Barratt and Oke, 2007).

It is also important to distinguish between enterprise resilience and supply chain resilience (SCRES). Enterprise resilience refers to the capacity of a firm to prepare, respond and adapt to change based on its internal resources, such as individuals and systems. On the other hand,

SCRES is related to how supply chains can refrain the ripple effect from spreading to other organizations and control the spread of the disturbance to the whole system (Kamalahmadi and Parast, 2016). Despite the increased debate on SCRES, the literature in the area tends to focus on the organizational perspective (Jüttner, 2005). As SCRES depends on how companies and activities are reconfigured, coordinated and controlled during any event (Christopher and Peck, 2004; Kamalahmadi and Parast, 2016; Leat *et al.*, 2013), it is dependent on the interfirm relationship and the compatibility within firms. Therefore, it is important to evaluate the supply chain context (SCC) as an important enabler of, or challenge to building resilience, as it can amplify the effect of a specific event to the whole supply chain, or restrict the capacity to respond to the event (Juttner et al., 2003).

Supply chain context (SCC)

A supply chain is a set of organizations that are interconnected by way of a flow of products/services, money and information from the origin to the final customer (Christopher and Peck, 2004; Mentzer *et al*., 2001). Supply chains are subject to internal specificities, such as interfirm relationships (Cao and Lumineau, 2015; Dyer and Singh, 1998; Williamson, 1979) and demand and supply uncertainties (Giunipero and Eltantawy, 2004; Mason-Jones *et al*., 2000) . Firms within a supply chain differ in terms of how they define, manage and control their processes (Lockamy and McCormack, 2004; Mortensen et al., 2008; Vargo and Seville, 2011).

Governance mechanisms are used by a company to coordinate, collaborate and control interfirm relationships. Two extreme mechanisms are defined in the literature: transactional and relational (Cao and Lumineau, 2015; Dyer and Singh, 1998; Williamson, 1979). While the former is based on formal contracts and controls for reducing opportunism and ensuring short term gains, the latter is associated with close and long-term relationships that are built upon trust and commitment (Dyer and Singh, 1998; Kim *et al*., 2015; Liu *et al.*, 2009; Poppo and Zenger, 2002). The appropriate governance mechanisms depend on interfirm interdependence, or the number of alternative buyers/suppliers they have in the market (Emerson, 1976; Pfeffer and Salancik, 2003). In arm´s length relationship, collaboration is unusual and hard to achieve (Christopher and Peck, 2004).

Organizations in a supply chain are heterogeneous in terms of their resources, needs and capabilities and this has an influence on interfirm relationships (Mortensen *et al*., 2008). The maturity of a firm within the supply chain relates to the way the organization defines,

manages, measures and controls its own processes in order to achieve a better performance and great effectiveness (Lockamy and McCormack, 2004). To engage in more collaborative and strategic relationships, culture and management principles should be compatible (Dyer and Singh, 1998; Mentzer et al., 2001). In terms of risk management and resilience maturity, firms differ in terms of risk perception, planning and how they adapt to any unexpected event (Hillson, 1997; Vargo and Seville, 2011).

Despite calling attention to the importance of the supply chain context for building SCRES, no empirical study was identified in the literature that investigated how the supply chain context influences resilience. Therefore, this study aims to fill this gap.

3 Method

The goal of the present research is to investigate and build theory regarding the influence of supply chain context on resilience to an extreme weather event in a food supply chain, using a major drought as the central phenomenon. Data were collected and analyzed from 28 firms representing agricultural producers, processors, manufacturers, as well as relevant associations and governmental agencies in Brazil. In this embedded multiple case study (Yin, 2009), firms are considered subunits of three groups comprising agricultural producers, food processors and manufacturers. Considering that SCRES is a collective behavioral process (Tukamuhabwa *et al.*, 2015), we applied a qualitative analysis focusing on the nodes and the liaisons of the supply chain in the process of building resilience.

Sampling

The current study focused on businesses located in the Southeast (SE) region of Brazil, which suffered a major drought in 2014 and 2015. The extended drought affected not only the population, but impacted service activities, energy and water supply and agricultural sectors.

Two main food supply chains were selected, orange and sugarcane. Brazil's SE region is responsible for supplying 60% of the world's orange juice, and concentrates almost 75% of orange production in Brazil (INVESTE SP). Brazilian citrus groves are among the largest in the world and account for the largest share of concentrated orange juice consumed on all continents (Paulillo and Almeida, 2009). Brazil is also a worldwide leader in sugar and ethanol knowledge and technology from sugarcane, with production estimates of 38.69 million tons for 2017 (MAPA, 2017); 61.60% of Brazil's sugar production is concentrated in São Paulo state (UNICA, 2016).

The orange and sugarcane supply chains are composed of agricultural producers, while food processors (sugar mills) provide the initial industrialization for transforming sugarcane into sub-products, such as sugar, fuel and industrial ethanol, bioenergy, or *cachaça* (alcoholic drink made from sugarcane juice in micro and large stills), and oranges into frozen, concentrated orange juice, fresh or pasteurized orange juice, and packed fresh fruit. Finally, the food and beverage manufacturers (F&B Manufacturers) produce soft drinks, juice and processed food.

Data collection

Our main source of data were the 41 semi-structured interviews carried out in two different periods (July-November 2015 and July- November 2016). We used a protocol involving semi-structured questions that had been previously reviewed by specialists. Whenever possible, two researchers conducted the interview to increase internal validity (Eisenhardt, 1989; Barratt *et al*., 2011). Interviews were recorded upon agreement of the interviewees and transcribed for data analysis. For triangulation purposes, data were also collected from secondary documentary sources (e.g. websites, PowerPoint presentations, reports and organization newsletters).

In 10 cases, this research conducted more than one interview with more than one interviewee, which allowed us to validate information and resolve discrepancies. The interviewees held different functions in the firms' operations and in supply chain management.

The sample is composed of five producers, five processors, ten food processors that have their own agricultural production (Producers & Processor) and. four manufacturers. We included firms of different sizes that operate in the State of São Paulo, in the SE region. Table 1 presents the characterization of the sampled firms and their position in the supply chain.

TABLE 1 HERE

Data Analysis

During data collection, the main findings were summarized immediately after each interview and the emerging themes were explored in the subsequent interviews. We applied the constant comparison technique, whereby the collected data are compared to existing literature to determine whether each identified category should be expanded (Eisenhardt and Graebner, 2007).

Coding was carried out to identify the extent of the perceived impact of the extreme weather events, the immediate response to them, the preparation for future events and the perceived risks and collaboration in the supply chain. In the literature review we identified a number of factors and attitudes which were included in the initial coding scheme. Four researchers coded the interviews separately, sharing and discussing the coding schemes. Then analysis started with identification of the major concepts within each group (producers, processors and manufacturers) and moved on to cross-case comparison (Yin, 2009). We treated the firms as multiple sources and analyzed the similarities and differences between informants within each group (Miles *et al*., 2013). We identified the main categories as we codified the texts. As new interviews were analyzed, new codes were introduced and the previously coded interviews were reviewed. The categories initially identified were factored into new category classes that better condensed the patterns (Miles *et al.*, 2013).

Findings were consolidated within each group and each firm was classified according to its channel position. During this process, it was noted that the Producers & Processors group focused on processing operations rather than on agriculture production. Our analysis, therefore, grouped them with the other processors in the within-case analysis. Finally, this research carried out a cross-case analysis, comparing group responses and attitudes.

This study applied several measures to ensure the rigor of data collection and analysis, as well as the credibility of our findings (Table 2).

TABLE 2 HERE

4 Results

Sugarcane and orange crops have a long production cycle. Relationships in both supply chains are managed differently. In sugarcane supply chains, relationships between producers and processors are based on formal contracts, signed for six to seven years (Feltre and Paulillo, 2013a). The main reason for this is lower demand for tying up capital and the safeguard of long-term supply security for processors (Feltre and Paulillo, 2013b). Spot market purchases are not a usual alternative and most processors are vertically integrated (produce up to 80% of their own sugarcane supply).

In the early 2000s, sugarcane producers and processors located in the State of São Paulo signed an environmental regulation and protection agreement. The Environmental Protocol contained a commitment to mechanize the harvest (to avoid the practice of burning the

sugarcane) and reduce the use of water in processing (SMA/IEA, 2008; UNICA, 2017). So, over the last decade sugarcane producers and processors have had to adapt their procedures to come into line with the new regulation, which included the treatment of new types of crop pests.

Relationships between producers (citrus growers) and processors in the orange supply chain are customized. Contracts are issued on the basis of individual specificities that reduce transaction costs for processors (Paulillo and Almeida, 2009). As markets become more concentrated with few large processors, orange growers have reduced bargaining power. Some orange producers try to find better negotiations on the spot market, while 80% of the large orange processors have contracts and vertical integration.

For orange producers, HLB (citrus greening disease, caused by the *Huanglongbing* bacteria) is considered to be the worst global citrus disease (Coelho and Marques, 2002) and is a constant threat and one of the major drivers of an increase in citrus production costs in Florida (USA) (FUNDECITRUS, 2017). Orange processors have also been concerned with demand fluctuations and product substitutes, such as soft drinks.

We now present our within-case analysis, followed by a cross-case analysis of the meaningful groups.

Within-case analysis

Within each group (producers, processors and manufacturers), we analyzed the perception of climate, the event response and planning. We also summarized the adaptation measures and the perceived vulnerabilities reported by the interviewees. We consolidated the findings at each node in the supply chain, thus producing different perspectives of the event.

Climate variations are an important source of risk to food production, particularly for producers, as agriculture is highly dependent on natural resources and very vulnerable to weather extremes. Despite awareness of climate risk, Brazilian agriculture is broadly exposed and adaptation measures, such as drip irrigation, are not applied in some crops and regions (Monteiro et al., 2015). Specifically, in the São Paulo State (SE region), there is an historical perception of favorable weather and natural conditions, where extreme events are rare. This historical perception has been challenged by the recent ("since 2009") experience of climatic events, with a higher frequency of weather extremes, higher temperatures and random rainfall distribution. This recent experience, however, has not been able to change their historical perception (Table 3).

TABLE 3 HERE

Climate was largely regarded as an uncontrolled aspect and an "act of God". Producers and processors had their sources of weather forecast (on average covering 30 days ahead), producers considered the information that was available to be insufficient, while processors and manufacturers considered the need to understand recent weather variations and the possible implications of climate change. Except for two firms (Sugar Mill 6 and F&B Large), the respondents were not proactively searching for information regarding climate change and long-term forecasts for the SE region. Thus, the perception of climate was mainly based on historical experience instead of on scientific knowledge and future projections.

The severe drought (2014-2015) had an overall negative impact on both sugarcane and orange supply chains. In terms of losses, agricultural production suffered major direct losses, with up to a 40% reduction in total output and a deterioration in quality. These impacts (table 4) had repercussions in food processing with supply shortages and increased costs, but less intensely. Firms in the manufacturing sector suffered lower negative impacts and there was even an increase in the sales of soft drinks. Therefore, the event caused a disruption upstream in the supply chain.

TABLE 4 HERE

As the event "surprised" the firms, most respondents were not prepared or had not planned for the impacts, except for Orange Processor 2 (Table 5). Given the agriculture production cycle, producers had no capacity to develop an immediate response. The immediate response of processors was to search for alternative suppliers and some integrated processors have already diversified their production in terms of region. The water shortage affected the sugarcane mills and orange processing, so firms accelerated their conversion towards closed circuit production. Even though manufacturers did not experience major losses, aggravation of the crisis in the major cities (including São Paulo, the state capital) generated a sense of responsibility and accountability in terms of water use. Concerned about their public image, manufacturers accelerated the development and implementation of eco-efficiency and water reuse projects.

TABLE 5 HERE

When asked about planning for future events, firms demonstrated different attitudes toward risk, but a general optimism. Based on their past experience, producers considered extreme weather events rare and, therefore, the low probability of events would not pay off the investments in terms of adaptation measures. In terms of food processing and manufacturing, firms considered that closed circuit and eco-efficiency projects reduced water dependency and increased resilience to future events. The orange cooperatives (Orange Coop Local 1, Orange Coop Local 2 Orange Coop Large) and government agency (Gov Assistance) intended to influence producers to implement irrigation projects. In the sugarcane supply chain, however, opinion was unanimous that "sugarcane doesn't have to be irrigated in São Paulo".

Resilience in terms of weather events, particularly drought events, include long-term adaptive responses and long-term planning (Berrang-Ford *et al.*, 2011; Haigh and Griffiths, 2012). In the case of the agricultural production of oranges and sugarcane, irrigation (sprinkler and drip for oranges and basin and ferti-irrigation for sugarcane) is one of best known measures, followed by the use of resistant plant varieties (genetically modified), soil protection and reforestation to promote water retention. For processors and manufacturers, the water shortage could be mitigated by way of closed circuit production and water reuse systems, the use of alternative sources, such as drilled wells (when authorized), and supplier diversification (Table 6).

TABLE 6 HERE

Our data provided evidence that other risks (than climatic) are perceived as sources of vulnerability (table 7). First, firms were concerned with their financial situation in the sugarcane supply chain, which mainly derived from their bank debts and the "ethanol crisis". In terms of environmental regulation, producers and processors were concerned with increasing environmental demands, such as the Environmental Protocol for sugarcane and the required licenses for water use. Fierce competition was a major issue for orange processors and exporters as well as pests, such as the HDL ("*citrus* greening disease"). Labor demands and deliberately-set fires were issues in sugarcane production. Manufacturers were mainly concerned with the public image of their firms. Finally, distilled *cachaça* producers perceived taxes as a major threat in the short-term.

TABLE 7 HERE

Cross-case analysis

During data analysis we identified the supply chain context as an important component in influencing the process of resilience-building among organizations in the supply chain. The agri-food supply chains investigated are characterized as slowly evolving industries, with little innovation, especially when looked at from the producers' perspective. Our data provided evidence of relationship governance adopted and different resilience levels. These components had different effects on SCRES in drought events.

The two supply chains studied are marked by transactional relationships. With their standard products and vertical integration (production and processing), processors are little dependent on outside supply. In the sugarcane sector, contracts are standard and processors can secure their supply from few players. In the orange supply chain, cooperatives centralize product sourcing and processing. Consequently, there is no tradition of collaboration in either of the supply chains; companies are largely interdependent. In fact, we found evidence of tensions or friction in relationships, rather than collaboration.

Those aspects also shape a SCC of little complexity, with a reduced number of components (sugarcane and oranges) to be supplied (Bozarth *et al*., 2009). In the upstream supply chain, which includes the producer-processor relationship, there were few contracts to be monitored and controlled. As informed previously, in some of our cases, producers and processors are vertically integrated. In addition, the geographical limitation confined sources of supply. We also found little complexity in relationships downstream (processors and manufacturers), given the standard products and concentration of the processing market.

These two components of SCC did not change after the extreme weather event. Data demonstrate that firms reacted in isolation as the drought affected their operations. Upstream in the supply chain, producers needed larger investments in farming, but there was no reaction or planning for future events. As an example of this, one interviewee mentioned the possibility of using vinasse for irrigating their production better, but mentioned that processors were not interested in a joint solution. Processors, on the other hand, could deal with the drought due to the changes that were implemented following the recent environmental regulations. As responses to the crisis were isolated, there was little collaboration in the supply chain for building resilience (Table 8). The exception was the reported intention of orange cooperatives to promote irrigation among producers. Therefore, the governance structure did not facilitate collaboration in the supply chains when the drought occurred. On the other hand, the low complexity of the supply chains helped in the search for

alternative supply from outside the region and diversification in the case of processors; this helped confine the impact in the upstream supply chain.

TABLE 8 HERE

Finally, firms demonstrated different levels of planning and adaptability to future extreme weather events. Applying Vargo and Seville's (2011) classification levels of resilience, producer behavior tends to be classified as latent resilient, with some respondents unaware of risks imposed by future climate events and with no intention of investing in adaptability, while some are aware, but have no formal processes for dealing with risks. We credit that behavior to the general perception that the weather would return to its historical patterns, a perception that was socially embedded in the supply chains we studied. Processors and manufacturers achieved a higher level of resilience maturity, having implemented most of the processes needed to respond to future events. Both processors and manufacturers are more conscious of the future and their vulnerabilities and intend to adapt to the new environmental conditions.

FIGURE 1 HERE

Climate vulnerability and the low resilience maturity of producers confine them to the higher risk position in the supply chain. Paradoxically, processors and manufacturers were better prepared for future events, even though not as vulnerable. Such misalignment limits resilience capacity in the supply chain and confines solutions to specific nodes and firms.

5 Discussion

In this section we further explore how SCC influences resilience in agri-food supply chains. Our data showed that transactional governance has an influence on collaboration and agility capabilities. From a buyer's perspective, in the context of relative independence between buyer-supplier and repeated transactions, the most appropriate purchasing strategy is based on medium to long-term contracts and negotiations to minimize costs, optimize volumes and exploit bargaining power (Kraljic, 1983). In this scenario, companies will try to protect their own interests rather than focus on a common goal. Because of standard products and an abundance of suppliers, companies do not need to work in a complementary way and collaboration between buyer-supplier is not commonly required in the supply chains studied.

As companies focused on their individual interests and supply chains were more dispersed, there was no coordination of activities between processors and producers. Therefore, there is no information or knowledge exchange between nodes, thus reducing collaboration possibilities.

When dealing with an unexpected event, companies should work together to minimize the consequences of the impact to their operations. However, in a transactional context, companies are not used to collaborating. Thus, they seek isolated responses, as we have seen in our evidence, rather than using common strategies to mitigate the risk for the whole supply chain.

Resilience literature also proposes that companies have to develop redundancy as a mitigation strategy for dealing with risk (Jüttner and Maklan, 2011; Sheffi and Rice, 2005) . One of the most cited mitigation strategies is a multi-supplier strategy. In a context of abundance of suppliers, with low costs for switching to alternative producers, many processors suggested that they will increase their supplier database to reduce the impact of potential new drought occurrences. Therefore, we propose:

P1: In a supply chain context of transactional relations and low dependence, a firm's resilience is provided by supply diversification (redundancy) rather than collaboration.

As we saw in our data analysis, the studied supply chains are embedded in low complex supply chains, with few low-tech products to manage, an integrated supply base and suppliers that are geographically concentrated. As a supply chain competes on price, all efforts in transactions should be directed towards minimizing waste and optimizing costs to increase efficiency.

The supply chains studied tend to focus on their internal supplier structure, thus reducing the possibility of developing new suppliers and closer relationships. Producers focus on increasing their productivity to increase their value share in the relationship, as their gains are basically derived from volume. Processors also buy raw material from producers and sell products to manufacturers based on cost minimization, scale and efficiency. In their relationships with external producers, processors have low switching costs, which results in higher flexibility to change suppliers and increased redundancy in terms of the supplier base. On the other hand, as suppliers are geographically concentrated, they are also dependent on regional supply, which limits their capacity to buy from alternative suppliers and increase

agility. Alternative producers for the current supply chain are geographically far from the processors, increasing lead times and transportations costs, which affects efficiency, a key aspect in commodity supply chains (Martin and Towill, 2000; Mason-Jones *et al*., 2000). Therefore, their intention to search for alternative suppliers during the drought cannot be assumed to be a long-term strategy.

Our findings also provide evidence that manufacturers are less vulnerable to the drought than producers, or even processors, but they are more concerned with their image (Kim *et al*., 2016). Our data, however, provided no evidence of any plan to monitor or mitigate risks and impacts upstream, as suggested by Kim *et al.* (2016) suggesting that they do not have full visibility of the whole supply chain.

Supply chains are also embedded in a slow evolution scenario, based on historical data and experience. In this context, it is hard for organizations to develop a visibility capacity in terms of new, upcoming events. Consequently they assume that the future will follow the same pattern as it did in the past. In fact, our evidence suggests a short-term perspective, with organizations collecting climate information for only 3 months and a belief that climate extremes will be rare. They do not anticipate the risk and do not develop resilience. Therefore, we propose that:

P2: In low complexity supply chain, companies are less effective in developing visibility and agility.

The SCRES concept is anchored in the assumption that organizations are interconnected and risks at the individual level may impact the whole supply chain *(*Leat *et al*., 2013; Ponomarov and Holcomb, 2009). Our data, however, provided evidence that different nodes of the supply chain were affected and reacted in distinct ways to the same event. The losses at the producer level could have resulted in supply disruption, with a reduction in product supply, a poor quality product and cost increases having a ripple effect along the whole of the supply chain (Bode and Wagner, 2015). Nevertheless, processors and manufacturers reported lower direct impacts in their operations. Additionally, downstream nodes in the supply chain had a better planning process and more response strategies due to their higher risk maturity level. In fact, they already had processes in place that helped them to deal with the unexpected event. This finding suggests that different resilience levels in the supply chain foster resilience and the higher individual level do not necessarily foster SCRES. Therefore, we propose:

P3: In supply chains with uneven enterprise risk management and resilience levels, individual resilience is prioritized rather than SCRES.

6 Conclusions

The SCRES construct has been discussed in literature as the capacity of the whole supply chain to prepare, react and adapt in a cost-effective and timely way to unexpected events that surpass the organizational boundary (Christopher and Peck, 2004; Kamalahmadi and Parast, 2016; Ponomarov and Holcomb, 2009). The literature and empirical research into the topic, however, have neglected the SCC as an important influence on the firms' capacity to develop resilience in a supply chain. This study aimed to fill this gap by exploring two supply chains that were affected by an unprecedented extreme weather event.

This research contributes to knowledge of SCRES in three ways. First, we investigated how the SCC influences the capacity of building SCRES. Our findings suggest that as interfirm relationships are usually transactional, the search for joint solutions and collaboration is not considered when dealing with unexpected events. In fact, each organization adopted isolated planning and adaptive actions and there was no coordination between the firms studied. The lack of organizational compatibility and difference in terms of risk and resilience maturity also favors enterprise resilience rather than SCRES.

Second, we explored a slow onset event that lasted almost two years and whose impacts were cumulative and difficult to perceive immediately (data was collected at two moments in the crisis), thus filling an empirical gap in SCRES studies that normally research sudden events and at only one phase.

Third, the study explores the perception of climate, the event response and planning at each supply chain node, bringing a broader perspective of resilience in the supply chain. The literature on supply chain management and resilience normally focuses on one perspective in the dyad, and often, on the focal buyer's side (Spina *et al.*, 2013). Thus, the existing literature brings the perspective of resilience from the downstream view of procurement and supply management, and overlooks the implications to upstream suppliers. The analysis of different perspectives (producers, processors and manufacturers) allowed us to compare how they were affected by the same unexpected event and their reactions to it and compare how mismatched information and maturity affect the capacity of building resilience.

Managerial and social implications

This study brings light into the disparities in terms of environmental perception, planning and preparedness at different nodes of the supply chains. One practical implication of this finding is that resilience strategies cannot be evenly built in the supply chain and that firms might have to focus on diversification, and multi suppliers' solutions. However, in long-term perspective more collaborative initiatives should be instigated by the associations and cooperatives.

Additionally, our study demonstrates that the most vulnerable nodes of the supply chain, the agriculture producers were least prone to build resilience in their operations. Indeed, in our results, we identify that the influence of historical perception was more prominent in business's decisions than recent events and future projections. Therefore, the need to intensify communication and dissemination of climate change knowledge in the agri-food supply chain and particularly among producers.

Moreover, the impacts of extreme weather events are unevenly distributed across firms, and those industries that are more dependent on natural resources present higher vulnerability, such as in the case of agriculture (IPCC, 2012; Winn *et al*., 2011). Particularly in emerging countries, agricultural activities are expected to double by 2050 (UNESCO, 2015); thus, the challenge for countries such as Brazil to address the necessary adaptation and to increase the resource efficiency.

Limitations and further research

Our study has some limitations. The first limitation refers to the sample. Even though our sample contains firms from two different agri-food supply chains, these sectors have peculiarities in terms of weather dependence and market environment that are not present in all industries. Moreover, our study was carried out in a single institutional context of an emerging economy that was facing a political and economic turbulence. As institutional contexts have implications in the dynamics of interfirm relationships, our sample lacks heterogeneity. The second limitation relates to the case study method and the difficulty in establishing the external validity of the study findings (Eisenhardt, 1989). We tried to reduce this problem in the triangulation with other studies and interviews with associations and influential stakeholders, but the findings of this study should be tested with a broader and more heterogeneous sample of firms. Future studies might compare different institutional and supply chain contexts, to validate the findings and to promote the exchange of knowledge.

Additionally, further research should explore the difference between a slow onset event and a sudden onset event to better understand if a situational crisis management could influence resilience capacity.

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Table 1: Cases Studied

Given Name	Supply Chain	Product	Channel Position	Size*	#Interviews /# Respondents
Cachaça Producer 1	Sugarcane	*Cachaça*	Producer	Micro	2/1
Cachaça Producer 2	Sugarcane	*Cachaça*	Producer	Micro	1/1
Cachaça Producer 3	Sugarcane	*Cachaça*	Producer	Micro	2/1
Orange Producer	Orange	Orange	Producer	Small	2/1
Sugar Producer	Sugarcane	Sugar/Ethanol/Bioenergy	Producer	Medium	1/1
Orange Coop Local 1	Orange	Orange	Processor	Small	1/1
Orange Coop Large	Orange	Orange	Processor	Large	2/1
Orange Coop Local 2	Orange	Orange	Processor	Small	1/1
Orange Processor	Orange	Orange	Processor	Medium	1/1
Sugar Coop	Sugarcane	Sugar/Ethanol/Bioenergy	Processor	Large	2/2
Bioenergy	Sugarcane	Ethanol/Bioenergy	Producer & Processor	Large	2/2
Cachaça Processor	Sugarcane	*Cachaça*	Producer & Processor	Large	3/3
Orange Processor 1	Orange	Orange	Producer & Processor	Large	3/2
Orange Processor 2	Orange	Orange	Producer & Processor	Medium	1/1
Sugar Mill 1	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	1/1
Sugar Mill 2	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	2/1
Sugar Mill 3	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	1/1
Sugar Mill 4	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	1/1
Sugar Mill 5	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	1/1
Sugar Mill 6	Sugarcane	Sugar/Ethanol/Bioenergy	Producer & Processor	Large	1/2
F&B Large	Sugarcane & Orange R	Food	Manufacturer	Large	1/1
F&B MNE	Sugarcane & Orange	Beverage	Manufacturer	Large	1/1
F&B Medium	Sugarcane & Orange	Beverage	Manufacturer	Large	1/1
F&B Small	Sugarcane & Orange	Beverage	Manufacturer	Small	1/1
Gov Assistance	Sugarcane & Orange	Assistance	Association/ Government	N/A	3/3
Gov Research	Sugarcane & Orange	Research and Assistance	Association/ Government	N/A	1/1
Orange Association	Orange	Orange	Association/ Government	N/A	1/1
Sugar Bioenergy Association	Sugarcane	Sugar/Ethanol/Bioenergy	Association/ Government	N/A	1/1

Source: *size of companies by number of employees (SEBRAE, 2017)

Table 2: Trustworthiness of the Study and Findings

Trustworthiness Criteria	Method used in this Study
Credibility (extent to which the results appear to be acceptable representations of the data)	• Use the research protocol and definition of questions as per the literature. • Two researchers collected the data and four researchers worked on data analysis. • Three-page summary of initial interpretations was provided to the respondents for feedback.
Transferability (extent to which findings from one study in one particular context will apply to other contexts)	• Theoretical sampling based on food supply chain within two distinct industries: sugar/energy and orange. • Sample presented firms from different nodes in the supply chain and of different sizes.
Dependability (extent is unique to time and place; stability or consistency of explanations)	• Respondents related experiences covering the phenomenon studied (water crisis), as well as historic data from other severe events. • Data collection in two periods with an interval of one year. • More than one informant per firm. • Triangulation with associations and government as well as with documents.
Confirmability (extent to which interpretations are the result of the participants and the phenomenon, as opposed to researcher bias)	• All interviews and documents were analyzed by four co-researchers. • Summaries of preliminary findings were analyzed by other team members who acted as controllers.

Source: Based on (Flint *et al.*, 2002; Kaufmann and Denk, 2011)

Table 3: Weather perception

Channel Position	Historical Perception of the Weather	Recent Perception of the Weather	Weather Information
Producer	Extreme events are rare in the SE region	Increasing variance in last years	We have a short-term forecast
Processor		Extreme weather was a surprise/atypical	Weather info is not reliable; we need to understand climate change
Manufacturer	-		

Table 4: The Drought's Direct Impact on Firms

	Given Name	Supply Chain	Direct Impacts
Producer	*Cachaça* Producer 1	Sugarcane	Restricted supply of sugarcane and increased supply costs
	Cachaça Producer 2	Sugarcane	Lower product quality
	Cachaça Producer 3	Sugarcane	Productivity decrease (agriculture)
	Orange Producer	Orange	Lower quality
	Sugar Producer	Sugarcane	Productivity decrease (40% agriculture)
Producer/Processor	Bioenergy	Sugarcane	Positive impact given the increased price of energy
	Cachaça Processor	Sugarcane	Productivity decrease (17% agriculture)
	Orange Processor 1	Orange	Productivity decrease (25% agriculture) and lower quality
	Orange Processor 2	Orange	Lower quality
	Sugar Mill 1	Sugarcane	Productivity decrease (20% agriculture)

	Sugar Mill 2	Sugarcane	Productivity decrease (agriculture)
	Sugar Mill 3	Sugarcane	Productivity decrease (10% agriculture)
	Sugar Mill 4	Sugarcane	Restricted water supply in production and a productivity decrease (agriculture)
	Sugar Mill 5	Sugarcane	Restricted water supply in production and a supply shortage
	Sugar Mill 6	Sugarcane	Productivity decrease (agriculture)
Processor	Orange Coop Large	Oranges	Lower quality
	Orange Coop Local 1	Oranges	Productivity decrease in processing (5%)
	Orange Coop Local 2	Oranges	Supply shortage and increased costs
	Orange Processor	Oranges	Supply shortage and increased costs
	Sugar Coop	Sugarcane	No significant impact
Manufacturer	F&B Large	Sugarcane/ Orange	No significant impact
	F&B Medium	Sugarcane/ Orange	No significant impact
	F&B MNE	Sugarcane/ Orange	Lower quality (oranges) and sales increase
	F&B Small	Sugarcane/ Orange	Increased supply costs (oranges)

Table 5: Drought Response and Planning in the Supply Chain

Activity	Immediate Response	Further Planning
Agricultural Production	None	No investment given the perceived unfavorable cost/benefit ratio
Food Processing	Intensified the development of closed circuit production and search for alternative suppliers	Develop closed circuit projects Cooperatives: Foster irrigation projects with producers, by selling projects and equipment
F&B Manufacturing	Eco-efficiency projects	Develop closed circuit projects

Table 6: Adaptation to drought events

Agricultural Production	Processing & Manufacturing
• Sprinkler irrigation, drip irrigation or trickle irrigation (orange crops) and basin irrigation (i.e. terraces for water retention in the soil for sugarcane crops) • Ferti-irrigation with reuse of the vinasse in border irrigation and ashes from bagasse furnaces and other elements (sugarcane residuals), thus contributing phosphorous and potassium as organic fertilizers • Genetically-modified (GM) sugarcane resistant varieties • Integrated crop-livestock-forestry systems • Reforestation, soil conservation and environmental protection of water springs • Root deep penetration technology (sugarcane) • New ways of replanting sugarcane, using pre-budded seedlings • Relocation	• Closed circuit (water reuse) process • Drilling wells • Diversification of supply sources

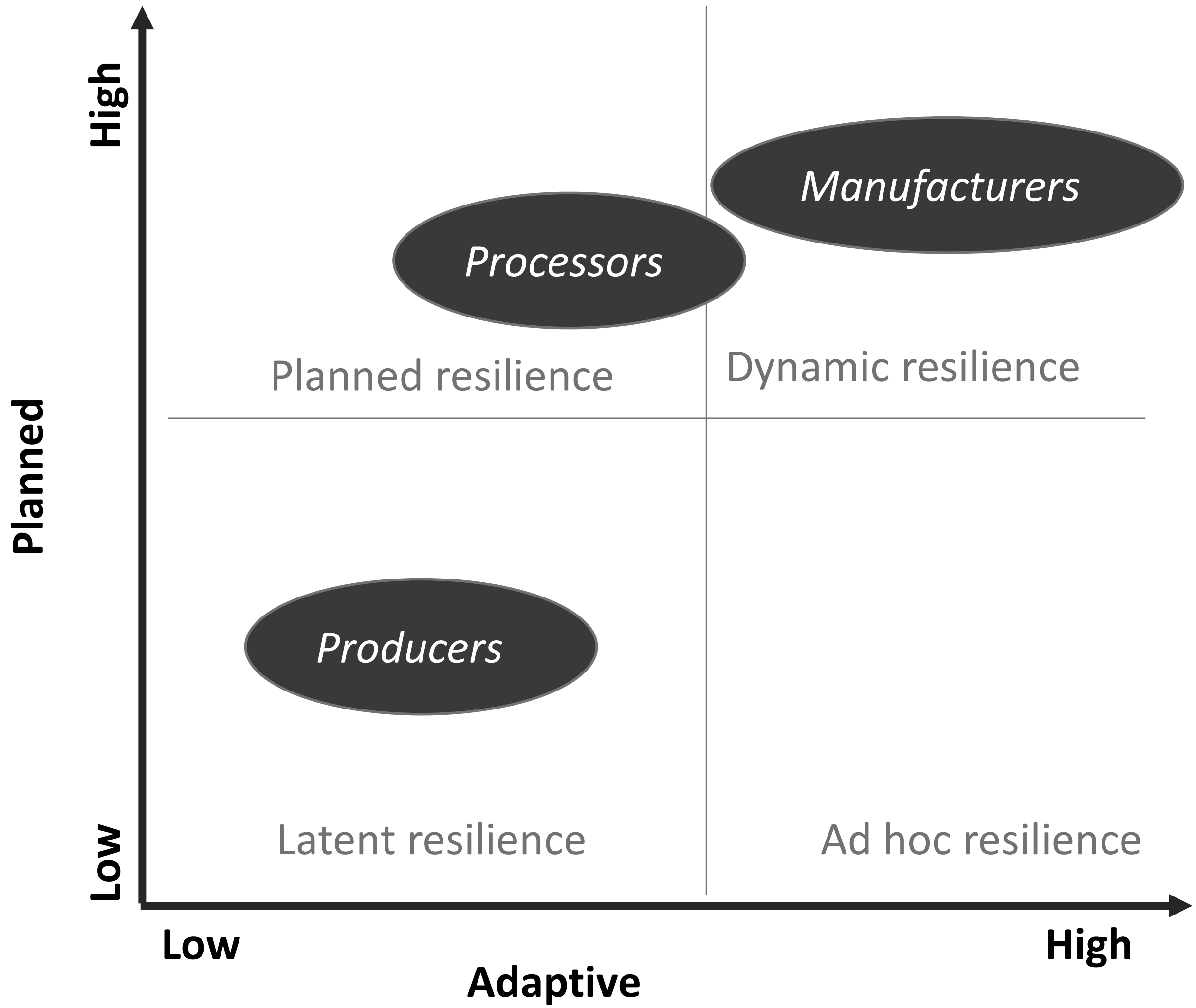
Table 7: Other reported vulnerabilities

Risk Concern	Producer	Processor	Manufacturer	Associations/ Government	Total Mentions

Financial situation	22%	66%	6%	6%	32
Environmental regulation	13%	48%	3%	35%	31
Competition	33%	53%	0%	13%	15
Labor demands	25%	75%	0%	0%	12
Ethanol crisis	18%	82%	0%	0%	11
Pests – crops	10%	50%	10%	30%	10
Taxes	75%	25%	0%	0%	8
Market demand variation	0%	50%	50%	0%	8
Public image	0%	14%	71%	14%	7
Fire	40%	60%	0%	0%	5

Table 8: Supply chain implications

	Given Name	**Collaboration**
Producer	Cachaça Producer 1	What collaboration could there be in a crisis?
	Cachaça Producer 2	
	Cachaça Producer 3	There is no collaboration in the SC
	Orange Producer	
	Sugar Producer	There is no collaboration in the SC
Producer/Processor	Bioenergy	
	Cachaça Processor	There is no collaboration in the SC
	Orange Processor 1	Collaboration tried with buyers to tackle demand problems, and with suppliers to develop varieties and equipment
	Orange Processor 2	
	Sugar Mill 1	
	Sugar Mill 2	There is no collaboration in the SC
	Sugar Mill 3	Concern with supply capacity of supply (outbound) for clients
	Sugar Mill 4	The crisis led to dialogue between associations (producers and processors)
	Sugar Mill 5	Considers collaboration monitoring by the sugar Coop
	Sugar Mill 6	There is no collaboration in the SC
Processor	Orange Coop Large	Contact with irrigation technology firms to promote drip irrigation and capacity building with cooperative members
	Orange Coop Local 1	Promoting drip irrigation and capacity building with cooperative members
	Orange Coop Local 2	Promoting drip irrigation and capacity building with cooperative members
	Orange Processor	There is no collaboration in the SC, small processors and large manufacturers
	Sugar Coop	There is no collaboration in the SC
Manufacturer	F&B Large	Risk assessment with some suppliers
	F&B Medium	Some clients demanded information regarding water consumption
	F&B MNE	There was a trial partnership in the supply chain, but projects were discontinued
	F&B Small	Dialogue with suppliers to try and secure supply


High
Low
Planned
Manufacturers
Processors
Planned resilience
Dynamic resilience
Producers
Latent resilience
Ad hoc resilience
Low
High
Adaptive