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How can cross-functional integration support the development of resilience capabilities? The case of collaboration in the automotive industry — Source link

Tayanne Ferraz da Silva Poberschnigg, Márcio Lopes Pimenta, Per Hilletofth

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Abstract

Purpose: The objective of this study is to analyze cross-functional integration processes and their respective impacts on resilience capabilities, with particular emphasis on collaboration, in an automotive supply chain.

Design/methodology/approach: A case study was conducted in an automotive supply chain through eighteen in-depth interviews with managers from six different companies: two suppliers, one focal manufacturer and three customers. The automotive industry is one of the most vital industries in the Brazilian economy and is still recovering from the 2015 financial crisis, making it an interesting case for this research.

Findings: The findings reveal several links between resilience and cross-functional integration literatures through the analysis of three basic categories: Disruptions (lack of product, interruption of production, delivery delay, organizational bankruptcy and sales loss); Capabilities (redundancy, flexibility, adaptability, collaboration, visibility and agility); and Integration factors (cross-functional meetings, adequate communication, longevity of relationships, cross-functional training, recognition of interdependence and the consideration given to informal groups).

Practical implications: This research addresses several implications for practitioners. Managers should pay attention to the cross-functional teams, which may provide internal collaboration and hence collaboration in the supply chain.

Originality/value: This paper suggests a new concept for the collaboration capability. According to our results, collaboration is the capability of dealing with formal and informal factors to integrate both the internal functions and supply chain members, which can provide visibility, agility and adaptability towards supply chain resilience.

Keywords: Resilience; Cross-functional Integration; Supply Chain; Automotive Industry.

1. Introduction

Increased competition (Christopher and Peck, 2004; Sheffi and Rice Jr, 2005), complexity (Sheffi and Rice Jr, 2005) and the presence of global and outsourcing partnerships (Singhal *et al.,* 2011;Wiesmann, *et al*., 2017) have resulted in rising vulnerabilities in supply chains, making these more susceptible to breakage (Pettit *et al.,* 2010). Thus, vulnerability to internal, external or environmental events is linked to the risk of disruptions in the supply chain, and may be related to problems in production capacity, quality or variability of supply (Christopher and Peck, 2004; Sheffi and Rice Jr., 2005; Kamalahmadi and Pärast, 2016).

In view of recurrent situations that generate risks of disruptions, the supply chain management literature has been discussing resilience. The concept of resilience is related to the capacity of the supply chain to quickly deal with changes and recover from a break or other event affecting the flow of the supply chain (Christopher; Peck, 2004). Resilience is achieved both by the existence of capabilities in the supply chain, which can reduce vulnerability (Pettit *et al.,* 2013), and by using the knowledge acquired after suffering earlier events, thus facilitating a faster and more efficient response to certain events (Kendra and Wachtendorf, 2003).

Several authors address capabilities as strategies and skills to manage and build resilient supply chains (Rice Jr. and Caniato, 2003; Fiksel, 2003; Christopher and Peck, 2004; Sheffi and Rice Jr., 2005; Pettit *et al.,* 2010; Jüttner and Maklan, 2011; Pettit *et al.,* 2013; Soni *et al.,* 2015; Sansone *et al*., 2017). Among these studies, the most frequently cited capabilities are: redundancy, flexibility, agility, visibility, adaptability and collaboration. In particular, collaboration is a concept which has been discussed in the internal integration literature (Kahn, 1996; Kahn and Mentzer, 1996; Kahn and Mcdonough, 1997; Kahn and Mentzer, 1998; Ellinger *et al.*, 2000; O'leary-Kelly and Flores, 2002; Pagell, 2004). About this subject, Gimenez and Ventura (2005) state that integration can be external or internal.

Internal integration is also called cross-functional integration and involves the relationship between different organizational areas such as production, logistics and marketing (Frankel and Mollenkopf, 2015; Ferreira *et al.,* 2019).

Cross-functional integration can be understood as a process in which the alignment between areas or departments occurs through formal and informal mechanisms, with the intention of improving the company's performance (Kahn, 1996; Kahn and Mentzer, 1996; Kahn and Mentzer, 1998). This study focuses on cross-functional integration, rather than external integration. Therefore, when considering the complexity of the market environment, we believe that the integration of internal functions can help to achieve greater resilience in the supply chain, as mentioned by Freitas *et al.,* (2020). This perspective is also grounded in the study of resilience capabilities, especially regarding collaboration. Swink and Schoenherr (2015) also state that cross-functional integration is crucial in reducing uncertainties and misunderstandings, and can be considered as a *key capability* for information processing within the supply chain. However, these authors did not investigate the role of cross-functional integration in the resilience of the supply chain.

Resilience is important for supply chain management; it involves the ability to overcome turbulence (Christopher and Peck, 2004), surviving, adapting and growing in the face of adversity (Pettit *et al*., 2010). The more resilient a chain is, the lower the chances that disruptions will hinder its performance (Blackhurst *et al.,* 2011). Pimenta *et al*. (2016) mentions some cross-functional integration factors that have also been highlighted in the resilience literature, such as "cross-functional teams". These teams are seen as a facilitator to quickly and efficiently overcome a disruption in the chain. On the other hand, the "education and functional training" integration factor allows the mutual understanding and mobility of employees within and between organizations (Rice Jr. and Caniato, 2003).

Resilience and cross-functional integration are also related in the sense of addressing capabilities for the development of resilience in the supply chain. Cross-functional integration can bring positive impacts in terms of internal collaboration (Kahn and Mentzer, 1996), visibility (Christopher and Peck, 2004), agility (Braunscheidel and Suresh, 2009) and flexibility (Schoenherr and Swink, 2012). Among the findings regarding the relationship between these two themes, the capability that stands out is collaboration, as it is widely discussed in the resilience literature (Rice Jr. and Caniato, 2003; Christopher and Peck, 2004; Pettit *et al.,* 2010; Pettit *et al.,* 2013; Scholter and Shilder, 2015). However, while authors such as Christopher and Peck (2004) note that cross-functional integration is relevant to address disruptions in the supply chain, they do not seek to clarify how it should be practiced in order to improve resilience. Moreover, neither specific cross-functional integration factors (Kahn, 1996) nor their impact on resilience are discussed in depth in terms of formal actions or informal mechanisms.

The following research question is suggested: How can cross-functional integration processes be practiced in order to support resilience in the supply chain? The objective of this study is to analyze cross-functional integration processes and their respective impacts on resilience capabilities, with particular emphasis on collaboration, in an automotive supply chain.

After this introduction, we have a theoretical review about resilience and cross-functional integration. The methodology section identifies the criteria for conducting a case study in an automotive supply chain and explains the procedures for data collection and analysis. Finally, we have the conclusions, with an emphasis on the explanation of points of contact between the theories that explain cross-functional integration and resilience in supply chains.

2. The role of cross-functional integration in supply chain resilience

Resilience is a relatively new concept in the academic environment. Etymologically, the word comes from the Latin *resiliens*. Considering its origins, the term resilient refers to flexibility in which there is a quick ability to restore or recover from some instability (Pinheiro, 2004). Since the 1970s, resilience has been addressed in several areas, such as ecology and psychology, as mentioned by Ponomarov and Holcomb (2009) and Ponis and Koronis (2012). However, although there were some research efforts before 2000 (Horne and Orr, 1998), from an organizational perspective, it is clear that research on this subject is new.

The interest in the topic originated from researchers' awareness of the damage caused by interruptions in the supply chain (Bakshi and Kleindorfer, 2009). In the organizational setting, Rice Jr. and Caniato (2003) state that the concept is applied to analyze the reaction of businesses to an unexpected disruption in order to reestablish their activities after the event. Sá *et al*. (2020) state that resilience does not depend only on the whole supply chain synchronization efforts, but rather on the ability of individual companies to reconfigure the resources required to control disruptions.

The literature on supply chain resilience often exposes the relationship between risk management and reactive aspects after an unexpected disruption (Macdonald *et al*., 2018). In a more refined definition, Pettit *et al*. (2019) state that resilience is not risk management in itself, but a type of enhancement of it. These authors developed a framework that facilitates the exploration of a balance between supply chain vulnerabilities and capabilities, where the company can simultaneously avoid excessive risks and still achieve profit.

For this study, we understand that resilience is both related to reactive and preventive aspects in order to achieve stability in the supply chain, approaching, therefore, the vision of Kamalahmadi and Parast (2016). These authors argue that the terms agility, adaptability and

flexibility are implicit in the definition of resilience, as they are capabilities that can contribute to its achievement. Table 1 highlights the capabilities addressed in this study, as well as their respective references.

[Insert Table 1 about here]

As collaboration is an essential construct to understand both themes studied in this paper, it will be positioned as the central capability that may represent a point of contact between supply chain resilience and cross-functional integration. Ali *et al*. (2017) explained that resilience capabilities can provide five types of abilities to the supply chain: the ability to anticipate, to adapt, to respond, to recover and to learn with regard to a disruption situation. About this latter ability, "learn", Scholten *et al*., (2019) detailed that resilience capabilities can generate learning mechanisms that help to adapt processes in order to recover from a disruption. For these authors, collaboration is an essential capability to stimulate knowledge transfer during disruption.

Researchers that shed light on the relationship between cross-functional integration and resilience capabilities often emphasize the importance of collaboration (Rice Jr. and Caniato, 2003; Christopher and Peck, 2004; Pettit *et al*., 2010). Collaboration may generate other capabilities in the supply chain, such as agility and flexibility (Pettit *et al*., 2013; Scholter and Shilder, 2015).

According to Scholter and Shilder (2015), who conducted a particularly robust study, collaboration can help to generate other capabilities such as visibility, agility and flexibility. They also revealed several integration factors that could be related to achieving collaboration in the supply chain, including: information-sharing, collaborative communication, joint relationship effort and jointly created knowledge. The main difference between the focus of

Scholter and Shilder (2015) and the focus of our proposed framework is that the latter emphasizes internal integration and its effects on external integration. It represents a relevant and rare perspective that embraces at least two particularities: 1) the influence of internal hierarchical structures and company culture on integration (Seno *et al*., 2019), and 2) the influence of internal integration on external integration (Gimenez and Ventura, 2005). These particularities may be paramount in increasing resilience, as the internal functions are responsible for starting and managing the business processes that will go through several links of the supply chain (Lambert and Cooper, 2000; Mentzer *et al*., 2001).

For many years, more traditional organizational structures, such as functional ones, prevailed in organizations. However, more recent studies have discussed a proposal that is less rigid about the division of tasks (Galpin *et al*., 2007). It happened because current organizational dynamics are based on interdependent functions, and so require cross-functional integration efforts. Cross-functional integration is "the quality of the state of collaboration that exists among departments that are required to achieve unity of effort due to demands of the environment" (Lawrence and Lorsch, 1967, p. 11). Several authors define integration as processes generated by formal and informal factors (Kahn, 1996; Kahn and Mentzer, 1996, Kahn and Mentzer, 1998; Ellinger *et al*., 2000; Pagell, 2004).

Pimenta *et al*. (2016) proposed a framework for the different constructs involved in integration processes: boundary spanning activities, integration factors, formality/informality, level of integration and integration impact. Boundary spanning activities are activities or tasks that require cooperation between two or more internal functions in order to fulfill a given business process, while integration factors are mechanisms that are applied formally, informally or through both modes. Table 2 presents several integration factors.

[Insert Table 2 about here]

The level of integration, in turn, can be high, medium or low, being defined by the presence or absence of certain integration factors. It is influenced by the application of these factors through formal or informal managed methods related to cultural traits and personal willingness (Pimenta *et al*, 2016; Ferreira *et al*., 2019). Finally, the impacts are the results of the application of the integration factors on boundary spanning activities. They can exert influence on both the firm and functional levels (Pimenta *et al*., 2016).

2.2 Preliminary framework

Pimenta *et al*. (2016) highlighted several integration impacts on the efficiency of internal and external supply flows, such as: reducing storage costs and freight, avoiding a lack of products in the market, avoiding delivery delay, preventing upselling over logistics capacity, increasing responsiveness to the market, generating faster problem-solving and improving demand forecasting accuracy. These impacts are linked to the capabilities discussed in the previous subtopic. Redundancy, for example, could prevent a lack of a product in the market, since it implies resource reservation (Sheffi and Rice Jr., 2005). Moreover, flexibility may help to avoid delivery delays through adjustments in order fulfillment in case of supply breaks (Pettit *et al*., 2010). Agility, which indicates greater readiness to face unexpected events, may be connected to faster problem-solving and improved demand forecasting accuracy (Christopher and Peck, 2004).

There is evidence in the literature that cross-functional processes are related to resilience capabilities, and that "internal and external integration is also necessary to ensure a connected and coordinated response to meet unforeseen changes" (Braunscheidel and Suresh, 2009, p. 120). Among other benefits, Flynn, Huo and Zhao (2010), Schoenherr and Swink (2012) and Swink and Schoenherr (2015) highlighted that cross-functional integration improves efficiency in decision-making, increases visibility and reduces uncertainty.

This research aims to clarify the operation of the processes shown in Figure 1. A field study was conducted in order to investigate cross-functional processes, detailing cause and effect relationships and actions taken within each construct, through the observation of different occurrences in a supply chain.

[Insert Figure 1 about here]

The main idea of Figure 1 is that the integration factors can generate different capabilities and, consequently, help to prevent or resolve supply chain disruptions. There may be integration factors that are formally implemented or that emerged informally within the boundary spanning activities, in which there may be potential causes of disruptions. These integration factors should be assessed in their modus operandi and frequency. The next step would be studying the perception of the people involved in the process, aiming to describe whether each integration factor identified helps to create resilience capabilities, as well as how these capabilities could prevent or overcome disruptions in the supply chain studied.

3. Methodology

Resilience management in the supply chain is a recent research theme, which also features introductory studies in Brazil, such as: Graeml and Peinado (2014), Pereira *et al*. (2014), Sá *et al*. (2020). Consequently, we opted for a qualitative approach through a case study that allows answering questions like "how" and "why", based on abundant empirical evidence (Yin, 2001).

The following criteria were adopted for case selection: 1) the existence of integration factors: the internal functions work in an integrated manner via managed integration factors; 2) High turbulence level in the supply chain: the supply chain tends to seek resilience when

there is a greater risk of disruption. According to Kahn and Mentzer (1996), turbulent environments require high levels of cross-functional integration. From these considerations, a case study was conducted in an automotive supply chain, including: a focal company, which is a multinational automotive parts manufacturer, two suppliers and three automobile assemblers (customers).

3.1 Data Collection

Data collection took place from August to December 2017. Eighteen in-depth interviews, each lasting between 40 minutes and an hour and a half, were conducted, with managers of production and logistics related departments. In the focal company (a manufacturer of bearings and clutches), the interviewees were asked to indicate other co-workers who engage in processes with disruption risks in their supply chain. In addition, interviewees from the purchasing and supply chain areas were asked to indicate suppliers and client companies who were also involved in these processes.

For the interviews, we used a protocol addressing the following constructs: 1) characterization of the main potential disruptions, their respective processes and related functions in the chain (Pettit *et al*, 2010; Christopher & Peck, 2004); 2) characterization of existing capabilities in the chain: redundancy, flexibility, visibility, agility, adaptability and collaboration (Rice Jr. and Caniato, 2003; Kendra and Wachtendorf, 2003; Mahfouz and Arisha, 2017; Christopher and Peck, 2004; Pettit *et al*., 2010;. & Maklan Jüttner, 2011); and 3) characterization of the integration factors practiced within these processes (Kahn, 1996; Dawes and Massey, 2006; Murphy and Poist 1996 Pagell, 2004; Ellinger *et al*., 2006).

The interview was conducted in order to 1) characterize the modus operandi of each construct; and 2) question the cause and effect relationship between the integration factors and resilience capabilities. Table 3 shows the profile of the respondents.

[Insert Table 3 about here]

3.3 Data Analysis

A classic content analysis was performed, following the procedures recommended by Bauer and Gaskell (2002) and Bardin (2008). Figure 2 brings more details about the adopted procedures.

[Insert Figure 2 about here]

In order to seek greater reliability of the data collected, we followed the recommendations from Butterfield *et al*. (2005): 1) recording the interviews: the interviews were audio recorded and transcribed; 2) data saturation check: the interviews were completed only when most parts of the codes began to be repeated or when no new codes emerged from the interviews; 3) coding taken together: to avoid biases in the data analysis, two authors performed the coding to obtain a consensus on the analysis; and 4) checking the results: after encoding, the analysis of the collected data was made available to the respondents for them to confirm its meaning.

4 Results

4.1. The major disruptions in the supply chain

The main disruptions that occur in the supply chain studied are: halted production, lack of product, late deliveries, supplier bankruptcy and loss of sales. Table 4 shows three disruption points: Organizations, supply chain and environment.

[Insert Table 4 about here]

Each point has four problems mentioned by the respondents, which can be considered as causes of disruptions. The point that generates the most problems in the chain studied is the "supply chain", with 23 causes of disruptions mentioned by the interviewees. "Environment" presented 22 causes and "organizations" nine. The most frequent causes of disruptions are: financial crisis, with 13 references; and fluctuations in demand, with 12. The financial crisis has affected many organizations financially. The main consequence related to the crisis is supplier bankruptcy, with six references by respondents (*Supplier 2 Purchasing Manager; Focal Company Supply Chain Manager; Focal Company Logistics Manager; Focal Company Supply Chain Supervisor; Focal Company Purchasing Supervisor; Customer 3 Internal Logistics Supervisor*).

The "supplier bankruptcy" disruption has a negative impact on the supply chain, as the search and validation of alternative partners is not particularly fast, and so the bankruptcy of a supplier, for example, can lead to other disruptions such as a lack of product (Supplier 2 Purchasing Manager; Customer 3 Internal Logistics Supervisor) delivery delay (Focal Company Logistics Manager; Focal Company Supply Chain Supervisor; Focal Company Purchasing Supervisor) and halted production (Focal Company Supply Chain Manager; Customer 3 Internal Logistics Supervisor). Therefore, it is possible to conclude that "supplier bankruptcy" and "delivery delay" are disruptions that generate other types of disruptions.

4.2. Analysis of the capabilities

Figure 3 shows the presence of six capabilities in the chain studied: redundancy, flexibility, visibility, agility, adaptability and collaboration. Overall, respondents from the various organizations agreed that these capabilities are present in the chain, but with different degrees of importance due to the characteristics of each organization. According to the literature, the presence of capabilities indicates that the supply chain is less susceptible to

vulnerabilities and more able to cope with events that cause disruptions. Table 5 reveals the characteristics of these capabilities in the chain studied.

[Insert Table 5 about here]

The emphasis of this research is on 'collaboration', as a capability. Some researchers have identified that the practical application of collaboration is closely related to the existence of cross-functional integration factors (Swink *et al*., 2015; Freitas *et al*., 2020). The relationship between integration factors and several resilience capabilities is analyzed in the next section of this paper, with support of empirical data. Respondents believe that collaboration is well developed, both within the companies and among the members of the supply chain studied.

> *"Internally, for example, sometimes stopping production led to a breakdown of equipment. The equipment stood still for one week, or two days, the staff that is available in this production unit can collaborate and go to another production unit and join, because demand there is bigger and vice versa. That's a fact. We can also collaborate this way externally"* (Focal Company Purchasing Manager).

Internally, collaboration is related to teamwork, joint efforts to solve conflicts, the mutual understanding of each other's duties (Focal Company Sales Analyst), cross-functional meetings (Supplier 2 PPC Analyst, Focal Company Logistics Manager), joint planning, information sharing and good communication between functions (Supplier 2 PPC Analyst). On the other hand, collaboration between the links in the chain involves: joint planning for demand forecasting (Focal Company Supply Chain Manager, Focal Company Logistics Manager, Focal Company Sales Supervisor), workshops (Focal Company Purchasing

Supervisor, Customer 1 Purchasing Supervisor), sharing human resources (Focal Company Logistics Manager, Focal Company Purchasing Manager, Focal Company Purchasing Supervisor, Customer 1 Purchasing Supervisor) and devices (Focal Company Sales Manager), financial aid (Focal Company Supply Chain Manager), and information sharing, which was cited by all respondents in the six organizations studied.

4.3 Cross-functional integration as a contributor to supply chain resilience

Table 6 illustrates the perceptions of respondents about the contributions of cross-functional integration on supply chain resilience. The following analyses highlight that a high level of external integration is not enough to be resilient. It is also necessary to develop internal integration.

[Insert Table 6 about here]

Based on the relationships identified in Table 6, it is evident that several cross-functional integration factors may contribute to the resilience of the supply chain studied, as they facilitate the development of capabilities. Among these, in the study we identified that three chain capabilities may primarily depend on the development of organizational capabilities: agility, visibility and collaboration. The summary links between integration factors and disruptions and capabilities of the supply chain can be seen in Figure 3.

[Insert Figure 3 about here]

The agility in the supply chain may be achieved through internal agility (Focal Company Supply Chain Supervisor, Focal Company Sales Manager, Customer 2 Engineering Supervisor, Customer 3 PPC Supervisor) and internal collaboration (Focal Company Sales

Manager, Focal Company Sales Analyst, Customer 2 Engineering Supervisor, Focal Company Logistics Manager, Customer 3 PPC Supervisor). Moreover, visibility in the supply chain needs the support of internal collaboration (Focal Company Purchasing Manager, Focal Company Supply Chain Supervisor).

Such internal collaboration contributes to the existence of collaboration in the supply chain (Focal Company Purchasing Manager, Focal Company Supply Chain Manager, Focal Company Supply Chain Supervisor, Focal Company Sales Analyst, Supplier 1 Sales Manager, Customer 1 Purchasing Supervisor). Therefore, several internal collaboration practices are also applied for collaboration in the supply chain as a whole, for example, communication via groups in WhatsApp, training and information sharing. Subsequently, collaboration in the supply chain involves the existence of these external integration initiatives.

4.4 . Exploratory propositions

Several links between collaboration and other capabilities were found in the chain studied. We detected that internal collaboration can generate visibility, as argued by Christopher and Peck (2004). Some respondents (Focal Company Purchasing Manager, Focal Company Sales Supervisor, Customer 1 Purchasing Supervisor) complement this vision by providing a practical description of how this influence may occur in both formal and informal integration processes.

> *"When we talk about customers, in order to understand customer demand, we call a consensus meeting. That is a team that develops a forecast[s] for the next three months. It is formed by the sales department, logistics and purchasing"* (Focal Company Purchasing Manager).

"*Even if they do not have sufficient technical knowledge about the situation itself, people have [a] willingness to share information and to solve problems"* (Focal Company Sales Supervisor).

This situation underlies the following proposition:

> P1: Companies that have formal and informal actions of internal collaboration tend to have greater visibility in the supply chain.

Collaboration can also generate agility, mainly from the specific collaboration between internal areas of the companies. For the Logistics Manager of the Focal Company, the speed of the supply chain depends on the internal speed (organization). If the processes are not fast, there may be disruptions caused by the lack of internal agility.

"I think that is our strength (internal collaboration). It was better in the past, but some features have worsened a little bit, but we still can ... I think we are the most agile in the market, due to [our] internal collaboration. We help each other to solve conflicts of functional performance, focusing on meeting demand specifications, that is an example". (Customer 1 Purchasing Supervisor)

This situation underlines the following proposition:

> P2: The existence of collaboration within the companies helps to develop agility in their supply chains.

The influence of collaboration on agility was already discussed by Scholter and Shilder (2015), but, according to our findings, supply chain agility may also depend on supply chain visibility and two organizational capabilities: internal agility and internal collaboration.

This connection is shown in Figure 3 and contributes to both literature of cross-functional integration and supply chain resilience.

Collaboration can also generate adaptability. Between the links of the supply chain studied, adaptability is manifested in occurrences such as: 1) system changes (Focal Company Logistics Manager) and 2) fast forwarding requirements (Customer 2 Engineering Supervisor) and 3) taking advantage of interruptions (Customer 2 Engineering Supervisor). The two latter aspects were also mentioned in Pettit, Fiksel and Croxton (2010). In addition, adaptability can be seen as a cultural issue, as the interviewees perceive that "Brazilians are used to improvising and having an alternative plan" (Focal Company Purchasing Manager).

> *"I think it is very much related to the Brazilian culture itself, which adapts easily to any situation, irrespective [of] whether [it] is a good or bad situation. Brazilians always have to improvise. Some days you have production, others you haven't. Some days you hire, others you fire"* (Focal Company Purchasing Manager).

> "*Recently, we had a disruption due to [the] lack of capacity of a plant in Slovakia. Then the plant declined an order that was already confirmed in the system, for our client here in Brazil. We got desperate. So there was collaboration between the internal areas in order to develop and assemble national material for this customer"* (Focal Company Supply Chain Manager).

Thus, adaptability may be described as a capability of the supply chain to improvise or plan a new format for a disrupting process. Adaptability may be dependent on internal issues, such as organizational culture traits grounded in cross-functional collaboration. This may strengthen the informal relationships and the mutual understanding between internal functions, in order to improve the velocity and the quality of decisions. However, it may be useless if an organization proposes a new technology for inter-organizational information

exchange (Pettit *et al*., 2010) if the partners in the supply chain are not interested or ready for this change. This underlies the following proposition:

> P3: An organizational culture grounded in cross-functional collaboration can facilitate the development of adaptability through the strengthening of the informal relationships and the mutual understanding between internal functions.

5. Discussion

Based on the propositions above and on the detailed results of this paper, we suggest a new concept for collaboration in the context of supply chain resilience: *the capability of dealing with formal and informal integration factors to integrate the internal functions and the supply chain members, which may provide visibility, agility and adaptability towards supply chain resilience.*

This study contributes to the literature of supply chain resilience, mainly with regard to the explanation on how cross-functional integration may support supply chain resilience capabilities. Through empirical evidence from the supply chain studied, we may conclude that cross-functional integration is relevant to resilience in the supply chain. This conclusion is largely based on the analysis of Table 6, which indicates integration factors that contributed to resilience in the supply chain studied. The following paragraphs present three exploratory propositions supported by extant literature and by the results of this study. These propositions are preliminary statements about the studied theme, as they were built based on the study of a particular supply chain. Therefore, future studies can check their validity through several methods, such as surveys and multiple-case studies.

Although mentioned in previous research (e.g. Christopher & Peck, 2004; Braunscheidel and Suresh, 2009; Schoenherr and Swink, 2012; Pimenta *et al*., 2016), the link between cross-functional integration and supply chain resilience was only briefly discussed.

Through the results of this study, it is possible to empirically observe the necessity of internal integration for the existence of resilience. More than this, it was also possible to understand how integration is supposed to occur in terms of formal and informal integration factors.

These results complement the literature about supply chain resilience regarding the influence of cross-functional integration on the resilience capabilities. Specifically, this study describes how cross functional integration factors could generate specific capabilities and their respective impacts. So, the findings contribute to fill a gap in the resilience literature, in which main discussions were related to external integration instead internal integration. Due to the methodology applied, it was possible to clarify the influence of cross-functional integration factors in the chain, as the managers gave examples of their routine. Another contribution was discovering that integration factors collaborate to the presence of internal capabilities, such as internal agility and collaboration, which may be necessary to generate and maintain chain capabilities.

Resilience in supply chains has been largely studied in developed countries, however emerging countries constitute a significant part of supply chains (Tukamuhabwa *et al* 2017). This topic began to be discussed in the 2010s in Brazil, although the country's literature in this subject continues to lag. From a theoretical point of view, regional issues can shed light on specific types of disruptions, such as those found in this study. They differ from most cases abroad, which are mainly focused on acts of terrorism and natural disasters. Some Brazilian resilience research includes: Graeml and Peinado (2014), Pereira *et al*. (2014), and Sá *et al*. (2020). Among these and other papers from the international literature, studies that detail the role of cross-functional integration on resilience are scarce. Specific studies identified relationships between these two basic themes (Christopher and Peck, 2004; Schoenherr and Swink, 2012; Pereira *et al*., 2014). However, they did not reveal how internal integration and its respective mechanisms could be operationalized to build resilience.

In this sense, this study also sheds light on the causes (Christopher and Peck, 2004) of specific disruptions in emerging countries and how to either avoid or overcome them in order to maintain the desired performance of the supply chain (Blackhurst *et al*., 2011). Therefore, this study showed that supplier bankruptcy and delivery delays are disruptions that may generate other types of disruptions in the chain studied.

Moreover, we identified several integration factors that contribute to the development of agility in the supply chain: top management support, longevity of relationships and physical proximity. This relationship between cross-functional integration and agility in the supply chain had already been discussed by Braunscheidel and Suresh (2009), who state that external integration also helps in the development of this capability. However, the authors did not conduct a discussion on the subject with the same depth as this study, which analyzed operational details, revealing the importance of specific integration mechanisms to achieve greater resilience.

6. Conclusions, implications and further research

This study aimed to answer the following question: How can cross-functional integration processes be practiced in order to support resilience in the supply chain? The case studied revealed that cross-functional integration not only helps to generate capabilities in the supply chain, but may also create two organizational capabilities: internal agility and internal collaboration. This research sets out that internal agility is linked to how internal functions can quickly respond to problems that threaten the fulfillment of activities. It can be developed by the proximity between departments, the support of senior management in integration practices and the longevity of relationships, which increases the level of trust.

Collaboration may be defined as the capability of dealing with formal and informal integration factors to integrate the internal functions and the supply chain members, which

may provide visibility, agility and adaptability towards supply chain resilience. In this paper, collaboration is positioned as the central capability that may represent a point of contact between cross-functional integration and supply chain resilience.

Regarding internal collaboration, initially we adopted the definition addressed in the literature about cross-functional integration. Such a definition is related to formal and informal practices that generate cooperation across internal functions (Kahn, 1996) in order to solve problems that impact the organization and thus the supply chain. Internal collaboration is facilitated by multiple integration factors, among which are: willingness to work together to resolve conflicts, consideration of informal working groups, information sharing, longevity of relationships, recognition of functional interdependence, cross-functional education and training, a mutual evaluation and rewards system, and cross-functional teams.

This research also addresses several implications for practitioners. Managers should pay attention to the 'cross-functional teams' factor, which provides greater control of the process due to various functions working together (Murphy and Poist, 1996; Ellinger *et al*., 2000; Pagell, 2004; Kahn, 2009; Flynn *et al*., 2010). Moreover, this factor generates internal collaboration and hence collaboration in the supply chain. Finally, it was possible to identify that the 2015 financial crisis indirectly affected several of the organizations studied, as many suppliers went bankrupt. From this, it is recommended that organizations analyze the financial health of their stakeholders, thus potentially preventing the abrupt disruption of supplies.

The study has some limitations related to methodological aspects. The analysis was based on an exploratory research study using data collected from interviews with managers and documents provided by the participating organizations. Future research should examine the relationship between cross-functional integration and organizational resilience through a multiple-case study, including more respondents in each organization and using quantitative support to assess the level of cross-functional integration in organizations (see Ferreira *et al*.,

2019). Future research could also provide a more thorough analysis of specific processes in supply chains (e.g. product development and demand planning) in order to discover points of disruption where activities usually fail and identify adequate integration factors to overcome them.

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Figure 1 - Interface between cross-functional integration and resilience in the supply chain

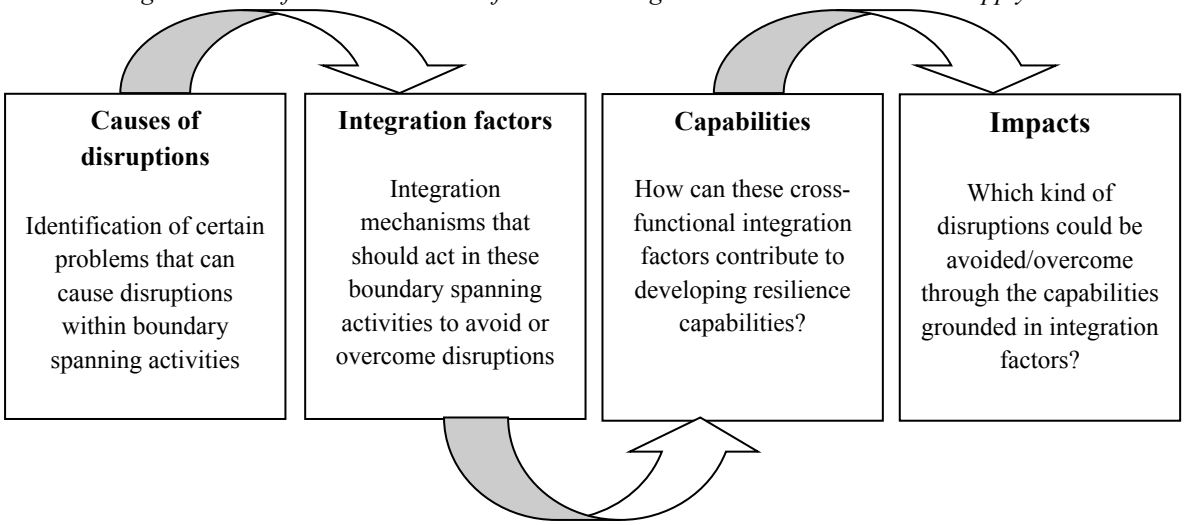

Figure 2 - Diagram for the analysis of the corpus

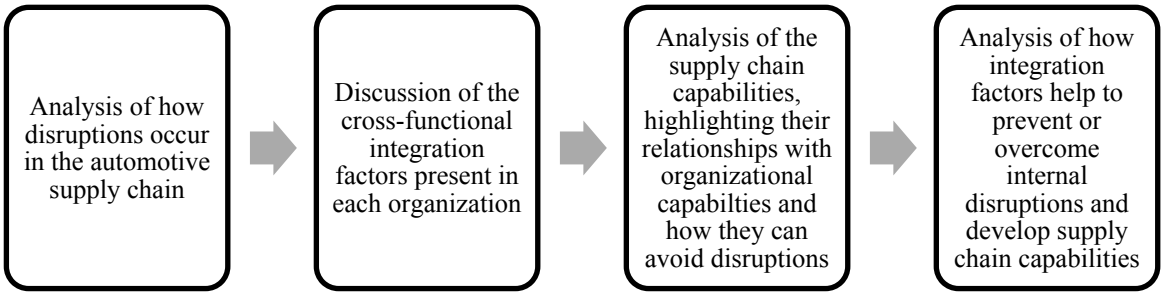

Figure 3 - The relationship between integration factors, capabilities and disruptions in the supply chain studied

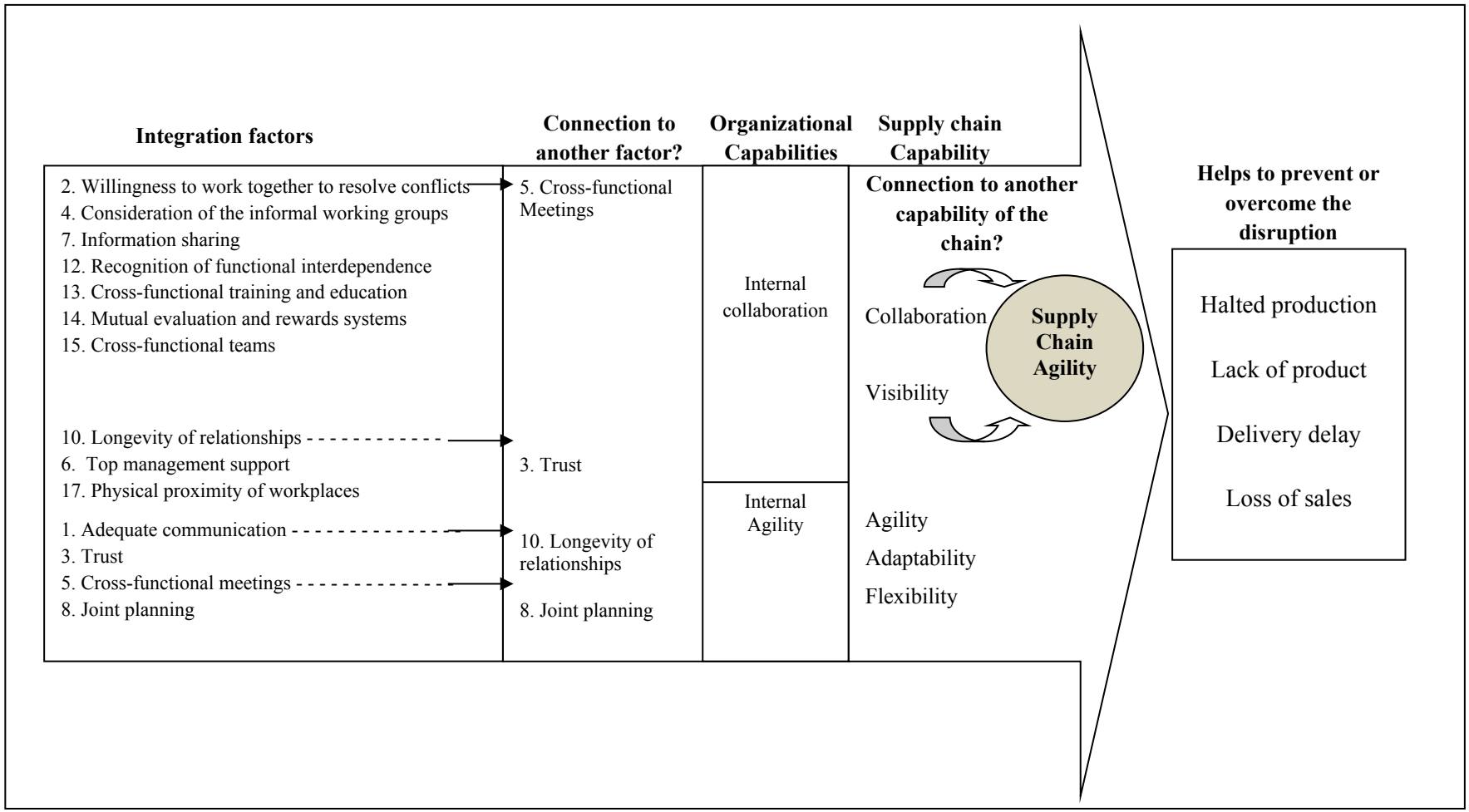

Table 1 - Capabilities for supply chain resilience

Capability	**Definition**	**Authors**
Redundancy	Using safety stock to maintain the capacity to respond to any disruption in the supply chain	Rice Jr. and Caniato (2003); Sheffi and Rice Jr. (2005); Soni et al. (2015); Ali et al. (2017); Adobor and McMullen (2018)
Flexibility	The creation of capabilities to perceive and respond to the threat of disruption. It represents investments in people's skills and infrastructure, a production system that accommodates multiple products, and flexibility in sourcing and in order-fulfillment	Rice Jr. and Caniato (2003); Christopher and Peck (2004); Ali Mahfouz and Arisha (2017), Adobor and McMullen (2018)
Visibility	Knowledge about the availability of the operating assets, coordination mechanisms, risks and chain environment	Chopra and Sodhi (2004); Christopher and Peck (2004); Pettit et al. (2010); Jüttner and Maklan (2011); Adobor and McMullen (2018)
Agility	The ability to quickly respond to market changes, and potential and actual interruptions	Kendra and Wachtendorf (2003); Christopher and Peck (2004); Jüttner and Maklan (2011); Ali Mahfouz and Arisha (2017)
Adaptability	The ability of the organization to make changes in their operations to address challenges or seize opportunities	Fiksel (2003); Pettit et al (2010)
Collaboration	Collaborative forecasting, relationship management with customers, and internal and external communication. There is a close link between this capability and the literature on cross-functional integration in relation to formal and informal mechanisms	Rice Jr. and Caniato (2003); Christopher and Peck (2004); Pettit et al. (2010); Jüttner and Maklan (2011); Pettit et al. (2013); Scholten and Schilder (2015); Ali Mahfouz and Arisha (2017); Scholten et al. (2019)

Table 2 - Integration Factors

Integrating factor	Authors
1. Adequate communication	Poist and Murphy (1996); Pagell (2004); Ferreira et al. (2019)
2. Willingness to work together to resolve conflicts	Murphy and Poist (1996)
3. Trust	Ellinger, Keller and Hansen (2006); Dawes and Massey (2006)
4. Consideration of informal working groups	Kahn (1996); Ellinger, Daugherty and Keller (2000)
5. Cross-functional meetings	Poist and Murphy (1996); Flynn, Huo and Zhao (2010)
6. Top management support	Poist and Murphy (1996); Pagell (2004)
7. Information sharing	Pagell (2004); Flynn, Huo and Zhao (2010)
8. Joint planning	Poist and Murphy (1996); Ellinger, Daugherty and Keller (2000); Seno et al. (2019)
9. Mutual understanding of each other's activities	Kahn (1996); Murphy and Poist (1996)
10. Longevity of relationships	Kraiselburd and Watson (2007)
11. Non-conflicting goals	Kahn (1996); Ellinger, Daugherty and Keller (2000)
12. Interdependence recognition	Dawes and Massey (2006)
13. Cross-functional education and training	Poist and Murphy (1996); Ellinger, Keller and Hansen (2006)
14. Mutual evaluation and rewards systems	Poist and Murphy (1996); Pagell (2004)
15. Cross-functional teams	Poist and Murphy (1996); Flynn, Huo and Zhao (2010); Jugend et al. (2018);
16. Congruence of functional goals with strategy	Kraiselburd and Watson (2007)
17. Physical proximity of workplaces	Pagell (2004)
18. Group spirit	Murphy and Poist (1996), Pimenta et al. (2016)

Table 3 - Profile of Respondents

No.	Organization	Function / Area	Hierarchical level
1	Supplier 1 (Steel)	Sales	Manager
2	Supplier 2 (Springs)	Sales	Analyst
3	Supplier 2 (Springs)	Production Planning and Control	Analyst
4	Supplier 2 (Springs)	Purchasing	Manager
5	Focal company (Bearings and clutches manufacturer)	Supply chain	Manager
6	Focal company (Bearings and clutches manufacturer)	Logistics	Manager
7	Focal company (Bearings and clutches manufacturer)	Purchasing	Manager
8	Focal company (Bearings and clutches manufacturer)	Sales	Manager
9	Focal company (Bearings and clutches manufacturer)	Supply chain	Supervisor
10	Focal company (Bearings and clutches manufacturer)	Sales	Supervisor
11	Focal company (Bearings and clutches manufacturer)	Purchasing	Supervisor
12	Focal company (Bearings and clutches manufacturer)	Sales	Analyst
13	Customer 1 (car assembler)	Purchasing	Supervisor
14	Customer 2 (car assembler)	Engineering	Supervisor
15	Customer 3 (car assembler)	Production Planning and Control	Supervisor
16	Customer 3 (car assembler)	Sales	Manager
17	Customer 3 (car assembler)	Internal Logistics	Supervisor
18	Customer 3 (car assembler)	Product Engineering	Manager

Table 4 – Causes of disruptions in the case studied

		Disruptions				
Disruption Points	**Causes**	**Halted production**	**Lack of product**	**Late deliveries**	**Supplier bankruptcy**	**Loss of Sales**
Organizations	Broken equipment			2		
	Inefficient internal communication	1	1	1		
	Lack of knowledge about integration		1			
	Inefficient production scheduling		1	1		1
Supply chain	Transportation	1		3		
	Inefficient external communication		1			
	Demand fluctuations	1	2	6		3
	No answered orders	1	2	3		
Environment	Blackout		1	3		
	Financial crisis		3	3	6	1
	Strikes	1		3		
	Natural disasters	1				

Table 5 - Characteristics of the study's resilience capabilities chain

Capability	Characteristics	This capability also generates	Interviewees
Redundancy	Existence of safety stock. Low incidence of this capability due to the dynamics of the sector and the high costs	Agility	Focal Company Sales Manager, Customer 1 Purchasing Supervisor, Customer 3 Product Engineering Manager, Customer 3 Sales Manager.
Flexibility	In case of demand fluctuations, organizations tend to adapt the capacity to the market. There is flexibility of supply and order fulfillment when the exchange of transport or supplier is required. Air transport can be used in cases of priority to meet deadlines or to avoid disruptions, despite the higher costs.		Product Engineering Manager, Supplier 1 Sales Manager, Focal Company Supply Chain Manager, Focal Company Logistics Manager.
Visibility	Knowledge of production capacity, logistics capabilities, information sharing, and supply and demand visibility. Dependent on collaboration between chain entities to generate shared vision.	Agility (through collaboration)	Supplier 2 PPC Analyst, Supplier 2 Engineering Manager, Focal Company Logistics Manager, Supplier 2 Sales Analyst, Focal Company Purchasing Manager, Customer 1 Purchasing Supervisor.
Agility	There are problems that can be quickly solved in the chain; others not so much. Demand fluctuations may cause: halted production, delivery delays and sales loss. It is a capability that depends on transportation and supplier flexibility. The redundancy also helps to generate this capability, but to a lesser extent, due to the high costs. Finally, agility depends on the internal collaboration between the departments of each company in the chain.		Focal Company Purchasing Manager, Focal Company Sales Manager, Focal Company Sales Supervisor, Focal Company Purchasing Supervisor Focal Company Logistics Manager, Customer 3 PPC Supervisor, Customer 3 Product Engineering Manager
Adaptability	This capability is related to operational changes in the internal processes, and in the way the company handles raw materials, machinery, and learning and change processes.		Focal Company Supply Chain Manager, Focal Company Logistics Manager, Focal Company Sales Analyst, Focal Company Sales Supervisor, Customer 1 Purchasing Supervisor.
Collaboration	This capability is well developed in the supply chain studied, considering both the internal collaboration between the functions of each organization and the external collaboration between the companies.	Visibility Adaptability Agility	Supplier 2 Purchasing Manager, Focal Company Logistics Manager, Focal Company Purchasing Manager, Focal Company Purchasing Supervisor.

Table 6 - Integration factors such as resilience generation

Integration factor	Operationalization	Related Capabilities	Interviewees
Adequate communication	It is a way to discuss ideas across functions, regardless of the hierarchical level. There is the possibility of ideas being implemented by a manager.	**Adaptability in the company**	Focal Company Sales Manager, Customer 3 Product Engineering Manager
	It is useless when internal functions communicate quickly and clearly but do not work together on time.	**Agility in the chain**	Supplier 2 Purchasing Manager, Focal Company Logistics Manager, Focal Company Supply Chain Manager, Focal Company Sales Analyst, Customer 1 Purchasing Supervisor.
Longevity of relationships	When people are fully aware in advance, communication between them is easier and more informal, which streamlines processes. This facilitates working together, understanding and mutual respect between functions.	**Agility in the company** **Collaboration in the company**	Focal Company Logistics Manager, Focal Company Supply Chain Manager, Focal Company Sales Analyst, Focal Company Supply Chain Supervisor, Focal Company Sales Manager, Focal Company Purchasing Supervisor, Supplier 2 Sales Analyst, Customer 2 Engineering Supervisor, Customer 3 Internal Logistics Supervisor.
Willingness to work together to resolve conflicts	This occurs in cross-functional meetings, in which the subject is approached and negotiations are made to arrive at a conclusion favoring the supply chain and avoiding disruptions	**Agility in the chain**	Focal Company Purchasing Manager, Focal Company Sales Analyst, Customer 3 Sales Manager.
Trust	When there is trust among internal functions, activities flow better, bringing agility in communication. This helps to avoid time wastage and rework functions.	**Agility in the company**	Focal Company Sales Manager, Focal Company Purchasing Supervisor, Focal Company Logistics Manager, Supplier 2 PPC Analyst.
Consideration of the informal working groups	Managers recognize and stimulate informal workgroups where spontaneous collaboration emerges. It improves the flow of information and inhibits conflicts between the functions. People from different areas seek to work together and help each other. This internal collaboration generates agility in the supply chain.	**Collaboration in the company** **Agility in the chain**	Supplier 2 PPC Analyst, Focal Company Supply Chain Manager, Customer 2 Engineering Supervisor.
Cross-functional meetings	In meetings, the functions share knowledge, increasing the visibility of problems that impact the chain. In addition, they are an opportunity to propose quick solutions to what is pending, thus generating agility.	**Visibility in the chain** **Agility in the chain**	Supplier 2 Sales Analyst, Focal Company Supply Chain Manager, Customer 3 Sales Manager, Focal Company Purchasing Supervisor, Focal Company Sales Analyst, Focal Company Supply Chain Supervisor.
Top management support	There is the delegation of authority, so people can make decisions that fit their function without being questioned by other functions, for example, about a change of transportation model or a change in product packaging.	**Flexibility in the chain** **Agility in the chain**	Focal Company Logistics Manager, Focal Company Supply Chain Supervisor. Customer 2 Engineering Supervisor, Focal Company Sales Manager, Customer 2 Engineering Supervisor,

Integration factor	Operationalization	Related Capabilities	Interviewees
			Customer 3 PPC Supervisor.
Information Sharing	The information provided by external organizations from the chain should be shared internally to align functions' decisions.	**Visibility in the supply chain**	Focal Company Supply Chain Supervisor, Focal Company Purchasing Manager.
Joint planning	The information about demand is supplied by customers, and should be analyzed by several internal functions to improve the accuracy of sales and capacity planning.	**Visibility in the supply chain**	Focal Company Supply Chain Manager, Focal Company Purchasing Manager, Customer 3 PPC Supervisor.
Recognition of the functional interdependence	This consists of the visibility of the role of each function within the processes. It quickens communication, introducing agility into the process of solving problems affecting the supply chain	**Visibility in the company Agility in the chain**	Focal Company Supply Chain Manager, Focal Company Sales Analyst, Focal Company Supply Chain Supervisor.
Cross-functional training	Cross-functional training practices that aim to align thinking and disseminate knowledge about customers and suppliers among various internal functions.	**Collaboration in the company and in the chain**	Focal Company Purchasing Manager, Customer 2 Engineering Supervisor,
Cross-functional teams	The formal and joint work from the cross-functional teams allows its members to understand how the other functions develop their activities. This understanding facilitates the functions to better assist each other. Such arrangement improves the flow of information in the chain.	**Collaboration in the company and in the supply chain**	Supplier 1 Sales Manager, Customer 1 Purchasing Supervisor, Focal Company Purchasing Manager.
Physical proximity of workplaces	The proximity leads the functions to come into contact with each other more quickly. The communication received from suppliers and customers is discussed between the functions quickly, often generating up to date information.	**Agility in the supply chain**	Focal Company Sales Manager.