New Frontiers in
Supply Chain Management

Judy Dickens

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Edited by
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THE "INDY WAY": LESSONS FROM BRAZILIAN SUGAR-CANE BIOFUEL SUPPLY CHAIN

ABSTRACT

This paper explores how the Brazilian sugar-energetic processors used Indycar rac-ing to increase exports to the United States and create value by transforming the Brazilian ethanol from a commodity fuel to an advanced biofuel, between 2009 to 2012. This case study uses the relationship between Brazilian Sugar-cane Industry Association (UNICA), Brazilian Trade and Investment Promotion Agency (APEX-Bra-zil), and the IndyCar Racing League (IRL), to show the ability to learn and perform in a competitive scenario. Absorptive Capacity (ACAP) theory is used to understand how the Brazilian sugar-energetic processors identified, assimilated, transformed, and exploited knowledge from this relationship, as well as how this experience could be used in other industries. As a trading result, Brazilian biofuel exports to the United States increased 758.22% during the studied period and the Volumetric Ethanol Excise Tax Credit (VEETC), an American tax act in vigor since the 1970's, was extinguished at the end of 2011. The main contribution of this study: Identify how the Absorptive Capacity Theory can explain such impacts in the Brazilian Biofuel exports through the relationship between partners in the U.S. and Brazil.

KEYWORDS | Absorptive capacity, Indy car racing, Brazilian ethanol biofuel, case study, sugar-cane biofuel.

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INTRODUCTION

> All that we don't know is astonishing. Even more astonishing is what passes for knowing.
> - Philip Roth

Many firms seek international markets as an alternative for value creation in its supply chain networks and global value chains (Chiarvesio & Di Maria, 2009; Gereffi, Humphrey, & Sturgeon, 2005). Not just firms, but entire countries had based the development of their economies in the internationalization as a source of its competitive advantage (Gereffi & Lee, 2012)). Increasing expaorts was accepted as one of the earliest processes for a firm seeking internationalization as part of its long-term strategy (Guillouzo & Ruffio, 2005). Paiva and Vieira (2009) argues that internationalization as an operations strategy is the most significant challenge for the Brazilian industries.

Different arguments explain why Brazil did not break through this barrier. Including logistics, infrastructure obsolescence, and challenges in the governance mechanisms (Bittencourt, Fontes, & Campos, 2012; Gereffi et al., 2005; Humphrey & Schmitz, 2001; Paiva & Vieira, 2011). Thus, evidences have indicated that managers from different industries in Brazil have tried to internationalize its operations. However, there is lack understanding how accurately manage operations and also understand the best way to do business with that specific target market.

The relationship between UNICA, APEX-Brazil and IndyCar Racing League (IRL) in the U.S. through an official sponsorship agreement, made Brazil the exclusive fuel supplier for racing teams between the years 2009 to 2012. During this period all racing teams used, in 16 of 17 races including the Indianapolis 500, Brazilian sugarcane biofuel was the only supplier. More than US$ 40 million dollars was invested in this relationship. UNICA spend more than US$ 500,000 dollars to lobby for the end of VEETC ethanol tariffs, as well as various other ethanol amendments in the U.S. Senate (Schroeder, 2011).

The primary idea to APEX-Brazil was to use the Indy 500 Race as a showcase, learn how to do business with the U.S. and introduce Brazilian biofuel to the world. Also, increase Brazilian ethanol exports and other products to the U.S. Considering this scenario, the present study proposes the following research question: How being an Indy Car supplier impact the company's ability to learn and perform on in an competitive scenario?

ACAP was selected as a theoretical construct to understand how the Brazilian biofuel companies absorbed, assimilated, and applied knowledge from this relationship. Also contributes to enlighten us how to generate new business, improve and even exploit their own operational and financial performance. This knowledge can be applied to other productive sectors, whether in the sucro-energetic supply chain or other production chains.

This case study has as the unit of analysis the relationship formed by UNICA, APEX-Brazil, and IndyCar between 2009 and 2012. UNICA is a representative association of sugar, biofuel, and energy mill processors in the Southeast region of Brazil. APEX-Brazil is a government agency that promotes Brazilian products and services, while aims to attract foreign investors to the country. IndyCar is the body responsible for managing the Indianapolis 500, also known as the Indy 500. Indy 500, with more than 100 years of existence, is considered the most magnificent racecar spectacle in the world, with about 300,000 people attending race-day and millions of dollars in prizes for the winners.

Data collection used primary and secondary data. The primary sources were participant observations and interviews. Participant observations occurred between 2008 and 2012 when two of the researchers had different opportunities to reach participants in the investigated case. Examples of these observations include three site visits on sugar-cane mills in Brazil, participation in 25 IndyCar Races all over the U.S. Interviews were conducted to guarantee reliability and avoid bias. Twelve interviews were conducted with different representatives of this case between April 2016 and July 2017. As secondary sources of data, historical archives were considered to analyze the evolution of Brazilian ethanol exports during the period. Also, 121 newsletters from UNICA between 2009 and 2013 were investigated. Interviews were recorded and transcribed. When two or more of the researchers were present during the interview, one of them was responsible for taking notes. Data analysis was performed independently and then discussed afterward by all the researchers.

The paper is structured in the following way: first, we provide a brief literature review with particular emphasis in ACAP. Then, we present the methodology based on qualitative approach followed by results

presentation of the actors pertaining the case study selected, with focus on different phases of ACAP and analysis section. At last, we discuss the consequences of ACAP in the context of the supply chain and period studied, and provide final considerations with theoretical and practical implications.

RESEARCH BACKGROUND

The concept of ACAP originated in macroeconomics, where it refers to the ability of an economy to utilize and absorb external information and resources (Adler, 1965; Tu, Vonderembse, & Ragu-Nathan, 2006). In the organizational management, the origins of ACAP are found in organizational learning literature of the 1980s, when researchers first started to explain the process through which firms learn, develop, and assimilate new knowledge for competitive advantage (Revilla, Sáenz, & Knoppen, 2013). The ACAP construct was defined as the ability to recognize the value of new, external information (knowledge), assimilate it, and apply it to commercial ends (Cohen & Levinthal, 1989, 1990).

R&D investments could create Firm's absorptive capacity according to seminal model, operations management, and direct investments and they intended to comprehend the impact of learning environment characteristics in R&D costs. In this sense, R&D is responsible for generate new knowledge and contribute to firm`s ACAP (Oliveira, Vasconcelos Neto, & Malachias, 2014), and this process could be pointed as a specific-asset.

The ACAP concept has been expanded over the last three decades. Zahra and George (2002) identified the key dimensions offering a reconceptualization of the construct proposed by Cohen and Levinthal (1990), introduced as a specific-asset to an organization's capability (or set of capabilities) required to manage knowledge with an objective of value creation.

Roberts, Galluch, Dinger, and Grover (2012) highlighted that is necessary to note the difference between these views (Cohen & Levinthal, 1990; Zahra & George, 2002) of conceptualizing as a specific-asset or as a capability or a set of capabilities. An asset is defined as anything tangible or intangible that a firm owns, controls, or has access to on a semi-permanent basis (Helfat & Peteraf, 2003). When viewed as an asset, ACAP is conceptualized as the level of relevant prior knowledge possessed by the focal firm(Roberts, Galluch, Dinger, & Grover, 2012).

As a capability, absorptive capacity considers the routines and processes that firms use to identify, assimilate, transform, and apply external knowledge. Roberts et al. (2012) recommended that researchers conceptualize as a capability rather than an asset. They affirm that researchers who wish to investigate only the level of prior related knowledge should be clear that they are not examining ACAP. Furthermore, the concept is a multidimensional construct with several interrelated capabilities (e.g., knowledge identification, assimilation, and application). As so, it could not be understood only as an asset. ACAP should be empirically investigated using metrics that fully capture each of its dimension and considering as a collective construct (Roberts et al., 2012).

The proposed dimensions for ACAP after Zahra and George (2002) reconceptualization as a capability (or a set of capabilities) were an acquisition, assimilation, transformation, and exploitation. Acquisition refers to the firm's capability for identifying and acquiring knowledge (Zahra & George, 2002). Assimilation relates to how the company understands and uses the new knowledge on its processes and routines (Szulanski, 1996). Transformation refers to the development and refinement of methods, combining existing knowledge with the acquired and assimilated knowledge (Zahra & George, 2002), and finally exploitation refers to the organizational ability to expand its capacity based on and process it improved with the new knowledge eventually generating operations and or operational performance (Cohen & Levinthal, 1990).

According to Roberts et al. (2012) there is more significant agreement in conceptualizing ACAP as a capability, there are several measurement problems: (1) researchers often define ACAP as a capability, yet operationalize it as an asset; (2) researchers have attempted to adapt measures of organizational ACAP to the individual level; and (3) researchers often do not use established measures of ACAP in a similar context.

Measurement problems also arise regarding field domains. For example, a firm may have high ACAP in new product development yet have low ACAP in supply chain operations (Roberts et al., 2012). In this sense, where possible, researchers should avoid general measures of ACAP and attempt to specific knowledge domains.

Research on ACAP had taken place in the context of R&D or innovation activities (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998) and kept this atten

tion (Volberda, Foss, & Lyles, 2010). However, has been applied in a diverse range of research streams, such as knowledge management (Alavi & Leidner, 2001) and information systems (IS) (Fichman & Kemerer, 1997; Roberts et al., 2012).

Yet, despite a critical mass of research that draws upon ACAP, there has been few studies focused on Operations Management (OM) (Tu et al., 2006), in the specific context of buyer-supplier relationships (Dobrzykowski, Leuschner, Hong, & Roh, 2015; Rebolledo, Halley, & Nagati, 2009; Revilla et al., 2013; Sáenz, Revilla, & Knoppen, 2014), or supply chain management research (Azadegan, 2011; Meinlschmidt, Foerstl, & Kirchoff, 2016; Oliveira et al., 2014).

A large majority of IS research investigates ACAP at the firm level (64 papers, or 65 percent of all studies) (Roberts et al., 2012). Only 35 percent of the firm-level studies conceptualize ACAP as a capability. Roberts et al. (2012) identified just two studies of ACAP at the group level (Pavlou & El Sawy, 2006; Tiwana & McLean, 2005) and relatively few studies (seven papers, or less than eight percent) that investigate ACAP at the inter-organizational level.

Comparing IS research's literature review with OM literature review from a narrow perspective, a major part of articles on OM chose the capability point of view, avoiding measurement problems highlighted by seen the ACAP only as an asset (Roberts et al., 2012). One reason to explain these multiple capabilities for analysis is that researchers have invoked different theories and perspectives in studying ACAP, such as organizational learning, industrial economics, and the resource-based and dynamic capabilities perspectives (Zahra & George, 2002). The emergence of the ACAP constructs coincided with the development of the resource-based view of the firm (RBV) and its offshoot the knowledge-based view of the firm (Lane, Koka, & Pathak, 2002).

Zahra and George (2002) suggest that ACAP has two general states: potential and realized. Potential ACAP makes the firm receptive to acquire and assimilate external knowledge developed elsewhere and is related to firm's ability to recognize and assimilate knowledge from a specific collaboration, such as routines promoting social interactions and inter-organizational knowledge bases (Dyer & Singh, 1998).

While the realized ACAP centers on converting, exploiting the same knowledge, and is linked to the possession of prior related knowledge, communication mechanisms, and governance mechanisms (Cohen & Levinthal, 1990; Zahra & George, 2002). In this sense, ACAP could be seen from two general perspectives: as an "ability" to absorb knowledge or as a "stock" of prior related knowledge (Roberts et al., 2012).

ACAP capacity depends on prior related knowledge because, without some previous relevant knowledge, a firm will not be able to determine the potential value of external knowledge accurately. It is also important to note that an organization's ACAP depends on its individuals. As such, a firm's ACAP is formed from an overlap in individual members' knowledge structures. These overlaps imply that ACAP is firm-specific and therefore cannot be bought and quickly integrated into the firm (Roberts et al., 2012).

Finally, ACAP is path-dependent. Accumulating absorptive capacity in one period will permit its more efficient accumulation in the next (Roberts et al., 2012). These two features of ACAP - cumulativeness and its effect on expectation formation - imply that its development is path-dependent

Figure 1: Absorptive Capacity, Prior Related Knowledge, and Outcomes
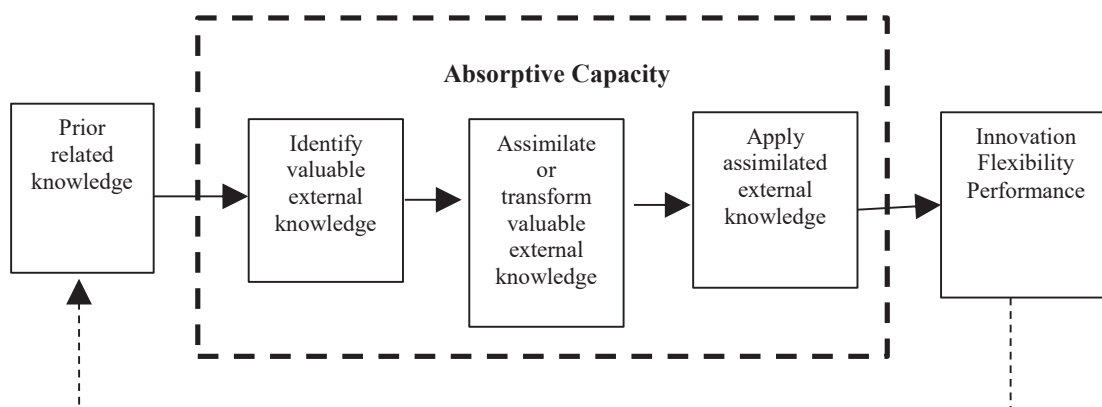
METHODS

This study starts from an inductive approach, and it was not intended to generate hypotheses, but to explain a phenomenon in-depth (Yin, 2013). It begins with a theoretical sample that allows understanding the capabilities applied to a single case study based on sugar energetic supply chain for ethanol biofuel. There is a growing number of empirical studies in OM centered on the use of qualitative research techniques through the case study method (Yin, 2013) to provide initial information to generate better constructs (Eisenhardt, 1989; Eisenhardt & Graebner, 2007) such as problem definition and construct validation, are similar to hypothesis-testing research. Others, such as within-case analysis and replication logic, are unique to the inductive, case-oriented process. Overall, the process described here is highly iterative and tightly linked to data. This research approach is especially appropriate in new topic areas. The resultant theory is often novel, testable, and empirically valid. Finally, framebreaking insights, the tests of good theory (e.g., parsimony, logical coherence.

This research follows this approach through a case study because it understands that when the interest of research is to study in a contextualized and in-depth a unique phenomenon in organizations. Instead of using techniques of quantification and measurement of variables, the case study is recommended (Eisenhardt, 1989; Miles, Huberman, & Saldaňa, 2014; Yin, 2013). According to Yin (2013), three important situations are necessary to determine the research method, in which any study fits, which is: (1) form of the research question, (2) required control of behavioral events and (3) focuses on contemporary events. Thus, case study design is the appropriate method to conduct this research, to answer the question: How being an Indy Car supplier impact the company's ability to learn and perform on in an competitive scenario? The unit of analysis is the relationship formed by UNICA, APEX-Brazil,

and IndyCar between 2009 and 2012. Figure 3 represents how the supply chain is organized with the main members that act in the commercial use of biofuel for purposes of this study. The illustration considers that the Brazilian biofuel producers follow a supply chain similar to that described by (Neves, Waack, & Marino, 1998). Thus, for simplifying effect, it does reproduce it again.

The case presented, the agreement between UNICA, representing sugar mill processors, Apex-Brazil and IRL to make the Brazilian sugarcane the sole fuel supplier for the Indy Car Races between 2009 and 2012. Represented a unique event and opportunity to better understand the relationship between organizations from different countries. Responsible for research, developed, and commercialized new biofuel technology. That directly impacted in the learning capabilities and supply chain performance (include exports performance).

This case study was selected to collect evidence from a recent period between 2009 and 2012, the period that maintained the relationship between the IRL (U.S.) and UNICA and APEX (Brazil). Thus, the empirical context used was the Formula Indy car racing. There is no need to carry out any control of the behavior of the events, and we are in search of answers of how the facts influenced the results of the firms involved.

This study relies on qualitative analysis of data obtained from multiple sources. Part of the evidence was obtained by action participation research in the sense that one researcher had actively participated in exploring knowledge and creating value to develop new projects for Brazilian products, in this case, biofuel from sugar energetic industry. Another researcher could be made site visits on three biofuel sugar mills, and also on UNICA office in São Paulo. A protocol guideline was built, discussed and pre-tested by specialists before fieldwork. Protocol research questions are presented in Exhibit 1.

Exhibit 1: Research protocol guidelines

Research Question	Possible Data or Evidence to Support Discussion	Specific Study Research Questions	Protocol Questions
Why and how being an Indycar provider impacts on the company's performance?	∀Interview quotations ∀Secondary data ∀Site visits ∀Observations	1. Which factors led your company to become an Indycar Supplier?	1. Please tell me about your company. 2. Could you tell me about your partnership with Indycar? 3. How long your company is an Indycar Supplier? 4. Was a planned decision or an opportunity that arose for your company became a Indicar supplier? 5. How did you choose the products that would be part of this partnership?
		2. How is the company prepared to take advantage of this partnership?	6. Let's talk about how your company prepared for this partnership: 　a. Does company has / or is required to have a system or some quality certification? 　b. During the partnership your company had to hire other employees? Or used the current team. 　c. Do you use any internal policy to manage this partnership? 　d. Does company knows how to use the data produced in this partnership? 　e. Did you keep the same suppliers? Did you change suppliers? 　f. How this partnership contributed to your company? Give some objective examples.
		3. How do this partnership influence the company performance? (both operational and financial?)	7. Let's talk about which improvements comes from this partnership: 　a. Can you evaluate results in the industrial process of this partnership? Give some examples. 　b. Was there any impact on operational performance (quality, flexibility, delivery and cost)? And about financial costs? Any other impact? 　c. How do you consider the partnership with Indycar have influenced your company on the last couple years? What and how has influenced it? 　d. Were there sales increasing as a result of this partnership? 　e. There was some marketing gain for your company during the partnership? Explain how and why. 　f. Is there anything you think that should have been done differently?

These actions improve research reliability because researchers were aligned to use specific questions and terminologies, avoiding probably bias and helping analysis.

This role has given us access to valuable empirical data for scientific analysis. Several sources of information were collected and analyzed to describe the case with substantive issues connected to our theoretical lens: financial data; historical archive analysis, public use files (Brazilian and United States export statistics), secondary data, participant observation in 25 races (2009-2012), outside observation (2008-2015), 12 interviews (2016-2017); newsletters from sugarcane industry association during 2009-2013 (54.698 words compiled in 121 newsletters); information accumulated during field notes in site visits (six times between 2013-2014). Performance data about racing teams were used covering IndyCar races during the years from 2009 to 2013.

RESULTS PRESENTATION

For the biofuel supply chain, the main uses are related to the consumption of anhydrous alcohol, in addition to the hydrated fuel industry for the chemical industry, and neutral, for the food, cosmetics and pharmaceutical chemical industry (Neves et al., 1998). Neves et al. (1998) present the detailed mapping on the agro-industrial system of sugarcane according to figure 2 considering the three types of configurations for sales and operations planning (S&OP).

Figure 2: Agroindustry System in Brazil for Sugarcane
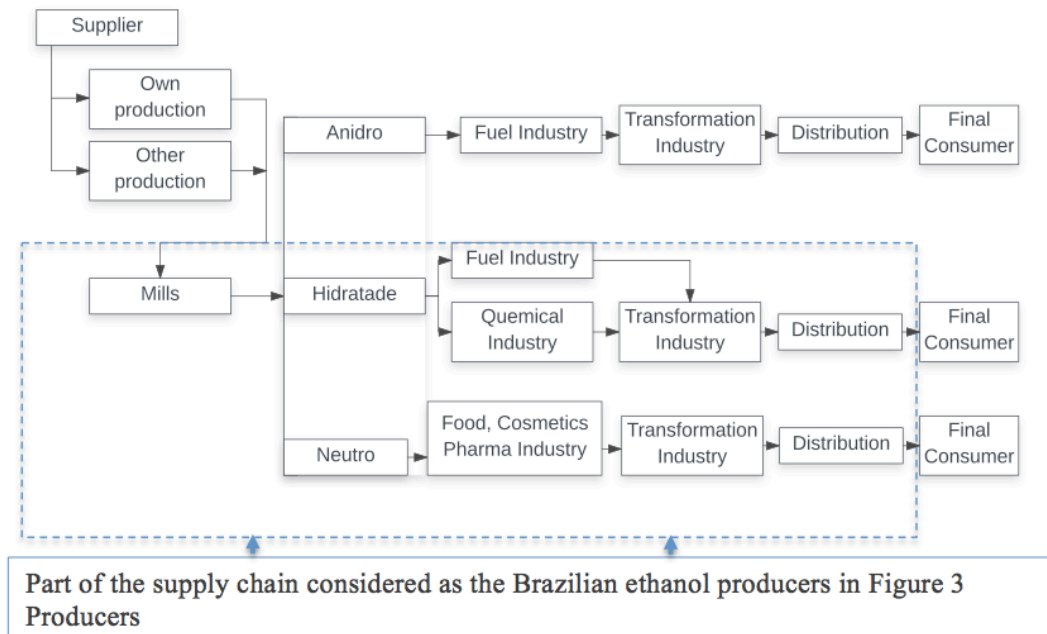
Source: Neves et al. (1998)

Brazilian Biofuel and IndyCar Supply Chain Case Main Actors

The Brazilian Sugarcane Industry Association (UNICA)

The Brazilian Sugarcane Industry Association (UNICA) is the organization in Brazil representing sugar, ethanol and bioelectricity producers. It was created in 1997, following a consolidation process involving regional agencies in the State of São Paulo after government deregulation of the sugar and ethanol sectors. UNICA members answer for more than 50% of all ethanol produced in Brazil and 60% of overall sugar production. As part of its mission, UNICA seeks to play a leading role in "consolidation of the Brazilian sugarcane industry as a modern agroindustry complex equipped to compete sustainably, in Brazil and around the world, as suppliers of ethanol, sugar, and bioelectricity" (UNICA,

2017). UNICA is very politically active with international presence, in Washington and Brussels, to engage in constructive dialogue about the use of fuels from renewable sources.

The Brazilian Trade and Investment Promotion Agency (APEX-BRAZIL)

APEX-Brazil works to promote Brazilian products and services abroad, and to attract foreign investment to strategic sectors of the Brazilian economy. Apex-Brazil organizes several initiatives aiming to promote Brazilian exports abroad. The Agency´s efforts comprise trade and prospective missions, business rounds, support for the participation of Brazilian companies in major international trade fairs. Also, the agency arranges technical visits of foreign buyers and opinion makers to learn about the productive Brazilian structure, and other select activi-

ties designed to strengthen the country's branding abroad (Lewandowski, 2012).

### *IndyCar Racing League (IRL)*

IRL is an American-based auto racing sanctioning body for championship auto racing. The organization sanctions four racing series: the premier IndyCar Series (often abbreviated ICS) with its centerpiece Indianapolis 500, and developmental series Indy Lights, the Pro Mazda Championship and the U.S. F2000 National Championship, which is all a part of The Road to Indy. IndyCar is also known to be inno-

vative. In 1964, it introduced the methanol fuel, and in 2006 it started to use a blend of 90% of Ethanol and 10% methanol. By 2007, the league announced that all Indy cars would race the entire season using 100% of ethanol (Clarke, 2007).

Brazilian sugar-cane biofuel providers

UNICA had to organize more than 110 Ethanol producers in Brazil to become the official biofuel supplier for the IRL. Together this companies represents around 60% of all ethanol and sugar production in Brazil.

Figure 3: Investigated Case
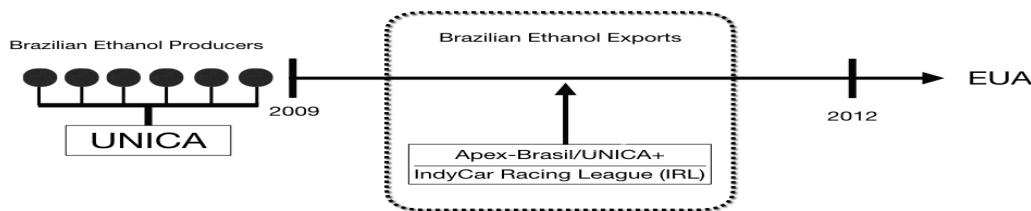
Note that in this representation, the sugar mill processors are at the same time connected to UNICA, in Brazil, and to the biofuel distributor, in the United States. Inside the square, represent the unit of analysis, that connects the links: UNICA, APEX-Brazil, and IRL. Without this connection, there would be no agreement, and per consequence, no physical movement of goods would be needed. Once the agreement is established, the biofuel then follows its physical, logistical path to go from the producers up to the be able to fill the IRL race tracks in the U.S.

ANALYSIS

The categories of analysis from the ACAP originated after the literature review were the acquisition, assimilation, transformation, and exploitation. Analysis started by interviews with the main actors within the Brazilian part of the supply chain. In this process, began codified the transcriptions texts from interviews records and other gathered sources (newsletters, observations, secondary data, etc.).

Were consolidated findings and classified each part of the supply chain according to its evidence towards a better understanding about how firms capture knowledge from relationship focused on the development of new technologies to answer the question how being an Indy Car supplier may impact the company's ability to learn and perform.

Potential Absorptive Capacity (Acquisition) 2007-2008

In 2007, the IRL decided that cars should run using a blend of more than 90% ethanol instead of methanol, a non-renewable alcohol-based fuel. This fact made the Indy Car Series a potential partner for Brazil's biofuel sugar mill processors to initiate the approach with American distributors, also present the use of sugarcane ethanol for all final consumers.

In this scenario, the Brazilian biofuel processors visualized the potential access to the most disputed market in the world. The primary objective of Brazilian biofuel processors was to establish con-

nections to 1) understand how to do business in the U.S. and 2) access and increase the biofuel supply chain of this market.

To achieve maximum results, the Brazilian biofuel processors worked in a unified manner, through UNICA, in charge to design the plan to reach the main objectives proposed. The following steps were considered: (1) become a sponsor and supplier of the biofuel used in the IRL; (2) encourage the U.S. Environmental Protection Agency (U.S. EPA) to approve the decision on Brazilian position in advanced fuels; (3) carry out the search and connect the Brazilian sugar mill processors and the main biofuel distributors in U.S. and (4) carry out a national publicity campaign presenting Brazilian biofuel to potential distributors and consumers.

Potential Absorptive Capacity (Assimilation) 2009

In 2008, UNICA signed an agreement with IRL and became the official supplier of ethanol for 2009's, on 16 of that season's 17 races, including the Indy 500. The goal was to demonstrate to U.S. distributors that Brazil could be a potential biofuel supplier. This is the way the Brazilian biofuel processors found to build awareness of the Brazilian production, its sustainability, and energetic power efficiency.

Several different actions were carried on to support this goal. Between 2009 and 2010, UNICA and APEX-Brazil promoted specific events, such as a particular event during the Miami-Florida race, with a gas station to sell the same biofuel that was being used in the IRL. It was a way to get closer to the final customer (Thomaz, 2016). Also, to promote the energetic power efficiency of the Brazilian biofuel, UNICA also used this action to build awareness of the protectionist measures used by the American government.

> During that weekend, we offered a special discount on the pump, to the final customer of US$ 0.85 dollar per gallon, which was by then equivalent of how much Americans could be paying less per a much cleaner and more efficient fuel if it wasn't per the tariffs. It was was crazy, there were large lines in the gas station, and I almost freaked out when I saw helicopters flying above us, to learn then they were from TV stations broadcasting the event – that was cool! (UNICA, Interviewee 03, 2017).

Similar action was planned to May 2010 in Washington-DC, but this time offering a discount of US$ 0.54 dollar, equivalent to an additional amendment on the VEETC. This promotion, however, was canceled at the last minute by the Capitol Petroleum Group, which did not prevent a 500% increase in the visitation at UNICA's website that encourages the use of sugarcane biofuel rather than corn biofuel (TOMAZ, 2016). Brazil's biofuel exports to the U.S. increased 15% by the end of this year.

Realized Absorptive Capacity (Transformation) 2010-2011

Since 2010, U.S. EPA considered Brazilian sugar-cane ethanol as an advanced biofuel (Low-carbon fuel standard). A biofuel is advanced when it has its ability to reduce greenhouse gas emissions (GHG) by at least 50% compared to gasoline. Brazilian biofuel produced from sugar-cane meets the Renewable Fuel Standard (RFS) requirement, emitting up to 61% less GHGs in relation to fossil fuel, having a great advantage over corn ethanol produced in the U.S., which reduces GHG emissions by only 38%, which does not meet the requirements of RFS to qualify as advanced biofuel.

Short TV ads spotting IRL drivers proudly talking about the sugar-cane biofuel were transmitted all over the internet and many TV stations. They were released in May 2010, close to the date of the Indy 500 of that year. During this period, a very important link was established in this supply chain. Sunoco became the official distributor. "Sunoco will supply 100 percent fuel-grade ethanol to the IZOD IRL beginning in 2011 in partnership with UNICA", said the chief representative for UNICA in North America Joel Velasco. This is a great opportunity to partner at their retail locations on the IZOD IRL circuit to get the word out to consumers about the many benefits of ethanol fuel" (Konrath, 2010). Sunoco added Brazilian biofuel to 4.700 gas stations, expanding the partnership. Brazil's biofuel exports to the United States increased 112% by the end of 2011.

Realized Absorptive Capacity (Exploitation) 2012

At the end of 2011 the VEETC, an American tax act since the 1970's was extinguished. The Brazil biofuel exports to the U.S. reach very high numbers. In this study were used data from exports total amount as the benchmark of the outcome measure.

Exports before the partnership in 2009 were 270,190 (1,000 liters) and continued to grow in 2012 to the total of 2,048,651 (1,000 liters). This shows a growth of 758.22% in the period studied. Also, in 2011 the Brazilian biofuel sugar-cane producers expanded their relationship and started to provide biofuel to Sunoco to added Brazilian ethanol to 4,700 gas stations.

Brazil's sugar-cane biofuel receives a very low 'carbon intensity' (CI) score by the California Low Carbon Fuel Standards, which gave it a tremendous competitive advantage. Brazilian biofuel exports to the U.S. increased 212% (2011 to 2012) and reached its record. The evolution of the Brazilian sugar-cane biofuel exports from 2009 to 2012 is illustrated in Figure 4.

Figure 4: Ethanol – Brazilian Exports to US (in 1.000 liters)

Year	2009	2010	2011	2012
Total	270,190	309,935	655,89	2,048,651
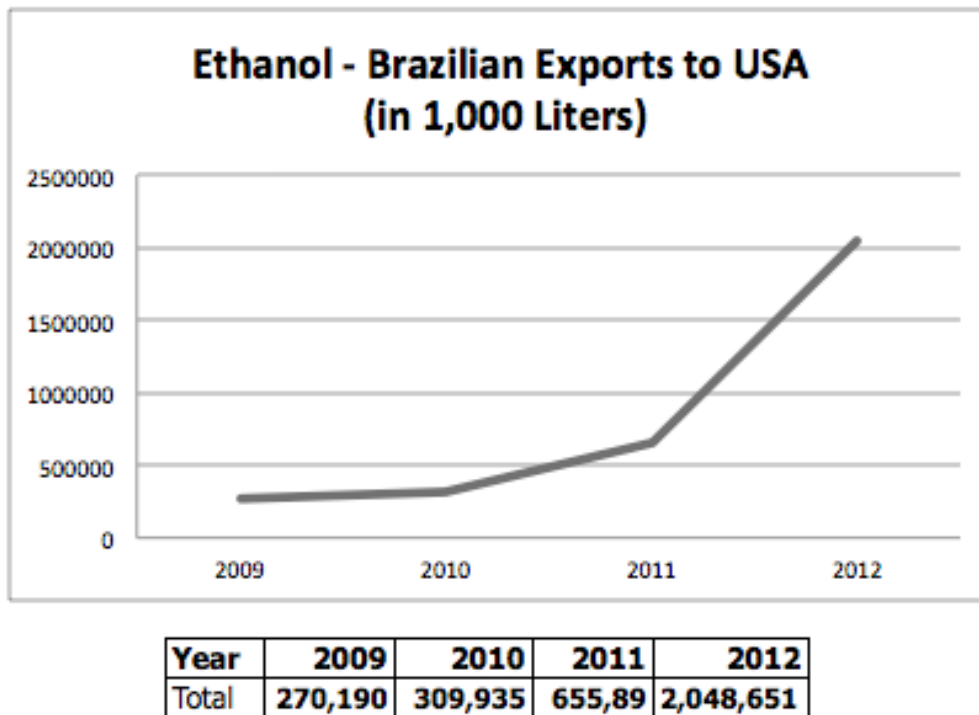
Source: www.unicadata.com.br

The Brazilian sugar-cane biofuel is known and respected by its efficiency and sustainability. But APEX-Brazil interviewees mention that they have learned much more than they have initially anticipated.

> "We learned much more than we thought we would in the beginning. The Indy [Car] partnership helped us to open our mind, and I mean not just APEX-Brazil, but many business people, even CEO from large Brazilian firms have never seen the America market as such exports opportunities as we were able to create through this partnership."

APEX-Brazil mentions that one of the greatest and very unexpected learning was actually to understand how to use large sports events to promote an environment for fruitful B2B network and business opportunities. While being an IRL's customer APEX-Brazil mentioned that learned the "science of good hospitality". IRL would make sure they would have everything they needed to create a good business environment. "We felt so much support, and so comfortable in that environment, that we wanted to recreate this kind of the same feeling to our customers in Brazil", APEX-Brazil mentions that everything

B2B related they did during the 2014 World Soccer Cup that happened in Brazil was inspired by what they learned from being an IRL partner.

> Despite the German 7 and Brazil 1, we were very successful during the [2014 World Soccer] Cup. We were able to successfully organize more than 2,000 buyers from all kind of industries, from all over the world. We prepared the events in the same manner as the IndyCar does with its partners. We have nothing to complain, everything was great, lots of business were generated, and more will keep being generated during the years to come. We feel honored to have had the opportunity to learn a little bit of the Indy way to host events and do business.

Exhibit 2 brings some of the main evidences of ACAP in the investigated case.

Exhibit 2: Types of Absorptive Capacity Evidences

	Absorptive Capacity types			
	Potential AC		Realized AC	
	Acquisition	**Assimilation**	**Transformation**	**Exploitation**
	2007-2008	2009	2010-2011	2012
IndyCar (IRL)	-Indy Car starts to explore running on Ethanol			-Last year of the official relationship
UNICA	-Brazil reaches the agreement to become the sole ethanol supplier for the IndyCar races	-16 out of 17 of the Indy Car races on Brazilian ethanol -Ethanol Exports to the U.S. increases 15%	-U.S. Environmental Protection Agency (U.S. EPA) designated Brazilian Ethanol as an advanced biofuel by the Renewable Fuel Standard (low-carbon) -Sunoco added Brazilian Ethanol to 4.700 gas stations, expanding the partnership -Exports to the U.S. increases 112%	-Brazilian Ethanol receives very low score for carbon intensity (CI) by the California Low Carbon Standards, which gave it an important competitive advantage -Exports to the U.S. increases 212% (record)
Apex-Brasil				-Apex launch a program for 2,000 buyers from all different industries to happen during Brazil's World 2014 Soccer Cup based on what they learn from their experience with IndyCar – "How to host as Indy, the Indyway"

DISCUSSION AND FINAL CONSIDERATIONS

This research investigated the case of the relationship between UNICA, APEX-Brazil, and the IRL in the U.S. between the years 2009 to 2012. During that time, Brazil became the official biofuel supplier for the IRL and all Indy cars ran 95% of all those races on of Brazilian sugar-cane biofuel.

The initial idea of sponsoring the race was to better understand the American market and how to better do business in this market, help raise awareness of the Brazilian sugar-cane biofuel, its efficiency, and sustainability-related merits, and eventually help increase the biofuel exports to the U.S. A lot of companies want to internationalize their operations, but the reality is that a lot of them do not know exactly what to do. Few of them have the humbleness to ad-

mit this, and even fewer are willing to pay their future customers to teach them.

This was the case for APEX-UNICA-IRL relationship to establish biofuel supply chain. Using it, looking at primary data and secondary data, theoretically based on the ACAP concept, this research wanted to understand how being an Indy Car supplier might impact the company's ability to learn and perform.

During the four years of the relationship, the Brazilian sugar-cane biofuel exports to the U.S. increased 758.22%, besides being recognized as an advanced biofuel by EPA and the VEETC, was extinguished in the end of 2011.

The convergence of evidence provides the following discussion: 1 - Participation as a supplier of the IRL generate results of financial gains for its participants. 2 - The relationship reaches a favorable environment for the development of the ACAP, between the participants, involving the firms and all phases of the process, from the acquisition, assimilation, transformation, and exploitation participation in this action, placed the sector in envy with the local buyers (distributors).

The results are shown in the increase in the volume of exports (government state data) and the beginning of new commercial relationships, opening the doors to begin commercial relations. The combination of the resources allowed not just the fulfillment of the proposed goals but also learning of unexpected possibilities that allowed new business. Taking advantage of a current supply structure and established business relationships are part of the ACAP objectives, enabling participants to accelerate the capture of knowledge and apply it for commercial purposes.

In this case study, UNICA and its associates made the most of it and were able to identify these results during the relationship. In general, were found evidence on the phases of ACAP, as well as on its path-dependent process, and finally manifestation in operational, financial, and reputational performance for different players in this supply chain.

Financial performance is evidenced by an increase in the Brazilian biofuel exports by 758.2% during the period of the partnership. It impacted directly sugar-cane and biofuel sugar mill processors. Operational performance could be evaluated by the several different processes created by APEX-Brazil who not just opened different and important opportunities for Brazilian industries in the U.S., but also learned the "Indy Way" to do business and continue to increase their relationship with their customers at home.

The learning inspired an entire set of B2B events related during the Brazil 2014 World Soccer Cup from the Indy Way. This impacted and will continue to affect internationalization as an operations strategy of different industries in Brazil who are connected with APEX-Brazil, not just the sugar-cane industry.

And finally, a reputational benefit was also perceived. Due to UNICA efforts, Brazil's sugar-cane biofuel sales and operations planning earns international recognition for efficiency and sustainability. Figure 5 brings some interviews quotes from the data that help to illustrate the evidence of ACAP development in the researched case.

Figure 5: Absorptive Capacity path dependence evidences in the investigated supply chain
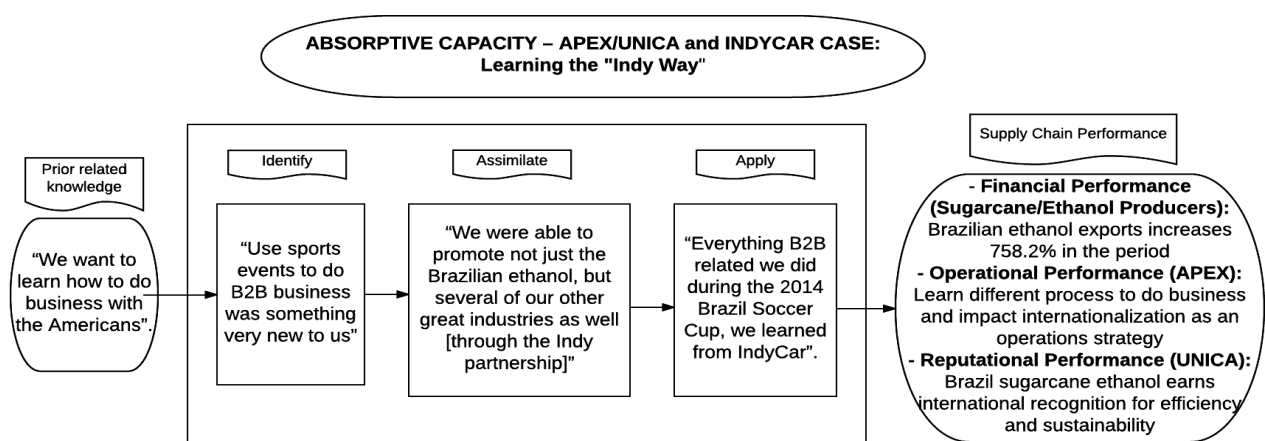
As limitations of this study, a sample of interviews looked in the supply chain from a perspective of the impacts to the Brazilian players. This research did not further investigate how this partnership had (if it did) impact in the IRL supply chain members. Regarding methods, the richness of the context created by the exploratory qualitative approach used could be complemented with further quantitative research to measure the impact of this learning in the different members of the supply chains involved.

Furthermore, currently research recognize that it certainly was not just the single fact that of APEX-Brazil and UNICA relationship with IRL that supposedly caused the almost 758.2% increase in the Brazil's exports of sugar-cane biofuel to the U.S. As mentioned by one interviewee from UNICA, the Indy relationship "was a piece of a big puzzle that we, [UNICA], we're trying to assemble".

In parallel to the relationship with IRL, it is necessary to highlight the amount of time, money, and effort dedicated in the political scene as well. UNICA played and plays a relevant role in guaranteeing the seriousness and credibility of the Brazilian sugar-cane biofuel in the U.S. through its engagement in Washington D.C.

UNICA played a significant part in making sure that, at the same time that the benefits of the Bra-zilian sugar-cane were well known by a significant portion of the American population; they also made sure to highlight the harm that VEETC was doing to U.S. taxpayers (Bridges, 2012; Hanna, 2011).

Overall, present research contributes with empirical and real-world data from ACAP and enlighten how crucial it was for APEX-Brazil and UNICA to learn the "Indy Way" and how they were able to exploit this learning in different performances for different players in their supply chain.

Also, it brings a different perspective to answer what was driving the surge in sugar-cane ethanol imports from Brazil. Previous answer for the phenomena were related to the fact that Brazilian ethanol, classified as an advanced biofuel by the U.S. RFS made it the best economic option to fulfill obligations to reach this goal (Irwin & Good, 2012).

Although these facts make a lot of sense, especially if added to the end of the VEECT tariffs against imported biofuel in the U.S. at the end of 2011, it was expected that the imports of Brazilian biofuel in the U.S. would continue to grow over the following years. Interesting enough, it did not. The Brazilian biofuel imports in the U.S. fell drastically over the next years and is still trying to catch up.

Figure 6: Ethanol – Brazilian Exports to US - The "IndyEffect"

Ethanol - Brazil Exports to USA (in 1,000 Liters)

The 'Indy Effect"
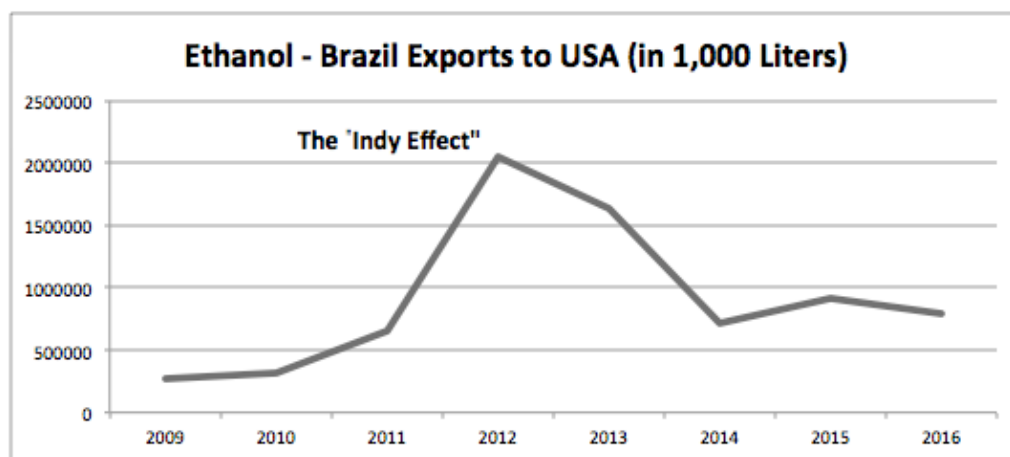
Year	2009	2010	2011	2012	2013	2014	2015	2016
Total	270,190	309,935	655,889	2,048,651	1,636,618	719,232	915,364	786,638

Source: www.unicadata.com.br

Finally, further research is necessary to look into possible causes and effects of this fact. For now, this research calls attention for the significant period of growing exports of Brazilian sugar-cane ethanol to the U.S., which coincides precisely with the APEX-Brazil/UNICA relationship with IRL, as the "IndyCar Effect" was perceived, and invite further research upon it.

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A STRUCTURED-LITERATURE-REVIEW OF THE SUPPLY CHAIN PRACTICES IN DAIRY INDUSTRY

ABSTRACT

Dairy industry plays a vital role in enriching the socio-economic status of rural India, particularly in women empowerment. In general, either a structure or subcomponents of dairy supply chain is discussed in the literature, but the rational (why, what, how) is missing. Further, the structured-literature-review (SLR) of dairy supply chain manage-ment (DSCM) practices is scarce. This paper presents an SLR of articles published in the context of DSCM practices. The paper further assesses the extent to which the SLR approach can be applied to DSCM so as to produce a consistent knowledge stock by evolving a context-sensitive study. The key challenges discussed in reviewed articles are highlighted. Authors selected the articles published in peer-reviewed journals and categorized the articles published in recent eleven years into three main subjects of supply chain i.e. distribution management (DM), risk management (RM), and decision-making strategies (DMS). The findings of this study show that the food safety, product quality, and associated economic benefits in dairy industry can be achieved through technological innovation, eradication of uncertainties, and introducing the global SCM practices into lean and green initiatives.

KEYWORDS | Supply chain management, structured-literature-review, dairy industry, strategic management, decision-making.

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INTRODUCTION

In the current global market, industries cannot ignore the success factors such as economic trends, competitive position, technology advancement, and operations and SCM activities. SCM is a generic term related to a set actions to manage various entities such as supplier, procurement process, production, product delivery, the flow of information, customer demand etc. in an organization. SCM is viewed as a system of interaction among various stakeholders (Christopher, 1992; Lambert, 2008). The improved product quality, elimination of uncertainties and high brand value leads to better SCM and offer the decreased costs (Cooper, Lambert, & Pagh, 1997; Wisner, 2003). Effective SCM and logistic activities include managing the customer need, on-time product delivery, and flow of information across the supply chain (SC) network (Srivastava, 2006). SCM address various methods for achieving consumer focus through process effectiveness (Zokaei & Hines, 2007). Cooper et al. (1997) stated that SCM is more extensive than coordination management as it includes the linking of key business activities over the interconnection. Mentzer et al. (2001) and Wisner (2003) emphasized on the significance of firm and cross-firm coordination. The framework for logistical activities involves the execution of basic activities, value-added activities, planning and control, and strategic decision measures (Hsiao, Van der Vorst, Kemp, & Omta, 2010). Competitiveness in the supply chain has been a key issue for organizations and 'mapping the competitiveness of an organization help to form the sound basis for business strategy development. Each stakeholder in SC must intend to turn out in a dynamic and competitive way for sustainable business operations (Mor, Bhardwaj & Singh, 2018a; 2018b; 2018c).

The fundamental difference between food supply chain (FSC) and other is the continuous and significant variation in product quality over time. SCM activities like service, delivery, and information flow are still key challenges in the food sector. Strategically, rather than competing within the low-cost market segment, many food producers are working on different marketing strategies to target the rural market. This has led the industries to implement a range of sustainable practices like local sourcing, reuse, recycling, and green purchasing (Mor, Singh, & Bhardwaj, 2016; 2017). The role of logistics, packaging and on-time delivery are some worries in food processing sector like dairy (Jahre & Hatteland, 2004). Further, due to the highly perishable in nature of dairy products, they entail special treatment, cooling mechanism, handling and quick actions starting from milk procurement to distribution or retailing. DSC entails four main elements as raw milk supplier/farmer, milk processing plant, retailer, and the end consumer. The dairy industry has observed vast changes in their business structure like globalization, technological development, the enhanced shelf life of products, and seasonal demand fluctuation. It needs significant development in their competitiveness status so as to meet high product quality, consistency, and safety standards of the export market (Bhardwaj, Mor, Singh, & Dev, 2016). Diverse characteristics make it more challenging to manage the supply chain activities in dairy industry. Quality management appears to be the most important factor in dairy industry followed by inventory management, supplier management and technological innovations (Mor, Bhardwaj, & Singh, 2017).

Literature review is a research approach and content analysis of the relevant literature (Krippendorff, 2004). Content analysis is a systematic way of briefing many words of text into a smaller set of contents (Weber, 1990). Structured literature review (SLR) aims to address the issues in a particular research area through *identifying*, *evaluating* and *integrating* the outcome of the relevant available studies leading to various research questions. An SLR study must address the following (Baumeister & Leary, 1997; Bem, 1995; Baumeister & Leary, 1997):

- Establish to what extent the prevailing research has been developed in a particular area.

- Find out the relations, conflict and research gaps in literature, and formulate the conceptualization of a problem (Sternberg, 1991).

- Define the future research directions, and extend or develop a new theory.

Structured reviews vary from traditional reviews by assuming a detailed technology aimed at reducing the bias through exhaustive literature examinations. An SLR offers various research questions that form the basis of a research problem (Massaro, Dumay, & Guthrie, 2016) and research questions. The first step in performing an SLR is to create a list of structured questions or groups. The second step is to execute an in-depth search of the relevant available literature. Thus, SLR is a way for reviewing the scholarly literature to develop insights, critical reflections, future research area (Massaro et al., 2016).

Thus, current paper is an attempt to review the relevant available literature concerning SCM practices in the dairy industry. The rest of the paper is organized as follows. Section 2 covers the methodology part, and section 3 includes the analysis of articles. The discussion is given in section 4, while, section 5 is the conclusion, and limitation and future scope in continuation to this study.

METHODOLOGY

In this paper, the target population is the articles published recently in various databases. The articles were searched on various scientific databases like Google Scholar, Open access Journal, Web of Science, Scopus etc. by using the title, abstract field and keyword. These databases offered numerous articles which were reduced by applying the limiting criteria in selecting and evaluating the body of literature on DSCM, for example, year of publication, research area i.e. dairy industry, supply chain management, operations management, food processing etc.; type of journal and document etc. (Mor et al., 2016). A sample size of more than 100 articles of recent eleven years (2008 to 2018) concerning supply chain management practices was considered. The selected articles concern three main research areas i.e. DM, RM, and DMS in the context of dairy supply chain management (DSCM). The reviewed articles were classified on the basis number of year of publication, journal name/type, subject and area of research.

Validity and Reliability

Validity is the degree to which a measuring process signifies the quality of obtained results leading to as realistic. External validity is related to whether the sample of study agree to the population or not (Neuendorf, 2002; Krippendorff, 2004). In this paper, all the articles are related to SCM practices and hence, the external validity is assured. Subsequently, face validity is confirmed that whether the developed instrument measure exactly what it is intended to measure or not and approve the outcome if reasonable (Neuendorf, 2002; Krippendorff, 2004). The articles reviewed in this paper have been tested by the subject experts and academicians whether it is sufficient to assess the proposed results, and content validity is measured. An instrument is supposed to support the content validity if it covers all aspects of the research area which it is proposed to measure, and hence the content validity has been checked by the authors. Weber (1990) confirms that the article selection must be reliable to develop valid implications from the expression, and the reliability issue occurs due to the uncertainty of word definitions. In the current paper, the percent agreement technique is used to assess the reliability by simply adding up the selected cases by the three experts, and dividing by the total number (Mor et al., 2016). Finally, the reliability gained in the current paper comes out to be 76%, and thus deemed as reliable.

ANALYSIS

Khadar and Sandesha (2016) highlighted the effectiveness of SC practices w.r.t dairy products in Dakshina Kannada dairy and observed a clear focus on milk quality, brand loyalty, customer demand and brand image. De Steur, Wesana, Dora, Pearce, and Gellynck (2016) presented SLR to show that the potential of value stream mapping to identify and reduce food waste. Authors concluded that a multi-stakeholder collaboration in FSC is vital for successful execution of lean. Sharma, Chandana, & Bhardwaj (2015) investigated various performance indicators along with sub-factors in green inventory network management. Gautam, Virmani, and Singh (2016) found the effect of marketing activities on Amul's success in Indian dairy industry and found the marketing strategies as critical for firm's success. Parenreng, Pujawan, Karningsih, and Engelseth (2016) investigated the RM issues due to food traceability and innovation through a contextual study of Sulawesi in Indonesia. Deshpande et al. (2016) explored the dairy product's market in India and found that about 50% of dairy products in India are retained for self-consumption, 40% is procured and distributed by unorganized milkmen, and 10% form the organized sector. Further, the international companies and local cooperative organizations consume 55% and 45% of milk produce respectively. Mor et al. (2017) developed a framework for the evaluation of procurement performance in dairy supply chain practices in the context of Indian dairy industry. Exhibit 1 depicts the list of key journals referred for sampling of articles published in this context.

Exhibit 1. List of key Journals referred for Sampling

Sr. No.	Name of Journal(s)
1	Annals of Operations Research
2	International Journal of Production Economics
3	Journal of Management Sciences and Technology
4	International Journal of Services Technology and Management
5	Production Planning and Control
6	Journal of Industrial and Production Engineering
7	International Journal of Production Research
8	Review of Agricultural Economics
9	International Journal of Production Management and Engineering
10	International Journal of Physical Distribution and Logistics Management
11	Journal of Dairy Science
12	Agricultural Economics Research Review
13	International Journal of Logistics and Supply Chain Management Perspectives
14	International Journal of Supply and Operations Management
15	International Food and Agribusiness Management Review
16	International Journal of Scientific and Engineering Research
17	Journal of Manufacturing Technology Management
18	Industrial and Engineering Chemistry Research
19	International Dairy Journal
20	IOSR Journal of Business and Management
21	Proceedings of the International Conference on Industrial Engineering and Operations Management

Subburaj, Babu, and Subramonian (2015) focused on improving the operational efficiency of DSC in Tamilnadu through SWOT analysis, and identified five areas of focus namely, the creation of the special dairy zone, implementing dynamic milk procurement process, reinforcing the cooperative societies, creation of feed bank and increasing fodder productivity, integrated animal health plan and information technology. Banasik et al. (2016) developed a scientific model of waste handling and expressed the exergy loss as an environmental indicator in FSC. Sharma et al. (2017) ranked the key performance indicators responsible for implementation of GSCM in Indian dairy sector through extensive literature review and personal interviews. Handayati, Simatupang, and Perdana (2015) surveyed the FSC practices to identify key coordination issues. Chen, Zhang, and Delaurentis (2014) developed a model to study the 'quality measures' in FSC via a case study and concluded that the decentralized SC lead to distortion in food quality. Behzadi, O'Sullivan, Olsen, Scrimgeour, and Zhang (2017) investigated the effectiveness of robust and resilient strategies along with the profit gain through optimal RM and SC planning decisions. Mangla, Sharma, and Patil (2016) proposed that it is expected to focus on basic success factors to enhance the execution of FSCM practices. Zubair and Mufti (2015) assessed the DSC risks and found key risks of competition, quality of raw materials, and natural disasters etc. Nicholas et al. (2014) indicated that the preference of low-input and organic DSC members in Belgium, Finland, Italy, and the UK lies in developing the innovations to improve animal welfare and forage quality. Boland et al. (2015) found that

firms must balance the need of multiple areas like the general public, employees, cooperative members, external funding organizations etc. Daud, Putro, and Basri (2015) concluded that extensive RM practices are crucial for milk supply chain like biological, natural, operational and institutional risks. Dora, Kumar, and Gellynck (2016) identified the product perishability, retailer's behavior, traditional production process and layout as significant factors in the food sector for lean implementation. The subject-wise classification of articles is shown in Figure 1.

Figure 1. Subject-wise Classification
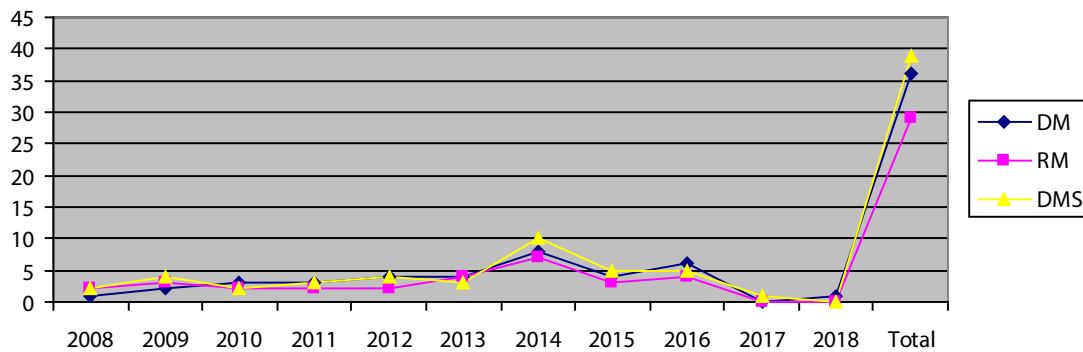
Minarelli, Raggi, and Viaggi (2015) identified the determinants of innovation and revealed that an association exists between product, process and market innovation due to the technological factors in the food sector. Bamgboje-Ayodele, Ellis, and Turner (2014) recognized a research gap in perishable food chains for knowledge optimization concepts, the influence of firm-level absorptive capacity and ecological uncertainties. Bharti (2014) dealt with the potential and difficulties in the frozen food products in India. García-Arca, González-Portela, and Prado-Prado (2014) directed that there is a significant probability of improving cost efficiency (about 26%) in smallholder dairy. Ghosh, Sindhu, Panghal, and Bhayana (2014) analyzed various risk enablers in the dairy sector with interpretive structural modeling (ISM) approach. Khan and Prashari (2014) analyzed the growth and development of Indian dairy sector in the context of the role of government agencies and policymakers. Kumar (2014) evaluated the performance of inventory management in dairy industry and proposed a theoretical model for a co-ordinated production network. Lemma and Gatew (2014) presented the modeling and optimization approaches discussed in literature focusing the perishability of products, wastages and loss assessment in DSC. Okano, Vendrametto, and Santos (2014) demonstrated that it is possible to organize DSC by using indicators to rank them and modeling best practices to improve productivity and become a sustainable productive chain. Patel, Modha, Patel, and Patel (2014) discussed that India ranks 1st in milk production as well as consumption and stands distinct with the lowest cost of milk production. Patushi and Kume (2014) suggested the cluster development to increase business competitiveness through policy guidance, and proposed a model for enhanced productivity, lowered costs and better product quality. Banaszewska, Cruijssen, Claassen, and van der Vorst (2014) performed contextual analysis in dairy industry and focused on the benefits obtained from whey treatment. Verma and Seth (2014) highlighted the poor road infrastructure and absence of cold chain infrastructure in Indian dairy industry. Khoi and Dung (2014) provided a close look at value chain and its application in the dairy industry in Vietnam. Mahajan, Garg, and Sharma (2014) concluded that India ought to play a crucial role in adhering to food safety norms for its domestic market as well as for global processed food business. Muhammad, Akhter, and Ullah (2014) introduced the significance of dairy production practices in Pakistan and found that SC disruption as a critical issue that is based on informal channel. Kumar (2014) revealed the connection between DSCM, operational performance, inventory management and lean SC practices. Glover, Champion, Daniels, and Dainty (2014) applied institutional theory to explore the role of supermarkets in developing the sustainable practices across DSC. Luxton, Sankaran, and Carroll (1999) analyzed the interactions of SC coordination in New Zealand dairy industry with special emphasis on operation research

applications. Kumar and Prabhakar (2013) recognized the different issues in Indian dairy industry to enhance the productivity of DSC. The year-wise classification of articles is shown in Figure 2.

Figure 2. Year-wise Classification
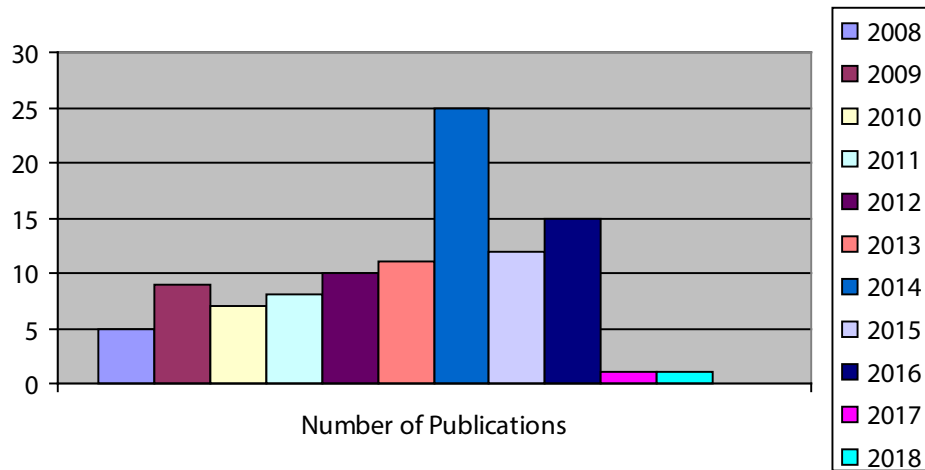
Prakash and Pant (2013) suggested that the importance of balance scorecard approach in India is different from the developed countries due to infrastructural issues, variable milk production, poor breed of cattle, poor sourcing, unavailability of cold infrastructure and poor information systems. Prasad and Satsangi (2013) concluded that it is a popular belief that Indian cooperative system is a failure, but Amul with cooperative structure is an example of grand success in this context. Sharma (2013) emphasized on various aspects of lean management, complex production system and cold chain infrastructure in DSC. Bilgen and Celebi (2013) explored the issues in Yogurt production in a dairy plant through mixed programming model. Augustin, Udabage, Juliano, and Clarke (2013) introduced the drivers for an aggressive dairy industry and the associated issues of producing dairy products. Gold, Udabage, Juliano, and Clarke (2017) studied the factors affecting the supply chain performance in global agri-food business. Vlontzos and Theodoridis (2013) evaluated the efficiency change in 29 Greek dairy firms by nonparametric approaches and data envelopment analysis models. Rao, Raju, Reddy, and Hussain (2013) concluded that significant changes are needed in milk procurement and processing phases in Indian dairy sector to compete globally. Gupta and Roy (2012) conducted some case studies to measure the associated benefits gained with vertical integration in Indian dairy industry. Kumar et al. (2012) probed into the conceptualization of geographic information system (GIS) in the dairy industry and offered

the execution of RM tools. Kajananthan and Achchuthan (2013) recognized that the dairy sector needs to design the marketing and DM plans at large scale. Ashok and Sriwastwa (2012) examined the strategy and purpose of the low input DSC and the role of information system in DSCM. Samuel et al. (2012) presumed that agri-food production system is completely in a developed stage in the USA, UK, Australia and New Zealand, however, it is advancing itself in the developing nations like China and India. El-Osta and Morehart (2000) analyzed the effect of technological innovation and demonstrated that innovation would significantly increase the profitability of the dairy industry. Barbe, Gonzalez, Triay, and Hughes (2011) revealed some insight into the vertical integration to enhance the efficiency of British dairy farmers through the effective production systems. Kumar, Staal, and Singh (2011) concluded that the progressive DSC has a comprehensive structure, and the traceability and food security issues are the barriers in a dairy production system. Mishra and Shekhar (2011) contended that perishable nature of dairy products leads to high wastage and it reduces the product value. Pinior, Belaya, Petersen, and Selhorst (2011) realized the arrangement of hierarchical interaction in German dairy industry by exploring the inter-departmental relationship in supply chain network. Rathod, Nikam, Landge, and Hatey (2011) investigated the Gokul dairy cooperative for the benefits of dairy farmers through a pretested questionnaire survey in 150 dairy industries in Maharashtra. Singh and Javadekar (2011) focused on

the usage of IT by the unorganized sector for SCM of perishable food products in Pune and found enormous wastage of food products due to non-usage of IT. Vandeplas (2011) revealed that effective information systems can improve the system efficiency, productivity, and traceability of dairy industry. Bowonder, Raghu Prasad, and Kotla (2005) discussed the application of information and communication technology (ICT) in the dairy industry and revealed ICT can help in improving the overall productivity of dairy industry. Kumar (2010) explored the issues related to the decision-making process in dairy industry and demonstrated that it leads to better SCM in the dairy industry.

Popovic and Radovanov (2010) recognized the vertical integration as a key driver in SCM practices in Serbian dairy industry. Wamba and Wicks (2010) characterized the role of inventory management, RFID, and transportation system in dairy industry's growth. Kumar et al. (2010) observed the expenses and return in the conventional dairy system to assess its marketing process and the capability to handle demand fluctuations. Berkum (2009) examined

the structure of dairy production system by pointing out that the dairy sector is yet in developing state in many nations. Punjabi (2009) studied the factors affecting the performance of dairy industry through Porter's five elements i.e. ability towards the entry of new players, bargaining power of supplier and buyer, the threat of substitutes, and challenges among the existing players. Saravanakumar and Jain (2009) proposed the value-added chain management for the dairy sector through variables like information costs, and non-value factors like innovation. Tordecilla-Madera, Polo, Muñoz, and Rodríguez (2017) designed a robust logistics system for the milk storage and refrigeration system for optimizing the usage of the cooling tank for procurement and distribution. Schlecht and Spiller (2009) considered the business connection between the dairy industry and dairy farmers in north-western Germany, especially regarding arranging the conditions of the DSC network. Jansik (2009) inspected the research gaps at different levels of DSC including milk production, procurement, and processing. Figure 3 represents a comparison of articles on the basis of sector.

Figure 3. Sector-wise Classification
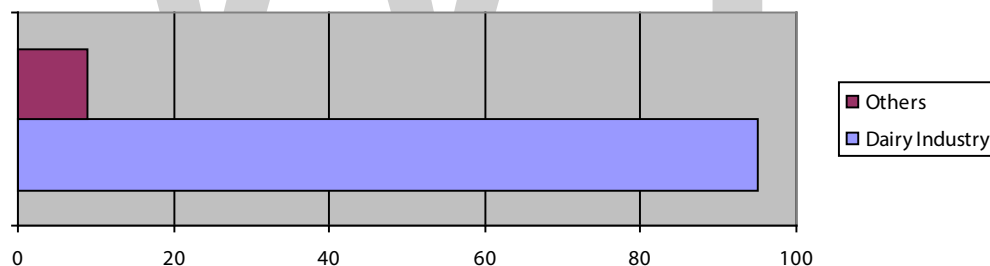
Pieniadz, Hanf, Voicilas, Wegener, and Götz (2009) found that effectiveness of DSC can be attained through better coordination between different interfaces of a supply chain. Rangasamy and Dhaka (2008) explored the effect of advertising on the productivity of the private dairy plants in Tamil Nadu in 20 dairy industries along with the logistics and transportation management agencies. Schotzko and Hinson (2000) proposed a solution to the issues that hamper the dairy industries to be more sustainable and competitive. Bremmers, Poppe, Wijnands, and Meulen (2008) concluded that the impacts of regulatory overheads are intervened by creativeness, organizational culture, food safety standards etc. in the food sector. Szajner and Szczególska (2007) argued that the policymakers in Polish dairy industry should promptly stimu-

late the sustainable SC activities and brand value. Srikanth (2007) discovered the effect of operations management on dairy products in four dairy cooperative industries in Karnataka. Spicka (2013) concluded that the vertical business relationship in DSC is a key weakness of Czech dairy industry. Amorim, Alem, and Lobo (2013) suggested that it is possible to reduce the percentage of expired products that reach the end of their shelf-lives by using the risk-averse models. Taylor (2011) proposed the cluster development to raise the business competitiveness in the dairy industry through policy guidance. Lapar, Garcia, Aditto, and Suriya (2005) evaluated the cost of employing effective information system in 130 smallholder dairy farms along with its benefits. Calker, Antink, Beldman, and Mauser (2005) introduced a contextual

analysis of DSC in collaboration with the production system for performance analysis. Chandra and Tirupti (2003) depicted that market changes considerably affects the small dairy farmers and the firms with good product quality probably succeed in the milk processing sector.

DISCUSSION

This paper provides a summary of the studies published recently in the area of DSCM. One of the qualities of this paper is the theoretical framework used. The reviewed articles present a sound hypothesis base for DM, RM, and DSM. The articles discuss various strategies for smoothening the DSC by eliminating the uncertainties, execution of effective information systems, technological innovations etc. in the dairy industry sector to meet the global standards. The conceptual framework established to classify the

selected articles show that 32%authors framed SCM as a process, 23% as a system approach, 14% as a management activity, and rest as a business strategy. Out of the reviewed articles, about 93% articles are related to dairy industry and rest 7% are related to another food sector; and about 34% articles discuss DM, 28% discuss RM, and 37% discuss DMS practices in the context of the dairy supply chain. Further, the researchers like Mor et al. (2015; 2016; 2017; 2018a; 2018b; 2018c), Bhardwaj et al. (2016), Sharma et al. (2017) etc. have come up with some explanations to the issues of high wastages and improvement in food processing and dairy sector. The research questions framed in this paper also suggest a significant role of SCM practices in the dairy industry.

The current paper wrap-up with the key supply chain challenges in dairy industry identified through this structured literature review that differentiate the DSCM from another generic supply chains (Exhibit 2).

Exhibit 2. Key challenges in DSC

Sr. No.	Challenges
1	Effectiveness of information systems
2	Perishable nature of dairy products
3	Traceability of quality related issues
4	High risk of milk adulteration/contamination
5	Effectiveness of cold chain
6	High demand fluctuations
7	Logistics, transportation and road infrastructure

Due to the perishable nature of dairy products, it is a challenge to effectively manage the dairy supply chain. Further, these products need quick responding supply chain supported by effective coordination throughout the supply chain network. Thus, the shop-floor executives and top management of industry need to manage their supply chain activities in an effective way by considering the above factors in order to compete globally.

CONCLUSIONS

This paper starts with filling the research gap in literature with an emphasis on supply chain practices in dairy industry. The articles concerning three subjects, i.e. distribution management, risk management and decision-making have been selected for review. The articles were compared on the basis of year of publi-

cation as well as the research area. The comprehensive literature review suggests that though SCM is a more generic term related to all sectors, the characteristics like demand fluctuation, perishable nature of product, seasonality, traceability, small-scale production etc. are the major concerns that differentiate the dairy supply chain from other. Dairy industry currently calls for an effective and competitive supply chain strategies along with food safety and security to meet the standards of the export market. In above context, the managers and professionals in the dairy industry need to develop high responsiveness in supply chain directing on the coordination and effective information system. An integrated supply chain approach along with the excellence in decision-making can significantly improve the competence of dairy industry. In conclusion, the strategies discussed in this

paper can assist the dairy industry to achieve higher level of competitiveness and leanness.

Limitations and Future scope

The current paper has some limitations that authors might want to recognize. The principal restriction is the arrangement of selected papers. In any case, it ought to be noticed that the authors' judgment is a factor in choosing and ordering the articles. Authors recognize that there can be numerous different approaches to sort the articles. It must be noticed that the publication year for each article is most significant when reported. In those studies, that included reviews or field surveys, authors did not reveal the time of their information collection specifically. In such cases, authors accepted that the information was accumulated in conjunction with presenting the article. Future research studies can be conducted for other subjects of supply chain such as integration, collaboration, quality management, supplier management, SC trust etc. in order to benchmark the best DSCM practices.

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THE ROLE OF COLLABORATION FOR RESILIENCE OF THE SUGARCANE-ENERGY SUPPLY CHAIN

ABSTRACT

The drought in the sugarcane-energy supply chain of São Paulo occurred between 2014 and 2015 was the phenomenon observed in this case study whose starting point was the following question: how can collaboration bring on resilience in sup- ply chains experiencing a disaster? Deductive qualitative approach has empirically contributed to the knowledge of possible disruptions focused on the agribusiness. For those purposes, aspects involving vertical (suppliers, focal company and buyers) and horizontal (NGOs, government, research centers, focal company and their com-petitors) collaboration was analyzed among the links of the chain (triad: farmers, processers and buyers). Vertical collaboration between buyers and focal company, if compared to that of focal company and suppliers (the weakest link) is more sig- nificant. The findings in this study, however, should be considered solely within the context of the supply chain analyzed once new researches in different cultures of the agribusiness, regions and types of disasters have yet to be done.

KEYWORDS | Agribusiness, case study, risks, disruptions, droughts.

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INTRODUCTION

Cost increase caused by disruptions in supply chains has led researchers and professionals to question the traditional risk- management approach where elaborating mitigation strategies is based on assessing the probability of an event and on how serious the impact is expected to cause (Jüttner & Maklan, 2011; Pettit, Croxton, & Fiksel, 2013; Pettit, Fiksel, & Croxton, 2010). That is so because along the last years researches on risk management have targeted on identifying risk sources through a proactive vision based on forecasting possible events able to cause disruptions (Jüttner, 2005; Punniyamoorthy, Thamaraiselvan, & Manikandan, 2013; Sodhi & Lee, 2007; Stecke & Kumar, 2009): "The focus of business toward increasing efficiency and reducing costs has resulted in supply chains that are efficient during normal times, but at the cost of being vulnerable to disruptions. From time to time, frequent as well as rare catastrophes also disrupt supply chain operations. We collect and compile data from many sources and show that there has been a marked increase in both the frequency and economic losses from natural and man-made catastrophes. We find that business losses constitute a major percentage of the total losses caused by these catastrophes. The statistics suggest that for terrorist attacks, the vulnerability of U.S. business interests is much higher than others. Examination of the geographical and chronological distributions of catastrophes provides useful information for managers concerned about such disruptions. We develop a catastrophe classification framework that matches different types of catastrophes to a variety of infrastructural components of supply chains. The framework also connects a variety of mitigating strategies to appropriate catastrophe types. We identify factors that can be used to assess the vulnerability of a supply chain. They can also be useful to compare possible alternative decisions based on the vulnerability they may cause in the supply chain. To manage vulnerability in supply chains, we propose strategies that can be implemented by a company to decrease the possibility of occurrence, provide advance warning, and cope after a disturbance. We reveal potential benefits from mitigating strategies during normal times, which indicate that well-developed strategies can also result in better efficiency. We identify many future research areas concerning disruption handling in supply chains. [ABSTRACT FROM AUTHOR] Copyright of Journal of Marketing Channels is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use. This abstract may be abridged. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material for the full abstract. (Copyright applies to all Abstracts..

That vision, however, can be limited when organizations and supply chains are not able to realize in advance and efficaciously unexpected events; or yet risks that despite being foreseen inevitably cause serious disruptions without low mitigation potential (Pettit et al., 2013). That is why, based on the assumption that some risks are unpredictable, organizations and their supply chains need to build up resilience when facing rare and uncertain events (Knemeyer, Zinn, & Eroglu, 2009; Pettit et al., 2010) by adding to their forecast proactive vision actions able to trigger reactions of response and post-impact recovery.

Resilience has been defined within organizational environments as the capacity of going beyond absorbing an impact and recovering from it, and it also incorporates the capacity of adapting and building up flexibility. Due to the interconnection in supply chain networks, organizations' interdependence can increase consequences of disruptions thus making resilience be extended at that the level of that chain (Ponomarov & Holcomb, 2009; Tukamuhabwa, Stevenson, Busby, & Zorzini, 2015; Wieland & Wallenburg, 2013) in order to ensure continuity of operations and delivery of goods to buyers (Ambulkar, Blackhurst, & Grawe, 2015; Christopher & Peck, 2004).

Resilience in supply chains (SCR) is an incipient, fragmented area of research, despite a promising one (Ali, Mahfouz, & Arisha, 2017; Blackhurst, Dunn, & Craighead, 2011; Kamalahmadi & Parast, 2016), in spite of the still limited number of the existing empirical researches (Kamalahmadi & Parast, 2016; Tukamuhabwa et al., 2015). In this sense, although there is an increasing body of literature on resilience definitions, it is still outdated related to the approach of the strategies to be implemented beyond the organizations' borders, of its diversification and verification of existence of synergies or trade-offs among them (Tukamuhabwa et al., 2015).

A possible strategy for supply chains' resilience should take into consideration redundancy and multiple suppliers as a way of limiting both disruption and effects in sequence (Rice & Caniato, 2003; Tukamuhabwa et al., 2015). An alternative to that could be collaboration between buyers and suppliers involving shared

resources for their mutual benefit (Pettit et al., 2013; Zacharia, Nix, & Lusch, 2009). In spite of the potential success of both strategies, maybe they are not viable in all situations or for all links of a supply chain.

Literature on SCR contains few investigations that consider at least the triad composing supply chains, in this case farmers, processers and buyer, as the unit to be analyzed (Hahn, Pinkse, Preuss, & Figge, 2015; Odongo, Dora, Molnár, Ongeng, & Gellynck, 2016). Although the concept is discussed within organizations, networks and supply chains (Ali et al., 2017), we have to understand how organizations build up resilience and its impact on supply chains (Kamalahmadi & Parast, 2016).

To understand the different organizational strategies to mitigate, prepare, respond and recover from serious disruptions impacting on a supply chain's final performance, this study was based on the following research question: how can collaboration bring on resilience in supply chains experiencing a disaster?

Although the understanding of collaboration stands for a main topic for practices of risk management in supply chains, SCR literature lacks empirical insights approaching beyond the perspective of one single organization (Scholten, Schilder, & Wagner, 2015).

For the purposes of filling up this theoretical gap, pointed out Scholten *et al.* (2015), this study intended to analyze how collaboration activities among members of the sugarcane-energy supply chain have been able to increase their resilience even when experiencing several risks and disruptions in the drought occurred between 2014 and 2015. It is worth stressing that despite the problems experienced, that chain has remained competitive when compared to other commodities used to produce foods, fuels or energy.

In addition to its economic, social and environmental relevance added to its historical vulnerability resulting from a myriad of threats (governmental interference with prices and products' characteristics, labor-related issues similar to slavery, bad soil conservation in agricultural areas, intensive dependence on water resources in the industrial area, among others), up to this date no researches have been published on the theme of resilience and its empirical contributions in the agribusiness sector in Brazil. This equally evidences the academic relevance of this study for the national scenario once recently there has been several productive discussions about the sugarcane-energy supply chain (Aquila, Pamplona, Queiroz, Junior, &

Fonseca, 2017; Biazzin, Paiva, Di Serio, & Andrade, 2015; Brunhara, Corrêa, & Mazini, 2018; Dias et al., 2015; Fuess, Rodrigues, & Garcia, 2017; Julca-Briceño & Fava Neves, 2011).

This article has been structured in five sections, starting with this introduction (first section). Next are presented: theoretical foundation based on literature review on the capacity of collaboration for resilience in supply chains and types of collaboration (second section); the research methodology step-by-step by using a qualitative approach by means of case study (third section); the findings emphasizing the information arising from the participant's speeches gathered in interviews and analyzed by means of data triangulation, and also in other sources of information such as documents, reports and observations made in field visits, in addition to discussions among the authors of this study (fourth section); and, finally, final considerations including the research's limitations and suggestions for future studies (fifth section), followed with the list of references of the works quoted.

THEORETICAL FOUNDATION

It was chosen to work with the capacity of collaboration once formative elements of resilience in supply chains should be adopted by all members targeting on joining strengths in case of a risky event (Jüttner & Maklan, 2011). As Supply Chain Resilience (SCR) is a concept that exceeds an organization's limits, it becomes insufficient as an efficacious strategy able to search for flexibility, speed, visibility or other capacities which singly compose resilience.

To develop a broad strategic network of flexibility and to reduce the uncertainty it is important to build up collaborative relationships among all links of a supply chain (Stevenson & Spring, 2007). Sometimes a relationship may cause direct conflicts because maintaining a long-term contract with a supplier my help decreasing uncertainty, increase trust and willingness to adopt small changes, provided that an arms-length relationship is maintained – thus minimizing suppliers' dependence and maximizing bargaining power (Dyer & Singh, 1998).

Dyer and Singh' analysis (1998, p. 662) suggests that alliances among companies only result in competitive advantage if there is a relationship with additional characteristics to those attributed to that market by means of different capacities existing in the respective supply chains.

The study authors propose four more common categories in studies involving supply chains. Relationship-specific assets, represented by specialized assets together with the assets of a partner. Information-sharing routines where regular interaction patterns are used which enable transferring, recombining or creating specialized knowledge. Complementary resources and capacities identified in partners' assets which collectively bring about more benefits than the sum of the assets obtained from individual agreements with each partner. Finally, effective governance understood as a set of mechanisms used to align diverging interests of partners in a supply chain aiming at minimizing transactions' costs and maximizing the value of the agreement through cooperation (Dyer & Singh, 1998; Paulraj, Chen, & Lado, 2012).

Exhibit 1. Four Categories Determining Collaboration and Facilitating sub-processes

Collaboration determining factors	Relationship description	Facilitating sub-processes
Relationship-specific assets	Specialized assets together with a partner's assets	• Duration of contractual guaranties • Volume of transactions among companies
Information-sharing routines	Regular interaction patterns enabling transferring, recombining or creating specialized knowledge	• Absorbing capacity of a partner • Incentives to encourage transparency and discourage free agreements
Complementary resources and capacities	The partners' assets that collectively bring on bigger benefits than the sum of those obtained from individual agreements with each partner	• Capacity to identify and assess complementarities' potential • Role of organizational complementarities to access complementary strategic resources
Effective governance	The set of mechanisms used to align diverging interests of the partners in the Supply Chain in order to minimize transaction costs and maximize the value of agreements made through cooperation	• Capacity to use self-application instead of application by third parties of the governance mechanisms • Capacity to use formal and informal self-applicable governance mechanisms

Source: Adapted (Dyer & Singh, 1998; Paulraj et al., 2012)

As to the supply chain, collaboration can be defined as a partnership process aimed at planning and carrying out the chain's operations to obtain mutual benefits (Cao & Zhang, 2011)firms have strived to achieve greater supply chain collaboration to leverage the resources and knowledge of their suppliers and customers. The objective of the study is to uncover the nature of supply chain collaboration and explore its impact on firm performance based on a paradigm of collaborative advantage. Reliable and valid instruments of these constructs were developed through rigorous empirical analysis. Data were collected through a Web survey of U.S. manufacturing firms in various industries. The statistical methods used include confirmatory factor analysis and structural equation modeling (i.e., LISREL. Collaboration capacity stands for the level of decisions shared and joint work at tactical, operational and strategic levels, between two or among more members of the supply chain (Zacharia et al., 2009), regardless of the position they occupy therein.

Specifically in the agribusiness case collaboration is adequate to minimize costs, increase profits, to meet quality requirements and, should those results be positive, to gain buyers' trust (Prima Dania, Xing, & Amer, 2016). Collaboration involves all activities, such as production processes, information sharing, infrastructure, capacities and knowledge in the agribusiness chain links: farmers, processers, distribu-

tors, retailers, cooperatives, governmental agencies, NGOs and input suppliers, including financial ones.

Holding the definition above as starting point, Cao and Zhang (2011) developed a list with six main characteristics: (1) information sharing, (2) congruence of goals, (3) in-synch decisions, (4) alignment of incentives, (5) collaborative communication and (6) joint creation of knowledge among partners in the supply chain. Nyaga *et al.* (2010) summarize this understanding in just three priority factors: (1) information sharing, (2) efforts for joint relationship and (3) dedicated investments.

When dealing with risk and resilience in supply chain, collaboration is influenced by the existence of proper systems of management and by following up the performance by means of plans integrating the chain (Leat & Revoredo-Giha, 2013). This implies suppliers, focal company and buyers coming closer to each other, (vertical collaboration), involvement of partners at the same level in the chain, such as competitors, NGOs, Government or even other supply chains (horizontal collaboration) (Barratt, 2004).

A study on vertical collaboration in African sugarcane-energy supply chains shows that aspects of the organizational behavior, such as commitment, trust and cooperation, are relevant to maintain contractual relationships (Masuku, Kirsten, Rooyen, & Perret, 2003). In that assessment, in the producers-plants dyad, Masuku *et al.* (2003) highlight that individuals' trust is more important than contractual relationships.

Still according to the authors mentioned above, two pillars were highlighted: management of configurations and management of the relationships in the sugarcane-energy supply chain, once both attest the need of more flexibility in the supply chain because collaboration performs an essential role in enabling new configurations among the links of that chain and, moreover, based on the relationship, those structures can be shared (Masuku et al., 2003).

After the literature review on collaboration in agribusiness chains, Prima Dania et al. (2016) highlight the relevance of interaction among producers-plant owners when they state that inefficiency tends to be caused by small and behavioral problems instead of matters demanding structure (Prima Dania et al., 2016). Additionally, local autonomy is crucial to support the relationship between farmers and local plants (Prima Dania et al., 2016).

Therefore, interaction among farmers, processers and buyers in agribusiness chains points out that different interests, goals, levels of power (such as access to credit, for instance) and perspectives of future become obstacles for creating a satisfactory collaboration (Prima Dania et al., 2016).

Keeping collaboration along all phases of the supply chain is rather complex because the more stakeholders participate in the collaborative system, the more difficult it becomes (Prima Dania et al., 2016). Without collaboration, however, the price for buyers would be higher once at each phase of the chain values would be increased for the purposes of decreasing risks and increasing benefits (Prima Dania et al., 2016).

METHODOLOGY

Holding the sugarcane-energy supply chain defined as analysis unit, the method used was case study, which aimed at investigating how organizations occupying different positions in the supply chain used collaboration to build up resilience when experiencing the disruptions resulting from a natural phenomenon – the drought, occurred between 2014 and 2015 in the state of São Paulo.

Although disruptions caused by hydrological factors (droughts or floods) are known in Brazil, for the southeastern region there had not been any precedents for the last five decades (de Almeida, Welle, & Birkmann, 2016; Nobre, Marengo, Seluchi, Cuartas, & Alves, 2016; Pivetta, 2016b, 2016a)visualise and communicate different levels of exposure, vulnerability and risk in Brazil. The index may sensitise public and political decision-makers towards the important topic of disaster risk and climate change adaptation. This article aims to explore the feasibility and usefulness of such a national risk index that considers both natural hazard phenomena and social vulnerability. The exposure to natural hazards was assessed by using four indicators that describe the exposure of people towards landslides, floods, droughts and sea level rise. Whereas vulnerability dimension consists of susceptibility, coping capacity and adaptive capacity was calculated on the basis of 32 indicators which comprise social, economic and environmental conditions of a society. The county comparison provides an initial ranking of exposure and vulnerability. Specific analysis of coping and adaptation capacities also indicates that risk or vulnerability are not pre-defined conditions, but rather are constructed by societies exposed to natural hazards. The results of the DRIB Index were mapped and

classified by means of a GIS system to show different patterns of exposure, vulnerability and risk on global scale. The national perspective of risk clearly shows that the vulnerability of a society or a country is not the same as exposure to natural hazards. The information provided by the DRIB Index highlights the need for preventive measures towards Disaster Risk Reduction and Climate Change Adaptation in the country as a whole, but also at regional and local scales. The results showed that the risk is strongly interwoven with social-economic and cultural conditions and normal everyday life, as well as with the performance of state institutions dealing with Disaster Risk Reduction (DRR. That region, where rains are regular, represents the main area for sugarcane cultivation in the country considering the abundance of hydrographic basins, which results in strong concurrence of hydric resources for agricultural and industrial production and supply for highly populated cities.

Analyzing organizations in different links of the sugarcane-energy supply chain composed by the farmers, processers (plants and distilleries) and buyers tried, in addition to cooperatives, research centers and associations representing the sugarcane-energy sector, was the objective of this simple case study. The organizations were screened according to a theoretical sampling process based on their capacity of rendering information on the matter (Eisenhardt, 1989). The data collected and analyzed involved 24 organizations, one sector-relevant association and an agribusiness-related governmental agency.

As the interviews were conducted, managers were requested to supply additional companies according to their relationships within the supply chain. The data were collected in two different periods: from July to November 2015 and from July to December 2016. All participants in the first phase of interviews

were heard again in the second phase of the data collection (except farmer and processer 3).

The interviews followed a research protocol involving semi-structured questions previously prepared. Initially, after the first results had been analyzed, that protocol was adjusted and questions were added in order to increase our understanding of the supply chain (Ali et al., 2017). In the second round of interviews the initial cases were reviewed a total of 39 semi-structured interviews were considered.

The key-informants in charge of the operations (managers and directors of agriculture or operations and farmers), who had over 03-year professional experience in the participating organization, were searched targeting on ensuring the information coming from their experience in their respective organizations and on understanding the intensity of the impacts suffered from the phenomenon that created the disruption.

Finally, consultants of sector associations and governmental agencies were interviewed to enhance and verify the information obtained. The sample was composed of five farmers, 13 processers (12 out of those with their own agricultural production – vertically integrated), two cooperatives (one of producers and one of buyers), three plants (two of soft drinks and one of foods), one sector association and one governmental agency. Thus, the sample contains various organizations with different sizes and occupying different positions in the supply chain once that is the context able to influence the capacity of resilience (Sullivan-Taylor & Branicki, 2011). Exhibit 2 presents the characterization of the companies composing the sample as to their position in the supply chain, the titles of their informants and for how long they had worked in the participating company and its location.

Exhibit 02. Samples of Participants in Data Collection

1ª Phase of Collection					
Chain links	**Date**	**Interview type**	**Respondent position**	**Experience**	**City**
Government 01	07/10/15	In person	Director	24 years	São J. Rio Preto
Government 01	07/10/15	In person	Director	30 years	São J. Rio Preto
Government 01	07/10/15	In person	Agronomist	10 years	São J. Rio Preto
Farmer and Processer 01	17/11/15	Skype	Owner	12 years	Cerquilho

Farmer and Processer 02	17/11/15	Skype	Owner	17 years	Capivari
Farmer and Processer 03	13/11/15	Skype	Owner	10 years	Arealva
Processer 04	04/12/15	In person	Sustainability Manager	04 years	Pirassununga Co
Processer 05	03/10/15	Skype	Purchases Manager	03 years	Santa C R. Pardo
Processer 05	03/10/15	Skype	Agriculture Director	30 years	Santa C R. Pardo
Plant 05	07/10/15	In person	Agriculture Manager	20 years	Novo Horizonte
Cooperative 01	23/10/15	Skype	Agriculture Manager	42 years	Bebedouro

2nd Phase of Collection

Chain links	Date	Interview type	Respondent position	Experience	City
Government 01		*Skype*	Director	31 years	São J. Rio Preto
Government 01		*Skype*	Agronomist	11 years	São J. Rio Preto
Association 01	24/10/16	*In person*	Water Resources Consultant	12 years	São Paulo
Farmer and Processer 01	28/10/16	*Skype*	Owner	13 years	Cerquilho
Farmer and Processer 02	27/10/16	*Skype*	Owner	18 years	Capivari
Farmer 04	03/11/16	In person	Owner	20 years	Ribeirão Preto
Processer 04	10/11/16	In person	Agriculture Manager	12 years	Porto Ferreira
Processer 04	10/11/16	In person	Industrial Manager	20 years	Porto Ferreira
Processer 04	29/11/16	Skype	Sustainability Manager	05 years	Pirassununga
Processer 05		Skype	Agriculture Director	31 years	Santa C R. Pardo
Plant 01	17/10/16	Skype	Agriculture Manager	07 years	Descalvado
Plant 02	31/10/16	In person	Director of Operations	12 years	Lençóis Paulista
Plant 03	03/11/16	In person	Director of Operations	03 years	Ribeirão Preto
Plant 03	03/11/16	In person	Superintendent Operations	03 years	Ribeirão Preto
Plant 04	28/11/16	In person	Legal Manager	12 years	Sandovalina
Plant 04	07/11/16	Skype	Supply Chain Manager	12 years	Sandovalina
Plant 05	21/11/16	In person	Agriculture Manager	21 years	Novo Horizonte
Plant 06	25/11/16	Skype	Production Manager	09 years	Pitangueiras
Plant 07	25/11/16	Skype	Agriculture Manager	13 years	Ariranha
Plant 08	31/10/16	In person	Environmental Director	12 years	São Manuel
Plant 08	31/10/16	In person	Environmental Manager	12 years	São Manuel
Plant 08	01/11/16	In writing	Supervisor of Utilities	07 years	São Manuel
Cooperative 01		Skype	Agriculture Manager	43 years	Bebedouro
Cooperative 02	04/11/16	Skype	Institutional Assistant	03 years	São Paulo
Cooperative 02	22/11/16	Skype	Sustainability Manager	04 years	São Paulo
Bever. Network 01	18/11/16	Skype	Purchases Manager	07 years	São Paulo
Bever. Network 02	30/11/16	Skype	Quality Manager	09 years	Leme
Foods Network 01	18/11/16	In person	Sustainability Manager	05 years	São Paulo

In some cases the interviews, which were recorded, had more than one interviewee, which enabled validating information; additionally, whenever possible, they were conducted by two researchers in order to increase internal validity (Barratt, Choi, & Li, 2011; Eisenhardt, 1989). It is worth stressing also that for triangulation purposes, documents' data and Web sources (e.g., organization's websites, reports and information bulletins) equally served as source of research. Exhibit 3 presents a summary of the criteria previously adopted to increase reliability of this research's findings.

Exhibit 3. Reliability of the Case Study's Findings

Reliability criteria	Method used in this study
Credibility (to what extent the findings seem to be acceptable representations of the data)	• Research protocol used based on questions referring to literature on resilience in supply chain. • Two researchers collected data simultaneously during the first phase of collection; and all researchers analyzed the data. • A 3-page executive summary of the initial interpretations was held out to respondents for feedback.
Generalization of findings (to what extent the findings of a study within a context are applicable to other contexts)	• Limits for generalization once it is a simple case study based on the supply chain of sugar, biomass energy, biofuels and spirits or soft drinks. • Examples of companies in different links of the supply chain represented by the Farmers, Processers and Buyers triad.
Reliability (extension exclusive to time and place; stability or consistence of explanations)	• Interviewees reported experiences covering the phenomenon studied (drought) and historical data of other serious events. • Data collection in two periods with a one-year interval between them with participation of other informants of the first phase in the second phase of the data collection (except Farmer and Processer 3). • Interviewing more than one subject per company was always possible, but all with more than three-year experience. • Triangulation with association and Government and with documents and observations in the field.
Possibility of confirmation (to what extent the interpretations are the outcome of the participants' information and of the phenomenon instead of the researcher's bias)	• All interviews and documents were analyzed by the authors • Summary of preliminary findings were analyzed by other team members performing as controllers.

Source: Adapted (Flint, Woodruff, & Gardial, 2002; Kaufmann & Denk, 2011)

ANALYSIS OF FINDINGS

The interviews were analyzed by using the CAQDAS (Computer Assisted Qualitative Data Analysis Software), with the N-Vivo software, and were grouped in categories, by using Microsoft Excel to create different tables by following the tactics suggested by Miles, Huberman, & Saldaña (2014) to create significance, such as, for instance, searching for patterns, grouping information, elaborating metaphors, counting, elaborating comparisons, checking relationships among variable "types of collaboration", searching for other variables causing interferences, building up logical replication of evidence and elaborating conceptual and theoretical coherence.

The first data reduction happened for the purposes of selecting, among interviewees' speeches, sentences and/or paragraphs that were actually important to answer the research question (*in vivo* codes). The categories mostly found were: (1) information sharing (absorptive capacity of a partner and incentives to encourage transparency and discourage free agreements), (2) efforts to make joint relationships (ability to identify and assess potential of complementarities and the role performed by organiza-

tional complementarities to access complementary strategic resources), and (3) dedicated investments (duration of contractual guaranties and volume of transactions among the companies).

Information sharing among producers in the sugarcane-energy supply chain is not significant, and none of the participating producers presented any evidence of any partnership made, mainly due to the drought. One of the sugarcane producers, a medium-sized company, used as an example the exchange of sugarcane for vinasse for fertegation because logistic costs of transportation and storage of that product make establishing any collaboration among the chain links impossible.

Although the byproduct is abundantly available to the plants, among them and producers no efforts are made for a joint relationship, except Plant 02, which buys directly from a partner, an agriculture company, in a collaborative way. In the remaining cases collaboration of producers is limited to holding meetings and speeches with associations of regional producers.

As to distilleries, little collaboration was also verified.

The agriculture manager of a large distillery mentions that there was no collaboration to regulate supply during the drought period, mainly due to the strong competition with the remaining plants near the distillery: "we are eight plants around here, see, then there was not collaboration whatsoever, it was a race to come first, it was each one by himself" (agriculture manager of a large distillery).

And still according to that participant, lack of collaboration is caused by historical cultural traits represented by the character of the owners of the first sugarcane-energy plants, the so-called "colonels". According to him, that stance prevents the development of many regions due to competition related to labor, and he alleged that at places where there are many plants there was no other developing industries.

The large distillery's participant managers state that although some groups and research centers have been set up, the sugarcane-energy supply chain remains isolated, its potential is not totally recognized in the global market. Among the barriers to development, in their opinion, there is the government intervention in the sector through subsidies favoring fuel, energy and sugar commercialization.

Not always can the plants take advantage of the benefits to promote long-term integration and structur-

ing. The technical manager of plant 6 confirms the need of more collaboration, and justifies that due to lack thereof some plants have been shut down during the drought, exactly as a result of bad administration and lack of governmental support. Among them, two different scenarios were observed: at the plant not associated to cooperative 2, due to lack of any relationship action with the producer, there were major difficulties with the resulting economic problems (high prices of raw material) and financial ones (lack of capital for investment).

At the plants linked to cooperative 2, on their turn, sharing information took place through joint efforts for relationship, such as periodical meetings and dedicated investments: e.g., infrastructure to store cooperative 2's sugar, available at many plants, pointed out as a competitive advantage for its flexibility and co-location, in addition to information systems developed between cooperative 2 and the associated supplying plants.

One of the participants, an agriculture manager of plant 1, stresses that the information coming from cooperative 2 would circulate only internally in the company, but the use of new technologies related to the internet had helped their fast diffusion to the interested parties in the sugarcane-energy sector.

Plant 3 said that information was shared during the drought among the State Department of the Environment (SMA), Environmental Company of the State of São Paulo (CETESB) and the Department of Water and Electricity (DAEE), at meetings attended by experts of the Sugarcane Technology Center (CTC) to start defining joint plans.

As to buyers, food network 1 says that permanent internal committees were formed to follow the matters related to climate and sustainable use of the water, in addition to external relationships between plants of the food network and their suppliers through debates and assessments. Still in the opinion of the buyers, other organizations represented, such as the soft drink network 1, point out that some of its buyers demand sharing information on products and management of natural resources (which was done through emails both to buyers and to governmental inspection agencies).

Efforts for a joint relationship among companies in the sugarcane-energy supply chain were strongly evidenced between the plants (except for plant 7, not associated) and cooperative 2.

In addition to those pieces of evidence of vertical collaboration, efforts for joint relationship are very common between plants and research center or Institutions of Superior Education (IES), which also strengthen horizontal collaboration. Plant 2 says that it developed, in a partnership with the Superior School of Agriculture Luiz de Queiroz (ESALQ), a new soil systematization, with new technology to prepare and deepen roots: "we worked together with ESALQ, and we drew a new soil systematization and, in parallel, we made that preparation of deep soil, which is a new technology that we brought to the sector" (director of operations, plant 2).

Those efforts for a joint relationship have enabled plant 2 to develop follow-up tools which ease conducting analyses in order to increase predictability of information before making decisions. The director of operations highlighted also that the efforts for a joint relationship among plants, cooperative 1 and association of the industry enable the company to have opportunities to develop partnerships with international non-governmental organizations, such as the "Water Project", in a partnership with the World Wildlife Fund (WWF).

The superintendent of operations of plant 3 highlights another example of efforts for a joint relationship, but with companies outside the sugarcane supply chain targeting on emergencies in case of fire or burning, which are more usual during long dry periods.

The agriculture manager of plant 5 confirms the importance of those partnerships between research centers and superior education institutions focused on developing new technologies for handling varieties of sugarcane in the tillage, more resistant to pests and bad weather caused by the climate. Participant of cooperative 2 points out the Center of Sugarcane Technology (CTC) as an important link in the development of new varieties, although they are not oriented towards commercial demand. As to buyers, food network 1 relies on a research and development center and has contacts with suppliers aimed at creating, among other things, machinery to bottle products according to economic, social and environmental indicators.

And still as to buyers, food chain 1 confirmed that partnerships are made with its suppliers at each new product line launched for the purposes of assessing the use of water, fuel and electricity, among other utilities, thus corroborating the existence of strong vertical collaboration among them. The participant comments that it was necessary to set up standard procedures elaborated based on the response used at the plants in more critical situations.

According to that participant, the drought led to the creation of a permanent group at the holding company in charge of controlling food network 1 and developing several indicators to follow up the management of water resources among the companies of that holding company. He also adds that the relationship does not reach any third parties (considering the triad farmers, processers and buyers) and, for now, there has been only some approximation among suppliers related to that process; nevertheless, there was an alert about the negative impacts of a drought, and proposals started to be made in 2016, but they were not complete during the data collection from July to November 2016).

Finally, about dedicated investments, although there was no mention about the absence of information sharing at the large distillery among processers and producers, investments were pointed out with other partners linked to agricultural production and industrial process. "Everything that we could observe that was important we had already searched for. There are projects with heavy investments and so on, but there is nothing like that, imagine if I had it, no" (large distillery's agriculture manager).

On the other hand, for medium-sized sugarcane producers the companies performing in the sugarcane-energy sector have to be more united and government leadership is missing. The quality manager of plant 7 stresses, in this sense, that there is a bureaucratic barrier and also a decrease in long-term credit lines for renewing sugarcane plantations.

The sugarcane-energy supply chain has low incidence of pests (when compared to other cultures, such as orange, for instance) and in its cultivation it is necessary to work with the dry periods, which are positive up to a point, both for the product quality, once it increases sucrose, and to logistics, i.e., mechanical harvesting, a process that may be unfeasible during the rainy period.

The sustainability manager of cooperative 1 points out that the plant participates in meetings to deal with matters related to quality and sustainability. According to her, her area collaborates internally with the quality sector aiming at implementing actions and qualification, and at mobilizing the plants. Using the information shared with the plants, how-

ever, is relative because ones are more interested than others. Cooperative 2 reported that case studies have been used at the plants with the best practices in order to share information before and during the drought.

Collaboration was used for the following actions at the plants during the response phase: (1) developing technology to concentrate vinasse for fertigation, (2) enhancing practices to handle varieties, i.e., looking for genetic development of sugarcane young plants more resistant to water stress, or yet, (3) innovating

plating processes by using pre-sprouted plants (PSP) and developed in nurseries (meiosis). During the recovery phase were pointed out (4) soil conservation practices, such as systematization of use of terraces to prevent soil erosion and which are able to retain more water to supply the groundwater and, consequently, the springs.

Exhibit 4 presents evidence of the byproducts facilitating collaboration in the sugarcane-energy supply chain obtained in the interviews conducted.

Exhibit 04. Sub-processes facilitating collaboration in the sugarcane-energy supply chain

Aspects determining collaboration	Facilitating sub-processes	Examples Sugarcane-energy supply chain	*In vivo* codification
Relationship-specific assets	Duration of contractual guaranties	Contracts with farmers usually last five years with few sugarcane left for negotiations at the in-cash market	"When the drought came, there was no sugarcane in the market and everybody started panicking " (Agriculture Manager Processer 4)
	Volume of transactions among companies	Plants have contracts with Cooperative 2 for exports and large volumes for the internal market, including the soft drink network 1, which participated in the research, was mentioned	"The major part of our products, mainly sugar, is exported, but there is a volume for the national market, the soft drink network 1, buyer 2, buyer 3, usually are traditional, structured companies and they also are concerned about their supply chain"(Director of Operations Plant 3).

Information-sharing routines	Absorbing capacity of a partner	Plant belongs to an international group with over 100-year experience with international agriculture commodities	"As we have an international partnership controlling us, including crossing information of crops from other regions, Thailand, Australia, as to this aspect we are rather solid" (Superintendent Plant 3).
		Plant points out that the research centers and associations of the industry are important, but they used to have more resources	"Maybe the aspect that could improve a little is the issue of the best practices, benchmarking. The CTC used to play that role" (Director de Operations Plant 3)
		Cooperative Buyer shows that they work with internal relationship once they are inter-functionality oriented	"Actually this is a subject approached by the quality area, where we raise the subject, as we do with sustainability" (Sustainability Manager, Cooperative 2)
	Incentives to encourage transparency and discourage free agreements	Foods network participates in the international program for carbon-emission reduction	"We participate in the CDP, I don't know if you have ever heard of it, it is a global platform where industries declare their strategic plans related to the hydric crises, energy crises" (Sustainability Manager Foods network 1)
		Cooperative 2 holds meetings about more critical matters to prepare action plans together with the cooperated plants	"Then those are actually more critical matters, but the quality also has no direct action on the plants. So they discuss the matter, deal with it and guide what has to be done: let's prepare an action plan" (Cooperative 2).
Complementary capacities and resources	Capacity to identify and assess complementarities' potential	Plant discloses it learned during the drought by searching other sources of improvement	"Crises help you search other sources of improvement. One thing is the crisis, hydric crisis, for instance, the drought which does not depend on you, everybody ends up thinking "what can I do to improve independence from the weather?", and they end up by taking other complementary actions, and when they move, they do not come back to the previous level, they even move to a higher level" (Superintendent Plant 3).

Effective governance	Capacity to use self-application instead of application by third parties of the governance mechanisms	Plants have governance mechanisms in place together with Cooperative 2	"(…) for instance, in the audit's checklist, this environmental issue, social liability, mainly related to the environment, related to the community, how we are dealing with those crises. I mean, we have realized that it started to be something…" (Plant 3).
		Plants have their own norms and certifications	"And there is also the certifications we have, BONSUCRO, green ethanol, directly related to sustainability" Plant 3).
		Cooperative informs that the plants make their own decisions about engaging in actions related to sustainability	"We actually do not have a direct management, and that is why I said that if the plant is not willing to engage, it doesn't engage. Not all of them engage in the same way". (Sustainability Manager Cooperative 2)
	Capacity to use self-applicable formal and informal governance mechanisms	Cooperative 2 has formal and informal self-applicable on cooperated plant suppliers	"There is a formal area in the company which actually raises those pieces of information and is actually in charge of supplying the market, making contact with clients and areas such as quality and sustainability, they deal with the matter more broadly. Then we see the matter, work on it, gather the plants and discuss the importance of the matter, what is to be done, what we could do, we listen to them some and take some information from where we are being charged, from where the matter is gaining importance. There are two different ways of acting" (Cooperative 2)

FINAL CONSIDERATIONS

Comparing the capacity of collaboration of the links in the sugarcane-energy supply chain, buyers have strong capacity of collaborating with plants (processers), observed at all phases of the drought, mainly in the sample studied here which involves, among the organizations participating in this study, a global network of soft drink manufacturers and a cooperative which trades sugar worldwide.

In the case of the plants associated to that cooperative, the collaboration capacity was observed in the examples of information sharing deemed relevant for the chain in addition to joint efforts for relationships, dedicated investments and effective governance representing the status of the practice of collaboration in supply chains (Dyer & Singh, 1998; Nyaga, Whipple, & Lynch, 2010; Paulraj et al., 2012).

The weak link of collaboration lies in the farmers' position (producers), who receive the information shared at meetings, workshops, weather forecasts in the Internet, but without coming closer enough to make joint efforts and dedicated investments, little horizontal and vertical collaboration being highlighted (Barratt, 2004).

In the phase of response to the drought, more approximation was observed caused by the possibility of having some plants shut down. Horizontal collaboration composed by government agencies, sector associations and research centers during that period was strengthened because information was shared, dedicated efforts and investments in monitoring hydrographical basins were made, in addition to researches to develop new plant varieties and preserve water resources.

On the other hand, horizontal collaboration was weakened due to an increase in competition for water resources among plants and distilleries. The findings in this case study of the sugarcane-energy supply chain of São Paulo can be valid within this specific context. Due to the interdependence of the uncertainty and the processes to make economic decisions, future studies can compare organizations located at different regions where they face the drought, in addition to different agribusiness cultures.

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RUDIMENTARY CAUSES AND IMPACTS OF SUPPLY CHAIN RISKS IN SUB-SAHARAN AFRICA

ABSTRACT

Identification of the causes of supply chain risks is a logical step towards its effective management. The purpose of this study is to explore the causes of supply chain risks, their impacts, and the mitigating strategies used among the manufacturing firms in Nigeria. An exploratory qualitative multiple case research methodology combined with the quantitative content analysis is used for this study. A sample of ten manu-facturing firms cutting across three different sub-sectors (Pharmaceutical & Health, Food & Beverage, and Conglomerate) was chosen for the study. Partial and complete open-ended questions in the interview guide were used for the interviews conduct-ed among the respondents. The study revealed the common causes of supply chain risks in manufacturing firms in Nigeria which include; transportation delays, variation in raw material prices and quantities, unexpected customer demands, and constant power outages.

KEYWORDS | Supply chain risk, manufacturing firms, mitigation strategies, developing country context, case study.

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INTRODUCTION

Several studies on sources of supply chain risks and risk management have gained popularity among academics over the years (Blackhurst, Craighead, Elkins, & Handsfield, 2005; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Stecke & Kumar, 2009; Kleindorfer & Saad, 2005; Tang, 2006). For the sake of emphasis, the majority of the recent works in operations management especially the supply chain management literatures are focussed on the developed countries such as Germany and USA (Ambulkar, Blackhurst, & Grawe, 2015; Robb, Xie, & Arthanari, 2008; Beske, Land, & Seuring, 2014; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Heckmann, Comes, & Nickel, 2015; Hofman, Busse, Bode, & Henke, 2014; Oke & Gopalakrishnan, 2009; Scheibe & Blackhurst, 2017; Tang, 2006; Wagner & Bode, 2006; 2008; Wiengarten, Humphreys, & Gimenez, 2016).

Notably, there are disparities in the types of supply chain risks experienced in developing and developed countries. Some environment-specific factors are the reasons for the differences in performance of manufacturing firms in developing and developed countries (Luken, Rompaey, & Zigova, 2008). Despite the effects of globalization on aligning the diverse markets in the developing and developed countries, there are still considerable differences in firms' performances (Onwubolu, Haupt, De Clerrcq & Visser, 1999).

Due to some environmental sources of disruptions as a result of geographical, technological, and infrastructural differences, there is the need to identify the causes of supply chain risks, the mitigation strategies used in managing different risks in manufacturing firms in developing countries, especially in the case of Nigeria. Nigeria is chosen as the developing context investigated. This is because Nigeria has become an important part of the global supply chain due to her large market in the Sub-Saharan Africa (Pigato & Tang, 2015).

The need for academic scholars and practitioners in Nigeria to focus on the Nigerian manufacturing sector in order to ensure notable improvement cannot be overemphasized. There is need to take advantage of the recent diversification from oil and the move away from the mono cultural activities in the country (Uzonwanne, 2015). It is also an important step towards attracting more foreign direct investments (FDIs) in the manufacturing sector in Nigeria and creating aware-ness for investors about potential risk factors in the country. The global interest in Africa at large and particularly, Nigeria has made this research work of great significance. This study focused on identifying and creating awareness about the causes of supply chain risks and supply chain risk management strategies popular to the developing context investigated. Hence, some sources of supply chain risks peculiar to manufacturing firms in Nigeria and the mitigation strategies commonly used in managing different supply chain risks have been identified. In addition, this work also enumerated the impacts of supply chain risks on the manufacturing firms in Nigeria.

As earlier explained, there has been a significant amount of research conducted in the area of supply chain systems among academics but there have been little or none reported on supply chain risk management in relation to the manufacturing sector in Nigeria. Therefore, this work focuses on typical manufacturing-oriented supply chains in Nigeria. The objectives of the study included are three. First, to identify and state the supply chain risks that disrupt the manufacturing operations of firms in a developing context. Second, to identify and state the impacts of supply chain risks on the operations of manufacturing firms in the developing context investigated. Finally, to identify and state the different mitigation strategies used by manufacturing firms in the developing context investigated without considering the fit or matching of supply chain risks with specific mitigation strategies. In this regard, the question answered in this study is " what is the state of the supply chain risks among the Nigerian manufacturing firms". The state of the supply chain risk from this context connotes its causes, impacts, and the different mitigating strategies used to manage the risks with no particular interest in the fit or matching perspectives in this study.

There have been growing research interests in supply chain risk management among scholars in the developed countries with less focus on the developing world's supply chain risk management and manufacturing processes. This gap necessitates the need to account for the developing countries' context in order to examine the peculiar attributes of the environment. Therefore, this study contributes the following to the supply chain risk management literature. First, it explores the phenomenon of supply chain risks emphasizing the root causes and impacts on manufacturing firms from a developing country's context. Second, it investigates and highlights the

different mitigating strategies for managing supply chain risks from a developing country context specifically, Nigeria with no focus on fit or matching dimensions. Hence, the scope of this research study does not include the matching of supply chain risks to their best mitigation strategies for managing them. Third, this study answers the call of making use of content analysis for research which is rarely used in the field of operations management and or supply chain management (Akkermans & Vos, 2013; Chatha, Butt & Tariq, 2015; Flynn, Sakakibara, Schroeder, Bates, Flynn, 1990; Meredith, 1993; Mir, Lu, Cantor, & Hofer, 2018; Turker & Altuntas, 2014).

The rest of this paper contains the following: section two is the literature review of this study. Section three presents the research methodology which comprises the instrument design, sample, data collection and analysis methods. Section four involves the research analysis and discussion and finally, Section five presents the summary of findings, contributions to the literature, areas for future research and limitations.

LITERATURE REVIEW

Supply Chain Risks

Supply chain risks are adverse events that could be anticipated or unanticipated with negative consequences on supply chains (Bode & Wagner, 2015; Hendricks & Singhal, 2003; Svensson, 2000; Tang & Musa, 2011). The utmost outcome of supply chain risk is the shortage of the number of goods produced and or supplied to customers compared to the amount demanded by customers. Moreover, unexpected occurrences that hamper the flow of goods or materials from reaching assigned destinations can also be referred to as supply chain risks (Hendricks & Singhal, 2003; Svensson, 2000). Some negative impacts of supply chain risks have been identified from the developed countries' contexts (Wagner & Bode, 2006). According to Porterfield, MacDonald and Griffis (2012), supply chain risks have negative effects on the stock market and operational performance. On a similar note, supply chain risks can directly affect corporate stock prices by nearly 9 per cent and revenue losses by 20 per cent (Benyoucef & Forzley, 2007). In addition, supply chain risks can have long-term negative effects on a firm's financial performance (Tang, 2006). The significant negative impact of supply chain risk on customers is that the disruption hinders the ability of producing firms from meeting customers' demands as at when due.

Academic scholars are often interested in risks, risk management strategies and their categorization over the years (Stecke & Kumar, 2009; Jüttner, 2005; Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005; Finch, 2004; Oke & Gopalakrishnan, 2009). According to Guedes, Bittar, Di Serio, and Oliveira (2015), risks are many and most commonly reported supply chain risks from the developed countries' contexts are supplier capacity not meeting demand, raw material price increase or shortages, unexpected changes in customer demand, delayed or damaged or misdirected shipments and fuel price increases or shortages. In addition to those mentioned above, there are terrorist attacks, strikes, devaluation of currencies, transportation delays such as port stoppages, accidents, poor communication, spare part shortages, quality issues, major global economic disruptions, natural hazards and cybersecurity failures (Blackhurst et al., 2005; Chopra & Sodhi, 2004; Finch, 2004; Jüttner, 2005; Kleindorfer & Saad, 2005; Stecke & Kumar, 2009; Tang, 2006; Worthington, Collins, & Hitt, 2009).

Hanna and Skipper (2009) in their work assert that supply chain risks cannot be avoided because all supply chains are exposed to risks. This study deviates from the norm by focussing on investigating the root causes and impacts of supply chain risks from a developing country context. Stecke and Kumar (2009), emphasized the need to pay attention to potential risk factors when moving manufacturing plants to developing countries' contexts in Africa and Asia because of the availability of low labour and materials costs. Tang (2006) classified such developing countries' contexts as turbulent environments. Hence, the importance of this study emanates from the evaluation of the causes of supply chain risks and the potential impacts on manufacturing firms from a developing country context in Africa. This supply chain risks evaluation cannot be underestimated.

Mitigation strategies

The efforts towards the management of supply chain risk involve the use of mitigation strategies. Mitigation strategies are defined as strategies put in place to manage anticipated and unanticipated risks in order to reduce or completely eliminate their negative impacts on supply chains (Norrman & Lindroth, 2004). Therefore, it is essential for firms to adopt risk mitigation strategies for managing supply chain risks in order to ensure smooth supply chain systems. Risk management process could be expensive, challenging,

and complex since there are different tiers in a supply chain cutting across the downstream and upstream stages (Bozarth, Warsing, Flynn & Flynn, 2009; Jüttner, 2005; Onwubolu, Haupt, Clercq, & Visser, 1999; Tang, 2006). However, the costs of not managing risks are higher (Benyoucef & Forzley, 2007; Macdonald & Griffis, 2012; Tang, 2006). The achievement of resilient manufacturing operations, cost minimisation and enhanced customer satisfaction are the outcomes of effective risk management strategies (Tang, 2006).

Extant works of literature have emphasized developed countries' contexts specific mitigation strategies. Several categorizations of risk management strategies and philosophies have been developed such as; robust strategies, proactive strategies, advance warning strategies, supply management strategies, demand management strategies, collaboration and co-operation philosophy, contingency tactics, distributed problem solving philosophy, information management strategies, supply chain agility philosophy, coping strategies, and product management strategies (Braunscheidel & Suresh, 2009; Beske et al., 2014; Chan & Chan, 2004; Stecke & Kumar, 2009; Rudberg & Olhager, 2003; Tang, 2006; Tang & Musa, 2011; Wiengarten et al., 2016; Tomlin, 2006). Specifically, some of these mitigation strategies are; postponement, strategic stock, flexible supply base / multiple sourcing, outsourcing, economic supply incentives, flexible transportation, revenue management, dynamic assortment planning, silent product rollover, safe locations and multiple facilities (Christopher & Lee, 2004; Blackhurst et al., 2005; Hanna & Skipper, 2009; Tang, 2006; Lee & Billington, 199; Johnson, 2001). All these studies were carried out in developed countries. Hence, the need to be aware of the mitigation strategies that are used by firms in the developing countries' contexts. The evaluation of the current mitigation strategies used by the manufacturing firms in Nigeria will establish if the strategies in use are adopted and adapted or created to suit the types of supply chain risks experienced. Therefore, this study hopes to bridge the research gap by concentrating on identifying supply chain risks and various mitigating strategies used to manage them from the Nigerian manufacturing perspective with no specific attention to the fit of risks with mitigation strategies.

Manufacturing in developing countries

According to Bozarth et.al. (2009), it is not the geographical location that influences the performance of a plant when compared with other plants but the suppliers' ability to deliver as at when due. In opposition to this view, Bruun and Mefford (1996) asserted that every production system should be tailored to its environment. For instance, just-in-time (JIT) production system may be inappropriate for developing countries because of certain environmental requirements (Oral, Mistikoglu, & Erdis, 2003). This may be partly because of low connectivity, poor information technology and the limited number of people trained to use such technology (Basu, 2004; Dada, 2006). According to Seuring & Müller (2008), in order to achieve a sustainable supply chain, both environmental and social factors should be put into consideration, albeit the ability to make profit is determined by being able to add value to customers consistently.

Some of the attributes of developing countries such as high inflation rate, high interest rate, high costs of technology, high costs of quality systems, low labour costs, high costs of training, high power distance culture, high uncertainty avoidance culture, few numbers of domestic suppliers among others (Oral, Mistikoglu, & Erdis, 2003). Consequently, these unique attributes of developing countries could have interaction effects with supply chain risks, thereby increasing the degree of severity of supply chain disruptions. Moreover, environmental risk sources are external conditions that impact the supply chains negatively such as political instability, macroeconomic uncertainties, shifts in government policies, social uncertainties and natural uncertainties (Jüttner, 2005; Miller, 1992; Miller, 1993; Rao & Goldsby, 2009). It has been found that political instability, macroeconomic uncertainties, shifts in government policies and social uncertainties are common attributes of most developing countries (Feng, 2001; Serven, 2002). Hence, the need to put these factors into consideration when adopting strategies from the developed country contexts.

Bruun and Meffford (1996) confirmed that little or no attention is given to the environment's unique attributes in developing countries in strategy adoption rather strategies are made to conform to those of other industrial countries. This depicts that despite the unique attributes of developing countries, strategies are adopted blindly with little or no consideration for the environmental implications. It is important for developing countries to imbibe research and development strategies that are creative and adapted to their specific business environments

(Kumar & Saqib, 1996). Oyelaran-Oyeyinka, Laditan & Esubiyi (1996) emphasized that the Nigerian industries have the adaptive innovation to account for the bulk of technological change processes. Whereas in actual sense, it is better for the Nigerian manufacturing companies to use creative mitigation tactics that are unique to the environment rather than adopting the tactics used for mitigating supply chain disruption in the developed world. This is because generally, the unique attributes of the developing countries (Jüttner, 2005) would have a way of increasing the severity of supply chain disruptions on firms' performance and the manufacturing sector as a whole.

RESEARCH METHODOLOGY

An exploratory qualitative research methodology, specifically multi-case study is used in this study. There were little or unknown research studies on supply chain risks and management in the developing countries' contexts literature. This necessitates the exploratory nature of the study and it is recommended in production and operations management (POM) research (Akkermans & Vos, 2013; Flynn et al. 1990; Meredith 1993). The case study method is an important research for exploratory qualitative research studies (Yin, 1989; Eisenhardt, 1989). A case study involves comprehensive and exhaustive analysis of respondents in their natural institutional and social work areas (Ghauri & Gronhaug, 2005). The choice of the qualitative research method is based on the purpose of the research, which is to carry out an in-depth study on supply chain risk and its management from the Nigerian manufacturing perspective. This qualitative research method accounted for the choice of a semi-structured interview, a purposive sampling technique and open-ended questions for data collection. Open-ended questions are provided in order to allow the supply chain managers or equivalent managers to express their thoughts without restraints. The use of face-to-face interview as the data gathering tool ensures clarity of responses from respondents through clarifications and detailed explanations (Forza, 2002; Saunders, Lewis, & Thornhill, 2003).

Some previous works on supply chain risks made use of the case study approach (Blackhurst et.al, 2005; Oke & Gopalakrishnan, 2009) where retail and automotive supply chains were the focus respectively. Gimenez (2005), on the other hand, used a multiple-method approach, that is, the survey and the case study methods (as complementary approaches) for investigating the SCM-performance relationship. Jüttner (2005) made use of the explorative quantitative survey method such as postal questionnaires along with a focus group for obtaining data from senior-level supply chain management professionals. Sun, Hsu, and Hwang (2009) conducted a survey method for obtaining data from the manufacturing companies in Taiwan. In addition, Wagner and Bode (2006) made use of the cross-sectional survey for collecting data from top-level executives in logistics and supply chain management positions in Germany. However, because of the need for an in-depth understanding of the supply chain risk phenomenon from the points of view of the participants in their particular social and institutional work settings, the multiple case research methodology is found suitable for this study. This qualitative research method helped in examining the overall picture of the causes, impacts of supply chain risks and the risk management methods among manufacturing firms in Nigeria.

Instrument Design

The research instrument used in this study is an interview guide. The interview guide consists of standardized and pre-arranged open-ended questions that help in data gathering from different respondents (Kotzab, 2005). A brief introduction on the aim of the research and the definition of the key subject "supply chain risk'' was given in the guide. This was to ensure that the respondents have the good understanding of the phenomenon under consideration. All the questions in the interview guide were coined from extant studies (Craighead et.al, 2007; Elkins, Handfield, Blackhurst & Craighead, 2009) but rephrased in order to ensure that the uniqueness of the study under consideration is ascertained based on the recommendations from academic and management experts. This prior consultation with academics and managers in the area of supply chain management helped in refining the interview guide to suit the context investigated.

The interview guide in all contains three questions which are divided into three segments. One of the segments is related to identifying the causes and impacts of supply chain risk. The second segment was related to the identification of the mitigation strategies for managing supply chain risks. The third segment is focused on the personal details of the respondents.

Sample, data collection and validation

The manufacturing firms chosen are publicly quoted. The publicly quoted manufacturing firms are chosen because they are regulated by the Security and Exchange Commission (SEC) in Nigeria. This regulatory body requires the firms to observe certain procedures and as such, they are highly monitored. This tends to increase the quality of data obtained for the study. There are 3 different manufacturing subsectors among the publicly quoted firms sampled which are Conglomerates, Pharmaceutical & Health and Food & Beverage. A total of ten manufacturing firms were analysed in all which is adequate to give a detailed understanding of the supply chain risk phenomenon. Moreover, qualitative researches emphasize the detailed and in-depth study of small samples because relevance is given priority above representativeness. (Flyvbjerg, 2006).

Most of the firms are major players in their respective sub-sectors. The approximate size of the firms (using employees' size) ranges from 200 to 4000 in number (Table 1). The respondents' designations cut across four major positions which are operations, logistics, supply chain and purchasing departments. This is the case because of the absence of distinct department called supply chain department or properly defined job titles in some of the firms. The years of experience of the respondents in their respective positions ranges from at least 10 months to 10 years.

Table 1. Characteristics of the manufacturing firms and respondents

FIRMS	RESPONDENT'S DESIGNATION	NUMBER OF YEARS IN POSITION	SUB-SECTOR	APPROXIMATE SIZE OF COMPANY (EMPLOYEES SIZE)	OWNERSHIP STRUCTURE OF COMPANY
A	Purchasing Manager	7 years	Food & Beverage	>1000	Joint venture but mainly locally owned
B	Supply chain manager	4 years	Food & Beverage	200	Joint venture
C	Head logistics	7 years	Food & Beverage	1200	Joint venture
D	Head of operations	5 years	Pharmaceutical & Health	465	Joint venture
E	Logistics manager	8 years	Pharmaceutical & Health	500	Joint venture
F	Purchasing manager	3 years	Pharmaceutical & Health	263	Wholly local
G	Logistics manager	10 months	Conglomerate	>1000	Joint venture
H	Supply chain manager	3 years	Conglomerate	>3000	Joint venture but mainly locally owned
I	Supply chain manager	8 years	Conglomerate	1200	Joint venture (51% foreign,49% local)
J	Purchasing manager	10 years	Food & Beverage	4000	Joint venture (70% foreign,30% local)

The manufacturing firms are given pseudonyms in order to maintain their anonymity. The firms are named in alphabetical order based on their real names. They are also named using alphabets from A to J. At least one firm was chosen from the sub-sectors under consideration. One of the criteria used for choosing the firms is based on the years of operation. Manufacturing firms with long years of existence, that is, at least a decade are the ones selected. Such firms tend to have well-established supply chain process and have a good understanding of the phenomenon under consideration based on experience. Another criterion used in choosing the firms is based on the firms' focus on Fast Moving Consumer Goods (FMCGs). FMCGs are products with an expected high rate of turnover, therefore firms that produce such goods are expected to have well-established supply chain process from suppliers through to end consumers (Ghosh, 2015). In addition, FMCG supply chain is an amalgam of intertwined parties such as suppliers, manufacturers, logistics service providers, warehouses, distributors, wholesalers, retailers and consumers.

An important means of validating the data, that is, ensuring credibility in a qualitative research is through the use of a suitable sampling technique (Long & Johnson, 2000). The study was conducted through ten supply chain managers or equivalents from the manufacturing firms selected. This sample size of respondents is credible as respondents are chosen based on purposive sampling technique which allows for concise information to be obtained which translates to quality data, hence, the credibility of this study (Jette, Grover & Keck, 2003; Jüttner, Peck, & Christopher, 2003; Taps & Steger-Jensen 2007; Morse, 2000). In agreement with the aforementioned, eight or fewer informants provide theoretical saturation in a qualitative study (Strauss & Corbin, 1998).

The interviews began with some sets of open-ended questions from the interview guide. Respondents were probed and encouraged to provide detailed explanations and clarifications where necessary (Harris & Brown, 2010). The idea at the outset was to tape the interview sessions but because of the firms' refusal of the audio recording method, the text documenting method was resorted to. Most of the respondents explained that the interview questions were strategic. Due to this consistent claim, the respondents were assured of using the data for research purpose only, the confidentiality of their personal details and that of their firms in order to

ensure trust. This made the respondents more comfortable with the research and thus, helped in getting better responses from them. An average interview session lasted for about 2.5 hours.

RESEARCH ANALYSIS AND DISCUSSION

For the research analysis, the manual method is used for coding and analyzing the data collected through the interviews conducted. The use of the manual method is justified since the researcher is responsible for choosing the codes, themes and concepts based on the available data from outset (Bernard, 2013). This is necessary since the researcher is familiar with the data and is responsible for selecting the appropriate codes. Hence, personal involvement of the researcher is key to ensuring good analysis at the different phases from data collection through to analysis (Ghuari & Grϕnhaug, 2005; Kotzab, Seuring, & Müller & Reiner, 2005).

Four basic stages are followed in this study. Stage one involves transcribing of the semi-structured interview by summarizing the transcripts. In stage two, texts were coded by breaking down, examining, comparing, conceptualizing of data that yielded concepts that were further categorised. In stage three, three themes were established for each category of data collated by linking similar concepts after comparison. The final stage is composed of linking themes with some important quotations from respondents that were selected to support points for presentation in clear, coherent and concise manner (Eisenhardt & Graebner, 2007; Eisenhardt, 1991). In this study, the coding process is based on the themes established (Irvine, Warber, Devine-Wright, & Gaston, 2013). There are three established themes from the work which are particularly related to the important concepts in this research work which are: first, the causes of supply chain risk; second, mitigating strategies for managing supply chain risks and third, impacts of supply chain risks.

Thematic Analysis and Findings

In this study, quasi-statistics as a content analysis technique is used (Hsieh & Shannon, 2005). The quantitative content analysis approach involves analyzing texts in quantifiable forms and this method has been used in several studies (Cho & Lee, 2014; Harwood & Garry, 2003; Krippendorf, 2013; Lock & Seele, 2016; Priest, Roberts & Woods, 2002). This

method of analyzing qualitative research involves examining the frequency of repetition of concepts or terms from the different responses of the respondents (Becker, 1970; Holder-Webb, Cohen, Nath & Wood, 2009; Wu, 2008). Word counts as a quasi-statistics and a summative content analysis technique bring out the number of times of occurrence of ideas and their patterns in field notes and responses to open-ended questions (Denzin, 2005; Hsieh & Shannon, 2005). In this study, "word count" is used to analyse the responses under the three major themes.

Theme 1: Causes of Supply Chain Risks

A proactive investigation and examination of potential supply chain risks in an environment is a justifiable step towards their effective supply chain risk management. This is based on the logical perspective that there is no need waiting for occurrences of disastrous events before preventive mechanisms can be put in place. Hence, using the information obtained from the interviews conducted in the ten manufacturing firms, there are a number of supply chain risks that are predominant in the developing country context investigated, which are; variation in raw material prices and quantities, transportation delays such as port delays, unexpected changes in customer demand, constant power outage and related variation in fuel price and quantity, poor communication and poor visibility of the supply chain, quality issues, accidents, political instability, seasonality of inputs, devaluation of currencies that negatively affects the price and schedule of imported raw materials, natural disasters, strikes and major global economic disruptions such as recession.

Table 2. Manufacturing Firms Responses to Causes of Supply Chain Risk

Supply Chain risks	SUB-SECTORS			Total in Agreement (%)
	Pharmaceutical & Health (%)	Conglomerate (%)	Food & Beverage	
a .supplier capacity not meeting demand	20	20	0	40
b. variation in raw material prices and quantities	30	10	20	60
c. unexpected changes in customer demand	20	20	10	50
d. incessant power outage	15	15	40	70
e. variation in fuel price and quantity	0	0	30	30
f. terrorist attack	0	10	0	10
g. strikes	0	0	10	10
h. devaluation of currencies	20	0	0	20
i. transportation delays	15	15	40	70
j. accidents	0	0	10	10
k. natural disasters	10	0	0	10
l. poor communication	10	0	10	20

m. theft	0	0	0	0
n. quality issues	10	20	10	40
o.major global economic disruptions	10	0	10	20
p .political instability	20	0	20	40
q. fire	0	0	0	*0*
r. seasonality of inputs	10	0	0	*10*
s. hoarding of inputs	0	0	0	*0*

Based on the frequency of occurrence, among the causes of supply chain risks identified, transportation delays, constant power outages, variation in raw material prices and quantities, and unexpected changes in customer's demand have the leading counts of 70%, 70%, 60% and 50% respectively based on the informants' responses. These are followed by supplier's capacity not meeting demand and political instability based on the manufacturing firms analysed (Table 2). Some of the key respondents asserted the following: respondent A from firm A explained that "transportation delays are caused by bad roads and poor road networks and that raw materials are delayed because of transportation issues". Respondent C from firm C also puts forward that "poor power supply leads to increase in the use of diesel for generating sets coupled with exorbitant bills from the institution in charge of public electricity supply in Nigeria". Respondent F from company F stated that "transportation of raw materials from Lagos port takes a whole day because of bad roads and poor road networks." Respondent G from firm G said that "we experience a sudden surge in demand and incorrect information about orders leading to stock-outs" Respondent J from firm J mentioned that "seasonal availability of raw materials and frequent changes in prices are disruptive to production as a manufacturing firm."

This exposition also revealed that transportation delays and incessant power outages (Table 2) are the major causes of supply chain risks among the Nigerian manufacturing firms considered followed by variations in raw material prices and quantities and unexpected changes in customers' demand. Terrorist attack, strikes, accidents and the seasonality of inputs are the least causes of supply chain risk respectively. Some of the specific kinds of transportation delays accounted for involve shipment delays due to trans-shipment, poor road network nationwide, unnecessary delays at the port such as port clearance delay, long distances of sources of raw materials among others. The type of transportation delays with the highest prominence among the listed are the port delays according to the respondents. Inadequate power generation and vandalism are some of the factors responsible for the poor power supply in the country. Some of the respondents opined the following: respondent B from firm B stated that "port delays caused by poor documentation and bureaucracy result in demurrage, delayed production and disgruntled customers". Also, respondent G from firm G explained that "transportation delays and constant poor power supply are the major factors that affect production in the firm"

Theme 2: Impacts of supply chain risks

The attention to impacts of risks on performance is gaining prominence among academics and professionals (Hanna & Skipper, 2009: Hendrick & Singhal, 2003; Hendrick & Singhal, 2008; Hendrick, Singhal, & Zhang, 2009). This serves as a motivating factor towards employing prompt responses to supply chain risks by making use of effective supply chain risk management strategies. Based on the interviews conducted in this study, the impacts of supply chain risks in Nigeria are:production delays, inability to meet customer's demand, forfeited opportunities in markets, negative stock market responses and reduction in shares value, increased production costs, stock out, quality compromised goods, and vulnerability/exposure of the supply chain.

Table 3. Manufacturing Firms Responses to Impacts of Supply Chain Risk

Impacts of Supply Chain Risks	SUB-SECTORS			Total in agreement (%)
	Pharmaceutical & Health (%) (%)	Conglomerate (%)	Food & Beverage (%)	
a. production delays	15	25	50	90
b. corporate and network wide risk exposure	10	0	0	10
c. reduction in shares value	20	0	10	30
d. influx production of quality compromised goods	20	30	20	70
e. increase in costs	20	20	20	60
f. inability to meet customer's demands	35	30	35	100
g. stock outs	30	20	10	60
h. ineffective decisions	0	0	0	0
i. forfeited market opportunities to competition	20	35	35	90

Using the word counts method, the impacts of supply chain risks in the Nigerian manufacturing firms based on the study at hand revealed that production delays, influx of quality compromised goods, inability to meet customer's demand and forfeited opportunities in the market to competition with 90%, 70%, 100% and 90% frequency in percentages are the major impacts of supply chain risks respectively (Table 3). Quality compromised goods are goods that do not meet the stipulated quality standards.

The impacts of supply chain risks with the least counts are entire supply chain risk exposure, negative stock market responses and the reduction in shares value. The problem of unavailability of raw materials for production will result in production delay and inability to meet customers demands as at when due. This results in the loss of market share to counterfeit products because of porous borders. Some respondents put forward the following views: respondent F from firm F explained that "power issues increase their production costs since the firm relies on generators most of the time as an alternative source of power". Respondent I from firm I stated that " constant fluctuating and low voltage of power damaged the expensive, major production machinery that was imported from Germany causing outright production delay and inability to meet orders". In addition, respondent E opined that " the use of an independent source of power by the firm for an average of 8-10 hours a day adds to the overhead costs"

Theme 3: Mitigation strategies for managing supply chain risks

Mitigation strategies help firms to reduce costs, improve customer satisfaction and ensure sustainable manufacturing operations (Tang, 2006). Based on the face to face interview conducted with respondents, the mitigation strategies for managing supply chain risks in manufacturing firms in Nigeria are:the use of control systems, multiple sourcing strategy, the use of strategic stocks, flexible transportation, monitoring trends, outsourced manufacturing, collaborative planning with supply chain partners, supply chain redesigning, secured communication links, increasing transportation viability,choice of safe locations, enhanced visibility and communications, and the use of multiple facilities.

Table 4. Manufacturing Firms Responses to Mitigation Strategies for Managing Supply Chain Risks

Mitigation Strategies	SUB-SECTORS			Total in agreement (%)
	Pharmaceutical & Health (%)	Conglomerate (%)	Food & Beverage (%)	
a. control systems	20	10	20	50
b. supply chain redesign	10	10	20	40
c. awareness, prevention, remediation and knowledge management	20	0	20	40
d. Multiple sourcing strategy	30	35	35	100
e. postponement	0	0	0	0
f. strategic stock	20	20	30	70
g.flexible transportation	20	0	40	60
h. silent product rollover	0	0	0	0
i.safe locations	10	0	0	10
j.secured communication links	10	0	10	20
k. enhanced visibility and coordination	10	0	10	20
l.increase transportation viability	10	10	20	40
m.monitoring trends	15	15	40	70
n.multiple facilities	0	0	10	10
o.outsourced manufacturing	15	30	20	*65*
p.influence customers' choices	0	0	0	*0*
q.product variety	0	0	0	*0*
r. collaborative planning	0	20	20	*40*

Using the quasi-statistics, among the mitigating strategies employed in the Nigerian manufacturing firms, both multiple sourcing strategy and outsourced manufacturing are most prominent with 100% and 75% counts in agreement with these strategies respectively. These are followed by the use of strategic stock, monitoring of trends and flexible transportation respectively (Table 4). On the other hand, the use of postponement, silent products rollover, influencing customers' choices and product variety strategies are the least adopted strategies among the Nigerian manufacturing firms. The prevalence in the use of multiple sourcing strategy among the manufacturing firms is because of unavailability of locally sourced raw materials. Outsourced manufacturing is also becoming common as a risk management strategy to reduce the negative impacts of constant power outage and transportation issues associated with inbound logistics. Some of the respondents stated the following: respondent D from firm D explained that " as a firm, they encourage the use of many suppliers because they do not want to depend on only one supplier in order to prevent stock out and raw materials are rationed among the suppliers based on availability" Also, respondent E from firm E mentioned that "they outsource production to a Chinese firm and

import the finished products back in the country because it was realized that it is cheaper for to manage instead of experiencing incessant power outages and poor local supplies of raw materials locally". Respondent G from firm G explained that "in their firm, they hold up to 1-3months stocks of raw materials in the warehouse on a constant basis to ensure continuous production".

SUMMARY OF FINDINGS AND CONCLUSIONS

In this qualitative study, the causes of the supply chain risks have been enumerated based on the sampled manufacturing firms in Nigeria. In addition, the impacts of the supply chain risks and the mitigating strategies used to manage these risks have been investigated.   In concluding the study, the findings from the work are summarized in order to indicate the areas of contribution to existing literature, limitations, practical implications and finally, the areas for further research are stated.

Summary of Findings and Contributions

This research study has investigated the causes, impacts and the strategies adopted to manage supply chain risks from a developing country context especially in Nigeria. The need for this study arose from the fact that most of the studies addressing supply chain risks are concentrated on the developed countries' contexts (Bode & Wagner, 2006; Bode & Wagner, 2008; Oke & Gopalakrishnan, 2009). This study is carried out in order to fill this gap by concentrating on a developing country, that is, Nigeria. Therefore, this study investigated and enumerated the main causes of supply chain risks, their impacts and the mitigation strategies for managing supply chain risks.

From extant literatures, causes of supply chain risks are vast ranging from man-made, natural, firm internally generated and externally generated risks such as supplier capacity not meeting demand, unexpected changes in customer demand, terrorist attack, strikes and natural disasters and excess machine downtime (Blackhurst et al., 2005; Kleindorfer & Saad, 2005; Tang, 2006; Stecke & Kumar, 2009; Worthington et al., 2009).

Consequently, in a bid to contribute to extant literature and the need to focus study on the developing countries in the area of supply chain risk, an in-depth qualitative study of ten manufacturing firms in Nigeria produced the following findings; that the causes of supply chain risks common to the Nigerian manufacturing firms are not different from those experienced in developed countries except for transportation delays emanating from port delays, bad roads, poor road networks and poor power supply. Among the supply chain risks in this developing country context, transportation delays, variations in raw material prices and quantities, constant power outage and unexpected changes in customers' demand are the major causes of supply chain risks among manufacturing firms. In comparison with the extant literature from developed countries contexts, transportation delays and incessant power outage are the peculiar causes of supply chain risks in this developing context.

The impacts of supply chain risks from developing countries' contexts are in congruence with those from the Nigerian manufacturing context such as the inability to match the demand of the market to that supplied by a manufacturing firm, stock-outs and quality issues (Benyoucef & Forzley, 2007; Hendricks & Singhal, 2008; Porterfield et al., 2012; Tang, 2006). However, our findings showed a certain deviation from the developing countries' context which is the influx of quality compromised goods or counterfeit brands as the unique impact of supply chain disruptions because of the country's porous borders. Furthermore, the influx of quality compromised goods, production delay and inability to meet customer's demands are the major negative effects of supply chain risks in Nigeria.

An exhaustive research on mitigation strategies revealed that the mitigation strategies employed to manage supply chain risks from extant literature and mostly from the developed contexts are similar to those used in the developing country investigated such as multiple sourcing strategy, safety stock, postponement and strategic stock (Choi & Liker,1995; Craighead et al., 2007; Lee & Billington, 1993; Lee & Christopher, 2004; Stecke & Kumar, 2009; Tang, 2006). However, among the mitigation strategies, the most popular mitigation strategies employed in the Nigerian manufacturing firms, include; multiple sourcing strategy and outsourced manufacturing whereas the least employed strategies are postponement, silent products rollover and influencing customers' choices. In comparison to the developed contexts, outsourced manufacturing is now trending in the manufacturing sector

because of the prevalent issues of transportation delays, constant power outages and the associated costs. Interestingly, the use of multiple sourcing strategy and outsourced manufacturing is common to all the manufacturing sub-sectors selected.

It has been confirmed in extant researches that the occurrence of supply chain risks is inevitable (Hanna & Skipper, 2009). Thus, this study has created more insights and awareness for incumbent manufacturing firms to know the causes of supply chain risks, the possible impacts and the mitigating strategies that can be used in managing the supply chain risks in Nigeria. On the other hand, it has also created an eye-opening information for potential entrants into manufacturing businesses to be aware of the possible supply chain risks that are prevalent among manufacturing firms in Nigeria. Therefore, this study will help manufacturing firms to be pro-active in combating supply chain risks in Nigeria.

In general, this study contributes to the literature by concentrating on a developing country context and by examining the phenomenon 'supply chain risk' in the following ways: First, this study elaborates the causes of supply chain risk, the impacts of supply chain risks and the mitigating strategies in the Nigerian manufacturing firms. Second, this study shows some similarities between the developing and developed countries' contexts on the causes of supply chain risks, their impacts and the mitigating strategies for managing risks. Third, some peculiar causes and impacts of supply chain risks are highlighted in the study. To elaborate further, the occurrence of transportation delays are prominent in Nigeria because of excessive focus on road transportation, bad roads and associated inadequate road networks. Also, the problem of incessant power outages is common. Hence, these two factors contribute to the increased trend in the use of outsourced manufacturing as a mitigation strategy among the manufacturing firms. Since outsourced manufacturing allows firms to contract production to other firms who have expertise in managing the supply chain issues efficiently locally or in a geographical location where the supply chain risks are not existing. This is because the high cost of truck maintenance due to bad roads and independent power supply will increase the overhead costs of production. In addition, the influx of quality compromised goods that are imported or find their way in through the porous borders or those internally produced from poor quality raw materials in the

country is a unique impact of supply chain risks in Nigeria. It was also confirmed that the mitigation strategies used by manufacturing firms considered in this study to manage supply chain risks are adopted from the developed countries. This confirms the assertion by Bruun and Meffford (1996) that developing countries do not create strategies but mostly adopt and conform strategies used in developed countries to their environments.

In this study, we had certain limitations common to other research studies. First, the number of manufacturing firms interviewed was just ten. This is a small number compared to the number of manufacturing firms in Nigeria. On the other hand, the number is justified in that a qualitative study is about an in-depth study of a phenomenon (in this case, supply chain risk). Second, only one respondent was interviewed per manufacturing firm. This is sufficient in so much that the purposive sampling technique is used in this study. This is because the best informants that are knowledgeable with the valid assessment of the supply chain risk phenomenon are the supply chain managers or their equivalent managers in this regard (Jüttner, Peck & Christopher, 2003; Jette, Grover & Keck, 2003). Third, all the manufacturing companies selected are situated in Lagos State, Nigeria. This is justifiable because most of the vibrant manufacturing firms in Nigeria have their Head Offices in Lagos because of its commercial inclination. Therefore, the manufacturing firms in Lagos are good representatives of the firms in Nigeria. Fourth, the data collection via interview mode was the only method used beacause archival data on the phenomenon investigated were not available. Also, the generalizability of this study is limited since the developing country context investigated is only Nigeria.

Finally, this study puts forward possible areas for further research. First, this qualitative study could be analysed by using other quantitative techniques. Similar studies could also be carried out in other developing countries' contexts for the basis of comparison. Second, the unique supply chain risks to the manufacturing sub-sectors could be analysed. Third, it could be interesting to find out which industry is more prone to supply chain risks. Fourth, the effects of the mitigating strategies could be quantified in terms of the benefits and costs. Also, the fit of the mitigation strategies to specific supply chain disruptions could be analysed in this context.

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DO ANALYTICALLY-ORIENTED SUPPLY CHAINS BETTER MANAGE RISKS?

ABSTRACT

Risk management has emerged as a field of operations management research due to the greater exposure of organizations to internal and external risks, as a result of globalization, outsourcing, reduction in the number of suppliers, and the need to im-prove cost and inventory management. Although this subject has received attention in recent years, the relationship between analytical orientation and supply chain risk management is little explored. Thus, this research verifies the impact of analytical ori-entation over supply chain risk management. A questionnaire was applied with micro, small and medium-sized firms of Brazilian Southeast region, obtaining 111 responses. The structural equation modeling was used for analysis and the main conclusions in-dicate that analytical orientation has a strong and significant impact over supply chain risk management. In this sense, those supply chains that are more analytical manage their risks better, resulting in lower perception of uncertainty.

KEYWORDS | Supply chain risk management, analytical supply chains, analytical orientation, uncertainty, structural equation modeling.

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INTRODUCTION

In today's turbulent and uncertain environment, every company in the supply chain is susceptible to an endless number of events that can disrupt or interrupt its operations (Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scavarda, Ceryno, Pires, & Klingebiel, 2015; Sheffi & Rice Jr., 2005; Skipper & Hanna, 2009). Knowing that these events affect performance and can be devastating to the members of the chains (Blackhurst, Craighead, Elkins, & Handfield, 2005; Chen, 2018), the discussion about risk management in supply chains has grown globally both in the academic and professional arena for its potential to protect companies and chains from the negative effects of internal and external risks (Aqlan & Lam, 2015; Fahimnia, Tang, Davarzani, & Sarkis, 2015; Fan & Stevenson, 2018; Jüttner, Peck, & Christopher, 2003; Mohammaddust, Rezapour, Farahani, Mofidfar, & Hill, 2017).

Although the literature explores several factors as drivers of risk management efficiency, such as visibility, collaboration and flexibility (Kilubi & Haasis, 2015; Lavastre, Gunasekaran, & Spalanzani, 2012; Li, Fan, Lee, & Cheng, 2015; Nooraie & Parast, 2015; Tang, Matsukawa, & Nakashima, 2012; Tang & Musa, 2011; Thun & Hoenig, 2011; Wiengarten, Humphreys, Gimenez, & McIvor, 2016; Zhao, Huo, Sun, & Zhao, 2013), the impact of the chains' ability to collect, analyze and transform data into useful knowledge, in order to make decisions based on facts and data, that is, to be analytically oriented, is a point not yet explored in the literature when it comes to the use of this analytical capabilities to optimize risk management results.

The analytical approach involves the use of fact-based management to guide management decisions and actions (Ladeira et al., 2016). In this sense, being analytical allows companies to maximize decision-making processes by developing the organization's analysis and response capacity, providing better results, and generating value and efficiency in decision-making (Davenport, 2006; Davenport, Harris, De Long, & Jacobson, 2001; Laursen & Thorlund, 2010).

Therefore, analytical chains are those that provide members with useful information, compiled from the immensity of data collected, which facilitates decision-making (Sahay & Ranjan, 2008). In this sense, it is understood that if the chain is analytically oriented, it will be more efficient in identifying,

evaluating, and devising strategies to mitigate and control risks, avoiding the negative impact of unwanted events.

Thus, the present research has one main objective: verify the impact of supply chains analytical orientation on supply chain risk management (SCRM). The following aspects are also explored: a) the uncertainty perception according to both, analytical orientation and risk management levels; b) the levels of analytical orientantion and supply chain risk management considering firms size.

By proposing and testing a model to verify the existence of a relationship between these two important and emerging topics in the current literature, the research aims at presenting elements that will allow organizations to increase the efficiency of their risk management efforts, avoiding the negative effects that disruptive and disturbing events may entail. Moreover, we propose that chains with higher levels of analytical orientation and better risk management process tend to perceive less uncertainty in relations amongst their members. We also aimed at contributing with scales used to measure these two emerging constructs in the literature.

After this brief introduction, the theoretical framework will be presented, conducting a discussion on risk management, followed by an approach involving analytical orientation in supply chains. In the sequence, a conceptual model will be proposed to verify the constructs' relations. Finally, reflections about the model, data analysis and conclusion, as well as research limitations and suggestions for future studies are presented.

LITERATURE REVIEW

The theoretical framework will address the issues of supply chain risk management, analytical supply chains, uncertainty and the construction of research hypotheses.

Supply chain risk management

Organizations have realized the need to manage risks in order to mitigate and prevent them for some time. Despite its relevance, management of supply chain risks is still an unexplored issue in the Brazilian scenario and relatively new on the world stage (Tomas & Alcantara, 2013; Oliveira, Espindola, & Marins, 2017, Fan & Stevenson, 2018).

Supply Chain Risk Management (SCRM) consists of identifying, assessing and controlling internal and external risks that may affect chain performance to eliminate or reduce the likelihood or impact of events that may disrupt the operations of chain members (Jüttner, Peck, & Christopher, 2003; Sodhi, Son, & Tang, 2012).

Unlike traditional risk management, focused on the organizational level alone, SCRM understands that links make organizations dependent on one another and therefore assumes a wider perspective considering the sources of vulnerabilities. Thus, it is focused on the risks associated with the chain, as well as how collaboratively chain participants can manage them (Hallikas, Karvonen, Pulkkinen, Virolainen, & Tuominen, 2004; Thun & Hoenig, 2011). In sum, management of risks in supply chains is constituted by the intersection of theories of risk management and supply chain management (Zsidisin & Ritchie, 2009).

According to Lavastre, Gunasekaran and Spalanzani (2012), SCRM is the combination of three elements: the risk attitude, the instruments used in management, and the techniques used to minimize them. The authors' study pointed out that organizations, when confronted with risks, seek to manage them along with other members of the chain. Thus, transferring the risk and managing it individually, are strategies with little acceptance by managers, considering the French companies studied.

Though being a recent issue, it can be said that there are four main stages of SCRM, typical in most of the literature, namely: (1) risk identification, (2) risk assessment, (3) risk control, 4) risk monitoring. We will define each of them below.

(1) Risk identification: Fundamental and initial phase of risk management in supply chains. The risk events can be identified on an individual company or in chain relationships. Since they may interrupt or disrupt the operations of members of the chain, it is necessary to evaluate them and propose strategies to manage them (Aqlan & Lam, 2015; Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009). It is also necessary to identify the connectivity between risks, considering that approaching them individually and developing strategies to mitigate specific risks can increase the probability and the impact of

another (Chopra & Sodhi, 2004).

(2) Risk assessment: Procedure performed to classify each risk identified in step (1) on the basis of probability and impact, in order to elaborate appropriate control strategies (Aqlan & Lam, 2015; Giannakis & Papadopoulos, 2016; Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009).

(3) Control / risk management: This stage consists of developing and implementing, along with members of the chain, strategies to mitigate or prevent the occurrence of risks (Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009). The commonly used strategies are: risk transfer, risk taking, risk elimination, risk reduction, and other individual analyzes of risks (Giannakis & Papadopoulos, 2016; Hallikas et al.; 2004). For Thun and Hoening (2011), risk management tools can be divided into reactive and proactive. While proactive tools are focused, most commonly, on reducing the likelihood of occurrence of unwanted events; reactive tools seek to mitigate the negative impact.

(4) Risk monitoring: It monitors SCRM progress of, adding or removing risks from the risk checklist and making new assessments, that is, taking corrective measures according to changes in the technological environment, in the chain, in the customer needs, among others, in order to verify if it is possible to reach the desired level of performance (Hallikas et al., 2004; Tummala & Schoenherr, 2011).

SCRM, if well elaborated, makes it more difficult to interrupt the organization's operations due to interruptions in the chain, and also prepares them for the occurrence of risks, making them safer and less vulnerable (Norrman & Jansson, 2004). Thus, Li et al. (2015) found that risk sharing mechanisms, as well as risk information sharing, are important for risk management in supply chains, i.e., joint efforts to manage risks, associated with the chain, result in better financial returns for organizations.

It is assumed that risk management should be managed jointly with chain members, and an efficient SCRM, as discussed in this section, is capable of identifying, assessing, mitigating and monitoring the associated risks and, therefore, will be measured as such, according to Exhibition 1 below.

Exhibition 1. Measurement Scale for Supply Chain Risk Management (SCRM)

1. Risk management in supply chains (Reflective)	
Items	**Questions**
S1	It has formal processes to identify risks.
S2	Strategies are implemented to minimize the impact of risks.
S3	Risks are often assessed by ours members.
S4	Risks are often monitored by ours members.

Analytical supply chains

Satisfactory decision making within the organizational context is not an easy task, requiring analytical skills from individuals, organizations and networks of organizations to process information, look for alternatives, and predict consequences for designing actions (Simon, 1979). In this scenario, the use of data has become as ubiquitous as the need to use analytical methods and processes to extract useful information. Therefore, it is precisely from this need that the studies on the subject emerge *Analytics*.

The terms *Business Intelligence* (BI), *Business Analytics* (BA) and *Big Data Analytics* (BDA) are often used in similar and even interchangeable contexts. Although they present common characteristics, it is possible to delineate some differences that need to be made clear to avoid confusion among the concepts. Davenport (2014) differentiates these terms from a historical perspective. BI focuses on tools to support data-driven decisions, with emphasis on extracting information and reporting. On the other hand, BA encompasses the use of statistical and mathematical skills, aligned with IT skills and business insights for decision-making. Recently, the term Big Data has become more popular because of the large amount of data, structured or unstructured, produced continuously, that can be used to discover hidden patterns, correlations, and useful information.

We define *Business Analytics* (BA) based on Laursen and Thorlund (2010), as "making the right media available for decision at the right time and for the right people", and it can be seen as an information system composed of: technological elements responsible for collecting, storing and providing information; human skills; and business processes. If all organizations can access some information through simple statistical techniques, the analytical skills go even further, because, combined with information systems; they provide more sophisticated information (Davenport, 2006).

However, as pointed out by Davenport et al. (2001), sophisticated analysis tools as well as investment in technology are not enough for organizations to transform data into knowledge, hence into value, and the human capacity to analyze, interpret, generate and act on the insights is critical to drive results from this complex process of transformation.

This thought is aligned with the arguments by Laursen and Thorlund (2010) that emphasize the importance and responsibility of decision makers to analyze the information obtained through information systems and turn them into useful knowledge to improve or develop business processes and, consequently, to generate value.

Therefore, analytical capabilities consist of a set of analytical methods and tools (Acito & Khatri, 2014), involving statistics, information technology and business knowledge that provide the opportunity to deliver large volumes of data through organization, availability, analysis and interpretation, taking into account the reality and the specifics of the business, enabling a rapid response to environmental changes (Teo, Nishant, & Koh, 2016).

Once organizations have used analytical tools such as statistical and quantitative data analysis, explanatory models, and data analysis for decision-making, business processes will be affected by changes and reorganizations, making routines more efficient and generating more value than at an earlier time (Bronzo et al., 2013). However, this requires structuring of collected data for them to be transformed into analytical knowledge, which can be fully explored and used in decision-making processes.

The study of Davenport (2006) with 32 organizations found that analytical capabilities provide organizations with mechanisms to enable them to improve pricing, identify potential customers and develop new products. Similarly, Bronzo et al. (2013) have found statistically significant results for the impact of using Analytics on financial, learning/growth, market/consumer, and organizational process capabilities.

More specifically to the present study, analytically oriented supply chains are defined as those in which their members use a set of analytical methods and tools to make better decisions regarding the flow of materials through the chain, which can be descriptive, predictive or prescriptive (Souza, 2014). Similarly, Sahay and Ranjan (2008), argue that analytical chains allow, for example, the identification of opportunities of cost reduction.

Thus, analytical supply chains use analytical methods and tools – involving statistics, information technology, and management knowledge – to turn large volumes of data into useful information to support business decisions. Through the analytical approach it is possible to map scenarios, identify the impact of expected and unexpected events, minimize inventories and streamline product flow, providing benefits to key management processes

(planning, supplying, producing, delivering, returning), minimizing asymmetries (Chae, Olson, & Sheu, 2013; Chae & Olson, 2013; Davenport, 2006; Souza, 2014).

Empirically, Trkman, McCormack, Oliveira, and Bronzo (2010) verified that the use of a set of approaches and procedures for organizations to gather information, understand it and be able to apply solutions in the areas of *Supply Chain Reference Model* (SCOR) i.e., the use of the analytical approach in critical supply chain processes, results in better chain performance in addition to the findings that the relationship between analytical capabilities and performance is moderated by the organization's information systems. Still, Chae, Olson, and Sheu (2013) found the impact of analytically oriented chains on the individual performance of members and Zhu, Song, Hazen, Lee, and Cegielski (2018) explored the impact of analytics on the transparency of chains.

For the aims of this study, the analytical orientation measure in supply chains was based on Trkman et al. (2010) scale, and analytically oriented chains are considered as those in which their members efficiently process data through quantitative analysis in order to make fact-based decisions regarding chain processes. Exhibition 2 presents the proposed indicators.

Exhibition 2. Measurement scale analytical guidance in supply chains

2. Analytical orientation in supply chains. (Reflective)	
Items	**Questions**
A1	The quantitative analysis of the data directs the managerial actions.
A2	Members use the knowledge generated from the quantitative data analysis to improve the chain's processes.
A3	To support management decisions, members are able to process data efficiently.

Uncertainty

As in any day-to-day activity, as well as for each organization, innumerable are the events of risks and uncertainties inherent in supply chains. In general, the literature classifies such risk events as internal and external. External risks are related to the impacts on the environment caused by natural or human-made disasters that affect, directly or indi-

rectly, supply chains (Fahimnia et al., 2015; Thun & Hoenig, 2011). Earthquakes, tsunamis, terrorist attacks, hurricanes, as well as political instability and economic crises are characterized as examples of this typology of risks. Internal risks, according to Aguiar, Tortato, and Gonçalves (2014) are present in the organizational environment, and these are related to the activities of the organization and the

relationships between different companies in the chain. Examples of internal risks are an oscillation in demand, information delay, available capacity, and supplier inflexibility.

Chopra and Sodhi (2004) categorized risks into: disruptions, delays, system, forecasts, intellectual property, procurement, receivables, inventory, and capacity. In all, the nine risk categories added up to 28 risk drivers, demonstrating the range of risks in the chains. Contributing to the advancement of the theme, Aguiar, Tortato, and Gonçalves (2014) developed risk constructs for supply chains composed of the following dimensions: external environment; business processes; organizational structure; management components; internal environment; comprising 51 risk factors.

For Fahimnia et al. (2015), while some risks can be prevented, others must be mitigated. It should be emphasized that internal risks are more likely to occur, while external ones have greater impacts on the chains because they are usually associated with events with severe consequences (Thun & Hoenig, 2011; Kırılmaz & Erol, 2017; Revilla & Saenz, 2017).

To measure uncertainty, this study based on the argument that in supply chains affected by environmental uncertainties, their members perceive greater degree of uncertainty in the relationships they are involved, that is, in source and delivery. Thus, to measure the uncertainty perceived by managers, the following indicators were used, as shown in Exhibition 3, below:

Exhibition 3. Uncertainty Indicators

3. Uncertainty	
Items	**Questions**
IA1	There is uncertainty about the mix of demand. (variety of products)
IA2	There is uncertainty about the volume of demand.
IA3	There is uncertainty regarding the supply of materials. (Time and volume).

Hypotheses

From the preceding arguments, it is expected that if the chain is analytically oriented, its members will be able to process information more efficiently, i.e. "... capture, integrate and analyze data and information, and use the insights generated in the context of organizational decision-making" (Cao, Duan & Li, 2015, p. 385), favoring risk management through greater prevention capacity (Ittmann, 2015).

Tang and Musa (2011) argue the need to develop a quantitative approach to manage supply chain risks, and lack of information can undermine chain decision-making. Thus, it is necessary to improve computational efficiency. In addition, it is argued by Tummala and Schoenherr (2011) that data management enables you to query, store and add risk information, assisting in the management and enhancement of SCRM.

Also, the analytical orientation in supply chains is essential for the use of management tools (Ittmann, 2015), characterized as descriptive, predictive and explanatory techniques. Some examples are: "and if" (Hallikas et al., 2004; Lavastre et al., 2012; Tummala & Schoenherr, 2011); risk diagrams (Hallikas et al., 2004; Lavastre et al., 2012); cause and effect analyzes (Tummala & Schoenherr, 2011); mapping processes (Lavastre, Gunasekaran, & Spalanzani, 2012).

In this way, it is understood that in order to identify, evaluate, propose mitigation strategies and monitor risks efficiently, in addition to collaboration, flexibility, and visibility, supply chains are required to develop analytical orientation. Thus, we have the following research hypotheses:

H1: Analytical orientation positively impacts risk management in supply chains.

The research model is shown in Figure 1.

Figure1. Research Model
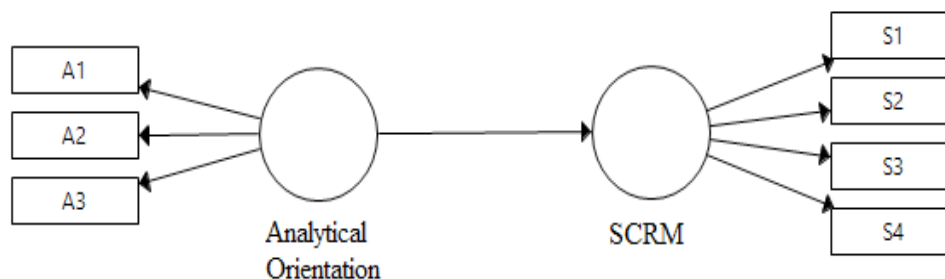
Based on the theoretical framework, it is understood that being analytical leads to a better understanding of the environment, reducing the perception of uncertainty. According to Galbraith (1974), the more complex and turbulent the environment, the higher the need for information processing. Likewise, identifying risks, assessing them, mitigating them and monitoring them, make the perception of uncertainty decrease, as companies feel capable of better managing environmental changes and, therefore, do not perceive them as uncertainties. Consequently, those supply chains that are more analytical or that better manage their risks reduce their uncertainty perception.

H2: Supply chains with higher level of analytical orientation have lower perception of environmental uncertainty than those with lower level of analytical orientation.

H3: Supply chains with higher level of risk management have lower perception of environmental uncertainty than those with lower level of risk management.

METHODOLOGY

Considering the purpose of the research, a questionnaire was developed to collect data referring to the constructs presented in the conceptual model. For the development of the questionnaire, a structured bibliographical review was carried out to delimit the constructs and operationalize them. In the next phase, a pre-test of the survey instrument was conducted in order to eliminate ambiguities and to validate the instrument. To do this, the questionnaire, prepared on the SurveyMonkey platform, was sent to ten professionals responsible for the production / supply chain of industries belonging to the research base, requesting them to report any doubts or issues experienced when answering to the questionnaire. Respondents considered the ques-

tionnaire quick and easy to understand, reporting no problems in answering it.

Thus, the questionnaire comprised 11 questions regarding the constructs, besides four items that made it possible to characterize the sample and served as control variables. In the questions related to the constructs, the 7-point Likert scale was used, with 1 equal to 'totally disagree' and 7 equal to 'totally agree'.

One of the difficulties of the research was to obtain a reliable database for sending the questionnaires. The best way was to use the industrial lists, which are vehicles for dissemination of companies organized through a partnership between the Industrial and Business Center of Minas Gerais and the Brazilian Editor of Special Guides (EBGE) with the federations of industries of the states involved. Considering that the registered population had 8,667 micro, small and medium-sized industries, it was decided to send to questionnaires to the whole cadastral base, given the feasibility of data collection, and considering the low costs of conducting the survey. It is worth emphasizing here that the authors of this research carried out the organization of this database to deal with problems of omissions and redundancies. Nevertheless, the difficulties to identify the population and obtain access to respondents should be mentioned, since it is not possible to guarantee that the total number of active companies in the list is correct, nor the identification of companies, because their emails could be no longer valid.

The data were collected in two stages from August to November 2017. First, an electronic contact was made with each of the registered companies in order to request the e-mail of the person responsible for the production, purchase, marketing or supply chain management of organizations. Considering that these were the subjects of the research, this proce-

dure was done to improve the quality of the questionnaire responses. This phase resulted in the return of 142 emails. In the second phase a reminder was sent for these emails with the link of the questionnaire to all the other emails registered on the databases, asking those who received the e-mail to forward it to the professionals who performed the already mentioned activities, as these were the subjects of the research. After all, 111 companies responded to the survey.

So, one of the limitations of the work is highlighted, since there is no guarantee that the available sample represents the population, due the amount of errors in the original list of companies. However, considering the descriptive statistics presented in section 3.1, a similar percentage for the three states is observed. There is also predominance of micro and small companies, reflecting the predominance in the Brazilian industry. Complementarily, approximately 83% of respondents are presidents, directors or managers, thus confirming that the survey subjects were reached. Moreover, given the hierarchical level of the respondents, good quality of responses can be expected. Thus, it is believed that this limitation did not generate significant bias in the conclusions.

The structural equations modeling was used to analyze the data. According to Hair, Black, Babin, Anderson, and Tatham (2009), the Structural Equations Modeling (SEM) provides the possibility of efficiently estimating a series of separate multiple regression equations, simultaneously calculating all of them, and using the relationships between the constructs. SEM empirically tests a set of dependency relationships through a model that operationalizes theory and provides the representation of relationships through a path diagram. The research aims at studying the relationships between constructs of analytical orientation in supply chains and the management of risks in supply chains. Therefore, the structural equations modeling and the statistical method of partial least squares (PLS) using the software SmartPLS® 3 were used.

PLS does not require large samples, does not generate identification problems and does not assume that the distribution is normal across the measurement variables (Chin, Marcolin, & Newsted, 2003). To calculate the sample size, we used the criterion of the number of arrows of a construct that points to another construct (Hair, Sarstedt, Ringle, & Gudergan, 2017). As previously reported, the database was

composed of 111 cases, supporting the analysis.

Sample description

Of the 111 industries that made up the sample, 34 were located in Espírito Santo (30.63%), 38 in Minas Gerais (34.23%) and 39 in Rio de Janeiro (35.10%).

Regarding company size, micro (42.34%) and small industries (40.54%) predominated. The remaining cases of the sample comprised medium-sized industries (17.12%). As a criterion of classification, the approach of the industrial registries themselves and SEBRAE was used to classify the size of industries based on the number of employees. Thus, companies with up to 19 employees were ranked as micro, from 19 to 99 as small, from 100 to 499 as medium size. Thus, 17.12% of the participating industries were classified as medium, 40.54% as small and 42.34% as micro.

About the profile of the respondents, 15 serve as chair (13.51%), 35 are directors (31.53%), 44 are managers (39.64%), 8 are assistants (7.21%) and 9 work in positions other than those specified (8.11%). Of these, 51 have the primary function of production (45.95%), 26 of purchase (23.42%), 14 of marketing / sales (12.61%) and 20 of other functions (18.02%).

Data analysis

The first step before running the structural equation model is to analyze the measurement model. Firstly, we investigated the reflexive constructs (analytical orientation and SCRM). According to Hair et al. (Cronbach's Alpha and Compound reliability), convergent validity (AVE and loads) and discriminant validity (Fornell & Lacker's Table).

By analyzing the reliability and internal consistency of constructs, it was observed that the values obtained from Cronbach's Alpha and composite reliability guarantee the internal reliability. Furthermore, all loads obtained values greater than 0.703, and the average variance extracted (AVE) of constructs were higher than 0.70, assuring the convergent validity. In addition, discriminant validity between constructs was verified, since the square root of the AVE of constructs was proven to be greater than the correlation between them. The results of the reflective measurement model are shown in Table 1.

Table1. Results of the reflective measurement model

Latent variable	Index	Convergent validity		Reliability and internal consistency		DiscriminatingValidity
		Load	AVE	Compositere-liability	Alpha de Cronbach's	
		> 0.70	> 0.50	> 0.60 até 0.95	0.60 - 0.90	
Analytical orientation	A1	0.773	0.703	0.876	0.790	Yes
	A2	0.877				
	A3	0.862				
SCRM	S1	0.820	0.749	0.923	0.888	
	S2	0.868				
	S3	0.903				
	S4	0.869				

After ensuring that the measurement models are valid and reliable, the next step was to analyze the structural model by means of its predictive relevance and the relation between the constructs, being evaluated the following steps: significance and relevance of the existing relationship in the structural model, the R^2 level; predictive relevance Q^2 (Hair et. al., 2017).

The significance and relevance of the path co-efficients were analyzed, verifying if they were statistically different from zero. Thus, it became necessary to perform the Bootstrapping procedure with 5,000 subsamples. Table 2 shows the results of significance and relevance tests of the path coefficients.

Table2. Significance test results

	SAMPLE MEAN	STANDARD DEVIATION	t	p
Analytical orientation -> SCRM	0.596	0.065	9.132	0.000

The results indicate that the analytical orientation construct has a positive and statistically significant impact on the management of risks in supply chains since the relationship showed a path coefficient of 0.596 and p-value of 0.000. Thus, the research hypothesis has been confirmed, indicating that supply chains where their members use quantitative data analysis to make facts-based decisions are also more efficient in managing risks.

Another measure widely used to evaluate structural models is R^2, and it is responsible for representing the effects of the combination of exogenous variables on the endogenous variable (Hair et al., 2017).

The results indicate that 35.50% of the variation in the supply chain risk management construct is derived from the variation of the analytical orientation construct. Although it can be pointed out as a medium value, it is understood to be a significant and relevant result because there are several other factors not addressed in the present study that affect SCRM. The adjusted R^2 of the model was 34.90%.

Finally, the Q^2 of the model, obtained through the blindfolding procedure with omission distance of seven was 0.245, demonstrating that the model has predictive capacity. According to Hair et al. (2017), Q^2 greater than zero represents that the exogenous

construct is, in fact, capable of predicting the endogenous construct.

Hypotheses tests

In order to form only two groups of chains (an environment with low uncertainty x high uncertainty); a cluster analysis was performed in SPSS software with the average of the uncertainty variables (IA1, IA2, and IA3). Out of all companies, 35 were classified with a low perception of uncertainty (one) and 76 with a high perception of uncertainty (two). In addition, to determine the degree of analytical orientation and the degree of risk management, the averages of the indicators of each construct were used.

From the transformations, a comparison, shown in Table 3, was drowned between the averages of the constructs for both industries with high uncertainty perception and industries with low uncertainty.

Table3. Test for difference of mean uncertainty

CONSTRUCT	UNCERTAINTY PERCEPTION	N	MEAN	STANDARD DEVIATION	STD. ERROR	WELCH TEST
Analytical orientation	Low	35	5.47	0.86	0.15	
	High	76	4.90	1.21	0.14	0.006
	Total	111	5.08	1.14	0.11	
SCRM	Low	35	5.10	1.01	0.17	
	High	76	4.38	1.35	0.15	0.002
	Total	111	4.60	1.29	0.12	

The results indicate that supply chains that perceive less uncertainty have higher average of both analytical orientation and risk management, comparing with those with high perception of uncertainty. It was also verified whetherthese two groups of chains (low perception of uncertainty x high perception of uncertainty) are statistically different regarding analytical orientation and risk management in supply chains, and Welch test was performed for equality of mean. The Welch test is used when it is not possible, through the Levine test, to verify the homogeneity of variances.

It is possible to verify that both the analytical orientation and the SCRM are statistically different across the groups. Thus, it is verified that companies that have both higher degree of analytical orientation and SCRM have lower perception of environmental uncertainty, whereas the contrary is also true. Therefore, hypotheses 2 and 3 were confirmed, corroborating the literature.

In addition, it was verified whether larger companies have both higher level of analytical orientation and better risk management. This procedure aimed at verifying if, regardless of size, industries are concerned with using quantitative data analysis in order to make better decisions involving the chain and if they understand the existence of risks associated with them and the need to manage them.

The results are presented in Table 4, as previously noted, when the size increases, the levels of analytical orientation and risk management also increase. Nevertheless, this difference was not statistically significant when conducting the tests for differences of averages.

Table4. Test for medium-sized difference

CONSTRUCT	SIZE	N	MEAN	STANDARD DEVIATION	DEFAULT ERROR	LEVINE SIG.	TEST OF AVERAGE SIG.
Analytical orientation	until 19	47	4.80	1.37	0.20	0.013	Welch
	20-99	45	5.21	0.91	0.14		0.75
	100-499	19	5.44	0.82	0.19		
	Total	111	5.08	1.14	0.11		
SCRM	until 19	47	4.39	1.42	0.21	0.059	ANOVA
	20-99	45	4.59	1.22	0.18		0.68
	100-499	19	5.16	0.98	0.22		
	Total	111	4.60	1.29	0.12		

DISCUSSION AND CONTRIBUTIONS

The results obtained, presented in Figure 2, are in line with the expectations presented initially in this study and with the construction of the central research hypothesis. It was observed that the supply chain analytical orientation has a positive, significant and robust impact on SCRM. Still, it can explain 35.50% of its variation.

Figure2. Result of the structural model

As a practical implication, the results show that if supply chains want to survive from disruptions caused by the imense number of risks inherent in them – that makes impossible to produce the right quantity to the right location at the right time and in a profitable way – its members must be able to process data efficiently and, as a consequence of being analytically oriented, better manage risks. In this way, analytical approach to decision making allows supply chain members to identify possible sources of risk and to propose appropriate strategies to mitigate them, allowing them to avoid risks, maintain or recover operations in case they occur.

From a conceptual and complementary point of view, it is interesting to note that the majority of respondents hold high hierarchical positions in organizations, which may lead one to infer that they have consistent professional experience. Considering that risk management could be influenced by the manager's experience, it could be assumed that the impact identified here would be a "spurious" impact. However, considering that the experience has certain homogeneity, in the sample surveyed, the relevance of this finding is further verified, since data-based decision making was proven to improve risk management in the supply chain.

Although it is not the primary objective of this research, it was observed that there is no difference across levels of analytical orientation and risk management for micro, small and medium-sized companies, that is, regardless of size, companies are awareness about the importance of making decisions based on data and with the adoption of risk management procedures. This can be a consequence of the better training of industrial managers, micro and small companies, and can also happen due to

the broad access to technologies and computational methods nowadays.

In a complementary way, this study showed that those chains with higher degree of analytical orientation or greater degree of risk management present lower level of uncertainty perception. This result makes sense conceptually because a greater capacity to use the data for decision making, and the understanding that the uncertainty is manageable imply greater security for the members of the supply chain, that´s why the perceived risk would be smaller. In this sense, what would be considered uncertain might not be uncertain depending on the levels of analytical orientation and risk management. Therefore, it is concluded that both constructs, the analytical orientation in supply chains and the SCRM, imply less uncertainty perception in their operations because the members of the chain are more aware of their processes and the risks associated with them.

Conceptually, this article intends to contribute to the literature by relating two constructs, relevant to the management of supply chains, considering that the environment is becoming increasingly uncertain.

Limitations and future research

As main limitation, the survey was answered by only one member of the chain, who gave his opinion about the chain as a whole, where the ideal would be to obtain answers from at least one supplier, one manufacturer and one buyer belonging to the same chain. Another limitation is the low number of medium-sized companies among those that participated in the research.

For future research, we suggest verifying the role of analytical orientation in the relationship between risk management and other capabilities that affect the construct, and if analytical orientation and risk management help supply chains recover from unexpected events by improving resilience. As a suggestion, new constructs can be included to increase the explanatory power to predict supply chain risk management, such as visibility, collaboration, and flexibility.

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ANALYTICAL SUPPLY CHAINS: ARE THEY MORE RESILIENT? A MODEL'S PROPOSITION

ABSTRACT

Understanding that disruptions can be devastating, the ability of supply chains to re-turn, as quickly as possible, to their normal state, after disruptions, has been consid-ered as important as optimizing their flows. According to the literature, companies must develop capabilities and invest in risk management to improve their supply chain resilience, however almost nothing has been investigated about the role of the analytical orientation for those purposes. Assuming that analytical orientation is es-sential for supply chains to recover from interruptions, this theoretical essay aimed at proposing its inclusion in an initial supply chain resilience model, based on literature review. As a contribution, this paper aims at presenting a model that will enlarge the discussion about this theme, which can be empirically tested in a future research.

KEYWORDS | Supply chain resilience, analytical supply chains, business analytics, resilience capabilities, model.

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INTRODUCTION

In today's turbulent and uncertain environment, characterized by huge global competition, large and complex chains, increased customer expectations, shortened product life cycles, rapid technological innovations, increased outsourcing, and demand volatility, each company in the supply chain is susceptible to an indefinite number of events that can interrupt their operations (Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scavarda, Ceryno, Pires, & Klingebiel, 2015; Sheffi & Rice Jr., 2005; Skipper & Hanna, 2009).

According to Zsidisin and Wagner (2010), interruptions in supply chains derive from events that can occur both inside and outside the supply chain's boundaries. Random events (earthquakes, illnesses, storms, hurricanes), accidental events (fires, human errors, equipment breakdown) or intentional situations (terrorism, robberies) are the main causes of supply chain disruptions (Carvalho & Machado, 2007; Sheffi & Rice Jr., 2005).

Given that such disruptions affect performance and can be devastating to supply chain members (Blackhurst, Craighead, Elkins, & Handfield, 2005), an important question, pointed out by Soni, Jain and Kumar (2014), is to identify what leads some organizations to collapse while others can thrive and grow. Thus, to become resilient, and quickly recover from disruptions, is emphasized, by both managers and academics (Brusset & Teller, 2017; Kamalahmadi & Parast, 2016)gaps in current research, and future directions on the topic. For this purpose, we employed two methods to collect publications in supply chain resilience. First, we selected keywords and searched the relevant databases and journals. Next, we tracked the references of those papers collected in the first method to look for other publications published in conference proceedings and book chapters. As a result, a sample of 100 papers was collected, studied, and analyzed. We summarize our findings in several areas including enterprise and supply chain resilience definitions, supply chain resilience principles, and supply chain resilience strategies. Based on the assessment, we develop a framework for the principles of supply chain resilience that can be used as a basis for understanding supply chain resilience. (C.

Thus, a proactive and effective method that allows supply chains to recover from expected and unexpected interruptions, is essential to build capabilities that make them more resilient, i.e. cabable to return,

after disruptions, as fast as possible to their normal state or improve in order to avoid collapse of their operations and maintain profitability of their members (Christopher & Peck, 2004; Jüttner & Maklan, 2011; Pettit, Fiksel & Croxton, 2010; Ponomarov & Holcomb, 2009).

In general, resilience capabilities more often identified in literature are collaboration, flexibility, and visibility, as well as risk management procedures (Brandon-Jones, Squire, Autry, & Petersen, 2014; Christopher & Peck, 2004; Colicchia, Dallari, & Melacini, 2010; Jüttner & Maklan, 2011; Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scholten, Scott, & Fynes, 2014; Wieland & Wallenburg, 2013)capabilities (visibility.

However, there is a gap in literature concerning the role and impact of supply chains ability to collect, analyze and transform data into useful knowledge in order to make decisions based on facts and data, that is, the impact of analytical orientation over supply chain resilience.

The analytical approach, as pointed out by Ladeira et al. (2016, p. 487), involves: "[...] the extensive use of critical data and explanatory and predictive models, as well as fact-based management to guide management decisions and actions." In this sense, being analytical allows companies to maximize decision-making processes by developing the organization's capacity to conduct analysis and act, providing better results by generating value and efficiency in decision making (Davenport, 2006; Davenport, Harris, De Long, & Jacobson, 2001; Laursen & Thorlund, 2010).

Under the supply chain perspective, being analytically oriented means being able to provide members with useful information, drawn from the vast amount of data collected, facilitating the decision-making process (Sahay & Ranjan, 2008) to overcome uncertainties (Chen, Chiang, & Storey, 2012) and to favor the recovery from interruptions. Thus, it is pertinent to consider the analytical orientation of supply chains as capability in resilience. According to Galbraith (1974), the more complex and turbulent the environment, the greater is the need for information processing.

Therefore, the present theoretical essay aimed at proposing the inclusion of analytical orientation in the preliminary model of supply chains resilience, based on literature review.

Using the taxonomy of Colquitt and Zapat-Phelan (2007), we expect to contribute to the discussion about resilience in supply chains by presenting a model that, although it has not yet been empirically tested, was conceptually grounded and validated. For this, we used the methodology known as Proknow-C (Afonso et al., 2012), where, based on 72 articles indexed on Web of Science or found on Ebsco, Science Direct and Emerald in the last 30 years with titles containing the terms "Supply Chain Resilience" or "Resilient Supply Chain". From the initial results, the most cited papers were selected (21 articles representing 90% of the citations on the topic) to identify the main antecedents of resilience in supply chains. Moreover, the most current articles, which were compatible with the theme and published in high-impact journals, were used to build the grounds of the initial model.

Thus, in line with Colquitt and Zapat-Phelan (2007), the initial model sought to capture the concepts developed by other theoretical and empirical studies, as well as to clarify and extend the conceptual approach used in previous studies, with two main contributions. The first by including a new construct in the model and the second by introducing new relationships between the model's constructs. That is, the idea is to propose an advance in the resilience knowledge and communicate with other researchers, making possible to test it empirically.

It is worth mentioning that the we intend to carry out empirical tests and publish the results in future paper. We intend to follow the taxonomy already mentioned, expanding the frontier of knowledge by building new theories based on theories available, making the cycle: conceptual advance, empirical test and new conceptual advance. Thus, expanding knowledge and presenting it in a new or different direction is possible (Colquitt & Zapat-Phelan, 2007). In order to develop an extended theoretical model, these two emerging and important themes were unified, aiming at contributing to both academics and practitioneers.

THEORETICAL DISCUSSION

In this chapter the theoretical foundations are presented involving supply chain resilience and supply chain analytics, which support the model presented in this paper.

Supply Chain Resilience

Authors such as Bhamra, Dani, and Burnard (2011) argue that the notion of resilience was grounded in ecology, related to ecosystem stability, whereas Ponomarov and Holcomb (2009) say that it has its roots in social psychology, considering the differences in behavior of individuals when facing adversity (Rutter, 2012).

However, it is known that resilience is a multidisciplinary construct that has many facets, being studied from ecological, psychological, economic and organizational perspectives. In recent years, the term resilience has gained strength in the research on supply chain management (Bhamra, Dani, & Burnard, 2011; Ponomarov & Holcomb, 2009)technological and environmental.

Christopher and Peck (2004) define resilience in supply chains as the chain's ability to return to its status quo or move to a more desirable one after suffering disruption. Ponomarov and Holcomb (2009, p. 131) argue that supply chain resilience can be conceptualized as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function".

The present study considers, from the readings and main definitions, that resilience of supply chains - SCRES - should be defined as a result, that is, the return of the chain to its natural state, or even improvement, after the occurrence of disruptive events, driven by the development of adaptive capacity and prevention. Thus, we argue that only recovery should be considered as a SCRES dimension.

This approach differs, for example, from the definition proposed by Ponomarov and Holcomb (2009) that consider the maintenance of the desired level of operations (robustness) and the preparation for events (risk management) as dimensions of resilience. Similarly, it differs from the definition proposed by Wieland and Wallenburg (2013) that is more closely associated with adaptive capacity, which we consider as being an antecedent of resilience.

Our thought goes along with Brandon-Jones et al. (2014) that consider resilience as a result provided by the development of capabilities, where maintaining operations means robustness and resilience means the return of operations. Similarly, it is observed that a deterministic disruptive event is the starting point of resilience, because only preparing for probabilistic events is related to risk management and does not determine resilience level (Jüttner & Maklan, 2011).

Christopher and Peck (2004), as well as Soni, Jain and Kumar (2014) argue that resilience can be built within the chains, that is, there are certain capabilities that, if developed, increase resilience. Sheffi and Rice (2005) present redundancy and flexibility, while Christopher and Peck (2004) develop a theoretical model involving collaboration, risk orientation/culture, agility and (re) building ability to return from disruptive events.

Research shows that in order to confront vulnerabilities, supply chains must develop capabilities, which are defined as "attributes that enable the company to anticipate or recover from disruptions" (Pettit, Fiksel, & Croxton, 2010, p. 6). It is relevant to point out that these are seen here as attributes which enable chains to recover or be prepared in order to recover from disruptions. As such, recovery would be associated to resilience and anticipation to risk management.

As previously discussed, the capabilities that most appear as determinants of SCRES are: collaboration, visibility, flexibility, speed and, in addition to these capabilities, risk management procedures (Brandon-Jones et al., 2014, Christopher & Peck, 2004, Colicchia et al., 2010, Jüttner & Maklan, 2011, Pettit et al., 2010, Ponomarov & Holcomb, 2009, Scholten et al., 2014, Wieland & Wallenburg, 2013). It is interesting to note that, according to Ponomarov and Holcomb (2009), the capabilities must be interrelated and improved together to be resilient.

It should be noted that although it is one of the capabilities that most appear as antecedents of resilience, speed appears to be a dimension of resilience, that is, the speed at which the supply chain itself manages to recover. Given that the chain's existing velocity is affected by the rupture, in addition to the absence of studies that specifically address the impact of speed on resilience, we chose not to approach it in the study as a resilience capability belonging to the resilience capability package.

Thus, it is proposed:

P1a: *Supply chain resilience is positively impacted by a resilience capabilities package.*

Collaboration

With regard to resilience in supply chains, Jüttner and Maklan (2011) have identified in an empirical multi-case study that, in a scenario of global financial crises, collaboration among members of the supply chain can function as a mechanism to contain negative impacts of disruptions.

It is also known that communication and cooperation among members of the chain impact, in a statistically significant way, the resilience of the chain as a whole (Wieland & Wallenburg, 2013). On the other hand, according to Scholten and Schilder (2015), although the existing literature points out that the collaborative relationship between supply chain members is part of the resilience, little attention has been given to how it actually exerts influence, being one of the gaps discussed in this study.

P2a: *Collaboration is a resilience capability that belongs to the resiience capability package.*

Flexibility

The importance of flexibility to adapt to environmental uncertainties is empirically verified in the study by Merschmann and Thonemann (2011), while Swafford, Ghosh, and Murthy (2008) verified the agility of chains and competitive performance of the business. On the other hand, Vickery, Calantone, and Droge (1999) did not find a statistically valid relationship between the importance attributed by the managers' perception of capabilities on flexibility and the amount of uncertainties suffered by supply chains.

According to Sheffi and Rice (2005), although redundancy, that is, having reserves of resources is an alternative to respond to disruptions, a better way is to improve the flexibility of the chain, as it results in benefits and gains in operating efficiency in normal routine.

In order to be resilient, the chain must develop a certain degree of flexibility, allowing rapid input changes or changes in the way inputs are generated, as well as outputs or the way outputs are generated, as Pettit, Fiksell and Croxton (2010) argue. These can be developed, for example, with multiple sources of supply and replenishment, contract flexibility, risk sharing, inventory management, among others.

Jüttner and Maklan (2011) found that the chain flexibility in reallocating and enhancing capacity utilization, inside or outside the network, allows costs to be managed and profits kept in situations of disruption. Scavarda et al. (2015) found, in a study of the Brazilian auto industry, that flexibility results

in resilience, however, they also found that the organizations investigated were more concerned with internal flexibility rather than flexibility in the supplier/buyer relationship.

P3a: *Flexibility is a resilience capability that belongs to the resilience capabilities package.*

Visibility

Visibility is essential to make the supply chain more resilient as it provides the ability to visualize, in complex environments, inventories and demand, enabling changes in flows when there are interruptions, and it is positively associated with agility, i.e. how quickly a supply chain would react to environmental changes (Brandon-Jones et al., 2004; Christopher & Peck, 2004).

Authors such as Jüttner and Maklan (2011) have qualitatively verified the relationship between visibility and resilience, since it makes it possible to quickly perceive the occurrence of the risk event and improve decision making. Brandon-Jones et al. (2014), therefore, were the first ones to verify this relationship quantitatively, observing a significant and positive impact. Therefore, based on these surveys, it is proposed:

P4a: *Visibility is a resilience capability that belongs to the resilience capabilities package*

Supply chain risk management

Supply chain risk management (SCRM) has a direct impact on the supply chain resilience, especially in relation to risk identification and evaluation, preventing chains from events that may disrupt their operations, as well as allowing the development of actions to recover from disruptions (Colicchia et al., 2010; Graeml & Peinado, 2014; Jüttner & Maklan, 2011; Wieland & Wallenburg, 2013).

Jüttner and Maklan (2011) argue that if risk management provides knowledge about environmental risks as well as how to mitigate their impacts, it makes the supply chain more resilient. Likewise, Graeml and Peinado (2014) found a positive impact of risk orientation over supply chain resilience, and Colicchia, Dallari, and Melacini (2010) found that adopting effective risk management strategies to deal with lead time variability, increases supply chain resilience.

P5a: *supply chain risk management has a positive impact on the supply chain resilience.*

Thus, it is observed that SCRM directly impacts the resilience of the supply chain, preparing it for the occurrence of events that may interrupt its operations, and so prevention can be considered a SCRM dimension, not a resilience dimension. At the same time, it is impacted by the capabilities package developed by the chains. This is because, for risk management to be efficient, the supply chain must adopt a collaborative management approach with its customers and suppliers, be flexible and able to receive and provide information in real time, with quality and precision, favoring visibility (Kilubi & Haasis, 2015; Lavastre, Gunasekaran, & Spalanzani, 2012; Nooraie & Mellat Parast, 2015; Tang, Matsukawa, & Nakashima, 2012; Tang & Musa, 2011; Thun & Hoenig, 2011; Wiengarten, Humphreys, Gimenez, & McIvor, 2015; Zhao, Huo, Sun, & Zhao, 2013).

P6a: *Supply chain risk management is positively impacted by the resilience capability package developed by the supply chains*.

Environmental uncertainty

Another point to be emphasized is that the need to develop capabilities is associated with the turbulence of the environment where the members of the chain are inserted. Uncertainty is related to events that can not be known with complete precision in order to develop risk mitigation strategies (Radivojevi & Gajovi, 2014). For Galbraith (1977, p. 36), uncertainty "is the difference between the amount of information *required* to perform the task and the amount of information already possessed by the organization." The greater the difference, the greater the uncertainty regarding the outcome of the decisions.

Factors such as globalization, outsourcing, supplier dependence and supply networks, consumer behavior and intensive use of technology have raised the level of environmental uncertainty, influencing the decision making and supply chain performance (Tang & Musa, 2011). Scavarda et al. (2006) and Pettit, Fiksel, and Croxton (2010) emphasize the importance of the balance between capabilities and vulnerabilities, since high levels of vulnerabilities and low capabilities result in excessive risk and, conversely, degrade profitability due to excessive investment in protection mechanisms.

Therefore, it is expected that all structural relations of the model will be moderated by the environment, since, when there is low turbulence, the proposed relationships amongst the package of capacities, supply chain risk management (SCRM) and chain resilience SCRES), tend to be smaller than those of more turbulent environments.

P7a: *The strength of the relationship between the capability package and the resilience of supply chains is moderated by the degree of uncertainty and dynamics of the environment.*

P8a: *The strength of the relationship between the capability package and the supply chain risk management is moderated by the degree of uncertainty and dynamics of the environment.*

P9a: *The strength of the relationship between supply chain risk management and its resilience is moderated by the degree of uncertainty and dynamics of the environment.*

Based on the literature on the subject, the resilience capability package, formed by collaboration, flexibility and visibility, is expected to positively impact the supply chain resilience. In addition, it is expected that this same package will have a positive impact on the supply chain risk management (SCRM) and, finally, on the supply chain resilience (SCRES) itself. Moreover, all relations hypothesised are moderated by the environmental uncertainty. Thus, this initial model is presented in Figure 1.

Figure 1. Proposed modern model
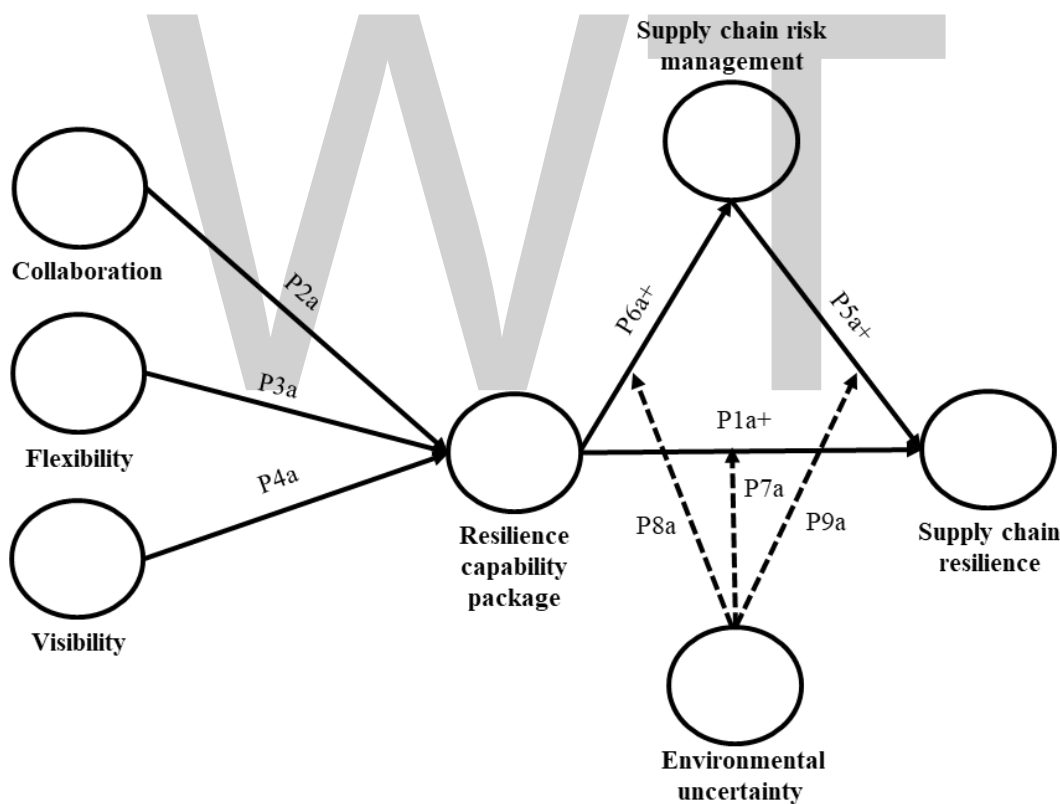
Source: The authors.

However, it is argued that the model initially presented is capable, but insufficient to explain the resilience of supply chains. This is because the literature ignores an essential factor to face the uncertainties and, consequently, to recover from disruptions. Thus, in view of the increasing volume of data that chain members have and may have access to, and the need to analyze them in order to make analytically grounded decisions, the insertion of analytical orientation as an additional capability in resilience will be discussed next.

Supply Chain Analytics

Simon's studies (1955, 1956, 1979) brought to the organizational research insights that broke ancient paradigms and paved the way for the emergence of new theories. If classical / economic theory considered an absolute rationality, apart from reality, in which there was the possibility of reaching an optimal decision, the author's findings showed that, in reality, man is endowed with a bounded rationality, since one does not have the time, information, or the knowledge to make an optimal decision. In this sense, any decision made by the individual will be at most satisfactory.

However, a satisfactory decision is not easy to achieve, requiring individuals, organizations and networks of organizations to have analytical skills to process information, seek alternatives, and calculate consequences for designing actions (Simon, 1979). It is precisely from this need that the studies on the Business Analytics theme emerge.

It occurs that (1) the large amount of data generated in organizations, on a daily basis, outside and inside their chains, (2) the reduction of the gap between business strategy and data management, and (3) the perception that grounded decisions are critical at each organizational level, are movements that intensify the usefulness and need of statistics to work along with information technology and business knowledge to transform data into information in order to improve decision making (Acito & Khatri, 2014). Still, the Business Analytics phenomenon is favored by the decrease in costs associated with the technological elements needed to be analytical (Acito & Khatri, 2014)

Business analytics (BA) is defined, on the basis of Laursen and Thorlund (2010), as to provide the right support for decision, at the right time and for the right people, and can be seen as an information system composed by: technological elements responsible for collecting, storing and providing information; human skills; and business processes. If some information can be used by organizations, by means of simple statistical techniques, the analytical skills go beyond of just simple statistics, since, in addition to information systems, they provide more sophisticated information (Davenport, 2006).

However, as pointed out by Davenport et al. (2001), only investments in sophisticated analysis tools and technologies are not enough for organizations to transform data into business knowledge, that is, useful knowledge that can add value to the organization. According to the authors, it is the human capability to analyze, interpret, generate and act with the insights generated through the data analysis and critical factors of this complex transformation process, using advanced technology and analysis, that is the driver of results that can add value to the business.

This approach is also in line with the arguments by Laursen and Thorlund (2010), since they emphasize the importance and responsibility of decision makers to analyze the information obtained through information systems and transform them into useful knowledge to improve or develop business processes and, consequently, generate value.

Therefore, analytical capabilities consist of a set of analytical methods, tools (Acito & Khatri, 2014) and skills, involving statistics, information technology and business knowledge that provide the opportunity to provide large volumes of data, through organization, availability, analysis and interpretation, considering the reality of the business and the specificities of the environment in which it is inserted, making it possible to develop and apply more satisfactory decisions. Importantly, visibility, previously presented as a capability in resilience, refers to the ability to visualize, in complex environments, inventories and demand. On the other hand, the analytical orientation does not refer to visualization, but to the analysis of descriptive, predictive, prescriptive, and inquisitive nature, conducted to guide and support the decision-making process.

Once organizations have used analytical tools such as statistics, explanatory models, and data analysis for decision making, business processes will be affected by changes and reorganizations, making routines more efficient and generating more value than at an earlier time (Bronzo et al., 2013). Thus, BA results in changes in the way managers see the business, allowing them to observe obsolete processes and replace them with new ones, more efficient and effective to the objectives of the organization. According to Bronzo et al. (2013), for this to occur, the data collected need to be transformed into analytical knowledge, which can be fully exploited and used in decision making.

As discussed by Teo, Nishant and Koh (2016), BA empowers identification of changes in consumer behavior, new product development opportunities,

new markets, and absorption of external information, for example, customer perceptions about the products and services, and thus, is adaptive, innovative and absorptive, therefore, a dynamic capability.

Davenport's (2006) study of 32 organizations involved in quantitative analysis found that analytical capabilities provide organizations with mechanisms that allow them to improve pricing, identify potential customers, and develop new products. Similarly, Bronzo et al. (2013) found statistically significant results for the impact of using Analytics over the dimensions of the BSC (Balanced Scorecard).

More specifically, Souza (2014, p. 595)I describe the application of advanced analytics techniques to supply chain management. The applications are categorized in terms of descriptive, predictive, and prescriptive analytics and along the supply chain operations reference (SCOR argues that "supply chain analytics focuses on the use of information and analytical tools to make better decisions regarding material flows in the supply chain". Similarly, Sahay and Ranjan (2008) argue that analytical chains allow, for example, to identify opportunities

for cost reduction.

Chae and Olson (2013) propose a framework that would represent analytical supply chains, composed by data management, process management and performance monitoring capabilities. In this way, the analytical approach, through the acquisition and transformation of data into information, qualifies supply chains, for example, to map scenarios, identify the impact of expected and unexpected events, minimize inventories and improve product flows, provide benefits to the key management processes (planning, supplying, producing, delivering, returning) and minimize asymmetries between the desired and actual performance (Chae, Olson, & Sheu, 2013; Chae & Olson, 2013; Davenport, 2006; Souza, 2014)data management resources (DMR.

Taking into account that analytical techniques can be descriptive, prescriptive and predictive, Souza (2014) summarizes them in relation to each dimension of the SCOR model, except to plan, since, according to the author, this dimension is present in all others. The summarization is presented in Table 1, below.

Exhibition 1. Analytical techniques.

Analytics techniques	SCOR Model			
	Source	Make	Deliver	Return
Descriptive	• Supply chain mapping	• Supply chain visualization		
Predictive	• Time series method (moving average, exponential smoothing, autoregressive models)			
	• Linear, non-linear and logistic regression			
	• Data-mining techniques (e.g., cluster analysis, market basket analysis)			
Prescriptive	• Analytic hierarchy process	• Mixed-integer linear programming (MILP)	• Network flow algorithms	
	• Game theory	• Non-linear Programming	• MILP	
			• Stochastic programming dynamics	

Empirically, Trkman, McCormack, Oliveira, and Bronzo (2010) found that the use of the set of approaches and procedures that allow organizations to gather information, understand them and be able to apply solutions to SCOR areas of supply chain management, i.e. the analytical approach, in processes, results in better chain performance, with the relationship between analytical capabilities and performance being moderated by the organization's information systems. Still, Chae, Olson and Sheu (2013) verified the impact of the analytics in supply chains over the individual performance of their members.

Based on the above discussion, it is expected that, if a supply chain is analytically oriented, its members will be able to process information more efficiently, i.e "[...] to capture, integrate, and analyze data and information, and use the insights gained from data and information in the context of organizational decision making." (Cao, Duan & Li, 2015, p. 385), favoring resilience through prevention, adaptation and efficient decision making.

If, on the one hand, no studies were found in the literature that directly relate the constructs, on the other hand the theories presented seem to support this relationship, since the definitions of supply chain analytical orientation are extremely related to the ability to collect and analyze information and events from internal / external environment, and make satisfactory decisions that allows organizations / chains to adjust and improve processes, adapt, and consequently facilitate the recovery or improvement of the production flow and information in case of disruptions. Therefore, it can be considered as resilience capability.

Therefore, from the foregoing, it is proposed:

P1b: *The analytical orientation in supply chains is a resilience capability.*

P2b: *The insertion of analytical orientation in supply chains as resilience capability strengthens the relationship between resilience capabilities package and supply chain resilience.*

In addition, authors such as Tang and Musa (2011) argue the need to develop the quantitative approach, both academically and in a practical way, in order to manage risks in supply chains, highlighting that the lack of information may undermine decision-making within the chains. Thus, it is necessary to improve computational efficiency. Similarly, it is argued by Tummala and Schoenherr (2011) that data management allows to browse, store, and add information about risks, helping with the management and improvement of SCRM as a whole.

In order to identify, evaluate, propose mitigation strategies and monitor risks, supply chains need to develop the capabilities discussed in previous sections, as well as be analytically oriented in order to efficiently identify risks and transform uncertainties into risks, so that one can manage them, make better decisions and, consequently, make the supply chains more resilient. Therefore, it is proposed:

P3b: *The insertion of analytical orientation into supply chains, as a resilience capability, fortifies the relationship between the resilience capability package and SCRM.*

P4b: *Indirectly, the insertion of analytical orientation into supply chains, as a resilience capability, strengthens the relationship between SCRM and SCRES.*

Figure 2 below shows the propositions.

Figure 2. Propositions with insertion of analytical orientation
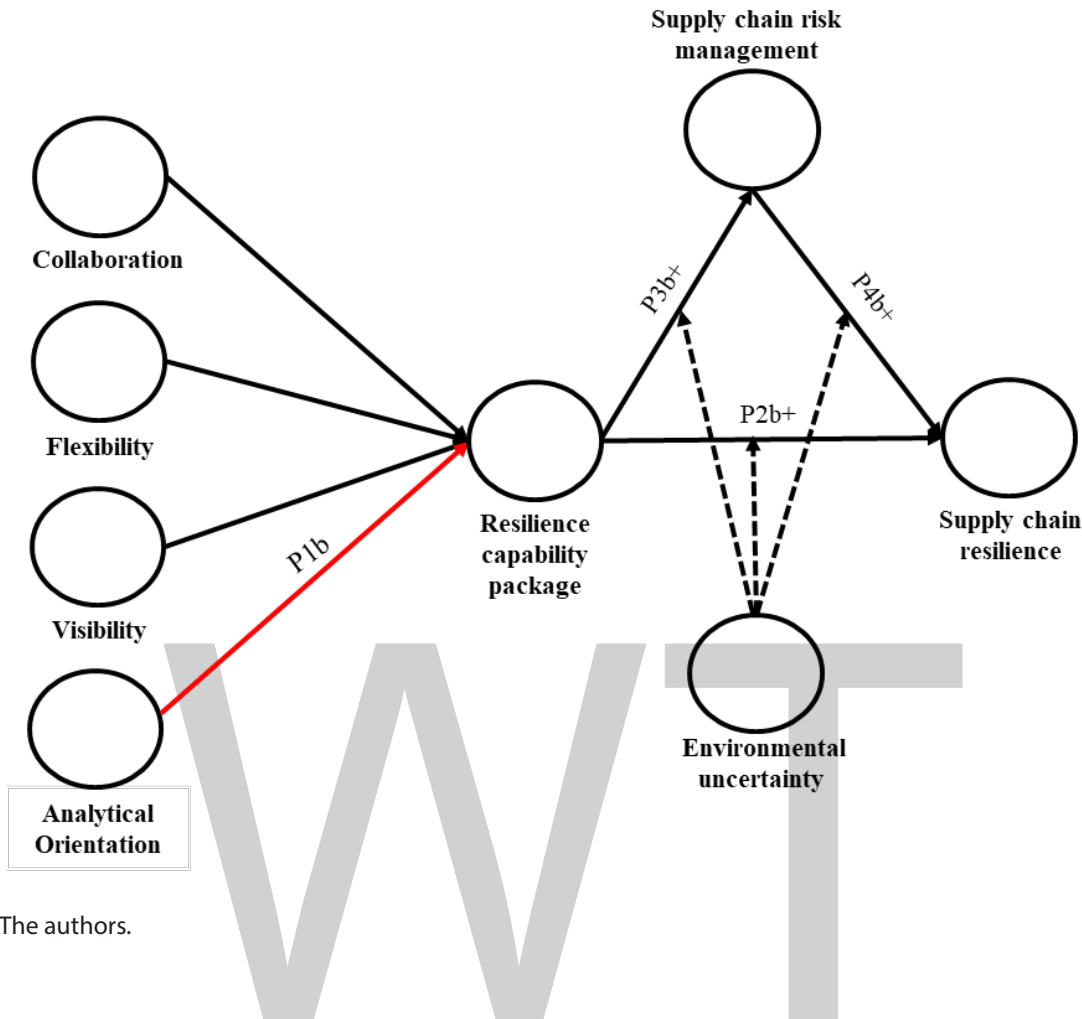
Source: The authors.

FINAL REMARKS

This theoretical essay was intended to discuss the insertion of the analytical orientation in an initial model of supply chains resilience, proposing an extended model. To justify its insertion, we discussed what is meant as resilience in supply chains, in addition to pointing out the main determinants of resilience addressed in the literature, presenting an initial model that was argued to be insufficient.

We highlight the view of resilience in supply chains adopted in this reserch. Although some previous researches assume adaptation and prevention as dimensions of resilience, in this research we assume that they both precede it. Therefore, resilience is composed by recovery and improvement dimensions. We assume the premisse that resilience can only be identified after disruptions.

In this sense, we argued that resilience in supply chains is a consequence, or a result from capabilities development. Therefore, the resilience capabil-

ity package, composed by collaboration, flexibility and visibility, is capable to impact and explain resilience variance. Likewise, risk management in supply chains, identification, evaluation and control of events, which can disrupt supply chain operations, makes them more preventive and resilient. Like resilience, risk management in supply chains is expected to be impacted by the resilience capabilities package. In addition, we propose that all relationships in the structural model are moderated by the environment.

However, we found a gap in literature that ignores the role as well as the impact of analytical orientation on the recovery of disruptions. Thus, in our view, a supply chain analytically oriented is more capable to adapt and be prepared, and, consequently, to be more resilient. Therefore, it is theoretically pertinent to extend the initial model by adding analytical orientation as a component of resilience capability.

The expanded model is shown in Figure 3.

Figure 3. Expanded model proposed
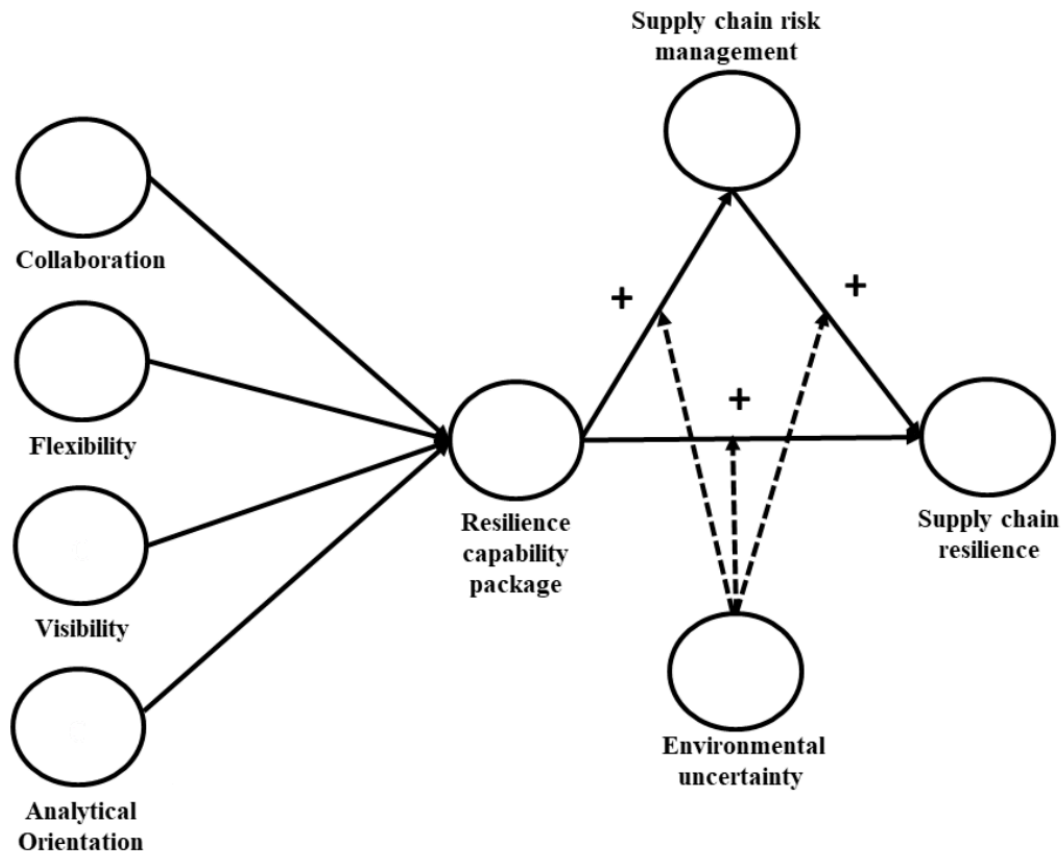
Source: The authors.

The argument that grounds these propositions is that to develop resilience, intuition alone is not enough. Goals, indicators and ongoing follow-up of those involved are required to develop, structure and maintain capabilities that will make possible risk management to return to the previous stage, after disruption. Neglecting such conditionings can increase supply chain risks for participants, decreasing their reputation and their ability to reach commitments made with their customers and suppliers. Reducing uncertainties helps decision-making and allows organizations to capture the appropriate results, improving long-term partnerships and alliances. In a specific context, the socio-political environment, where the supply chain members are inserted, can increase the level of uncertainty and generate the need to improve resilience capabilities to avoid operational collapse.

The disruption of Samarco dam in Mariana in 2015, the truck drivers strike in Brazil in 2018, the Philips factory fire im 2000 and the Japan earthquake in 2007, are just a few events that illustrate the impact of risks and uncertainties not only on a single company, but also on several members of its supply chain (Chopra & Sodhi, 2004; Freitas, Silva, & Menezes, 2016; Jüttner; Maklan, 2011).

Thus, this paper contributions are: (1) the understanding, the importance, and the impacts of developing different resilience capabilities to efficiently manage risks and become resilient; (2) deepening a theoretical debate about supply chains resilience dimensions; (3) theoretical development of a resilience package of capabilities including analytical orientation; (4) propose an extended model, that will be empirically tested, in order to verify whether the proposed relationships are statistically significant. (5) make possible to test the explanatory power of the initial model against the extended one. Moreover, empirically tests the change in strengths of relationship with the inclusion of analytical orientation construct, in the initial model, as a component of resilience capability.

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PRINCIPAL-AGENT PROBLEMS IN IMPLEMENTATION OF GHANA'S HEALTH INSURANCE SCHEME

ABSTRACT

principal-agent relationship exists between health service providers and their authori-ty and clients. It asserts that health service providers as 'imperfect agents' of the author-ity and clients will take actions that aim to maximise profits at the expense of author-ity and clients (principal). The situation is possible when reimbursement is based on fee-for-service or a diagnosis-related groups. It looks at relationships between health service providers as agents and health insurance authority, and clients as principals in areas of provision of health services, supply of drugs, medicines and reimbursement. Results showed the private health service providers prescribed more drugs and medi-cines for clients towards profit maximisation (agency) than their public counterparts. Also, it was found that the public health service providers continued to provide health services and drugs despite health insurance authority indebtedness to them exhibit-ing more stewardship towards health insurance authority. It recommends strict regu-lations in tariffs/vetting claims and prompt reimbursement.

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INTRODUCTION

This article focuses on three actors namely National Health Insurance Authority, health service providers and health insurance clients. NHIA is responsible for the implementation of National Health Insurance Scheme (NHIS) in Ghana. In this principal-agent relationship, NHIA (principal) contracts health service providers (agents) to provider healthcare services, drugs and medicines to health insurance clients. Another relationship is between health insurance clients as principal, who expect their agents (NHIA) and health service providers (hospitals and clinics) to provide them health insurance services, supply of drugs and medicines at health facilities. The aim of this study is to examines the implementation of National Health Insurance Scheme (NHIS) in the context of principal-agent relationships in the provision of health services, supply of drugs and medicines and the processes of reimbursement for the services and drugs supplied to health insurance clients in a developing world context of Ghana.

The agency theory provides the theoretical perspective. This study adopts largely a qualitative research design. The main research questions addressed include: do agents shirk responsibility? What about principals? in the implementation of National Health Insurance Scheme in Ghana. The study adds to existing literature on 'agency shirking', it also adds to knowledge in a new direction that, it is not only the agents that 'shirk responsibilities' but principals were found to be engaged in what the authors termed 'shift of responsibility' in the implementation of NHIS in Ghana. This study further adds to public-private partnership in the pharmaceutical supply chain (supply chain management) in a developing world context, with Ghana as a case study. In this regard, it strongly recommends stronger collaboration between public and private sectors and strict monitoring in supply of drugs and medicines in the implementation of NHIS in Ghana. The study attempts to bridge the seemingly gap between public and private sector management and supply of drugs and medicines in retail and bulk distribution as well as managerial interests couple with principal interests. Thus, it examines issues of interests' divergence in both sectors.

Theoretical perspective: Principal-agency theory

The agency theory (principal-agent relationship) provides the theoretical insights for the study. It helps to understand key issues of interests' divergence or incongruences in the supply chain particularly relationships between public and private suppliers, distributors of drugs in Ghana. The incongruences may be due to profit orientations of agents in the provision of services and drugs to health insurance beneficiaries. We look at relationships that exist between principal(s) and agent(s) in implementation of National Health Insurance Scheme (NHIS). The relationship emerges when the 'principal' contracts the 'agent' to perform some task(s) for the principal. The principal in this relationship takes a back stage (passive role) while the agent takes front-line role (active role) of executing principal tasks or duties on behalf of principal. The agent in carrying out the task(s) of principal, takes some decision or action which tend to have some consequences and the consequences in turn affect the welfare or wellbeing of 'both the principal and the agent' (Petersen, 1993, p. 277; 1995, p. 188). The principal-agent relationships abound in many fields of study and daily encounters like teacher-student, doctor-patient, insurer-insured, employer-employee, lawyer-client, owner-manager relationships among others. At organisational levels, such relationships may be between government agency and private organisation(s). In case of this study, this relationship takes the form of public-private health service providers partnership in provision of healthcare. At managerial levels, it takes the form of owner-manager relationship, the manager(s) has managerial skills and the capacity to perform the task of managing the activities of the organisation on behalf of the owner. In this relationship, the agent (manager) is assumed as skilful with expertise to manage or perform the task of the principal (owner of organisation).

The principal-agent relationships are without problems. Petersen (1993; 1995) identifies some two problems of the principal. The first is how to choose the agent-get the right, effective and competent agent or may be face with the risk of wrong agent ('adverse selection'). In situations where the principal cannot observe agent action(s), agent may have the incentive to 'shirk' duties/responsibilities-'asymmetrical information' (Winter, Skou, & Beer, 2008, p. 4). This may undermine the task(s) of the principal. Petersen has two assumptions on human nature on principal-agent: one, 'humans are hyper-rational' based on 'omnipotent calculators/computation'. The second assumption is 'actors behave selfishly and do so with guile' (Petersen, 1995, p. 190). Similarly, Moe (1984) asserts that bureaucratic

agents want to maximise their own interests against their principals. Thus, in the principal-agent relationship, there is issue of self-interest/self-seeking of one actor against the interest of another- 'moral hazards' (Bossert, 1998; Worsham & Gatrell, 2005; Winter, et al., 2008; Erlei & Schenk-Mathes, 2016). Another issue or problem in principal-agent relationship is the procedure use in rewarding the agent (benefits/rewards). It may be based on translation of action (input) into outputs or outcomes or both, or based on financial incentives to change the agent behaviour. Thus, principal and agent decide the kind of reward systems or 'incentives' to operate in their contractual relationships or dealings in agency cost and interests of managers of hospitals, clinics or pharmaceutical companies (Holmstrom & Milgrom, 1991; Pratt & Zeckhauser, 1991; Rees, 1985; Jensen & Meckling, 1976; Kipo, 2011).

On health policies implementation a number of studies have explore the relationships between principals and their agents in service provision, diagnoses, supply chain management and or pharmaceutical supply chains among others across the globe, across countries and or within countries. Nguyen (2011) examines principal-agent relationships in areas of prescribing patterns (drugs/medicines) and behaviours of health service providers' especially private ones.

Brinkerhoff and Bossert (2014) examine principal-agent relationship on behaviours of health system actors as well as their performance problems (multiplicity of social actors in health systems). The first actors being state actors-politicians, policy makers and implementers who work in public sector health bureaucracies like health ministries, agencies and other public sectors. Second actors as health service providers (hospitals, clinics, laboratories et cetera) in public and private sectors. The other actors are the citizens/clients (service users). Brinkerhoff and Bossert (2014) argue reforms that introduce elements of competition among service providers can increase clients' power and increase health service providers' incentives to be more accountable to health service users. Also, service users have the power/capacity to choose among service providers where to access health care while state actors provide policy direction. In Brinkerhoff and Bossert (2014) work, state actor acted as the principal while service providers as agents likewise the citizens as principals in a new public management sense and health service providers as agents satisfying the health needs and demands of the citizens/clients. Brinkerhoff

and Bossert (2014) identified three principal-agent problems as: accountability failures, power gap, perverse incentives and service users overconsumption of health services.

Winter et al. (2008) utilised principal-agent theory in the implementation of Danish welfare and employment policy at the front-line level. They conceived national government/parliament as principal while managers of local authorities (local politicians/management) as agents. They found that multiple principals created 'conflicting loyalties' of front-line workers to either superiors (national policy mandates) or keep to the preferences of local politicians/management. Bossert (1998) applied the principal-agent in decentralisation of health systems in developing countries with Ministry of Health as principal (initiator of health policy objectives) while the local authorities act as agents. The work focuses on what happens at the centre and periphery. Bossert (1998) work implies that centre (principal) should focus on designing appropriate health policies with right communication systems, incentives to monitor periphery to achieve goals. Nguyen (2011) also looked at principal-agent relationship issues or problems in health care in a developing country perspective 'from prescribing patterns of private providers' in Vietnam. This article focuses on principal-agent relationship in public-private health providers in Ghana.

Pharmaceutical supply chain

Pharmaceutical Supply Chain (PSC) is the medium through which essential pharmaceuticals are delivered to the end-consumers or end-users at the right quality, right time and at the right place (Enyinda & Tolliver, 2009; Mckabe, 2009). Pharmaceutical Supply Chains (PSCs) are 'major drivers' of the health care sector and their effective management is crucial in healthcare system (Narayana, Pati, & Vrat, 2014). All over the world the public sector alone cannot meet the health needs of the public in terms of supply and distribution of pharmaceutical products. Thus, there is the need for private sector engagement in the supply and distribution of drugs and medicines to complement 'state-run drug procurement and distribution systems' more especially in Africa (Ballou-Aares et al 2008; Mckabe, 2009).
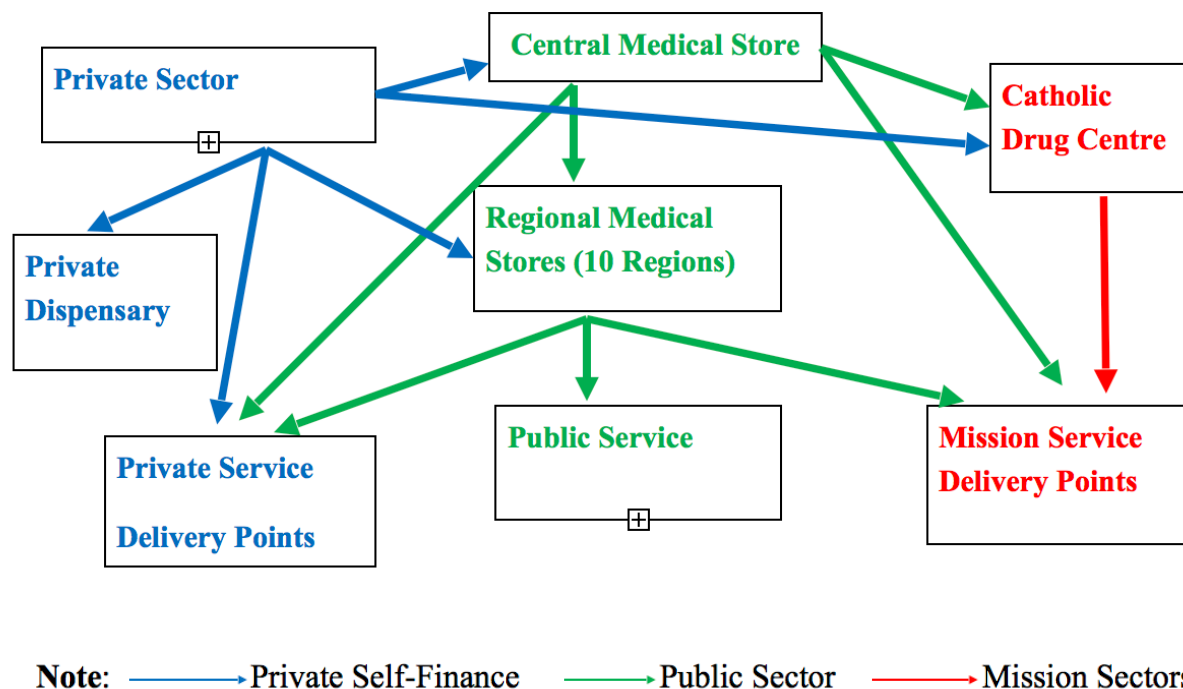
Pharmaceutical supply chain in Ghana

Pharmaceutical supply chain in Ghana is 'complex and interconnected', it involves interaction between the public, private self-financed and private faith-

based sectors. Public-private supply chain is two-directional: The Public Procurement Act (2003) permits public health providers to buy medicines/drugs directly from private sector suppliers under certain conditions (Government of Ghana, 2003b) and private self-financed and private faith-based health providers. The faith-based health providers are the religious-Christian/Muslim health service providers, they can also purchase from the Central Medical Store (CMS)-public source. CMS (located in Tema near Accra) supplies all public hospitals and clinics medicines through the ten (10) Regional Medical Stores (RMSs) for healthcare service delivery as well as private sector health care facilities in Ghana. In this respect, Seiter and Gyansa-Lotterodt (2008) argue that some RMSs in Ghana purchase drugs and medicines up to

80% from the private sector. They identified some challenges in private sector particularly the 'informal sector' where a number of unlicensed or unregulated drugs and medicines are sold to end-consumers/end-users (patients). This exposes the end-consumers (patients) in Ghana to substandard, counterfeit or low-quality drugs/medications. Despite these challenges, the private sector supply chain helps to fill some lapses, gaps and deficiencies in the public sector supply chain. The public-sector supply chain also has some weaknesses such as 'bottle necks and persistent drug stock outs' at health care facilities in Ghana (Ballou-Aares et al., 2008). Figure 1 illustrates Ghana's pharmaceutical supply chain (product flows) between public and private sectors.

Figure 1. Supply Chain (product flows) between

Note: →Private Self-Finance   →Public Sector   →Mission Sectors

Source: Developed from Ballou-Aares et al, 2008

Figure 1 shows the three main players in pharmaceutical supply chain in Ghana. The extreme *left* is the private self-finance sector which supplies thousands of private dispensaries, hospitals, clinics, maternity homes. The public sector (*middle*) shows CMS supplies all 10 RMSs, which then supply all public service delivery points (public hospitals, clinics) as well as mission and private self-finance sectors. The mis-

sion/faith sector at the *extreme right* supplies mission service delivery points and sometime supply public and private self-finance sectors in Ghana.

Pharmaceutical Supply Chain and NHIS Payment Mechanisms in Tamale Metropolis

In Tamale Metropolis, the Claims Processing Centre at NHIA regional office handles claims issues. The local level pharmaceutical supply chain and claims payment system is in Figure 2.

Figure 2. Pharmaceutical Supply Chain and NHIS Claims Payment System in Tamale
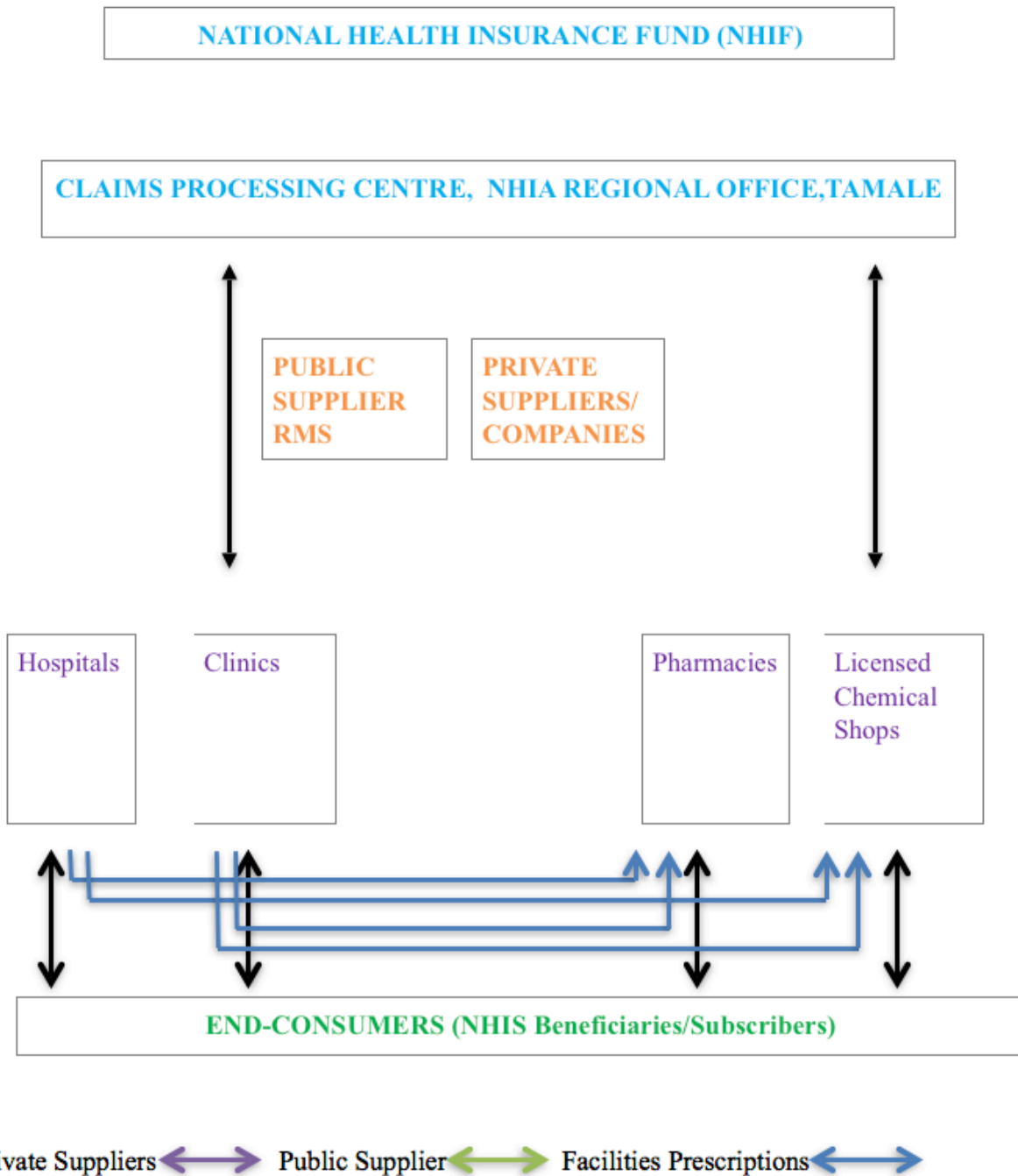
From Figure 2, the main source of funding for implementation of NHIS is the *National Health Insurance Fund (NHIF)* which is located and administered at the national capital (Accra). The funds are release from the top to NHIA regional or district offices for payments as subsidies (for people exempted from payment of annual claims) and re-insurance (other cost/expenses). Besides the NHIF other local level funds include payment of premiums and registration fees. The Claims Processing Centre (CPC) vets all claims submitted by health service providers in Tamale Metropolis and pay monthly claims into bank accounts of public and private health service provider. The health service providers monthly claims shall be paid 'within four weeks by schemes' (GoG, 2003, p. 17) or for a period 'determined by scheme and service providers' (GoG, 2012, p. 39). Public and private health service providers (clinics, hospitals, pharmacies and licensed chemical shops) purchase (buy) the pharmaceutical products from private suppliers or companies or from public suppliers (Regional Medical Stores) and stock their pharmacies or dispensaries to be provided to health insurance clients. Hospitals, clinics, pharmacies and licensed chemical shops are the Service Delivery Points (SDPs) who provide pharmaceutical products (drugs/medicines) to end-consumers (health insurance clients) in the implementation of NHIS at local level in Ghana. This shows the local level pharmaceutical supply chain.

RESEARCH METHODOLOGY: DATA COLLECTION TECHNIQUES AND ANALYSIS

This study was conducted in an urban setting of Ghana (Tamale Metropolis) with a population of 371,351 based on 2010 population and housing census (Ghana Statistical Services [GSS], 2012). Our choice of Tamale Metropolis is premise on its cosmopolitan nature and the city with the largest number of accredited health service providers in North of Ghana. We used duration, and number of services provided criteria to select four health service providers. Beside the four health service providers, we selected some pharmacies, pharmaceutical companies, suppliers in public-private supply chain. Table 1 shows the selected health service providers, suppliers and retailers in implementation of National Health Insurance Scheme (NHIS) in Tamale Metropolis.

Table 1. Selected NHIS Health Service Providers, Suppliers and Retailers

Health Service Providers	Ownership	Suppliers and Retailers	Ownership
West Hospital	Public	Regional Medical Store	Public
SDA Hospital	Private	Ernest Chemists	Private
Bilpeila Health Centre/Clinic	Public	Opac Drug House/Pharmacy	Private
Haj Adams Clinic	Private	Peekay Gombi Pharmacy	Private
		Tobinco Pharmaceuticals Ltd	Private
		S.M. Licensed Chemical Shop	Private

Note: S.M-Seidu Mashud

Most studies on the pharmaceutical supply chain adopt quantitative research methods and data sources like (Shah, 2004; Mckabe, 2009; Nguyen, 2011; Narayana et al, 2014). Our choice of qualitative methods of data collection and analysis is to help us explain this phenomenon better. Our use of in-depth interviews and focus group discussion enabled us interact with participants in their 'natural setting' (Yin, 2014). We interviewed pharmacists at their service delivery points, pharmaceutical product suppliers in their offices, reach out with licensed chemical shop dealers on-site, health service providers at workplace and then meeting various health insurance clients at homes, health insurance offices and at service delivery points in Tamale Metropolis. There have been many studies on Ghana's health insurance as well as studies on pharmaceutical supply chain like Ballou-Aares et al, 2008; Catherine et al, 2008; Mckabe, 2009; Makinen, Sealy, Bitran, Adjei, and Munoz, 2011). But not many studies on the principal-agent problems in the implementation of NHIS in Ghana. In contributing to the principal-agent problems in the implementation of NHIS, we specifically focus on patterns of prescribing and dispensing of drugs and medicines to health insurance clients in Ghana. The reason or motive for examining patterns of prescription of drugs and medicines from medical practitioners and dispens-

ing of drugs and medicines from pharmacies and drug stores aim to solicit the views of medical doctors, physician assistants and pharmacists on the administration of drugs. Moreover, we aim to get better understanding of the supply chain from both public and private service providers perspectives. Most literature on the principal-agent problems or relationships come from the western or developed countries, we are hopeful that our research or study will contribute to the little literature in the developing world especially Ghana. This area of research and the data collection strategies and analysis will hopefully add to the understanding of the relationships that exist between the two principals (NHIA and clients) and their agent (health service providers- hospitals, clinics). Qualitative research strategy is multi-method in focus, interpretive and naturalistic in approach.

Also, qualitative data provides useful insights into human behaviours. Such data sources include collecting life stories, personal experiences, interviews, historical, visual texts, observations, documentation and physical artefacts (Twumasi, 2001; Gray, 2009; Bryman, 2012; Yin, 2014).

We used 'purposive sampling method to select participants (health insurance officials, service providers officials and health insurance clients). We consciously selected the insurance clients based on categories through 'quota sampling' technique' (Twumasi, 2001, p. 28). This technique enabled us to have the various categories from contributors (formal/informal sectors) and those exempted from paying annual premium (children and those below 18 years, pregnant women, the aged (70 years and above), core poor in society (indigents) and pensioners (social security). The categorisation of beneficiaries was done in line with the health insurance policy documents; thus, we took those categories from the health insurance policy documents (GoG, 2003; 2012). To enable us understand task of the principal (NHIA), we solicited the views of health insurance officials at district and regional levels. Officials handling claims on drugs and medicines at the claims processing centre and officials handling registration and renewals of clients. We also sought the views of agents (health service providers-officials in hospitals, clinics, pharmacies, licensed chemical shops, public-private pharmaceutical product suppliers and retailers). We probed during interviews, we also used both 'closed and open-ended questions' in our interview guides. We administered the semi-structured questions in the study area (Bryman, 2012). In doing so, we created a friendly atmosphere for participants to share their life stories, experiences on supply of drugs and medicines, reimbursement and the problems they encounter in the daily implementation of NHIS in Tamale Metropolis. Table 2 illustrates the selected participants. Information obtained from various sources including interviews were analysed through coding, transcription, typing and using direct quotes, as well as content analysis along thematic areas. Towards 'reliability' of findings, we used data triangulation/multiple sources (Yin 2014) and 'credibility' (Zhang & Shaw, 2012) study research design was rigorous and back with theory. These validity strategies were used: 'member checking' participants having an opportunity to determine the accuracy of fieldwork information, this was possible due to 12 months fieldwork. We used 'rich thick description' with participants shared experiences and reliability procedures like transcription as we carefully translated local languages into English, 107 participants in all.

Table 2. Categories of Participants

Categories	Service Providers	NHIA Officials	Suppliers & Retailers	NHIS Exempt Group	NHIS Contributors	Total
Number	8	3	6	12	8	**37**

EMPIRICAL EVIDENCE: RESULTS/FINDINGS

This study is guided by the agency theory (principal-agent relationships) in provision of health services and the supply of drugs and medicines to health insurance clients in Ghana. For 'clarity of results' (Zhang & Shaw, 2012), we categorised findings along major themes in answering our research questions. Results, is followed with discussions of findings with theoretical insight.

Relationship between health service providers and suppliers of drugs and medicines

The questions asked focused the on suppliers of pharmaceutical products as in Figure 3 and the terms of payments. We tried to find out from health service providers (clinics/hospitals) where they take their pharmaceutical products from and how they pay their suppliers. The responses were mixed between the public and private health service providers. The public clinic officials (pharmacists/administrators) indicated that most of their pharmaceutical products came from Regional Medical Store (public supplier) through Ghana Health Service (GHS) Metropolitan Health Management Team (MHMT). The private clinic officials indicated that they have more suppliers to procure drugs and medicines. Also, they said the private clinic is free to procure drugs and medicines from the public supplier (RMS) and the numerous private sector suppliers.

On the two hospitals, we interviewed two officials, one in general administration and the other in the pharmacy unit. The public hospital main supplier of pharmaceutical products is Regional Medical Store (RMS). The public hospital administrative staff indicated that they had to follow procurement rules strictly to enable them procure other pharmaceutical products from private sector suppliers when the main public supplier (RMS) is not able to meet all their product needs. A pharmacist in private hospital revealed that they often take their supplies from three sources namely Ghana Adventist Health Services (GAHS), Regional Medical Store (RMS) and the various suppliers in private sector. We noted less bureaucracy in private hospital procurement.

We also made efforts to reach out with the main suppliers of pharmaceutical products on how they work with health service providers in the implementation of NHIS in Tamale Metropolis. The various pharmaceutical companies and other suppliers indicated that they prefer inter-bank payments through use of cheques than cash payments. We realised that due to fear of robbery, most suppliers especially salesmen preferred payments through the banks than cash payments.

Relationship between Principal (NHIA) and Agent (Health Service Providers)

All interviews and documentations were obtained from accredited facilities and their staff. The four selected health service providers received accreditation for the past years and have since been reaccredited periodically in line with the National Health Insurance Acts, 2003 and 2012 as well as the legislative instrument (1809), 2004 (GoG, 2003; 2004; 2012). The public hospital and clinic received some 'automatic' accreditation license from the National Health Insurance Authority (to operate NHIS in 2005 while the private clinic and hospital applied for accreditation and received 'provisional' accreditation license in 2005 to implement NHIS in the Tamale Metropolis of Ghana. However, this practice has changed since the passage of the new act (Act 852) passed in 2012 which require that both public and private health service providers must be credentialed (accredited) by NHIA before they implement NHIS in Ghana.

It is required for health service providers (agents) to submit their monthly claims to the NHIA (principal). The NHIA is expected to vet the monthly claims thoroughly and reimburse health service providers. Act 650 (2003) require NHIA to reimburse monthly claims within 4 weeks upon receipt of claims while Act 852 (2012) require that reimbursement should be made within an agreeable period between NHIA and health service providers. During interviews, we noted that both agreed that payments should be made within reasonable periods without exceeding six months after submission of claims to NHIA. Table 3 illustrates the responses (direct quotes) of participants (officials of NHIA as principal, and health service providers as agents).

Table 3. Direct Quotes from Participants

1. Public hospital pharmacist	"My bro health insurance is the surest way to health care, without it many lives will be lost. It is a guarantee for life once one subscribes to it. For the hospitals it has re-duce fear for service utilisation and that led to increase patronage for health services. Drugs that the poor cannot buy with cash they get them free of charge so what is more than this? But do you know the sad story of health insurance? It is delays in claims payments".
2. Public hospital pharmacist	"The delays though mild in the public sector yet contribute to stock-outs in many pharmacies and dispensaries because we need cash to procure some essential drugs since we cannot get all from the regional medical store".
3. Private hospital pharmacist	We like the health insurance scheme because it is a major source of revenue for the hospital; it also helps the poor to access healthcare services and have free access to drugs and other medications. However, payments of claims are the biggest problem. Sometimes it takes over six months without payments. Can you imagine how the hospital will manage to buy drugs and pay its staff salaries and other incentives? How can you provide services and drugs and will have to wait for over six months to be paid? That is bad and this affects us a lot. No wonder we sometimes go on strike to get our claims".
4. Public clinic administrative officer	"We are part of GHS we are paid by the state so why should we go on to boycott health insurance, we get our salaries and products from GHS".
5. Private clinic physician assistant	"What is the point embarking on strikes and losing lots of revenue? The more you refused to provide services and drugs to insurance clients the more you lose revenue to the facility that's why we don't embark on strikes".
6. Peekay Gombi pharmacist	"Eeeii we usually receive prescription forms from patients from all hospitals and clin-ics in Tamale. We don't discriminate between patients whether from public or private facility, once the prescription form is signed and stamped that is all, we accept it and provide the patients the drugs as prescribed. However, frequent delays in payments of claims are our biggest problems".
7. Licensed chemical shop seller	"Health insurance people don't often visit our drug store but those who come with prescription forms, we do provide them the needed drugs but delays in reimburse-ment is what affect our revenue and affect both quantity and quality of drugs. It is too bad that it can take over six months".
8. Metropolis NHIA officer	"We are very much aware of how some facilities refused to dispense drugs to clients but take their prescription forms to demand claims from us".
9. Metropolis NHIA line manager	"National health insurance fund is main source of funding from national, those we generate locally: registrations and payments of annual premiums. Most people are interested in health insurance and they do register and renew their membership. Though we cannot say it openly there is secret politics"
10. Regional NHIA officer at Claims Processing Centre (CPC, Tamale)	"We usually vet the monthly claims of facilities to see that right prescriptions and tariffs are charge. Also, we check to see if subscribers indeed visited their facilities. Payments of claims take two forms: services rendered and drugs supplied to sub-scribers. Deductions or additions are given to facilities for wrong charges or for fair-ness. On payments we sometime encounter delays due to rigid vetting at processing centre to check fraud. We always try to avoid non-payments beyond three months and not exceeding six months".

We asked questions in relation to reimbursement from NHIA for drugs and medicines provided to health insurance clients. These questions were directed to the principal (NHIA) regional and district officials. The same questions were also directed to the agents (health service providers). The responses of the NHIA officials are in Table 3, quotes 8-10. They indicated that they have fulfilled their contractual agreements through the rigorous vetting of claims, checking wrong charges and multiple entries as well as wrong application of tariffs on drugs and medicines. In addition, the principal (NHIA) indicated that periodic clinical audits are conducted as additional measures to check fraud and abuses from their agents (health service providers-hospitals/clinics and other service providers). NHIA officials admitted to delays in reimbursement for services, drugs and medicines but associated such delays to rigorous vetting and monitoring on agents.

On the other hand, the agents from both public and private indicated that their principal (NHIA) has failed in carrying out its contractual agreements such as payments within four weeks or not exceeding six months upon receipt of health service providers claims. The agents' responses to delays and non-payments of claims for months or over six months in Table 3, quotes 1-3, 6-7). But the agents were divided on the use of strikes or protests to demand for prompt payments.

While the faith-based hospital joined other Christian Health Association of Ghana (CHAG) to embarked on strikes across Ghana in 2013 and 2014, other private suppliers of drugs and medicines joined the strikes (Daily Graphic Newspaper publications on July, 2, 2014, p. 11) and other online publications (Ghanaweb News). Most private health service providers and pharmaceutical companies joined strike to boycott NHIS. But private for-profit clinic declined to join other private groups on strikes on grounds that the facility will lose revenue if it embarks on strike (see Table 3, quote 5). Public service providers did not embark on strikes as state health providers (Table 3, quote 4). They received more pharmaceutical products from the public supplier-regional medical store. We found that the private health service providers felt the delays in reimbursement more because they had to pay their workers salaries, procure drugs and medicines on their own. Thus, we noted more financial pressure was on the private sector health providers than public ones.

Despite the challenges or problems between the principal and the agents in reimbursement, we asked if there were some prospects in the implementation of NHIS. The responses of officials of the two hospitals showed that NHIS is a very good social intervention programme that has benefited the people of Ghana in terms of access to healthcare services and drugs. It has also contributed to increased patronage for healthcare services thus increased service utilisation. It has removed some financial barriers to healthcare since health insurance clients have free access to number of essential drugs (approved drugs) and wide range of services. Moreover, since the implementation of NHIS, the fear for payments for medical bills especially drugs and admission fees have been removed as such services are part of NHIS benefits package for clients.

Issues of Prescription Forms for Drugs and Medicines in Implementation of NHIS

When health service providers (hospitals and clinics) do not have certain drugs or medicines in their pharmacies or dispensing stores, the health professionals will normally issue a prescription form usually signed and stamped with details of health insurance client. The prescription form is presented to the client to be taken to other accredited pharmacies, licensed chemical shops (drugstore) for drugs and medicines that are out of stock at the hospital or clinic. This medical practice of issuing prescription forms to clients is an effective way of helping health insurance clients to have access to drugs and medicines that are not available at hospitals or clinics visited.

The accredited pharmacies and licensed chemical shops in turn provide health insurance clients drugs and medicines and forward their monthly claims to NHIA for payments. A pharmacist in one accredited pharmacy in Tamale Metropolis (Peekay Gombi Pharmacy) commented on their working relationships with health service providers (hospitals, clinics) and NHIA (Table 3, quote 6). An accredited chemical shop seller confirmed receiving prescription forms (Table 3, quote 7). However, we observed certain bad practices at accredited pharmacies and licensed shops which include the practice of receiving prescription forms without dispensing drugs and medicines to health insurance clients, problems no drugs, demand for some cash payments from clients due to differences in tariffs, the practice of not providing clients all the drugs prescribed by health professionals at hospitals and clinics, and the prac-

tice of 'go and come for drugs the next day'. These were observed at those accredited pharmacies and licensed chemical shops in Tamale.

We then interviewed officials of NHIA to solicit their views on some issues/complaints from four health service providers and the other accredited pharmacies and licensed chemical shops officials. Officials of NHIA admitted to delays in reimbursements and how it can affect quality of services, drugs and medicines but blame some of the accredited health facilities for engaging in malpractices which made them spend more time in vetting claims. Some accredited health service providers/facilities are busily cheating our subscribers and doing wrong things (Table 3, quote 8). Thus, decision to critically examine claims and vet them properly (Table 3, quote 10).

Moreover, NHIA officials at district and regional offices confirmed that some deductions were made on monthly claims of some accredited health service providers/facilities as complained by officials of health service providers. The NHIA officials maintained that those deductions were due to some abuses, errors or fraudulent deals. NHIA officials disagreed that they often owe their agents claims beyond six months contrary to the agreement they had with their agents.

Documentary evidence from the field confirmed deductions of health service providers monthly claims. The national office of NHIA was suspicious of some malpractices at local level across Ghana between local NHIA officials and some health service providers. There was suspicion of connivance between some NHIA officials and health service providers with the feeling that local health insurance officials were not diligent in vetting and verification of monthly claims at local level. In this regard, NHIA instituted *clinical audits* across the country. In the Tamale Metropolis clinical audit took place in March 2010 in which eight health service providers claims were audited. The clinical audit aimed to cross check claims vetted by local level NHIA officials. After the audit it was discovered that a huge amount of GH¢279,069.81 (72,485.67 USD) was wrongly paid to the eight selected health service providers in 2010. A second clinical audit was conducted in June 2012 in Tamale Metropolis by the national audit team. An amount of GH¢486,268.31 (125,679.33 USD) was deducted from thirteen health service providers. The national audit collected relevant documents including attendance books, monthly claims

reports, NHIS attendance registers et cetera. They thoroughly audited them and recommended that all wrongly paid monies be deducted from the affected health service providers claims. The most affected health service providers with more deductions was the private clinic, followed by the private hospital while the least affected was the public clinic (Tamale Metropolitan Mutual Health Insurance Scheme (TMMHIS) Annual Reports, 2010; 2012).

Relationship between Principal (Clients) and Agents (Health Service Providers)

The second principal-agent relationship is between health insurance clients (the principal and health service providers (agents) in the implementation of NHIS in Tamale Metropolis. We solicited the views, opinions and experiences of health insurance clients (end-consumers) of pharmaceutical products on the implementation of NHIS at the local level. We used both in-depth and Focus Groups Discussions (FGDs). The health insurance clients freely expressed their opinions and shared their experiences on the provision of drugs and medicines at the four selected health service providers (hospitals/clinics). The health insurance clients confirmed that they often receive drugs and medicines free from health service providers. Many mentioned of receiving drugs and medicines from accredited pharmacies like Peekay Gombi and Opac Drug House with their prescription forms. Few also mentioned of receiving drugs and medicines from licensed chemical shops in Tamale Metropolis. Some pregnant women interviewed confirmed receiving pregnancy medications without payments at the four health service providers as well as other accredited facilities. We also made on-site observations on the issuing of prescriptions forms and the dispensing of drugs and medicines to health insurance clients (end-users or end-consumers of pharmaceutical products). We noted there were long queues of clients at various Out-Patient Departments (OPDs) pharmacies and dispensaries waiting for drugs and medicines. Our observations confirmed the medical practice that in some instances where some drugs and medicines were not available at facilities pharmacies and dispensaries, prescription forms were issued by medical personnel to their clients to visit other accredited pharmacies and chemical licensed shops. Most responses from end-consumers or end-users of pharmaceutical products showed that private health service providers dispense more ex-

pensive drugs than their public counterparts (Table 4, quotes 2) in implementation of NHIS in Tamale Metropolis in Ghana.

Despite prospects of clients increased access to drugs and medicines and revenue for hospitals and clinics (see Table 4, quotes 10-11) and other accredited pharmacies and licensed chemical shops some clients still shared their frustrations in other areas. These frustrations/problems were noted during the in-depth interviews and FGDs. The health insurance clients indicated that some expensive drugs were either excluded or service providers demanded cash payments for them. Some health insurance clients were of the view that most of the drugs and medicines provided them free were less expensive particularly those obtained from the public sector. These observations revealed that the principal (health insurance clients) were not so happy with the performance of some agents (health service providers) in terms of access to expensive and effective drugs and medicines at point of service delivery (hospitals, clinics other providers).

We also found from the field habits like 'shopping spree' where some health insurance clients (end-users/consumers) visit many health service providers/

facilities to be provided with drugs and medicines for other family members or friends (Table 4, quotes 7) at the expense of NHIA. The principal (some clients) abusing the agent (NHIA) through use of other persons insurance cards to access drugs and medicines by fraudulent means. In some extreme cases some incidence of expired drugs and medicines were supplied by health service providers to health insurance clients (end-consumers) especially to the illiterates (those who cannot read English). We observed a similar case at a private pharmacy where the dispensing officer mistakenly dispensed expired drugs to health insurance client and when the client checked expiry date, he quickly returned those drugs. The dispensing officer apologised and promised it will not happen again since expired drugs are often removed from dispensing shelves and wondered why they were left there. If the client was an illiterate he or she would have gone with the expired product. Thus, the agents (health service providers) also abused the principal (clients) in some areas like supply of expired products/supply of less quantity as required. The end-users of pharmaceutical products (clients) responses at both in-depth interviews and FGDs are in Table 4, quotes 1- 9.

Table 4. Interview/FGDs Responses from Beneficiaries and staff of health care facilities

1. Indigent	"They don't respect we the poor ones. I sat here and many people are by-passing me to see the doctor".
2. Pregnant woman	"The drugs we get from facilities especially government clinics and hospitals most of them are cheap para, they don't cost much, expensive drugs like foreign pregnacare plus omega 3 will not be given to insurance people only those with cash will get them".
3. SSNIT contributor	"I don't normally fall ill but had to join health insurance it times of emergency or at periods of no money so it is my social security".
4. Aged	"Some NGOs helped to register me and they come to pick my card for renewals I don't pay pesewas when I go to hospital with health insurance".
5. Pupil (basic level)	"It is my mother who registered me for health insurance, I am always sick of malaria that is why my mother registered me".
6. Premium Payee	"I am a carpenter so I registered for myself, wives and all children, we don't pay money at clinics it is a good insurance for life".
7. Student(secondary)	"In the school we use friends' cards and we us this insurance card for mobile money, also my school authority asked all to register for it".

(continue)

8. Lamashegu FGD	Most participants complained of long queues at hospitals and clinics with health insurance, poor treatment from facilities. Four supported this while one praised health insurance saying. "it is my survival card when I visit hospital, no fears for medical bills".
9. Moshie-Zongo FGD	Members showed praises on health insurance as when there is no money, one can visit any hospital for drugs and medicines. A group member said this about health insurance "it saves life and reforms life and brings hope to the hopeless with health insurance card".
10. Private facility staff	"Health insurance is the main source of funding; we used money to buy drugs and pay workers and it is far better than cash and carry".
11. Public facility staff	"The people of Ghana are happy for this policy, which is very friendly to poor and vulnerable ones is society for free health care. The poor don't run away from bills".

DISCUSSIONS OF FINDINGS

Principal-Agent Issues and Problems in the Implementation of NHIS

The results or findings confirmed that there is a contractual relationship between the principal (NHIA) and agents (health service providers-the selected hospitals, clinics and other providers) through accreditation and re-accreditation in accordance with health insurance Acts (650; 852).

Findings on prescribing and dispensing patterns for drugs and medicines for health insurance clients from the various private health service providers concur with Moe (1984) assertion that 'bureaucratic agents want to maximise their own interests against their principals'. But this finding was not consistent with those in the public sector. The findings also agree with Nguyen (2011) that private service providers have desire to prescribe and dispense more drugs to insurance holders for profit maximisation. However, such prescribing patterns were not noted with public health service providers. These principal-agent problems were noted between NHIA and health service providers in the area of prescribing and dispensing of drugs and medicines to clients. The private health services providers were more 'self-seeking' or 'selfish' with more moral hazards than their public counterparts, which agrees with a number of studies on agents' self-interests/self-seeking (Worsham & Gatrell, 2005; Winter, et al 2008; Erlei & Schenk-Mathes, 2016). Other problems identified in this study is that the reward system for performance is not clear, this created some

mistrust or suspicion between the principal (NHIA) and the agent (service providers).

On the issues of monitoring of the agents (health service providers) by the principal (NHIA), The principal was found proactive in monitoring the actions of the agents in areas of rigorous claims vetting and clinical audits which helped in checking fraudulent acts from some agents. But, on reimbursement for services, drugs and medicines provided by health service providers, we realised that the NHIA as principal was not able to honour the agreement in terms of prompt payments of claims (reimbursement), it was indebted over six months to agents (health service providers). The agents honoured their part by rendering more services, drugs and medicines to clients but principal failed in keeping to its contractual agreement in line with insurance law. This confirmed shifting of responsibilities by the principal-NHIA as it concurs with Holmstrom and Milgrom (1991) and Pratt and Zeckhauser (1991) works on breaches on contractual relationships. The agents (health service providers) on the other hand, we noted breach of trust. For instance, the faith-based private hospital, some private pharmacies and suppliers of drugs and medicines embarked on nationwide strikes, denying clients access to healthcare services. For instance, the Ghana Chamber of Pharmacy (pharmaceutical distributors) on February 10, 2014 decided to withdraw the supply of drugs and medicines to NHIS accredited health service providers across Ghana. This behaviour amounts to 'breach of contract' or 'breach of trust' for their principals (NHIA and cli-

ents). This finding on agents particularly the private health service providers use of strikes to demand payments of claims in Ghana concurs with findings of Fusheini, Marnoch, and Gray, 2016.

We also found problems of 'conflicting loyalties' between the public and private health service providers where public providers were more loyal to NHIA than the private ones in areas of prescriptions, applications of tariffs, invoicing as reflected in both interviews and documentary sources of data (clinical audits). Such finding on 'conflicting loyalties' among the agents at the local level is consistent with Winter, Skou, & Beer (2008) findings in which multiple principals created conflicting loyalties in the implementation of Danish welfare and employment policy at front-line level. At some point the service providers appear loyal to one principal (NHIA or clients). Some abuses were found that affect the implementation of NHIS from health insurance clients in the forms of over-utilisations (frequent visits) in getting drugs for other relatives and friends. Some facilities also engaged in over-invoicing, over-billing, demanding cash payments etc. Some NHIA officials' connivance with facilities to cheat scheme through poor claims vetting.

Implications of findings for policy makers and international audience

The empirical evidence from the field suggests health service providers and medical stores have to strengthen pharmaceutical supply chain networks, build human resource capacity and take measures against pilfering of drugs to prevent frequent stock-outs particularly in public sector. The growing number of private drug suppliers is worrying at the local level with the influx of substandard and counterfeit drugs and medicines and this call for a stronger regulation and control by the pharmacy and drugs authorities in the distribution and retailing outlets. This is in line with McCabe (2009) suggestions for Ghana, Mali and Malawi pharmaceutical sector. Our findings also show that there is persistent pharmaceutical drug stock-outs in public sector (Ballou-Aares et al., 2008 and Makinen et al, 2011). Also, there is too much bureaucratic procedures at public sector and growing numbers of unregulated salesmen, middlemen and drug dealers at the local level. This Narayana, Pati & Vrat (2014), call for effective collaboration between public and private sectors partnerships in purchasing processes and supply chains networks. This study recommends that NHIS need to re-strategize in its payment mechanisms to include capitation systems where healthcare

facilities are pre-finance for some particular clients to minimise its indebtedness to service providers. Moreover, there is room for improvement in its recruitment processes to enable the scheme recruit highly qualified and competent staff to vet, to process and manage claims at various claims vetting centres and scheme offices across Ghana. Another problem identified is the politics of recruitment. This study recommends for stringent measures to minimised this practice to get the right personnel to save the scheme from possible collapse from its persistent high indebtedness to health service providers. This study finding on politics concurs with Fusheini Marnoch, and Gray (2016) findings that over-politicization, political interference and poor gate keeping system are key challenges affecting implementation of NHIS in Ghana. Thus, effective gate keeping mechanisms for referrals and prescription is very necessary for NHIS. Similarly, effective control measures should be instituted against abuses by clients by limiting the number times they will visit health service providers and with strict checking of clients' identities before services and provision of drugs at facilities. Financial malpractices by both health insurance officials and health service providers should be severely punished to deter others.

Contribution

This study found a new dimension, that not only agents 'shirk their responsibilities' but it noted a new pattern with principal engaged in 'shift of responsibility'. We recommend that future research or researchers would examine this new dimension and pattern of behaviour between principal(s) and agent(s) in supply chain management in Ghana or elsewhere in the world.

This study may have a geographic limitation but the findings can be transferable to other places with similar settings. It adopted largely a qualitative research approach which focuses more on 'analytical generalization' rather than 'statistical generalization' (Yin, 2014, p. 48).

CONCLUSION

Health policy formulation and design factors seriously need to be considered in order to make health policies more implementable. Framers of NHIS should have assessed the relationships between principals (NHIA) and agents (health service providers) in terms of incentives, profit maximisation and quality assurance in order to select the right agents. This

suggest that rigorous accreditation process is needed before granting health facilities license to implement NHIS. This will help to get agents whose interests and goals are in congruence with NHIS in Ghana. We recommend strict regulations in tariffs, vetting of claims and prompt claims reimbursement.

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THE BRAZILIAN OCEAN FREIGHT OSCILLATION: THE EXPERTS' EXPLANATION TO THE USA, EUROPE AND CHINA TRADE

ABSTRACT

This study aimed to identify the variables that contribute to the oscillation of the in-ternational ocean freight of the Brazilian trade of containerized cargoes. The ocean freight from and to East Coast of United States, Northern Europe and China to Brazil was studied by a qualitative approach through in-depth interviews with a panel of seven experts in charge of pricing the international ocean freight in the largest inter-national shipping companies operating in Brazil. After a first round with the experts, a table that tried to capture the causal relationship among variables and their influence in Brazilian ocean freight was developed. In a second round of interviews, the final table was submitted to the judgment of the experts. Considering the experts' opinion on the trade routes studied, it was noticed that the relationship between supply and demand with ocean freight is the variable that influences freight rates in Brazil's trade the most. Other variables such as vessels capacity, operating costs and competitors are among the variables that experts have identified as those that most contribute in Brazilian ocean freight oscillation.

KEYWORDS | Ocean freight, Brazilian maritime freight, containerized cargoes, Bra-zilian international trade, international logistics.

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INTRODUCTION

Many companies have realized the importance of trading products, raw materials, or even services at lower costs, higher quality, and wider variety. In this sense, the question is not about whether to look for more international resources or not, but how to manage this process and make it more efficient (Aykol, Palihawadana, & Leonidou, 2013; Grama, 2014; Trent & Monczka, 2003). Therefore, exporters and importers are more attentive to the costs involved in these processes, in order to make their products more competitive and, by logistic management, to establish policies that enable them to reduce costs and improve service level to the customer (Bygballe, Bø, & Grønland, 2012).

Transport costs represent a critical component of importation and exportation prices, and influence the development of a supplier or a customer (Anderson & Van Wincoop, 2004; Monroe et al., 2014). Freight rates bear a larger importance, compared to tax barriers (Binkley & Harrer, 1981; Hummels, 2001; Jacks & Pendakur, 2010). According to Fleury, Wanke, and Figueiredo (2012), generally production and marketing costs represent more than 70% of a company's revenues, while logistics costs stand at 19%. In addition, Ballou (2004) declares that 60% of logistic expenses originate in transportation, which explains the importance of managing freight rates, whether in domestic or international routes. These percent values prove that logistic expenses play a considerable part in the composition of the total cost of a product, which is why such values are the object of consistent reduction efforts as a means to improve profit margins.

On the other hand, in 2015, dry cargo shipments accounted for about 71% of total seaborne trade volumes, which means that "maritime transport is the backbone of globalization and lies at the heart of cross-border transport networks that support supply chains and enable international trade" (UNCTAD, 2016).

According to the Brazilian Ministry of Development, Industry, and Foreign Trade (MDIC, 2017), by the end of 2015, 90% of Brazil's international trade was transported by sea. Ocean freights placed on these imports and exports are formed by several variables. Although several studies have investigated some of these variables, such as the kind of goods shipped (Ho, Chiu, Chung, & Lee, 2017; Ortúzar & Willumsen, 1994), supply and demand (Jacks & Pendakur,

2010; Notteboom & Rodrigue, 2008; Ortúzar & Willumsen, 1994; Stopford, 2009), distance covered by the vessel (Banomyong, 2005; Hesse & Rodrigue 2004; Malchow & Kanafani, 2004), and vessel capacity (Leach, 2014; Notteboom & Rodrigue, 2008; Stopford, 1997), there are not many studies that addressed the variables behind the oscillations in international ocean freight rates set for exports and imports in the main routes serving emerging markets as Brazil.

The Brazilian Ministry of Development, Industry, and Foreign Trade (MDIC, 2017) indicates that the main economic regions that import to or export from Brazil are North America, Europe, and China. For Mongelluzzo (2013), the world's largest ports on a container flow basis are located in these continents. In the top 50 list, North America is represented by the Los Angeles, Long Beach, and New York ports with 8.08 million, 6.05 million, and 5.53 million of twenty-foot equivalent units (TEUs), respectively. In Europe, the largest ports are in the north, and include the ports of Rotterdam, Hamburg, and Antwerp with 11.87, 8.86, and 8.64 million TEUs, in that order. The Shanghai, Singapore, and Hong Kong ports are the main ones in Asia with 32.53, 31.65, and 32.13 million TEUs. In the same list, Brazil is represented by the port of Santos, which runs around 3.17 million TEUs. For this reason, Santos was chosen as a destination port, while Shanghai, Rotterdam, and New York (since it is located on the east cost of the USA) were selected as main ports in the analysis of freight volumes in the present study.

In this scenario, this study identified the variables that influence on the oscillations in international ocean freight rates for Brazilian containerized trade with its major markets. The investigation considered the perspective of the three largest cargo trade volumes with Brazil: the USA East Coast, Northern Europe, and China. The views and notions of a panel of experts active in three main company classes were analyzed: shipowners, co-loaders, and freight forwarders. The inclusion of these experts in different sectors helped understand the perceptions held by organizations that, despite sharing the same objective in terms of cargo transportation, could see the pricing of ocean freight rates from different points of view.

This article presents, first, a review of the theoretical background on the subject and the contribution of the variables that influence on the oscillations in

international ocean freight rates. Secondly, it will be discussed the methodological aspects to collect and analyze the data. After that, the data analysis obtained for the freight levels and the variables that influence the most on the oscillations observed are presented, as well tries to offer a proposal of a causal relationship among variables that influence freight in the trades studied. Finally, the implications of these variables are discussed.

THEORETICAL BACKGROUND

The supply chain and logistics

The globalization process has left a trail of economic uncertainties (Jacks & Pendakur, 2010). The increasing exchange of goods and services across nations has substantially acerbated interdependence and economic volatility. Local changes and crises bear immediate consequences and tend to spread globally.

Revisions in dollar exchange systems, recession, new international trade regulations, and higher oil prices are some of the uncertainty factors that affect a globalized economy on a daily basis. For logistics, which has to act based on a prediction of demand, producing and placing the correct product in the right place at the right time and at a fair price, increased economic uncertainties elicit significant difficulties to predict sales and plan activities (Fleury et al., 2012; Hesse & Rodrigue, 2004).

The supply chain, according to Bowersox, Cooper, Closs, and Bowersox (2014), encompasses companies that cooperate in order to leverage a strategic position and to improve operational efficiency. Ballou (2004) summarizes logistics and the supply chain as a "set of functional activities (transportation, inventory control, etc.) that repeat numerous times along the channel through which raw materials are converted into finished products, to which value is added in the eyes of the customer" (p. 29).

Since logistics is part of the supply chain, Bowersox et al. (2014) define it as the effort required to transfer and place an inventory in the supply chain. Banomyong (2005) agrees, adding that logistic management is an integrative process that aims to optimize the flow of materials and inputs provided by suppliers in the whole organization in order to meet customer's expectations. It is by a logistic process that materials travel inside the production capacity in an industrialized country, that products are distributed to consumers, and that value is generated to custom-

ers, suppliers, and any other stakeholder (Bygballe et al., 2012; Monroe, Teets, & Martin, 2014).

The international ocean shipping system

The role played by transportation in a logistics system is more complex than that of the transport of goods to customers (Zeng & Rosetti, 2003). This complexity may take effect only through a highly qualified management team. A well-managed system affords to transport goods to the right place, at the right time, aiming to meet the customers' need. It is transportation that helps promote efficacy, establishing a link between producers and consumers (Daividsson, Henesey, Ramstedt, Törnquist, & Wernstedt, 2005). Therefore, transportation is the basis of efficiency and savings in corporate logistics, and enhances other functions of the logistics system (Ballou, 2004; Grama, 2014). In addition, a good transportation system in a logistics network is beneficial not only to the quality of service, but also to a company's competition potential (Tseng, Yue, & Taylor, 2005).

It is widely accepted that water is the oldest means of transport. Ancient sailboats were replaced by steamboats in the XVIII century, and by diesel-propelled vessels around 1920's (Bowersox et al., 2014). Ships were first used to transport containers in 1956, when Malcolm McClean shipped the first cargo trailers towed by a 60-TEU World War II tanker, sailing from Newark, New Jersey, to Houston, Texas. Until then, most cargoes were transported loosely on ships, placed in wooden structures whose aim was to enable to hoist and to move goods by cranes on ports and on ships (Stopford, 1997). The result was that cargo ships spent about two thirds of operational time on ports, and that handling costs reached approximately one fourth of the total expenses. With increasing cargo volumes, this mode of operation became unfeasible both operationally and economically (Binkley & Harrer, 1981; Notteboom & Rodrigue, 2008).

The main advantage of ocean transport lies in the possibility to ship extremely large cargoes, besides lower costs when compared to airfreight (Ballou, 2006; Bowersox et al., 2014). As drawbacks, Tseng et al. (2005) highlight the longer delivery times, apart from the need to schedule mooring operations depending on weather factors. Other negative aspects include the distance between ports and production centers, and the need to invest in robust packaging solutions in order to protect goods, especially

against possible damage caused by mishandling during loading and unloading operations.

Ocean shipping costs to containerized cargoes

The advent of container transport in the 1960s changed irreversibly the environment of the global transportation business and it has become increasingly competitive due to the economic globalization (Finke & Kotzab, 2017; Fung, Cheng, & Qiu, 2003; Notteboom & Rodrigue, 2008). At the same time, along with market uncertainty, freight tariffs have been one of the highest priorities for importers and exporters since 2000, because container shipping lines have provoked great bargaining over price (Ho et al., 2017). In this sense, shipping rates can be defined as the fees charged by transportation companies when providing services, that is, the payment to cover the costs of transportation between two locations and the expenses associated with the maintenance of a traveling inventory (Grama, 2014; Sahin, Yilmaz, Ust, Guneri, & Gulsun, 2007).

The revenue of container shipping firms and, therefore, the freight price, is dependent on an interaction between price and quantity. That means the freight rate represents the price, and the quantity refers to the spaces used in a container vessel. So, the balance must be reached to offer a reasonable freight and, at same time, to transport cargoes that occupy the spaces in the vessel (Notteboom & Rodrigue, 2008; Tang & Sun, 2018).

In this sense, freight all kinds (FAK) is a general rate defined by shipowners to classify any goods being transported. As a rule, FAK is higher than the values charged to ship goods at loading, exactly to cover

for all cargo types, including dry cargoes (Bowersox et al., 2014; Maloni, Paul, & Gligor, 2003). Dry cargo is the term used to describe materials that do not need special care during loading. As opposed to gaseous or liquid loads, dry cargoes may be shipped in containers with no special temperature control measures. Dry cargoes are several types of cargo, such as dry finished products, metals (such as iron and steel), and even some heat and cold-tolerant grains (Ballou, 2004; Bowersox et al., 2014; Ho et al., 2007).

On the other hand, there are many costs that affect container freight that are not linked to the cost of shipping the goods. One of the most common is the terminal handling charges (THC) that are fees charged by shipping lines to cover costs of moving containers from the terminals to the ships (Fung et al., 2003; Slack & Gouvernal, 2011) Another important cost for containers is regarding the storage of empty containers in the terminal or in another warehouse abroad, while awaiting its reuse, as well as the costs of management and organization of the container reposition (Finke & Kotzab, 2017; Steenken, Voß, & Stahlbock, 2004).

Nevertheless, in pricing ocean freight rates, it was observed that several factors must be considered and some of these variables were discussed in several studies published in the past 20 years. So we have tried to summarize the main constructs that, at some point, interact with freight rates and have the power to provoke an oscillation of its level. A review of those studies enabled the identification of 12 variables to be analyzed by the panel of experts, with the purpose of understanding the contribution of these aspects to the oscillations in freight rates, according to Exhibition 1.

Exhibition 1. Variables that influence ocean freight rates

| Product/ Commodity	Several factors, based on density, packaging, facility to handle, and risks affect the freight rate of a product.	Ballou (2004), Bowersox et al. (2014), Fung et al. (2003), Ortúzar and Willumsen (1994)
Cargo weight and volume	The heavier the container, the higher the shipping costs. In addition, shipowners have to identify the best location of a container on board to balance it with other containers on the deck. Light cargoes are preferred, since they consume less fuel and cause less concern to the total weight of the ship.	Ballou (2004), Bowersox et al. (2014), Notteboom & Rodrigue (2008), Steenken et al. (2004), Tang and Sun (2018)

(continue)

(conclusion)

Supply and demand	Demand influences directly the freight rates, since it involves the market supply and demand relationships. In other words, when supply is high and demand is low, rates tend to go down, and vice-versa.	Ballou (2004), Ortúzar and Willumsen (1994), Sahin et al. (2007), Stopford (2009), Zeng and Rossetti (2003)
Distance sailed	A large number of the studies reviewed cover the composition of freight rate considering distance as the main factor in the definition of rates, independently on transport mode.	Banomyong (2005), Bowersox et al. (2014), Ho et al. (2017), Maloni et al. (2013), Malchow and Kanafani (2004), Hesse and Rodrigue (2004)
Cargo size/number of containers	When shipowners price a loading operation of one single container, the rates charged are normally excluded from the general FAK classification of product and rates. However, when cargo size and number of containers are known, a differentiated pricing strategy is adopted, if the other variables with the goods transported allow reducing ocean freight rates.	Florentino (2010), Notteboom and Rodrigue (2008), Slack & Gouvernal (2011), Zeng and Rossetti (2003)
Operational costs	Operational costs may affect the freight rate in different routes distinctively, since regional differences, such as the interaction between demand and supply of the shipped service, may inhibit the rise in freight rates.	Finke and Kotzab (2017), Fung et al.(2003), Grama (2014), Malchow and Kanafani (2004), Notteboom and Rodrigue (2008), Sahin et al. (2007), Stopford (2009)
Route	Freight may vary with departure and destination sites, and with the route followed.	Malchow and Kanafani (2004), Ballou (2004), Banomyong (2005), Bowersox et al. (2014), Hesse and Rodrigue (2004),
Economic situation of countries	Higher rates are charged in emerging economies, compared to developed countries, resulting in lower business volumes and revenues.	Hummels, Lugovskyy and Skiba (2008), Jacks and Pendakur (2010), Lee and Lee (2012), Murray (1996)
Possibility to return cargoes	The freight involves not only shipping costs, but also the shipping options available in the departure site and the possibility to return the cargo to the departure point.	Finke and Kotzab (2017), Grama (2014), Notteboom and Rodrigue (2008)
Bunker Adjustment Factor (BAF), additional fee for fuel.	Shipowners see fuel consumption as one of the main factors, since lasting oscillation in crude oil prices interferes directly in shipping.	Maloni et al. (2013), Notteboom and Cariou (2013), Notteboom and Rodrigue (2008)
Competition	Shipowners that do not face competition in determined route charge higher freight rates.	Ho et al. (2017), Hummels et al. (2008), Notteboom and Rodrigue (2008), Sahin et al. (2007)
Vessel capacity	Freight is affected by the relationship between ship capacity and demand.	Leach (2014), Notteboom and Cariou (2013), Stopford (2009)

RESEARCH DESIGN

The variables that influence ocean freight rate oscillation in Brazilian trade to the USA, Europe and China were analyzed using a qualitative approach due to the need of a wide and in-depth perspective of the study problem and the nature of the issue (Creswell, 1998). A qualitative study also enables greater flexibility, since several aspects associated with the fact or with the phenomenon under investigation are considered.

The research design for this study was divided in four steps, according to Figure 1. The first step started with the literature review, when, at the end, 12 variables responsible for oscillations in international freight rates were identified, according to Exhibition 1. Based on the 12 variables identified, a panel of experts was assembled, formed by managers responsible for pricing ocean freight rates in Brazil in their companies. The panel was arranged in order to obtain confirmation of the effect of the 12 variables on freight rates as well as to understand the relationships among those variables and between these and ocean freight.

Figure 1. Methodological steps
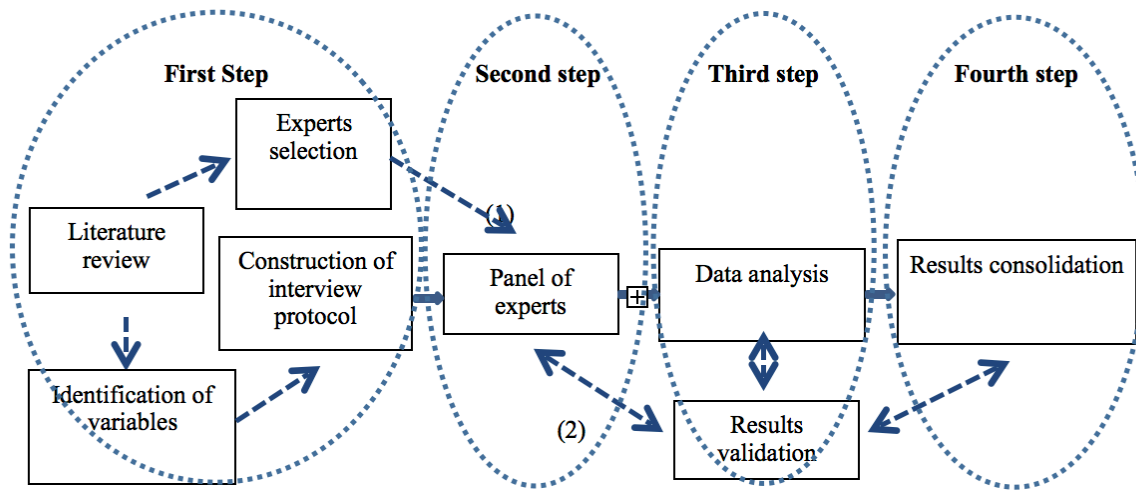
(1) First round of interviews.
(2) Second round of interviews.

Consulting other people's opinions has been commonly used as a strategy in the decisions involving themes surrounded with great responsibilities in terms of results or controversial subjects that entangle quite complex variables that lead to uncertainties as to the possible results (Yaniv, 2004). According to Budescu and Rantilla (2000), expert panels are recommended when (i) there is a need to make a decision in the short term, (ii) the possible results are surrounded with uncertainties, (iii) relevant information that may mitigate uncertainties is available, and (iv) it is possible to confer with experienced professionals who have relevant information.

To select the right specialists to perform an expert panel it is recommended a group of, at least, six judges with large experience on the subject to be discussed, according to Yaniv (2004). In this sense, the 13 most representative shipowners around the globe (Alphaliner Top 100, 2016), with operations in Brazil, were invited personally and by phone to become part of the panel. At the end of this phase, five shipowner representatives in Brazil agreed to participate in the panel.

In order to add different perspectives regarding freight rates, the researchers asked the five specialists to indicate freight forwarders and co-loaders that also offered maritime freight in Brazil. The five specialists indicated the same freight forwarder, classified as the 7th largest company in the seg-

ment, according Armstrong & Associates (2015), and one co-loader with consistent Brazilian market share. After a phone invitation, these two firms accepted to join de panel, as described in Exhibition 2.

In the second step, a first round of in-depth interviews with the seven experts was conducted. The third step consisted of the content analysis to assess the data as a means to understand the behavior of the variables pointed in Exhibition 1 and that influence ocean freight rates of containerized dry cargoes for Brazilian trade with the USA, Europe and China. For Bardin (1977), this analytical technique comprises three stages: (i) pre-analysis, (ii) exploitation of the material, and (iii) treatment and interpretation of results. Here, content analysis was chosen since, according to Kolbe and Burnet (1991), it is an observational research method that is used to systematically evaluate the symbolic content of all forms of recorded communications. To accomplish that, the analysis categories were restricted to the 12 variables identified previously in Exhibition 1.

After the content analysis of the first round of in-depth interviews (Exhibitions 3 and 4), the authors developed a table with the behavior of twelve variables listed in the context of Brazilian ocean freight, in order to capture the relationship among them. So, in the fourth step the relationship table was presented again to the same panel in a second round

of in-depth interviews with the aim of obtaining a consensus (Budescu & Rantilla, 2000) regarding the association between variables and international ocean freight (Exhibition 5).

DATA ANALYSIS

In the first round of interviews with the panel of experts, the 12 variables identified in the literature review (Exhibition 1) were presented to the panel, who evaluated the importance of each in international ocean freight pricing. The panel ascribed a score to variables in a 0 – 5 scale, in which 0 denotes the absence of any influence in pricing, while 5 indicates a strong effect on the definition of freight rates. Therefore, according to the panel, the variables *supply and demand* and *vessel capacity*, both with score 4.71, had the strongest influence on freight pricing. On the other hand, the variables *distance sailed* by vessels and *economic situation of countries* involved in the importation/exportation business, both with 2.57, were the ones with the lowest score, showing that they were the ones that least influence freight pricing.

After that, the experts were invited to talk about the variables that influence de freight oscillation and the possible explanations for those evidences. The Specialist E1 declared that "shipowners are increasingly looking for financial return in order to recover losses in previous years, though freight rates are consistently observed to fall in some trades".

To identify the cutoff value in the time series, four interviewees declared that a 3-year survey about trends in the markets involved in these trades would suffice. However, specialist E6 warned that:

When it comes to China imports, even a 10-year time series of freight rates would not afford to understand the reasons behind such oscillations, let alone predict freight rates in the next five years. For Europe, two years are enough to see that the market is stable, which allows for more assertive predictions.

In this sense, the authors decided to separate the analysis into two sets of trades: Brazilian freight rates with the USA and Europe trade, which represents a trade with more stable freight rates; and Brazilian freight rates with China trade.

Variables affecting freight in Brazilian, USA East Coast and Northern Europe trade

The freight rates charged by four global shipowners (all of whom are European) for trade with the USA East Coast were analyzed by the experts considering the New York port, which is the busiest one in terms of twenty equivalent unit (TEU) container flow in the region. According to the specialists, these rates were considered relatively low and could pose a risk to the financial health of shipowners operating in this trade route (Jacks & Pendakur, 2010).

The data analysis revealed that ocean freight rates in this trade also decreased in the recent years. According to the experts, this trade route exhibited a stabilization trend with minor pricing changes, though rates decreased consistently for a long period of time. The average freight of all kind (FAK) rate was about USD 1800 in 2012 and fell to USD1000 in 2014, pointing to a decrease in annual mean values. According to the specialists, this scenario may induce players to cease to offer freight services to the USA east coast, due to the low demand and freight rates, which makes business less attractive to most shipowners.

On the other hand, the freight rates were evaluated for a northern Europe trade route considering the Brazilian port of Santos and the Rotterdam, Hamburg, and Antwerp ports. The same process was carried out for freights between these European ports and Brazil. Three European and one Asian shipowners were considered, all of whom provide freight services based on their own ships. The average FAK in this route has been falling on a yearly basis. The freight rates exhibited a trend towards stabilization, despite the rises and drops observed at times, according to the experts.

To understand the trend exhibited by shipowners towards maintaining international freight rates within a safety net in these two trade routes (northern Europe and USA east coast), the specialists were inquired over the variables that helped to maintain these rates essentially free of oscillations. The answers provided point to an interaction between these variables, which afforded to analyze them separately and then establish a link between them and the other answers. Exhibition 3 presents the variables that helped maintain the stability in freight rates, as listed by the participant experts.

Exhibition 2. The panel of experts

Expert interviewed	Firm Position	Years in ocean freight	Firm Type	Firm's Country of origin	Year of foundation
E1	Regional Manager	14	Freight Forwarder	USA	1979
E2	Pricing Manager	8	Shipowner	Germany	1970
E3	Pricing Manager	18	Co-loader	Brazil	1994
E4	Global Account Manager	18	Shipowner	Denmark	1904
E5	Pricing Manager	17	Shipowner	Canada	1993
E6	Commercial Manager	35	Shipowner	Chile	1970
E7	Traffic Manager	6	Shipowner	France	1978

Specialist E1 added:

No considerable change in demand and supply issues were recorded in these markets... the services provided by shipowners during the period did not change as in other trade routes, like the China trade route, for instance... in addition, I think that the kind of goods shipped in these markets reduces the variation in freight rates.

The answers obtained allowed for the identification of some relationships between variables, such as predicting the markets where no change in the services offered will take place induces shipowners to maintain freight rates. In a similar way, the capacity of vessels, when adjusted for the demand, has the same effect for a 1-year period. Moreover, since the countries where the ports considered enjoy a level of economic activity, it is presumed that freight rates will remain essentially constant and within a safety margin, similarly to the other figures.

Variables affecting freight in Brazilian and China trade

The FAK rates applied by six shipowners (three Asian, three European) offering their own services and vessels in the China trade route to Brazil were evaluated by the specialists for a period of five recent years. The results indicated that FAK rates remained constant for more than 30 days, when importation from China is analyzed. Freight rate in this route in 2012 was USD1822 by TEU, and fell to USD1229 in 2013 and to USD1070 in 2014.

The content analysis of the questions addressed to the panel of experts showed that several variables influence freight rates for China trade with Brazil, according to Exhibition 4. The variable about the supply capacity and the market demand for international ocean transportation was mentioned by all specialists, though other variables were also mentioned as playing a role in the variations observed.

Exhibition 3. Variables influencing freight rates in Brazil, Europe and the USA trade

Europe and USA	E1	Supply and demand; Commodity; operational costs.
	E2	Vessel capacity; Cargo weight and volume; Competition.
	E3	Supply and demand; Vessel capacity; Competition.
	E4	Supply and demand; Vessel capacity; Competition.
	E5	Supply and demand; Vessel capacity.
	E6	Supply and demand; Vessel capacity; Return cargo.
	E7	Economic situation; Commodity; Supply and demand.

The analysis also revealed that the variables listed by specialists as responsible for the persistent oscillations in containerized dry cargo ocean freight rates in the China trade route are exactly the same as those that explain the relatively constant values on a yearly basis in the east USA coast and northern Europe routes, as shown in the previous section. In addition, it should be highlighted that the specialists pointed out the trend in large shipowners to form new partnerships. This would eventually add to the stability in the ocean freight rates, since they would become more profitable for freight companies, which could charge higher rates as compared to those reported in the present study.

Proposal of a causal relationship among individual variables

One of the objectives of this study was to understand the dynamics among the variables that influence ocean freight rate of Brazilian trade with the USA, Europe and China. Therefore, the set of data offered by the specialists in the first round of in-depth interviews were combined with the objective of proposing a set of causal relations for future quantitative analysis to validate its effects. However, some studies already explain the behavior of many variables in terms of ocean freight rates, which helped to a better understanding. (Ballou, 2004; Bowersox et al., 2014; Grama, 2014; Ortúzar & Willumsen, 1994; Stopford, 1997; Florentino, 2010).

Therefore, Exhibition 5 shows the proposal of a causal relationship among individual variables related to Brazilian freight rates of trade to the USA, Europe and China and how theses variables affect ocean freight rates. As observed, the variables *commodity, cargo weight,* and *number of containers* were classified as direct variables in the context of ocean freight rates, since any increase or decrease in the values representing these variables elicit oscillations in ocean freight rates, according to the specialists.

Exhibition 4. Variables influencing freight rates in Brazil and China trade

China	E1	Operational Costs; Supply and demand; Vessel capacity.
	E2	Supply and demand; Vessel capacity.
	E3	Economic situation; Supply and demand.
	E4	Supply and demand; Vessel capacity; Economic situation.
	E5	Supply and demand; Vessel capacity.
	E6	Competition; Vessel capacity; Supply and demand.
	E7	No opinion.

Exhibition 5. Proposal of a causal relationship in Brazilian freight based on experts' opinion

Variables	Relations among variables	Proposal of causal relations
Commodity (Com)	The higher the commodity value, the higher the freight value	+ Com ➔ + OFrg
Cargo Weight (CgW)	The heavier the container, the higher the freight.	+ CgW ➔ + OFrg
Number of Containers (NoC)	The higher the number of containers shipped, the lower the freight by container.	+ NoC ➔ (-) OFrg
Ocean Freight (OFrg)	The lower the ocean freight, the higher the demand.	
Demand (Dem)	The higher the demand for ocean freight, the higher the supply of ocean freight.	(-) OFrg ➔ + Dem ➔ + Sup ➔
Supply (Sup)	The higher the supply, the higher the competition.	➔ + Comp ➔ (-) OFrg
Competition (Comp)	The higher the competition, the lower the freight value.	

Supply (Sup)	The higher the supply, the higher the capacity of the vessel.	+ Sup ➜ + CoV ➜ + Fl ➜ + OpC ➜ ➜ + OFrg
Capacity of the Vessel (CoV)	The higher the capacity of the vessel, the higher the fuel consumption.	
Fuel (Fl)	The higher the fuel consumption, the higher the operating costs.	
Operational Costs (OpC)	The higher the operational costs, the higher the freight value.	
Economic Situation (EcSit)	The lower the business volume, the lower the possibility of return cargo.	(-) EcSit ➜ (-) RetCg ➜ + Frg
Return Cargo (RetCg)	The lower the return cargo, the higher the freight value.	

To endorse the relationships presented in Exhibition 5, a second round of in-depth interviews was carried out to validate and to obtain a consensus in the panel of experts regarding the relationships observed among the variables listed.

Considering the variable *commodity*, five of the seven specialists agreed that the higher the value of the goods, the higher the freight charged will be. However, specialist 4 warns that "yes, it is considered so, but it is not the most important, since, for example, the rate charged for wood is the lowest in the market, compared with auto parts or medical drugs, which are higher".

Specialist 2 confirms this notion, though in a more objective way, saying that "a more expensive product costs more and, therefore, freight should also be charged at higher rates". Thus, in spite of the fact that most specialists agree on the relationship between *commodity* and ocean freight rate, some studies did not take it into consideration when pricing ocean freights (Bowersox et al. 2014; Ortúzar & Willumsen, 1994). On the other hand, other studies pointed at the same direction as the specialists, stating that the cargo value impacts on freight rate due the risk of damage (Grama, 2014; Zeng & Rossetti, 2003).

The variable *weight/volume* is directly related with ocean freight rate, since, according to the specialists, the greater the weight, the higher the rate. Six of the seven specialists agree on the relationship between cargo weight and ocean freight rate, consistent with Maloni et al. (2013), Bowersox et al. (2014), and Notteboom and Rodrigue (2008). For example, specialist 1 declares that "as a rule, this practice is used in the market. However, overweight surcharge is applied for loads in excess of 20 tons, and lighter cargoes admit better negotiation bargains".

Similarly, specialist 3 believes that "ocean freight companies usually define a maximum weight acceptable for transportation, considering the freight rate informed. When the container's weight exceeds this value, an additional fare is charged as overweight. It is a means to charge more for heavy equipment". Specialist 7 states that "cargo weight, many times, influences freight rate, since the heavier the cargo, the more difficult to fill TEU slots in the vessel".

The variable *number of containers* is interpreted in terms of the cargo volume to be shipped, since specialists declare that the larger the number of containers regularly shipped, the lower the ocean freight rate charged. This point was consistent with de findings of Maloni et al. (2013) and Notteboom and Rodrigue (2008). The seven specialists agreed that this variable is directly correlated with rates. As specialist 7 puts it:

When the customer has a larger cargo to ship, we may negotiate a lower rate. We are always interested in filling up the slots in vessels. Larger cargoes allow to fill slots more easily than one or two containers per client only.

Specialist 3 adds that:

> *This happens for some contracts only. It is always possible to obtain better rates when the volume being negotiated is large. Yet, when the demand for transportation in a route is too high, the trend observed is usually the other way round, due to the limitation in shipping capacity of vessels. Full vessels imply higher rates.*

During the second round of results validation, based on the answers given by the specialists in first round of interviews (Exhibitions 3 and 4), some different statements were produced. The last

round showed that the lower the ocean freight, the higher the demand for international transportation services. Therefore, shipowners attempt to increase the available space in vessels and, as a result, new players make extra efforts to enter this market. As a result, with increasing competition, the trend would be towards lower rates (Tang & Sun, 2018).

The specialists reached a consensus on these relationships, though they brought a better explanation on the relationships that actually influence Brazilian ocean freight rates. Specialist 3 agrees on the relationship between these two variables, but adds that:

> The entry of new competitors in a promising ocean route induces a drop or the stabilization of rates. However, the cargo should be such as to afford to appropriately fill the slots in vessels, since shipowners tend to reduce the supply of space in order to avoid losses when this supply is high and the volume to be shipped is not high enough. It should be remembered that low freight rates are not the main factor to attract more business or demand for ocean transportation (E3).

Specialist 7 agrees with the declaration above, and offered a more in-depth analysis of these variables:

> The lower the ocean freight rate, the more companies feel encouraged to export, increasing demand, since transportation costs strongly influence the end cost of any operation in international trade. In a scenario of low rates, the main players will compete for cargoes, which will eliminate market space. As a result, freight rates rise again. Under low rates, there will always be players that can't follow the trend, which increases space. When rates are too low, new players may enter the market, as long as they manage to offer good service at the same freight rates as charged by the main competitors. Many times, smaller players can't proceed, due to the operational costs of the services they offer. But when they manage to, competition increases, which may promote a drop in freight rates, since there will be more options (E7).

However, specialist 6 disagreed with some relationships, and explained the reasons:

> Demand for international transportation services should not be subject to oscillations due to high or low freight rates. There are other reasons, of socioeconomic character, at a given time. Freight varies, as a rule, due to the unused capacity in vessels.

> This implies considering the entry of new players in trade routes (E6).

Specialist 4 agrees with specialist 6, and adds:

> If a specific service or route operates under low freight rates, shipowners do not underscore the supply of shipping space or even vessels, but the capacity is adjusted to the actual demand. Therefore, new players will hardly be able to enter this market, unless it is profitable (E6).

In this sense, some specialists argued that the low ocean freight rate boosts the demand for ocean transportation services, since it is directly correlated with competitiveness of exporter companies in the destination market (Notteboom & Rodrigue, 2008). Nevertheless, other specialists believe that the demand for ocean transportation services is not affected by freight rates. Therefore, the opposing views were analyzed in terms of the variables *supply* and *demand*, which, according to the specialists, is the main relationship to influence international ocean freight rates.

As for competition, all specialists mentioned the constant efforts of shipowners to adapt the available space in vessels to the actual demand. Yet, new players are more inclined to start operations in trade routes where freight rates are not too low, or when a route shows good business opportunities. Shipowners are not interested in entering markets where slot availability exceeds the demand. In spite of that, the specialists agree that increased competition may lead to a decrease in ocean freight rates, consistent with the findings of Grama (2014), Maloni et al. (2013), and Hesse and Rodrigue (2004).

The second round of the variables validation showed the lower the ocean freight rate, the higher the demand for associated services. In this sense, shipowners would be inclined to increase the space available in vessels. If one takes into consideration that supply and demand would trigger the flow of goods, the commercial status of countries with a role in exportation and importation markets would reach a level of stability, which would reduce the need for replacing containers in the country of origin and, for this reason, the trend would be towards increasing ocean freight rates.

The specialists analyzed the relationships between *ocean freight rate*, *demand*, *supply*, *economic situation*, and *return cargoes* in order to produce a clear picture of the contribution of each in the oscillation of

ocean freight rates. One specialist clarified the issue very objectively:

> With increased demands, the flow of goods tends to rise. This may reduce the need for repositioning containers, both in the origin and in the destination countries. This alone does not lead to higher freight rates, though it may raise profit contribution each shipment generates to the carrier. It may be necessary to increase rates when there is a lack of equipment in the departure port and an excess of equipment in the destination port (E4).

Nevertheless, the specialists disagree on the relationships in which the increase in the demand for international transportation services and the increased supply of vessels directly contribute to the improvement in the commercial relationship between the countries involved in the operation. On the other hand, a consensus was reached on the fact that the improvement in commercial situation of countries increases the chances for containers not to be repositioned in the destination, which means a greater advantage to the shipowner, since it will not be necessary to charge a low freight rate (Fung et al, 2003).

In the analysis of the relationships involving the variables *ocean freight rate*, *demand*, *supply*, *vessel capacity*, *fuel*, and *operational costs*, the specialists explained their views about the pricing of ocean freight rates. Exhibition 5 shows that the lower the freight the higher the demand for international transportation services. So, shipowners would try to increase available space in the long run based on vessel capacity. Therefore, the costs associated with fuel in larger ships would also be expected to rise, increasing the operational costs of vessels. As a result, the final freight rate would be down against the unit cost to ship one container.

Specialist 7 agrees, and warns:

> Larger vessels imply higher operational costs, though once they can carry larger numbers of units, this cost spreads across this extra volume. The freight rate is not necessarily reduced due to operational costs. However, large vessels require greater cargoes in order to fill up all slots. This need for more cargo is the factor that makes rates drop (E7).

Although large ships are designed to consume less fuel and therefore be more advantageous economically, they require greater effectiveness in the allocation of slots by shipowners (Fung et al., 2003;

Maloni et al., 2013). Therefore, by increasing capacity, shipowners need greater cargoes in order to load a ship to the full and split the high fuel and operational costs across the thousands of units on board.

According to the specialists interviewed, the trend for the years ahead is towards a readjustment in vessel capacity in trade routes in which ship occupation rates are below 70%, depending on the time of year, as observed in the trade routes with China. Concerning market stability and freight rates, specialist 6 does not envisage a real market stability, not until 2018, exactly due to the increase in ship size and in slot availability. In addition, for specialist 6, the balance between market demand and supplied capacity would be reached if shipowners stopped ordering new ships. However, orders for new ships and requests for increasingly larger ships are quite common today. This is disadvantageous to Brazil, since the port infrastructure is not fit to receive large ships, due to the large load-draught of these vessels and the logistic problems in the port and adjacent area.

At the same time, Brazil presents a delicate freight situation regarding its small share in worldwide trade. According to MDIC (2017), Brazil counts for about 1% of the total of international trade and any exchange rate fluctuation increases or decreases the imports or exports, but not in the same way. So, as the transportation costs of an empty container are similar to the costs of a loaded one (Finke & Kotzab, 2017), when Brazilian imports decrease, replacing the empty containers for Brazil results in additional costs and impacts on freight oscillation (Lee & Lee, 2012).

IMPLICATIONS AND FINAL CONSIDERATIONS

In a scenario of constant debate among Brazilian exporters and importers regarding the variables that influence freight rates, this study aimed not only to identify the variables involved on this matter, but also to characterize the relationships between these variables and freight rates in Brazilian trade to the USA, Europe and China. The final goal was also to help build a future tool that can predict oscillations or confirm the conservation of freight rates for the following period of shipments in Brazil.

A literature review of international databases of papers published in the past 20 years was conducted in this study (Exhibition 1) to identify the variables

that, at least in theory, affect ocean freight rates. That research indicated 12 variables that influence the ocean freight rates. These variables were discussed in qualitative interviews with a panel of experts. It was found that some of these variables do not explain directly the oscillations in freight rates in Brazilian trade with the USA, Europe and China. That was the case of the variables *distance sailed* by the vessel and possibility of *return cargoes*. These aspects could be explained by the nature of the Brazilian international trade that is based on commodities like iron ore, soy, coffee, and sugar in exports (MDIC, 2017) and don't need containers for transportation. On the other hand, there are more cargoes that need containers for Brazilian imports. The distance sailed was studied and could affect more freight for commodities as wheat (Binkley & Harrer, 1981).

Perhaps the same explanation could provide the reason of the variable *economic situation* of countries, which was cited by the specialists as one of the factors that less influence Brazilian ocean freight rates. It means that international commodities, the common goods exported by Brazil (MDIC, 2017), actually don't need containers. So, theoretically, one could argue that, given the lowest score, the variables *distance sailed* by the vessel, possibility of *return cargoes* and the *economic situation* of countries are suppressed or adjusted by the supply and demand of maritime transportation, as well as by the value of the goods transported.

Based on the experts' opinion, it was possible to observe that all relations presented in Exhibition 5 are capable of producing effect on Brazilian freight rates. However, although the variables discovered to influence the ocean freight rates charged in China trade route with Brazil are the same as those that affect rates in the USA and Europe trade with Brazil, a relationship observed can act in different manners in those two trades. For instance, during the two rounds of interviews, the specialists constantly underlined the stability between demand and supply as the main aspect to affect freight rates. When the demand for ocean transportation stabilizes within acceptable levels, considering the containers capacity made available by shipowners, the freight rates will eventually remain constant.

Nevertheless, in times when the demand for international transportation services increases, other different issues must be considered to influence freight rates, according to the specialists. These new

set of variables can be the free slots available in vessels and new ships with higher capacity offered in the trade route. It could provoke lower freight rates charged in the market, and, therefore, and stimulate the demand for these services.

The results of the present study pointed to the need for further investigations using a quantitative approach to prove the statistical value of these variables in terms of ocean freight rates using correlation and regression tests, for instance. In addition, some Brazilian specific conditions such as exchange rate, based on the time series of freight rates, could help build a systemic modeling considering all variables associated with ocean freight rates. This would enable the prediction of oscillations in rates based mainly on the fluctuations in the variables listed.

In this same sense, this paper did not discuss the effect of the type of maritime freight service that can be provided by freight forwarders (OFFs) or by container shipping lines (CSLs) directly. Ho et al. (2017) found some differences in pricing and conditions for using one of those type o firms. Studies that could isolate the influence of the type of service offered in the formation of Brazilian maritime freight would be fruitful.

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SUSTAINABLE PRACTICES IN THE COFFEE SUPPLY CHAIN IN THE CERRADO MINEIRO REGION, BRAZIL

ABSTRACT

The incorporation of sustainable practices in the supply chain management (SCM) has become recurrent in the business environment, resulting from a social reflection on the need to seek new development alternatives. In this context, the objective of this paper is to verify the existence of sustainable practices throughout the supply chain of coffee in the Cerrado Mineiro Region (CMR) and to understand the effects of this adop-tion regarding Green SCM. This paper focus on the relationship between producers and collective organizations, such as cooperatives and development foundations. To this end, a case study was carried out with the representatives of the supply chain members in CMR, which included coffee producers, cooperatives and a development foundation. It was verified the predominance of practices focused on environmental issues, followed by social and, finally, economic ones. It is also highlighted that the data identified allow us to understand that the development of sustainable strategies can bring positive effects to the agents studied. Considering that these aspects, evidently, improve the relationship of supply chain members, making it more collaborative. The results contribute to the systemic understanding of the way in which sustainability has been incorporated and operationalized in coffe supply chains in CMR.

KEYWORDS | Cerrado mineiro region, green supply chain management, sustain-ability, supply chain management, sustainable practices.

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INTRODUCTION

The depletion of patterns of development experienced since the twentieth century is evident. The understanding of this phenomenon, together with social reflection on the need to seek new alternatives for progress, has given rise to a new development model. The sustainable development model, which has been consolidating since 1972, the year in which the discussion of this issue, during the First Conference on Environment and Development held in Oslo, Norway.

In their investigations, Mathiyazhagan, Govindan, and Noorul Haq (2014) recognize that organizations in the most diverse economic sectors face pressures from public authorities, competitors and, above all, the consumer market to incorporate sustainable correct practices in their supply chains. This adoption occurs in order to minimize damage to the environment and society. This context, refers to the ideas of Elkington (1994), when the author deals with the Triple Bottom Line (TBL).

 In addition, Food Supply Chains are not excluded from this process. Although in a timid way, it is noticed that the food sector has been following the changes in the consumption pattern of the society, in which a trend is evident on the part of the consumers as to the option for foods obtained from production systems that adopt environmentally correct and socially just practices in their productive processes. The focus on SCM is an important step in the adoption and development of sustainability, and the concept of Sustainable Supply Chain Management ((SSCM) directs efforts in this perspective. However, Mathiyazhagan et al. (2014) recognize that the incorporation of sustainable aspects into supply chains is a practice still uncommon in most organizations, especially in countries from emerging economies.

Jakhar (2015) highlights that research must aim to encompass all the sustainable development dimensions advocated by Elkington (1994), ie, economic, environmental and social, in order to have an holistic approach to supply chain sustainability and an understanding of the mechanisms involved in the sustainable product supply. The studies from Fabbe-Costes, Roussat, and Colin (2011), Bask, Halme, Kallio, and Kuula (2013), Brandenburg et al. (2014), Su et al. (2016), Kumar and Rahman (2016), and Alshubiri and Hussein (2016) encompassed all dimensions of Sustainable development in supply chain management. Nevertheless, these studies were developed in a small variety of supply chain, with emphasis on the automotive industry, retail trade and metallurgical industry.

We have identified few studies with a holistic approach to sustainability in food supply chains, mentioning the studies of Walker and Jones (2012) and Türkay and Saraçoglu (2015), which were applied in agrifood supply chain in the United Kingdom and of Turkey, respectively. In addition, it can be seen that a considerable amount of studies directs its analysis to the final links of the supply chain, that is, in the distribution/consumption interface. In this sense, the studies from Carvalho, Paiva, and Vieira (2016), Migliore, Schifani, and Cembalo (2015) and Krystallis, Chryssochoidis and Scholderer (2007) should be highlighted.

The present study was developed at the production/processing interface, that is, at the initial links of the supply chain, comprising coffee producers, their cooperatives and development organizations. The focus is on Cerrado Mineiro Region, which is considered one of the main coffee producing territoriesin Brazil. It is the first region to produce coffee demarcated in the country, according to a decree of the Minas Gerais government, Brazil, since April 1995.

In this context, this paper aims to verify the existence of sustainable practices along the supply chain of coffees in Cerrado Mineiro Region and to understand the effects of this adoption with regard to the Green SCM focusing on the relationship between producers and collective organizations, such as cooperatives and foundations of development.

In order to attain this objective, it was conducted na applied research, with qualitative approach. A case study in Cerrado Mineiro Region was carried out in order to collect data through questionnaires and semi-structured interviews with the representatives of the coffee supply chain links. The research involved coffee producers, cooperatives and a development foundation. In a complementary manner, it was also conducted a documentary analysis based on reports provided by the aforementioned supply chain members.

This paper aims to broaden the discussion of the sustainability in coffe supply chains, by proposing an analysis of the existence of sustainable practices and a subsequent explanation of the effects of these in Cerrado Mineiro Region, Brazil. Besides that, this paper contributes for the academic literature by

identifying a research gap, considering that the recent researches have still not enough discussed on the dynamics of supply chains in the food sector, specifically in the case of coffee, from the perspective of the three sustainable development dimensions proposed by Elkington (1994). Regarding the managerial practice contributions, the analysis proposed in this study may favor the decision-making process by the agents that operate in the coffee supply chain, mainly in the case of producers, cooperatives and development foundations.

In addition to this introduction, the paper presents four other sections. In the first one, the theoretical basis under which the article is developed, which includes issues related to sustainability and the Green SCM, is presented. The second section presents and justifies the methodological procedures adopted in this research. In the third section, the results are presented and discussed later in the light of the theory. In the fourth and last section, the final considerations of the article are presented.

LITERATURE REVIEW

Supply chain: management and sustainability

One of the main definitions adopted in the literature for the term supply chain was disseminated by Mentzer et al. (2001). According these authors, this is a set of three or more companies directly involved in the upstream and downstream flow of goods, services, financial resources and information from the beginning of the chain to the end customer. In this context, Guarnieri and de Almeida (2016) recognize that for the existence of a supply chain, it is necessary to understand that customer satisfaction is the essential component. A supply chainstarts when the customer orders a product or service and ends when the payment is made.

Aligned with the understanding that a supply chain brings together a number of internal and external business processes of the business environment, it is essential to comprehend the fundamentals of SCM. One of the main definitions for the term was proposed by Mentzer et al. (2001), in which the authors state that SCM is a management model integrating the (systemic and strategic) traditional business functions within a particular company within supply chain, for the purpose of achieving long-term improvement.

The SCM concept has been recognized as a key factor in promoting organizational sustainability. In this sense, Stonebraker and Afifi (2004) emphasize that the success of a supply chain depends on management's ability to recognize changes in the corporate environment. In addition, Carter and Rogers (2008) define Green SCM as the strategic and transparent integration of social, environmental and economic aspects in the systemic coordination of organizational processes with a view to improving the long-term economic performance of the company and its supply chain. Carter and Liane Easton (2011) state that Green SCM is related to long-term improvement and has significant implications for the economic results of companies.

In other words, the Green SCM is defined as the management of material, information and capital flows, as well as cooperation between companies throughout the supply chain, while adopting sustainable development goals, i.e., the integration of the environmental, social and economic dimensions (Seuring & Müller, 2008). In order to meet the needs of stakeholders, according Ahi and Searcy (2013), the Green SCM consists of the creation of supply chain coordinated through the voluntary integration of economic, environmental and social policies with the interorganizational business systems designed to efficiently manage diverse processes of the company. This management constitutes a way to extend the profitability of the business, in addition to providing greater competitiveness and adaptability in the short, medium and long-term.

Regarding agri-food supply chains, which may include dairy products, grains, vegetables, meats, flowers and fruits, Routroy and Behera (2017) conceptualize that these are initiated from relationships with suppliers (i.e., materials and services of entry for farm-level operations) and are finalized through customer satisfaction through a specific distribution channel. Also in this context, Rais and Sheoran (2015) identified some factors that affect the performance of agri-food supply chains, such as cold storage unavailability, lack of government policies, inadequate connectivity, classification unavailability and classification technology, inadequate handling and packaging, unskilled labor, poor articulation in marketing, and other.

Clemens and Douglas (2006) state that some companies consider that adopting supply chain sustainability creates a commercial and competitive advantage.

Wang, Teng, and Lou (2014) understand Green SCM as a business strategy aimed at minimizing the environmental, economic and social risks of the organization to create corporate value.

Thus, Bask et al. (2013) point out that companies that adopt Green SCMrecognize that social and environmental impacts need to be managed in the same way as financial and commercial performance. They also suggest that in order to be competitive and survive in the market, especially in the coming decades, companies need to extend their sustainable practices throughout the supply chain. Therefore, companies need to foster their sustainability efforts beyond their own operations, including the practices of their suppliers and the satisfaction of their customers' sustainable expectations (Porter & Kramer, 2006).

In Koberg and Longoni's point of view (2018) sustainable supply chain management has been suggested to improve business sustainability results. Nevertheless, the authors acknowledge that this management model implies unique challenges as adopted in global supply chains, such as coffee. It is understood that such challenges advocated by Koberg and Longoni (2018) may be related to the configuration of the global supply chains, since the connections between the focal company and the various suppliers and customers, including the sub-layers, may be hampered by geographical issues and culture.

In relation to food supply chains, Wu and Huang (2018) reveal eight crucial characteristics for the success of adopting sustainability in supply chains: (1) the use of management software; (2) eco-innovation; (3) organizational culture; (4) storage capacity; (5) transportation options; (6) reduction of losses and waste; (7) availability of physical resources and; (8) regulatory frameworks. Among them, Wu and Huang (2018) highlight the two most important factors for the successful implementation of sustainability, being eco-innovation and reducing food loss and waste. These characteristics, which can also be understood as challenges for the management of supply chains, have reoriented business relationships within the agri-food sector (Cembalo, 2015, Wu & Huang, 2018).

METHODOLOGICAL PROCEDURES

Regarding to the methodological procedures used in this study, a case study was first developed with coffee producers, cooperatives and the Cerrado Minei-ro Development Foundation (Fundaccer). The data collectiion was based on the following research instruments: (1) Questionnaire applied to coffee producers included in the Cerrado Mineiro Region, Brazil; (2) Semi-structured interview script, conducted with the managers of the cooperatives to which these producers were associated and of Fundaccer (development foundation); (3) Direct non-participant observation, as well as videos and photos, both in relation to the coffee production process, as well as the inherent aspects of the relationship between producers, cooperatives and Fundaccer e; (4) Documentary analysis (Development Plan, Sustainability and Promotion of Cerrado Mineiro Region, Brazil 2015/2020, among others).

The research with coffee producers was developed with the aid of a structured questionnaire, which was adapted froma validated scale proposed by Zhang, Tse, Doherty and Akhtar (2018). Considering the adaptation of the questionnaire, it was sent to the validation of content by judges (professionals of the coffee industry and researchers in the area). After this evaluation, it was verified that the adaptation was coherent and, then, it was done with the re-construction of this instrument. For the measurement of variables, a Likert-type scale was adopted. It is a non-comparative scale, of the itemized type, in which the participant points out a single item, according to their degree of agreement (Malhotra, 2006). Due to the context of this study, we chose to use the Likert scale with five levels (1-5), considerint the 1 the lowest level and the 5 the highest level of concordance.

Data collection from cooperative managers and Fundaccer was carried out through interviews, conducted face-to-face and via Skype. In order to operationalize the method, a semi-structured script was used, which was also elaborated based on the scale proposed by Zhang, Tse, Doherty, and Akhtar, (2018), in order to triangulate the results of the questionnaires with the coffee producers and interviews conducted with managers. During the interviews with the managers, who had already been previously scheduled through e-mails and telephone calls, voice recorders were used, with the permission of the interviewees. The use of this instrument made it possible later that such interviews were transcribed and sent in a text file in order to be validated by them. So the participants of the interview could confirm or refute what they had said at the time of the interview. It should be noted that parts were complemented in this process.

The choice of the participants in the Fundaccer considered the criterion of representativeness, considering that managers interviewedhad information regarding the sustainable management of the supply chain. Two (2) collaborators of the organization were interviewed, who work in sectors directly linked to coffee producers. Regarding the choice of coffee producers, in the first moment, it was defined by convenience and accessibility. In a second moment we adopted the methodological technique of Snowball.

Sampling

Baldin and Munhoz (2011) point out that the Snowball technique is widely used in the social sciences mainly in qualitative research. In this techniquethe initial participants of the study indicate new participants who, in turn, indicate others and so, successively. It is indicated for identify study participants who are often geographically dispersed.

Regarding the representatives of the cooperatives, only managers who participated actively in the activities related to coffee, thecriterion adopted was also representativeness. Thus, the participants were selected considering the position they have within the cooperatives. It was decided to hide the names of cooperatives, considering that one of these organizations requested that its name not be mentioned. Thus, for purposes of standardization and guarantee of secrecy of information, cooperatives are identified by (1) Cooperativa Alfa; (2) Cooperativa Beta and; (3) Cooperativa Gama.

For the analysis and treatment of data, it was used the Content Analysis method, proposed by Bardin (1977). The content analysis was operationalized through the data collected in the interviews, both with producers and managers of the cooperatives, besides those from the systematic reviews. The logic of applying this method of analysis consists on the importance of establishing categories of analysis for the data collected, which are essentially qualitative in nature. Post-categorization was adopted, according to Bardin (1977). The categories were defined a priori based on the article by Zhang, Tse, Doherty and Akhtar (2018) and also adapted a posteriori, based on the cores of meaning of the interviewees' speeches. This procedure was established by Bardin (1977), considering the technique of thematic categorical analysis.

RESULTS

In terms of structure, although this study has analyzed only three members of supply chain (coffee producers, cooperatives and development foundation) it was evidenced that this chain is composed of other links, classified as 2nd level suppliers (tangible and intangible products), 1st level customers, among which also cooperatives, along with accredited exporters, coffee shops and final customers (direct sales), as well as logistics operators. However, it is observed that the 2nd level suppliers feed the chain with supplies used for the production of inputs such as fertilizers, fertilizers, machinery, equipment, and other. They also work in the provision of financial services, insurance, consulting and soil analysis. Table 1 presents the systematization of sustainable practices and behaviors identified in the relationship between producers and cooperatives of Cerrado Mineiro Region.

Table 1. Systematization of sustainable practices and behaviors identified in supply chain

Variables and items analyzed according to Zhang et al. (2018)	Dimension of sustainability	Evidenced Practices and Behaviors	Supply Chain Members		
			producers	cooperatives	foundation
Environmental sustainability in the coffee production process	Environmental	▪ Use of Electrostatic Spraying	x	-	-
		▪ Construction of rainwater harvesting systems	x	-	-
		▪ Use of wastewater cleaning and fertigation system	x	-	-
		▪ Partial adoption of biological control of pests and diseases	x	-	-
		▪ Use of precision agriculture	x	-	-
Environmental sustainability in supplier relationships		▪ Environmental auditing for supplier selection	x	x	x
Environmental sustainability in collaboration with customers		▪ Development of biodegradable packaging	x	x	x
		▪ Gradual replacement of the use of jute packs by big bags	x	x	-
Internal Green Management		▪ Operation of the Empty Packing Processing Center	-	x	-
		▪ Trainings of employees on sustainable coffee production	x	x	-
		▪ Development of compliance and environmental audit programs	x	x	x
		▪ Implementation of environmental management systems	x	x	x
Investment Recovery	Economic	▪ Holding of open auctions for the sale of scrap of machines and equipment	x	x	-
Diversity Management	Social	▪ Hiring employees without prioritization of a particular gender	x	x	x
Development and social involvement		▪ Day of Cooperate	-	x	x
		▪ Support to regional philanthropic entities	x	x	-
		▪ Food and toy collection campaigns	x	x	-
Security Management		▪ Sizing ergonomically correct workstations	x	x	x
		▪ Use of Personal Protective Equipment (PPE)	x	x	x
		▪ Training on health and safety at work	x	x	x

Regarding the data presented in Table 1, it was verified that coffee producers, in fact, agree and recognize the importance of adopting environmentally correct practices in coffee production. The agreement level was practically 100% in all analyzed variables. It was found that, in the case of coffee producers, there is a search to improve the coffee production process in order to reduce the consumption of materials and energy, as well as to increase the recycling rate of these materials.

Another identified practice is the reduction of the consumption of water withdrawn from the riverbeds and dams by reuse of rainwater from the coffee plantations. It was verified that this practice is being adopted in nine of the twelve properties analyzed.

In the opinion of cooperative managers, even if environmental criteria are directly or indirectly considered in the choice of suppliers, it is something that needs to be more absorbed by decision-makers within cooperative organizations. According to the Cooperative Manager Range:

As much as we know the need to consider this environmental issue, we still run into the issue of price or even ease of delivery of the product we need. As we work with harvest, we can not waste planting time waiting for some supplier that has this certification, which is not easy to get (Manager 3 - Cooperativa Gama).

Considering the statemente above, it is evident that for both coffee producers and cooperatives, maintaining and controlling internal sustainability is something that is already internalized. However, when this responsibility transcends the internal barrier of ownership and migrates to the external environment, it becomes something more complex to control.

It was verified that the vision of producers, cooperative managers and Fundaccer are aligned and are moving towards cooperation between customers in the search for a more sustainable Cerrado Mineiro Region - CMR coffee crop. According to the manager of the Gama cooperative, customers need to realize that coffee production in the CMR is tied to environmental care, ranging from how to irrigate coffee plantations (with something that can reduce water consumption) to even biodegradable packaging that is used in some coffee brands.

Also regarding to cooperatives, which are generally responsible for the storage process, an interesting practice was identified regarding the physical distribution of coffee, making logistics and handling of coffee beans more efficient within the warehouses. It is the gradual replacement of the traditional jute sack (vegetable textile fiber) by big bags.

Concerning issues related to training, it has been noted that it is sometimes intermediated by cooperatives and Fundaccer with the use of their own human resources or through partnerships with other institutions, such as Sebrae and Epamig. This aspect is indicative, as Jabbour, Azevedo, and Arantes (2013) state, that there is a cross-functional cooperation involved in coffee supply chain in Cerrado Mineiro Region. We could observe the frequent involvement of the agents of this chain in order to achieve better results in terms of coffee quality and the sustainability of coffee production.

Although it was verified the existence of environmentally correct practices within the properties, it is seen that some of these (3) still do not have an Environmental Management System formally developed. This group of producers also states that there is no regular practice of audits, whether internal or external, in order to verify the compliance of environmental actions in the realm of property. It is known, however, that the Environmental Management System is voluntary, due to there is no legislation that obliges producers or organizations to implement this system in their activities.

Regarding internal green management, it was verified that all cooperatives studied developed internal practices aimed at preserving the environment. The cooperative Beta, for example, in 2003, in partnership with the National Institute of Empty Packaging Processing (inpEV) - responsible for reverse logistics of pesticides and agri-chemicals - operates the Empty Packaging Processing Center in its headquarters municipality. The plant receives packaging of pesticides and similar products already used to contribute to reverse logistics, so as not to compromise the environment. This practice is also developed in a similar way in the Alfa cooperative and in the Gama cooperative, even though it is a legal imposition, due to specific legislation regarding the handling and transportation of pesticides and also as established in the Brazilian Policy of Solid Waste – Law12,305/2010 (Barbosa, Guarnieri, & Junqueira, 2017).

DISCUSSIONS

Regarding the sustainable practices developed within the supply chain, specifically the environmental

sustainability of the coffee production process, a favorable behavior was observed with regard to the supply chain links analyzed (coffee producers, cooperatives and Fundaccer). Practices adopted to reduce the consumption of materials and energy were identified, such as (1) use of electrostatic spraying; (2) construction of systems for collecting rainwater; (3) use of wastewater cleaning and fertigation system; (4) partial adoption of biological control of pests and diseases; and (5) use of precision coffee cultivation, among others.

These actions developed by the coffee producers in supply chain, besides expanding the possibilities of commercialization of the coffee grain and also to deal with the legal issues, can improve the efficiency of the business, since the reduction of the consumption of materials and energy directly reflects in the cost of coffee production. This fact can also be seen as a competitive differential in several aspects.

Regarding the existence of environmental practices in the relationship with suppliers, it was identified that this is an action still lacking in use in supply chain. Although some of the members of the supply chain analyzed promote an environmental audit for supplier selection, this practice is not a rule, but an exception. Thus, it is understood that it is necessary to establish supplier development programs in the perspective of environmental sustainability in the relationship with suppliers. What, according to the literature, needs to be an initiative of the focal company, in this case the Fundaccer.

At the other end of supply chain, referring to the environmental collaboration with customers, it was noticed that the established practices in this sense are also moderate, as well as in the relationship with suppliers. Although most of the links recognize this importance, only two practices associated with environmental collaboration with customers were identified, with (1) the gradual replacement of the use of jute packs by big bags; (2) the development of biodegradable packaging and; (3) practice of reverse logistics. Nevertheless, the evidence suggests that supply chain members are concerned that customers value when coffee production is linked to environmental practices, otherwise they are also aware that customers can boycott coffee brands that not meet environmental or social aspects.

Regarding to the internal green management variables, it was possible to perceive that both coffee producers, cooperatives and Fundaccer carry out some type of action internally, generally related to organizational and collaborator aspects. Some properties have Environmental Management Systems, as well the cooperatives. Consequently, some properties aim to establish compliance and environmental audit programs internally, and often subject their collaborators to training on sustainable coffee production.

With regard to the economic dimension of sustainability, an interesting practice was verified in the direction of the recovery of the investment in the assets destined to the sustainable coffee production. Two of the analyzed cooperatives sell unsecured materials (scrap, for example) through open auctions, which is a practice of reverse logistics. It is a practice that aims at least to recover part of the amount invested in the acquisition of these physical assets. Indirectly, practices in this sense were also observed in the daily life of coffee farms, besides of economic and environment protection results they comply with the environmental legislation related to reverse logistics.

In the social dimension, when it comes to diversity management, no evidence has been found that there is a prioritization for hiring employees based on sex, for example. Regarding the remuneration, what was perceived is that it occurs according to the activity performed. It should be noted that diversity in the supply chain workforce can be a two-way street. One is directed to an ethical and social commitment of the company and another related to the competitiveness in terms of market. However, this research did not focus in this an issue, which can be deepened in future researches, since some studies emphasize that the feminine labor suffers salary differences.

In terms of development and social involvement, a socially responsible, if still developing, behavior of coffee producers, cooperatives and Fundaccer was confirmed with the environment in which they are inserted. Various evidences were found in this sense, such as participation in community events in the form of sponsors, days of fields open to the population, campaigns for collection of goods to be later distributed, and other.

Finally, with regard to safety management, some actions were identified in order to promote safety in the production of coffees. In addition to ergonomically designed workstations, part of the links of supply chain aims to conduct courses and promote training on aspects such as health and safety in work related to coffee.

As emphasized in the theoretical basis of this study, organizations that aim to implement sustainable practices in their productive and organizational processes within the scope of supply chain, do so as a business strategy aimed at minimizing environmental, economic and social risks and thus create and extend the corporate value (Wang, Teng, & Lou, 2014).

In the Cerrado Mineiro Region supply chain, it is clear that there is some prioritization of the customers aimed to the coffees produced with social and environmental responsibility parallel to the economic issues. Therefore, the coffee production is driven to the market and the sustainable practices have received significant attention by the members of the supply chain of coffee in the Cerrado Mineiro Region. These practices are associated with TBL concept, proposed by Elkington (1994), aiming the balance amont environmental, social and economic dimensions.

Throughout the interviews withcoffee producers, cooperative managers and Fundaccer, it was observed that there is a predisposition to implement sustainable practices in the various productive and organizational processes of coffee supply chain. The practices previously discussed and summarized in Table 1 confirm this observation and also allow to verify that many of these are developed externally, that is, there are partnerships among supply chain members to implement and operationalize such actions. It is also important to emphasize that in the supply chain of Cerrado Mineiro Region of coffee, to obtain certification of origin, producers were impelled to integrate between cooperatives and developmentfoundation (in this case, Fundaccer), which has guaranteed the quality of the product, facilitated the dissemination of sustainable practices and also made possible their export in order to access previously unexploited markets. The foundation can be recognized as focal company, governing the supply chain, while cooperatives play two roles: the supplier of inputs and also the buyer of the product.

Similarly, it has been noted that many of the drivers of the ustainable practices are also external, and it is not something that is solely a concern of supply chain members, but rather of the consumer market. These results are presented as interesting findings, since the Green SCM literature assumes that the implementation of sustainable practices in supply chain is a result of external influences, especially of pressures, incentives and demands of the clients and the government.

Finally, it should be emphasized that the discussion of public policies to promote sustainable practices in food supply chains, such as coffee, can enable the implementation of sustainable practices, as well as their improvement. This fact is also important when considering that the coffee market is based largely on international buyers, who require a sustainable positioning in agri-food production, as a requirement in the negotiations. Considering the relevant participation of agribusiness in the Brazilian, the implementation of public policies for this purpose can have favorable effects and may be the object of future research.

FINAL CONSIDERATIONS AND RESEARCH AGENDA

In this study, we aimed to identify sustainable practices adopted in coffee production in the Cerrado Mineiro Region. A number of practices were identified, which encompassed all three dimensions of sustainability, although a greater number of practices focused on environmental issues were adopted, followed by social ones and, finally, economic ones.

The contributions observed from this study are related to the systemic understanding of the way in which sustainability has been incorporated and operationalized in the coffee Cerrado Mineiro Region supply chain. Therefore, it helps managers of the organizations researched and involved in the supply chain in the decision making process, since the adoption of sustainable practices may require financial investments. On the other hand, it is also worth noting that the data presented here are evidence that the development of sustainable strategies can have positive effects for the companies studied, since these aspects have proven to improve the relationship of supply chain members, teto the most collaborative ones.

Despite the efforts and contributions of the research, it is necessary to highlight the limitations. It was decided to analyze in this paper only three links ofsupply chain covering 12 coffeeproducers, 3 cooperatives and 1 development foundation (Fundaccer). By expanding this range ofsupply chain members, including such as associations and coffee shops, other views on sustainability could emerge and motivate further discussion.

Considering the aforementioned limitations, it is recommended to further studies: (1) To explore the in-

fluences that strategic management of sustainability in agri-food supply chains can exert on the internal orientation of organizations; (2) Analyze the internal and external drivers towards the adoption of sustainable practices in the coffee Cerrado Mineiro Region supply chain; (3) Analyze the barriers faced by supply chain members towards the adoption of sustainable practices in their productive and organizational processes; (4) Analyse the social related issues, as such as, female labour force and other issues.

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SOCIAL SUSTAINABILITY IN SUPPLY CHAINS: A FRAMEWORK AND A LATIN AMERICA ILLUSTRATIVE CASE

ABSTRACT

Social issues are under-represented in sustainability, considering historical predomi-nance of economic and environmental issues. This also applies to Sustainable Sup-ply Chain Management. Even with its definition clarified regarding Triple Bottom Line, research still advances disproportionately in environmental and economic di-mensions, facing the social dimension. This research aims to analyze how social sus-tainability is addressed in focal firms and managed into its supply chain. The study explores the concepts of social issues and governance mechanisms, presenting ele-ments discussed in the literature. A framework for managing social sustainability in supply chains is presented, followed by a case to illustrate the discussed concepts in a Latin American context.

KEYWORDS | Sustainable supply chain management, sustainability, social sustain-ability, governance mechanisms, Latin America.

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INTRODUCTION

A growing body of Operation Management's literature began to focus on the integration of socio-environmental management with Supply Chain Management (SCM), leading to the Sustainable Supply Chain Management (SSCM) field of study. The review of Seuring and Müller (2008) is one of the field's seminal works. The authors proposed the most widespread concept of SSCM, describing it as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements" (Seuring & Müller, 2008, p. 1700). The three dimensions refer to the Triple Bottom Line, a management model created by Elkington (1997) to operationalize Sustainable Development's definition. Seuring and Müller (2008) also initiated a call for further research on the social pillar of SSCM, that still echoes.

The lack of progress in the social dimension of SSCM represents a problematic situation. If, on the one hand, it may mean that companies find it much more difficult to identify and to develop practices in social sustainability than in environmental sustainability (Marshall et al., 2015), on the other hand, it may give the impression that sustainability, in its conceptual Triple Bottom Line (TBL) form, is only a theoretical construction with limited relevance (Brandenburg et al., 2014). This omission may also represent that social elements are particularly difficult to achieve or are less tangible when compared to environmental ones (Ashby et al., 2012).

Several reviews of the literature reinforce the social sustainability gap (Carter & Easton, 2011; Ashby et al., 2012; Marques & Cousins, 2013; Taticchi et al., 2013; Ahi & Searcy, 2015; Beske et al., 2015; Touboulic & Walker, 2015). Considering this context, this study seeks to analyze "How social sustainability is addressed in focal firms and managed into its supply chain?". To guide this research question, the study explores two essential concepts, social issues and governance mechanisms, and provides an illustrative case that explains these concepts in a Latin America context.

The focus on focal firms is indicated due to its leadership role in the supply chain and also for its need to answer society's pressure to adopt sustainable practices (Cooper & Ellram, 1993; Seuring & Müller, 2008; Silvestre, 2015). In turn, the focus on a Latin America context addresses the need for new empirical evidences and theoretical reflections outside supply chains from developed economies, the main field explored so far (Silvestre, 2015). In fact, studies investigating contexts of countries such as Brazil, an emerging economy, are highly recommended, once those environments represent a setting of vulnerabilities and demand more effort to adopt SSCM (Busse, 2016).

This study contributes to the SSCM literature by replying to the often calls to approach social sustainability in supply chains and adding a focus on Latin America, a context that also lacks of proper research in the subject. In a conceptual domain, the paper compiles the main literature findings and proposes a framework regarding the managerial practices related to the social dimension of sustainability, along the supply chain. In an empirical domain, it presents the main social issues and governance mechanisms adopted in a context of Latin America. The study represents an initial but important step towards deepening the knowledge on how focal firms from Latin America can address social sustainability along its supply chains. By overcoming the hurdle of address sustainability in its TBL form, companies from Latin America can create new strategies to manage its supply chains and create more value to its stakeholders.

The paper is divided into four topics besides this introduction. The first and the second topics discuss the main concepts of this study, social sustainability and governance mechanisms, considering its different approaches and perspective in SSCM. The third topic presents the elements that compose social issues, governance mechanisms and supply chain actors to create a framework to support the management of social sustainability along the supply chain. Also, an illustrative case is presented to discuss those concepts in a Latin American context. Lastly, the final considerations present and discuss research challenges and gaps related to social sustainability and its governance mechanisms in the SSCM. The paper also brings insights for future research on this important but yet overlooked topic.

SOCIAL SUSTAINABILITY IN SUPPLY CHAINS

Supply Chain Social Sustainability (SCSS) is understood as addressing social issues upstream and down-

stream of the focal company, going beyond internal operations to suppliers and stakeholders, such as the local community, society and consumers (Mani et al., 2015). Klassen and Vereecke (2012) highlight three points to manage social sustainability in supply chains: what; who and how. The "what" is related to social issues, the "who" is related to the stakeholders, and the "how" relates to practices adopted to extend sustainability along the supply chain, assumed here as governance mechanisms.

A variety of understandings has been considered for addressing social issues, the "what". In the definition of Klassen and Vereecke (2012, p. 103), for example, social issues in supply chains are the "aspects related to products or processes that affect human security, well-being and community development". In a broader definition (Chardine-Baumann & Botta-Genoulaz, 2011), social issues include: social conditions of work (employment, respect for social dialogue, health and safety, development of human resources); human rights (child and forced labor, freedom of association, discrimination); social commitment (involvement in the local community, education, culture and technological development, job creation, healthcare, social investment); customer issues (marketing and information, health and safety, protection of privacy, access to essential services); and business practices (fight against corruption, fair trade and promotion of social responsibility in the influence sphere).

Social sustainability has not yet reached a consensual understanding. Some contents already associated with social issues are presented in Table 1.

Table 1: Social Issues on SCM

Social Issues	Description	Authors
Working Conditions	Employee's working conditions include respect for social dialogue, development of human resources; wages, working hours, the right to form unions, employment contract and worker exploitation	Carter and Jennings (2002); Jorgensen (2008), Preuss (2009), Park-Poaps and Rees (2010), Chardine-Baumann and Botta-Genoulaz (2011), Klassen and Vereecke (2012); Simões (2014); Dubey et al., (2016)
Society	Considers elements such as corruption, support in actions for society (e.g., job creation, investments in R&D, culture, technology, infrastructure, support to local suppliers); education programs; acceptance (e.g., communication channels).	Jorgensen (2008); Chardine-Baumann e Botta-Genoulaz (2011); Simões (2014); Ahi e Searcy (2015)
Product Responsibility	Integrates consumer health and safety concerns into the product; information on product, ingredients, origin, use, potential hazards and side effects, with labeling. Marketing communication, with ethical guidelines for ads.	Jorgensen (2008), Chardine-Baumann and Botta-Genoulaz (2011); Simões (2014).
Human Rights	Rights inherent to all human beings, regardless of nationality, place of residence, sex, national or ethnic origin, color, religion, language. The right to equal rights, without discrimination and with freedom of association, is its core.	Carter and Jennings (2002), Jorgensen (2008), Mena et al. (2010); Preuss and Brown (2012); Simões (2014); Dubey et al., (2016); Mani et al. (2016)
Ethic	A team, department or division is responsible for ethical compliance in manufacturing facilities; establishes transparent, comprehensive and rigorous codes of ethical conduct; audits clients and suppliers for compliance with the code.	Carter and Jennings (2002); Dubey et al., (2016); Mani et al. (2016)

Health and Wellbeing	Audits suppliers and guarantees adhesion of occupational health policy; Ensures women safety and availability of minimum health care in supplier facilities	Hutchins and Sutherland (2008); Klassen and Vereecke (2012); Simões (2014); Mani et al. (2016)
Equity	Ensures diversity in in the workplace at customer and suppliers locations and compliance with gender and non-discrimination policies at customer and supplier sites.	Carter and Jennings (2002); Hutchins and Sutherland (2008); Simões (2014); Mani et al. (2016)
Philanthropy	Includes practices such as: donations to NGOs, encouragement for employees to volunteer and donate to NGOs; encourage suppliers in philanthropic activities, conduct health-related fields for society involving factory facilities	Carter and Jennings (2002); Mani et al. (2016)
Health and Safety	It includes physical and mental health that is directly related to safety and hygiene at work. It also describes hazardous working conditions, which could leave long-term effects on a worker's personal health.	Carter and Jennings (2002), Jorgensen and Knudsen (2006), Hutchins and Sutherland (2008); Ciliberti et al. (2009), Klassen and Vereecke (2012); Simões (2014); Dubey et al., (2016); Mani et al. (2016)
Child Labor	It is concerned with work by children under the age of 15 which prevents school attendance and work by children under 18 years of age that is dangerous to physical or mental health.	Kolk and Van Tulder (2002); Nadvi (2008); Zutshi et al. (2009), Lund-Thomsen et al. (2012)
Development of Minorities	Development of populations that are considered minorities in terms of population by virtue of their religion, race or ethnicity.	Krause et al. (1999), Carter and Jennings (2002); Maignan et al. (2002); Carter (2006),
Disabled/ Marginalized Inclusion	Groups that are mostly neglected in societies for physical disabilities or those neglected by the government. Population living below the poverty line is considered as marginalized.	Carter and Jennings (2002); Carter and Jennings (2004), Hall and Matos (2010)
Training Education and Personal Skills	It assesses the level of commitment to improving human capital skills and attempts to correlate the intellectual development of human resources and social progress achieved by the company.	Hutchins and Sutherland (2008); Simões (2014).
Gender	Equal treatment of women and transgender, with equal rights in the workplace	Tallontire et al. (2005), Preito-Carron (2008), Barrientos (2008)
Community	Supports with financial and material resources to benefit local communities. It focuses on cultural and educational interactions to improve the external social environment around the company.	Carter and Jennings (2002); Ashby et al., (2012); Simões (2014); Dubey et al., (2016)

Source: Jorgensen (2008), Simões (2014), Yawar and Seuring (2015) e Mani et al. (2016)

Some authors, such as Jorgensen (2008) and Simões (2014), link social issues with life cycle analysis in order to follow Social Life Cycle Assessment (SLCA). Under this perspective, social issues are divided into four categories of impact (i.e., human rights, labor practices and decent work conditions, society, and product responsibility). These categories are final indicators composed by other intermediate indicators, as follows: (1) for human rights, there are intermediate indicators such as non-discrimination (e.g. indicators of diversity); freedom of association and collective bargaining; child labor, including hazardous child labor; and forced and compulsory labor; (2) for work practices and conditions of decent work, one

has salary; benefits; physical working conditions; psychological conditions of work; work environment; and training and education of employees; (3) for society, there are incidents of corruption; support for development and actions for society; acceptance in the local community; finally, (4) for product responsibility, we have integration of consumer health and safety concerns into the product; product information for users; marketing communications.

In a second approach, Yawar and Seuring (2015) performed a systematic literature review and classified seven major groups of social issues: working conditions; child labor; human rights; health and safety; development of minorities; inclusion of disabled or marginalized persons; and gender. In their survey, they also identified responsible actions in supply chains, aligned in three strategies: the communication strategy, with reporting and labelling actions; compliance with standards/codes of conduct, auditing and monitoring actions; and development of suppliers, with actions of direct development of suppliers; indirect development of suppliers; trust and collaborative relationships. Such strategies would be under the "how", pointed out by Klassen and Vereecke (2012). The "who" point was also addressed by Yawar and Seuring (2015), that divided social issues into demands from internal and external stakeholders.

Mani et al. (2015) and Mani et al. (2016) also developed an approach of social issues with the three points of Klassen and Vereecke (2012). For "what", Mani et al. (2016) developed and validated a scale of social sustainability, applied with managers from India and focused on countries of emerging economies. In their findings, the authors consider six major groups of social issues: philanthropy, security, equity, health and well-being; ethics and human rights, described in Table 1. For "who" and "how", Mani et al. (2015) somehow integrated the "who" and "how" and classified social practices into four phases: supplier relationship phase; internal operations phase; relationship with society's phase and relationship with consumer's phase.

GOVERNANCE MECHANISMS FOR SSCM

To extend sustainability throughout its supply chain, focal companies can implement different management practices. The practices used to manage the firm's relationships are referred to in the literature as governance mechanisms. In a more focused view, Gimenez and Sierra (2013, p. 191) understand as governance mechanisms "the practices used by companies to manage relationships with their suppliers, with the aim of improving their sustainability performance". In an extended definition, Formentini and Taticchi (2016, p. 1921) describe governance mechanisms as "practices, initiatives and processes used by the focal company to manage relationships with 1) internal functions and departments, and 2) their chain members and stakeholders with the goal of successfully implementing their corporate sustainability approach". Thus, internal control mechanisms are actions limited to corporate limits, while external governance mechanisms, are actions extended at the supply chain level. The mechanisms for extending sustainability to suppliers are increasingly adopted, but the scope and mode of implementation vary significantly (Rao, 2002).

Governance mechanisms have been considered in the literature from four different perspectives (Gimenez & Sierra, 2013): analysis of the global value chain; social network theory; new institutional economics (such as Transaction Costs Theory); and supply chain management. The role of governance from a SSCM perspective is receiving growing attention from scholars and practitioners (Formentini & Taticchi 2016). This perspective is assumed in other studies in the area (Gimenez & Tachizawa, 2012; Gimenez & Sierra, 2013; Formentini & Taticchi 2016).

Table 2 presents a compilation of governance mechanisms considered to extend the sustainability of the focal firm into its supply chain. These mechanisms can be divided into integration activities and internal governance; screening/selection of future suppliers; incentive actions for improvement; assessment; monitoring; collaboration and development of suppliers.

Table 2: SSCM Governance Mechanisms

Governance Mechanisms	Description	Authors
Integration Activities and Internal Governance	Include: top management support; codes of conduct/ethics, guides and internal policies; goals, action plans and management systems; incentive systems and for internal members; supply chain systematic analysis, with suppliers classification; adhere to international initiatives (e.g. Global Compact); Certifications (e.g. ISO14001)	Bowen et al. (2001); Carter and Jennings (2004); Handfield et al. (2005); Mamic (2005); Pedersen and Andersen (2006); Ciliberti et al. (2009) Andersen and Skjoett-Larsen (2009); Pagell and Wu (2009); Tulder et al. (2009); Foerstl et al. (2010); Goebel et al. (2012); Hoejmose and Adrien-Kirby (2012) e Harms et al. (2013); Formentini and Taticchi (2016)
Screening/selection of future suppliers	Definition of minimum standards required; Process defined for supplier selection	Bowen et al. (2001); Min and Galle (2001); Carter and Jennings (2004); Mamic (2005); Vachon and Klassen (2006); Beske et al. (2008); Leire e Mont (2010); Ehrgott et al (2010); Harms et al. (2013)
Incentive actions for improvement	Establishment of consequences for non-compliance; Contracts with reward system; Encouraging competition based on sustainable criteria	Krause et al. (2000); Mamic (2005); Vachon and Klassen (2006); Andersen and Skjoett-Larsen (2009); Leire and Mont (2010); Gimenez and Sierra (2012); Gimenez and Sierra (2013); Formentini and Taticchi (2016)
Assessment	Activities related to supplier assessment, such as application questionnaires or company visit.	Handfield et al. (2005); Leire and Mont (2010); Gimenez and Sierra (2012); Gimenez and Sierra (2013); Harms et al. (2013); Sancha et al., (2016)
Monitoring	Seeks to guarantee expectations, with audits or certification by an independent third party. It reports on success and how agreed practices are implemented.	Mamic (2005); Handfield et al. (2005); Vachon e Klassen (2006); Carter and Rogers, 2008; Awaysheh and Klassen (2010); Leire and Mont (2010); Grosvold, Hoejmose and Roehrich (2014); Marshall et al. (2015)
Collaboration	Coordination with customers, suppliers and stakeholders to jointly improve results. May involve: NGOs membership/collaboration; Collective initiatives (sectoral)	Bakker and Nijhof (2002); Seuring (2004); Mamic (2005); Pagell and Wu (2009); Foerstl et al. (2010); Leire and Mont (2010); Peters et al. (2011); Wu et al. (2012); Gimenez and Sierra (2013); Marshall et al. (2015); Sancha et al. (2016)
Development	Training and education; Joint development; Follow-up activities; Supplier diversity; Knowledge and shared assets; Knowledge transfer; Local Suppliers	Bowen et al. (2001); Carter and Jennings (2002); Maignan et al. (2002); Mamic (2005); Vachon and Klassen (2006); Krause et al. (2007); Ciliberti et al. (2008); Pagell and Wu (2009); Leire and Mont (2010); Gimenez and Sierra (2012); Wu et al. (2012); Formentini and Taticchi (2016)

Source: Akhavan and Beckmann (2016), Formentini and Taticchi (2016) Gimenez and Sierra (2013)

Sustainable initiatives would then be moved along the supply chain through governance mechanisms (Mani et al., 2015) and, in this context, the interest in implementing sustainable initiatives should be combined with the interest in governance models to extend them along the supply chains (Vurro et al., 2009). Sustainable Supply Chain Governance (SSCG) studies are recent but have already highlighted important factors such as the formalization of mechanisms (Alvarez et al., 2010) and the role of collaborative approaches (Vurro et al., 2009).

SOCIAL SUSTAINABILITY IN SUPPLY CHAIN MANAGEMENT: FRAMEWORK AND ILLUSTRATIVE CASE FROM LATIN AMERICA

Figure 1 was elaborated from Klassen and Vereecke (2012) classification of three main points to manage social sustainability in supply chains (i.e., "what", "how" and "who"). The indication of "who" is characterized by the actors that constitute the supply chain (i.e., focal company, first and second tier suppliers, client and end customer), plus local community, society, government and NGOs, prominent stakeholders in the SSCM literature. The "how" relates to governance mechanisms to manage relationships in internal functions, supply chain members and other stakeholders with a view to adopt sustainability (Formentini & Taticchi, 2016).

The governance mechanisms identified are: integration activities and internal governance; screening/selection of suppliers; incentive actions for improvement; assessment; monitoring; collaboration; development (Gimenez & Sierra, 2013; Akhavan & Beckmann, 2016; Formentini & Taticchi, 2016). Finally, "what" refers to social issues mentioned when addressing social sustainability in supply chains. The social issues identified in the literature are: child labor; work conditions; health and safety; health and wellness; gender; equity; development of minorities; inclusion of marginalized persons; ethic; human rights; philanthropy; product responsibility; community; and society. It is emphasized that references to community and society were referred in the literature both as stakeholders ("who") and as social issues ("what"), which may indicate the complexity of inserting such actors in the SSCM, represented as subjects that interact with the focal company and as targets of management practices.

Figure 1: Framework for Social Sustainability in SCM
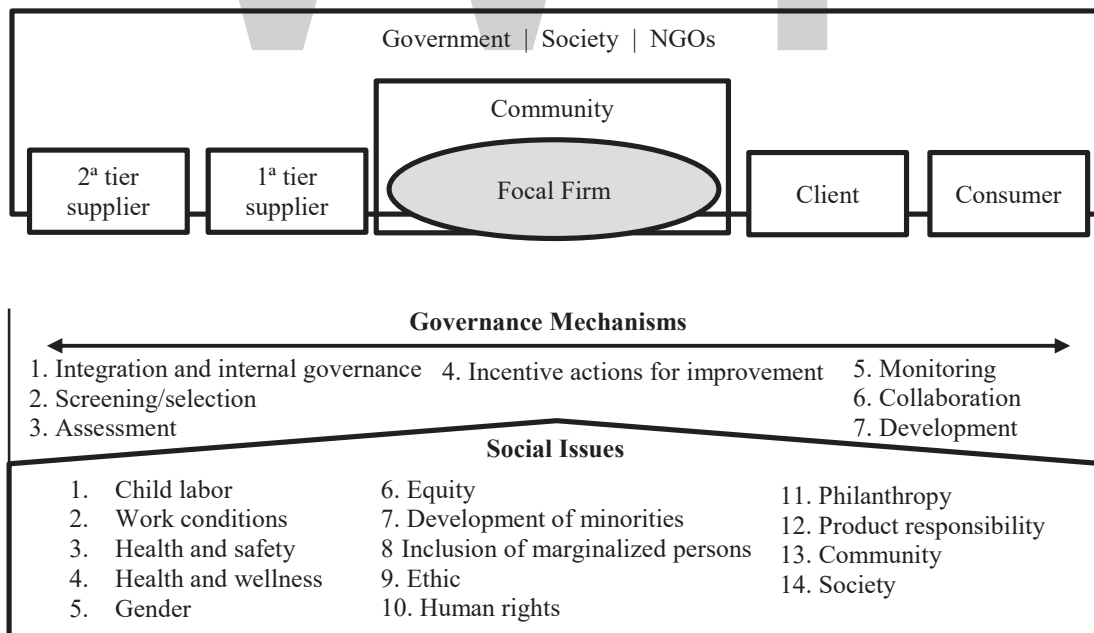
A case to illustrate how social issues can be extended along the supply chain, following the elements exposed in the figure above, is explored based on the initiatives of a multinational company from the food sector. As consumers are becoming more concerned with the products they consume, the food industry seems to be under distinctive scrutiny of the public for a while (Beske, Land, & Seuring, 2014). Also, this

industry is relevant for investigating SSCM, since its early stages involves a series of sustainable issues such as product safety and traceability, working conditions, environmental protection. The company investigated states as its propose "to feed the world in a responsible safety and sustainable manner", therefore, it is assumed that it adopts sustainability as a core element of its business strategy, and, thus, with the potential to develop sustainable practices at the supply chain level.

The company has presence in 70 countries. In Brazil, with headquarters based on São Paulo, the company operates in 15 States, through 18 factories and 8,500 employees. The company has completed 50 years in

Brazil and declares to implement a series of sustainable initiatives, internally and along its supply chain. These initiatives were disclosure in the company annual reports and also an interview with its sustainable manager provided information on the process of sustainability management in supply chain.

The data provided was compiled and is presented in Table 3 and represents findings of an illustrative case focused on how to manage social issues along the supply chain. As initial findings, it is possible to identify a concentration of initiatives related to governance mechanisms of integration and internal governance, as well as collaboration and development.

Table 3: Initiatives for Social Sustainability in SCM

Initiatives	Social sustainability in SCM		
	Who Supply Chain Interaction	How Governance Mechanism	What Social Issues
Adhere to international initiatives like National Pact to Eradicate Slave Labor and National Pact to Eradicate Children and Adolescent Sexual Exploitation	NGOs Society	Integration and internal governance	Work conditions Health and wellness
Working Woman Who Breastfeeds: initiative awarded by the Ministry of Health in recognition of the offer of maternity leave of six months, day-care assistance or nursery in the workplace and support room for breastfeeding	Focal firm female employees	Integration and internal governance	Work conditions Health and wellness Gender
Sustainability Committee: the president and nine leaders have the role of disseminating the sustainability strategy in other areas. Considers agricultural practices; health and safety; suppliers.	Focal firm top management and employees Suppliers	Integration and internal governance	Health and Safety Community
Investments in ports infrastructure	Society Government	Funding	Society
Available communication channels: a phone number to receive consumers doubts, suggestions, critics; online codes of conducts to suppliers and a phone number for denunciations; online compliance channel for employees.	Consumer Suppliers Focal firm employees	Monitoring	Society Product Responsibility Working Conditions

Right Hand Program: supports Childhood Brazil training multipliers to guide drivers and contracted carriers to combat children and adolescents sexual exploitation; truck drivers are trained/mentored and participate in health actions on special dates.	Suppliers Client (distribution) Community	Development	Health and wellness Community Working Conditions
Food safety Actions: apply a Global Food Safety Policy; has suppliers' quality standards; production process with label review stage; discuss public policies and regulation of food labelling.	Suppliers Consumer Government	Incentive actions for improvement Collaboration	Product Responsibility
From Grain to Grain: qualifies rural family farmers to improve quality and support vegetables supply and distribution. Encourage farmers to create cooperative and submit incentive programs.	Suppliers Community	Development	Inclusion of marginalized persons Product Responsibility
To know to nurture: in partnership with Abrinq Foundation, promotes training of community health agents and School Feeding Council member to disseminate healthy eating and local foods.	NGOs Community Society	Collaboration	Community Society
Inclusion: in partnership with Asdown, promotes individual care for people with Down Syndrome and awareness to the benefits of a balanced diet.	NGOs Community Society	Collaboration	Community Society
Vegetable garden at Home for the Elderly: a vegetable garden was planted to improve the food conditions of elderly and provide a healthier diet.	NGOs Community Society	Collaboration	Community Society
Corporate Volunteering: promotes workshops to train employees (e.g. Interactive board game, to promote children healthy eating; access to food, to promote home vegetable gardens; conscious consumption, to promote recipe that avoids waste)	Focal firm employees Community Society	Development	Philanthropy Health and wellness Community Society
More Sustainable Cocoa: promotes generation of income from cocoa production; monitors properties promoting actions to recover degraded areas and comply with environmental legislation	Suppliers Community Society	Monitoring Development	Inclusion of marginalized persons Society

Source: Empirical data

Initiatives undertaken by integration and internal governance were associated with social issues such as work conditions, health and wellness, gender and community and with stakeholders like focal firm's top management and employees, suppliers, NGOs, society. Initiatives carried out through development were associated with social issues like working conditions, health and wellness, the inclusion of margin-alized persons, philanthropy, product responsibility, community and society, and linked to stakeholders like focal firm employees, suppliers, clients (distribution), community and society. As for initiatives realized by means of collaboration, social issues identified were product responsibility, community and society and with stakeholders like NGOs, consumer, government, community and society.

Other governance mechanisms have been identified, such as monitoring, incentive actions for improvement. Funding could not be related to any of the mechanism recognized in the previous literature. The first, monitoring, dealt with social issues linked with working conditions, product responsibility and society and interact with focal firm employees, suppliers, consumers, community and society. Incentive actions for improvement were accompanying product responsibility and related with suppliers. Funding was assigned with an initiative regarding investments to improve and expand ports infrastructure. This investment was focused on benefits for the own company, but also created positive externalities that benefit society and government, once leaded to job creation, investments in infrastructure and increased transactions and tax payments. More initiatives that fit within this criterion should be identified and analyzed to understand if it really should be considered as a new governance mechanism.

It was possible to observe that implemented social initiatives tend to deal with multiple social issues and multiple stakeholders and sometimes can even be developed through more than one governance mechanisms.

Negotiating sustainable criteria with suppliers seems to be a hurdle in the food industry. According to the sustainability manager,

> "Depending on the type of supplier, if I create a barrier, such as 'you will only sell to me if you hand me the X document or if you have X percent of women', he will respond to me 'thank you, I will sell to your competitor because he seems to need me more than you'".

Thereby, many sustainable issues cannot be managed by one company in isolation, and, as a way out, collaboration and sectorial initiatives might take place. As he states:

> "For many years we started this journey, especially with agricultural producers, more than 10 years (...) and one of the convictions that we had, from the beginning, was that we alone would never solve the problem".

> "Although we are big, when you do not have the purchasing power necessary to influence the market, you have to work as a group. So, in many of our solutions, we always work with

the industry or with as many companies as possible, so that you can make a change that makes some sense (...) So we work with our direct partners, even our direct competitors can be partners of our projects"

This evidences the complexity of extending sustainability along the supply chain, which tends to be developed through synergy initiatives, often depending on the counterpart of other stakeholders as employees (e.g. corporate volunteering), response from suppliers (e.g. production standards) and partnerships (e.g. projects with NGOs).

CONCLUSION

The present study sought to analyze how social sustainability is addressed in focal firms and managed into its supply chain. To guide this goal, the study was based on two main concepts, social sustainability and governance mechanisms. These concepts were presented and compiled, considering different approaches in the SSCM's literature.

This study brings as contribution a response to the constant calls to approach social sustainability in supply chains. The three points highlighted by Klassen and Vereecke (2012) to manage social sustainability in supply chains (i.e., "who", "how" and "what") were explored and then articulated into a framework. The framework sheds a light on the elements that make up the management of social sustainability in supply chains and represents an initial effort, providing additional explanations with a case that illustrates some of its application's possibilities. The framework adopts a holistic view, which takes into account literature indications (Ashby et al., 2012). According to the authors, much of the studies that address the social dimension tend to focus on a specific area or practice, such as working conditions or human rights, and do not consider the whole perspective.

Also, a case from a company that operates in Latin America was addressed to illustrate how social sustainability can be extended into supply chains in this peculiar context, potentially more vulnerable and challenging (Busse, 2016). As stated previously, the study represents an initial but important step towards deepening the knowledge on how focal firms from Latin America can address social sustainability along its supply chains. By overcoming the hurdle of address sustainability in its TBL form, companies from Latin America can create new strategies to

manage its supply chains and create more value for its stakeholders.

Additionally, this study indicates as a research direction to investigate the phenomenon of partnerships and sectoral practices as a mechanism for governing relationships with suppliers to implement social issues along the supply chain. Other gaps related to the social side of SSCM are highlighted in the literature. For Meixell and Luoma (2015), future studies should explore aspects about awareness, adoption and implementation of social objectives in the SSCM. Seuring (2013) points to the opportunity to connect studies on the social side of the SSCM with studies on the basis of the pyramid. For Gimenez and Tachizawa (2012), surveys focused primarily on environmental practices and more research based on surveys could explore factors that facilitate the implementation of social practices. For Ahi and Searcy (2015), Tajbakhsh and Hassini (2015) and Taticchi et al. (2013), social issues are mostly neglected in research focused on performance measurement in SSCM. According to these authors, in order to ensure social issues treated in the same way as economic and environmental issues, it would be necessary to develop quantitative metrics in this area, which is not a simple task, since social elements are particularly difficult to achieve and, often less tangible than environmental ones (Ashby et al., 2012). Sancha et al. (2016) also indicate quantitative studies in the area, suggesting the elaboration of a scale that measures social constructs, such as social performance or social practices. It is noteworthy that Mani et al. (2016) validated a scale for social issues in the SSCM, as discussed in a previous topic. The authors proposed six major groups of social issues (i.e., philanthropy, security, equity, health and well-being, ethics and human rights), which could be investigated in the future in order to confirm their application in another context. The present study, considering its systemic perspective and exploratory nature, points out thirteen groups of social issues, described in the first topic and presented in Figure 01. Yawar and Seuring (2015) stimulate research in developing countries, indicating the need to focus studies on impacts on suppliers located in developing countries, where relevant social issues must be addressed. However, it should be emphasized that the local and national contexts in which research is inserted must be characterized and considered in greater detail, since similar contexts may occur in developed countries and in between developing countries. For example, issues of gender and human rights are linked to cultural and legislative aspects. Hence, associating such issues between countries like India, China and Brazil, all developing countries, but with distinct cultures and legislations, can be a superficial analysis. On the other hand, issues of corruption and lack of ethics have already been identified in both developed and developing countries. Considering a theoretical perspective, Touboulic and Walker (2015) suggest that in order to investigate human aspects of SSCM, authors could lend organizational behavior and psychology theories, such as Sensemaking Theory, or even extend well-known theories such as Maslow's hierarchy of needs.

All of these gaps reinforce the need to enhance knowledge in this area of research, a topic needed to bring sustainable supply chains truly into sustainability.

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TRANSACTION COSTS IN ENVIRONMENTAL PURCHASING: ANALYSIS THROUGH TWO CASE STUDIES

ABSTRACT

Environmental purchasing has been one of its most significant elements in Green Supply Chain Management (GSCM). By implementing environmental purchasing, companies adopt additional criteria for evaluating suppliers, which, as argued, gen- erates additional transaction costs. From the GSCM theoretical basis, and looking through the analytical lenses of Transaction Cost Economics (TCE), this article aims to discuss the transaction costs involved in the supplier selection process with the environmental purchasing approach. As result, this article presents five propositions of TCE within the GSCM in the light of two cases, which relate the possible transac- tion costs involved in each stage of the environmental purchasing process and also according to the main transaction elements.

KEYWORDS | Green supply chain management, environmental purchasing, trans-action cost economics, selection of suppliers, sustainable supply chain.

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INTRODUCTION

The complexity of supply chain management (SCM) has increased since the 1990s, and its scope has been extended beyond the assessment of traditional elements such as cost, quality and logistics, also incorporating other aspects such as environmental considerations. This dynamic is a result of the pressure experienced by companies for improving not only their social and environmental performance, but their supply chain (Vachon & Klassen, 2006).

In addition to the pressure and expectations of consumers, investors and buyers, due to strategic drivers such as cost savings, increased quality of products and services, risk management and even reputational issues (Walker, Di Sisto & McBain, 2008), companies are leading the so-called green supply chain management (GSCM). According to Srivastava (2007, p. 54), GSCM means "integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.

The buyer-supplier relationship is particularly important in this context, since the upstream activities are often responsible for large part of the environmental impact of the product, taking as perspective the complete life cycle (Tate, Ellram & Dooley, 2014). This fact has led to the development of the adoption of the so-called environmental purchasing. Carter, Kale and Grimm (2000) found that the adoption of environmental purchasing criteria proved to be positively related to the net income and negatively related to cost of goods sold. However, methodologically, the study addressed only the so-called production costs, ignoring the transaction costs that may be present in the supplier-buyer relationship.

Despite the fact that GSCM is becoming a widely explored field of research, few studies have been conducted to investigate how is the relationship between its agents, with regard to the environmental aspects, as well as very little research seeking to explore the behaviors, designs and structures with an inter-organizational approach (Sarkis, Zhu& Lai, 2011; Wetzstein, Hartmann, Benton Jr. & Hohenstein, 2016). In this study, in order to better understand this supplier-buyer inter-organizational relationship, we will focus on the purchasing process, which is, according to Srivastava (2007) definition, an important part of the GSCM process.

In this sense, the Transaction Cost Economics (TCE) is considered one of the promising organizational theories to address the issue of building relationships in GSCM. There is a clear need for the development of studies seeking to understand how the various uncertainties involved influence the relationships within the GSCM and how is the organizational commitment of the company in the relationship with other supply chain agents (Srivastava, 2007). After all, as Simpson and Power (2005) asseverate, "the inclusion of environment as a part of purchasing criteria, may attract significant transaction costs if not managed appropriately" (p. 64). Brito and Berardi (2010) also acknowledge the need of conducting studies that address the cooperation between agents in the supply chain, with regard to control procedures, definition of minimum standards and exclusion of suppliers, highlighting the need for the management of transaction costs in the relationships, not only regarding social and environmental issues, but for taking the SCM as a whole.

Therefore, seeking to address this theoretical gap, this paper aims to discuss the transaction costs involved in the supplier selection process according to an environmental purchasing approach. The concept of transaction costs is suitable for this intent because contributes to explain "the organization of firms and the way they interact along a supply chain" (Hobbs, 1996, p. 16).

This paper is divided into four main sections. First, we review the literature by discussing the purchasing process and the particularities of environmental purchasing. Then, we discuss the literature on TCE and we address the integration between GSCM and environmental purchasing and TCE. Second, in the methods, we describe the case research strategy and the procedures for data collection and analysis. Third, we discuss the cases of the two companies studied, comparing with the literature, which led us to develop five propositions. Finally, we conclude the paper by drawing final considerations.
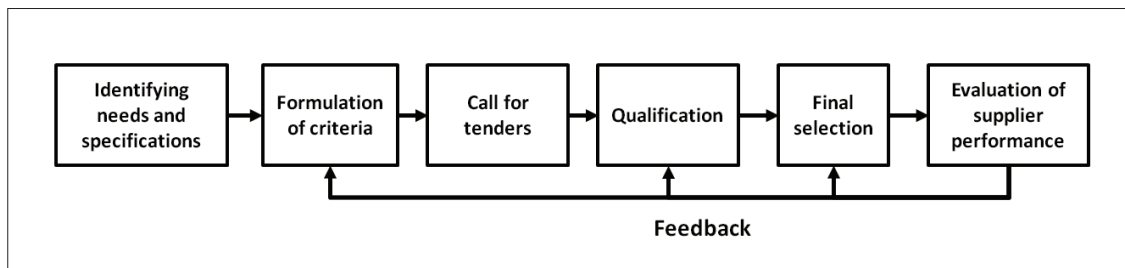
THE PURCHASING PROCESS

Broadly speaking, the purchasing process can be considered as the process of relationship with suppliers. With some suppliers, companies build closer and long-lasting relationships, and with others companies build the so-called conventional relationships. For both cases, companies adopt a supplier selection process. Those responsible for the purchasing process first analyze the supply strategies and then identify

the products and services regarded as central for the success of the company in the present and future. After that, they choose the supplier evaluation criteria, including aspects such as stability, profitability potential, quality, capacity and technology compatibility, volume to be purchased versus the supplier's ability to meet it. Intermediating the relationship with suppliers, the company works with product and service agreements (PSA).Specific PSAs are developed for each key supplier of the company. And for the other suppliers, there are generic PSAs for each set of suppliers. Based on these evaluation criteria and PSA, the company develops ways of measuring supplier performance, seeking to identify the profitability (Croxton, García-Dastugue, Lambert, & Rogers, 2001).

Igarashi, de Boer and Fet (2013) corroborate Croxton et al. (2001), presenting the flow of the supplier selection process in six steps, as shown in Figure 1.

Figure 1. **Supplier Selection Process**

Source: Igarashi et al. (2013, p. 248).

Although this process generally applies to a broad number of situations, there are situational factors that determine the type of purchasing method to be used. The main situational factors are the number of suppliers available, the importance of the purchase, the prior relationship with the supplier and the amount and nature of uncertainty present. In purchasing, the selection methods also vary according to the type of purchasing situation, classified as new buy, straight rebuy and modified rebuy (de Boer, Labro & Morlacchi, 2001).

In addition to the discussion of how the supplier selection process occurs, there is an urgent need to discuss the factors considered in the selection. Especially due to the fact that the supply chain management have focused on building long-lasting and strategic relationships (Spekman, 1988), the choice of suppliers have been increasingly guided by a larger number of factors, both quantitative and qualitative (Ghodsypour & O'Brien, 1998), which further reinforces the importance of the supplier selection process. The traditional criteria such as quality, delivery and cost, as described in the seminal study of Dickson (1966) (apud Weber, Current & Benton, 1991), are still prevalent and ubiquitous, however, new criteria such as management, research and development, flexibility, reputation, safety and the environment, among others, have been used (Ho, Xu & Dey, 2010).

It is essential to recognize, however, that depending on the specific context, the factors are considered or not and are assigned different weights for the different attributes considered (Dulmin & Mininno, 2003). The priority is to develop the best value in the supply chain, before the various criteria (Ketchen Jr. & Hult, 2007). Next, we explore the supplier selection process focusing on the environmental aspect, hereafter referred to as "environmental purchasing."

ENVIRONMENTAL PURCHASING

Advancing from its initial development to date, Shi, Baldwin, and Cucchiella (2012) point out that the studies approaching purchasing based on environmental criteria include issues that are highly related to inter-organizational aspects, such as support to the development of the environmental management systems of suppliers; meeting between suppliers of the same industry for sharing challenges and know-how; choice of suppliers based on environmental criteria; certification of products that meet environmental requirements; audits aimed at certifying the environmental performance of suppliers, among others.

Given its expanded scope, Sarkis et al. (2011) argue that the concept often comes up as a substitute to the concept of GSCM. This is because often the supply or procurement department, depending on the organi-

zational structure and the importance of the supply function, may be largely the main activity of the supply chain (Zsidisin & Siferd, 2001). This reflects in its definition as "the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment […]" (p.69). These concerns involve the acquisition of raw materials, selection, supplier evaluation and development, suppliers operation, internal logistics, packaging, recycling, reuse, efficiency in the use of resources and proper disposal of waste (Zsidisin & Siferd, 2001).

The decision regarding the adoption of an environmental purchasing process, however, is not conducted in an isolated manner, as it may significantly impact other factors such as price, quality, time and flexibility (Angell & Klassen, 1999), which makes the purchasing process more complex and more subject to trade-offs (Enarsson, 1998; Handfield, Walton, Sroufe, & Melnyk, 2002). On the other hand, Ghadimi, Dargi and Heavey (2016), quantitatively investigated the effects of integrating environmental and social sustainability into the process of supplier selection and order allocation and concluded that the financial performance of manufacturing improved, as well as that can lead to long-term sourcing relationships for the buyer-supplier dyad.

For this reason, the supplier selection process involves multicriteria. Figure 2 highlights the interaction of environmental purchasing as sub-process of the supplier selection process.

Figure 2. **Decision-making in the Environmental Purchasing process**
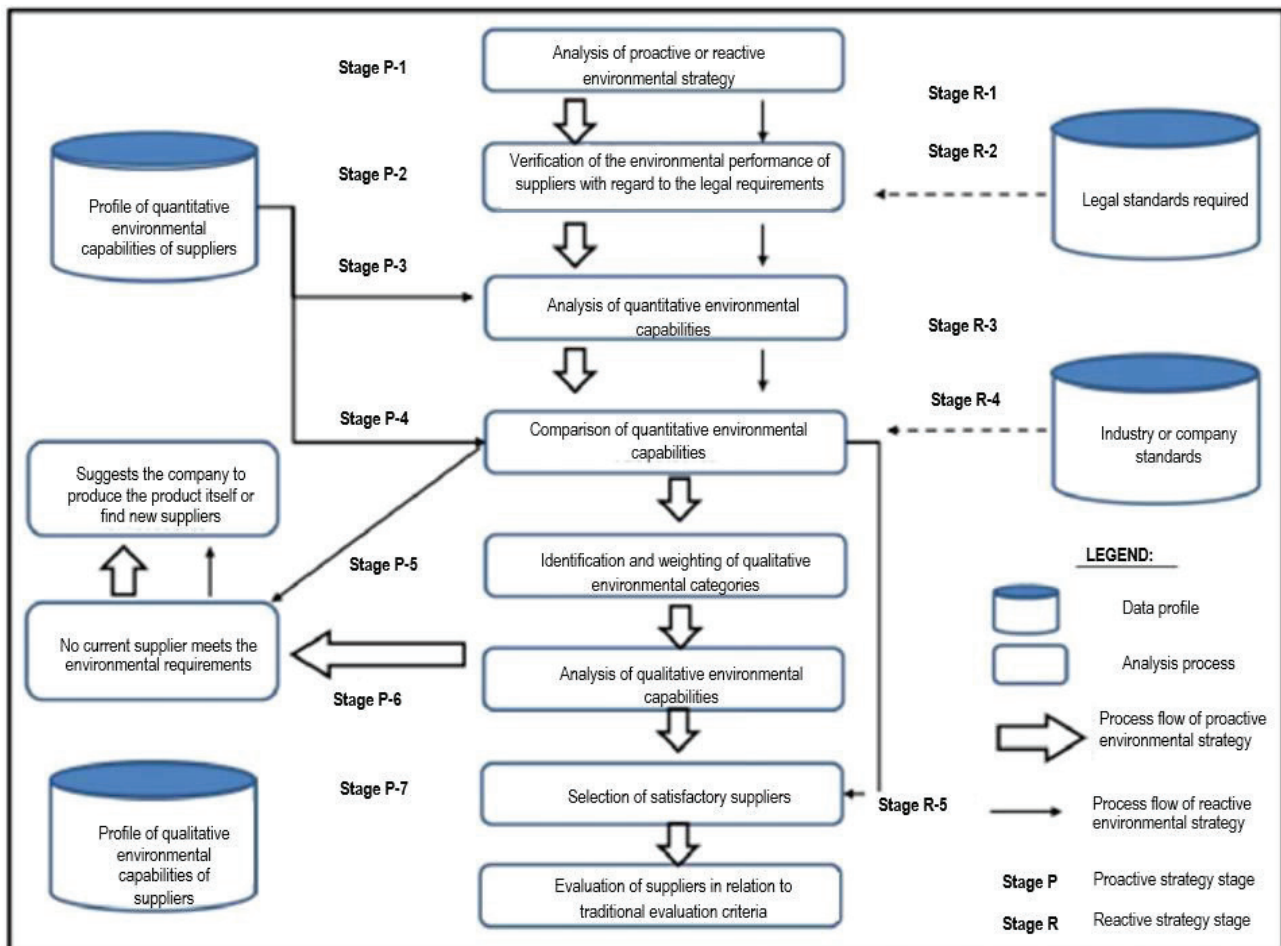
Source: Humphreys, Wong and Chan (2003, p. 351)

Analyzing Figure 2, it can be said that the environmental purchasing subprocess influences the supplier selection process in the Formulation of Criteria and Qualification stages. This influence is due to the orientation of the focal company and the establishment of environmental criteria in addition to the traditional criteria adopted.

Environmental purchasing criteria

In terms of environmental criteria, the effectiveness of the supplier selection methods is assessed in the light of three aspects. First, both qualitative and quantitative aspects must be subject to consideration. Second, it must be complete, in the sense that it should cover the largest number of relevant environmental aspects as possible. Third, the objectivity of the method of application should be a key aspect, as it aims to facilitate the decision-making process (Noci, 1997).

Some of the main quantitative and qualitative environmental criteria of supplier selection proposed in the literature are shown in Table 1.

Table 1. **Environmental purchasing criteria**

Quantitative criteria	Qualitative criteria
Emissions; Solid and liquid waste generated; Energy consumption and energy sources; Water consumption; Use of recyclable materials	Support from the top management; Training of employees; Information exchange; Environmental reputation; Design for environment (including recycling, reuse, remanufacturing, disassembly and disposal); Environmental management system (environmental policies, certifications); Environmental expertise (clean technologies used, use of eco-friendly materials, pollution reduction capacity and handling of materials from reverse logistics); Evaluation of suppliers (second-tier evaluation); Relationship with stakeholders; Compliance with environmental legislation; Logistics and transportation (means of transportation, geographic location, existence of reverse logistics).

Source: Adapted from Enarsson (1998), Handfield et al. (2002), Humphreys et al. (2003)

As shown in Figure 2, the evaluation of the quantitative environmental criteria is made prior to the qualitative criteria. One of the reasons that justify it is that they are more easily verifiable and easy benchmarking, either with the industry standard or government regulations, and therefore, they tend to be less costly to evaluate. Thus, suppliers who do not meet these basic requirements, may occasionally be eliminated in the beginning of the process.

Given the variety and complexity of the suppliers evaluation criteria, involving the management itself, the production process, product and logistics (Enarsson, 1998), as shown in Table 1, it is possible to foresee the difficulties faced by a company when implementing an environmental purchasing process. Rezaei, Nispeling, Sarkis and Tavasszy (2016), for instance, mentioned the often limited compatibility between environmental and traditional purchasing criteria and the trade-offs between these criteria sets.

Govindan, Kaliyan, Kannan and Haq (2014) conducted a study precisely seeking to identify the main barriers to the adoption of GSCM. Based on the literature review, expert opinion and a survey conducted with companies from various sectors, they initially identified 47 barriers, which, after another round of empirical validation with companies, resulted in 26 key barriers, categorized as outsourcing, technology, knowledge, financial, involvement and support. In terms of level of importance, the key barriers were ranked, and the most important was "Complexity of measuring/monitoring environmental practices of suppliers", ahead of others such as "Lack of new technologies, materials and processes" (2nd) and "Restriction of resources" (5th). This barrier is directly related to environmental purchasing with regard to the informational transaction buyer-supplier.

TRANSACTION COST ECONOMICS AND ENVIRONMENTAL PURCHASING

When conducting transactions with other companies, the companies do so with contracts, and according to this perspective, they may be characterized as a nexus of contracts (Coase, 1937). Similarly, the supply chain is a broad nexus of contracts mediated by the transaction characteristics and the institutional environment (Zylbersztajn & Farina 1999). The transaction characteristics influence the way the relationship between the agents will be governed, which in turn influence the transaction costs.

The transaction costs in a relationship may be *ex-ante*, incurred when searching for information, formulating, negotiating and registering contracts between companies, and *ex-post,* related to the cost of monitoring and enforcement of the contract (Williamson, 1985). These costs are influenced by behavioral elements, by the attributes of the transactions and the choice of governance mechanisms to govern the relationship.

As for the behavioral elements, TCE assumes that economic agents have limited rationality and opportunistic behavior, tending to act in a self-interested manner. As for the bounded rationality, it is clear that, faced with a highly complex environment, subject to many uncertainties, it is unlikely that the agents manage to anticipate, without a huge financial effort and time, all possible contractual problems and risks that may occur in the course of the relationships. With regard to the opportunistic behavior, it is understood that by having information asymmetry between agents and therefore, a party holds certain privileged information or taking advantage of unexpected contingencies *ex-ante*, some agents behave in a self-interested manner, benefiting themselves and to the detriment of the other agents (Williamson, 1985).

As for the transaction attributes, the TCE discusses three main elements that could affect the perception of agents regarding which governance mechanism is the most appropriate: frequency, uncertainty and asset specificity.

Frequency refers to the number of times the agents carry out transactions in a given period, being most relevant when considering the possibility of opportunistic behavior and the average costs of preparing the contracts. The transaction frequency is generally classified as one-time, occasional and recurrent (Williamson, 1979; 1985).Uncertainty refers to the in-

ability to predict all events involving the transactions, related to the complexity of the environment in which companies operate and the dynamism with which the relationship between the agents may evolve, which is what makes contracts be imperfect (Williamson, 1979; 1985).

Finally, asset specificity can be understood by measuring how a certain asset developed to serve a specific transaction between certain agents can be re-employed without losing its value, in the event the transaction is interrupted (Williamson, 1979; 1985). In fact, the higher the asset specificity, the greater the need for coordination between agents (Williamson, 1985). Ultimately, in the absence of specific assets in a relationship, it would not require the presence of safeguards, as the price mechanism would be sufficient (Zylbersztajn, 2005).

The central studies of TCE, by often discussing the suppliers' decision to buy or produce internally, relate naturally with the SCM (Ketchen Jr. & Hult, 2007). Hobbs (1996) was the first researcher to propose and highlight the potential of using TCE to investigate the SCM. In 2008, Williamson (2008), the most prominent theoretician of TCE, published an article highlighting the potential of the use of TCE in SCM and proposing some research agendas seeking to integrate the two concepts. Over time, Chicksand, Watson, Walker, Radnor, and Johnston (2012), based on a systematic review of three of the most important journals in SCM, noted that most articles about SCM are lacking a framework based on organizational theories.

The trend identified by Chicksand et al. (2012) is replicated in the area of GSCM and environmental purchasing, but in a more significant manner, as very few studies use TCE to investigate such phenomena (Zsidisin & Siferd, 2001; Carter & Easton, 2011; Sarkis et al., 2011; Appolloni, Sun, Jia & Li, 2014). Toubolic and Walker (2015), in a literature review about sustainable supply chain covering the period between 1995 and 2013, found out only 14 papers that use TCE to ground their analysis. For the same period, Appolloni et al. (2014) identified only two papers using TCE as theoretical lens to analyze environmental purchasing. Actually, there is a trend in most of the papers of not using any theoretical lenses. Thus, lack research both empirically and theoretically grounded in order both to test and build theory (Apolloni et al., 2014; Toubolic & Walker, 2015).

Seuring (2001) recognized that the costs within GSCM include direct costs, indirect costs and transaction costs,

however, he refrained from conducting an in-depth discussion on the latter. More recently, emphasizing the relationship between suppliers and focal company, Igarashi et al. (2013) noted that there were no studies addressing the environmental purchasing process from the standpoint of transaction costs. However, Tate et al. (2014) point out the importance of studying how transaction costs are distributed between suppliers and buyers and identifying the benefits of environmental initiatives in the supply chain.

As already discussed, the study directly or indirectly addresses some of these theoretical gaps by proposing as the research goal the discussion of the transaction costs involved in the supplier selection process according to an environmental purchasing approach.

METHODS

This study is characterized as exploratory, since it aims to provide a greater familiarity with the problem, namely the transaction costs in environmental purchasing. The study is based on a qualitative approach, beginning with a literature review, in order to generate insights on the subject to then justify the subject, methods used and make the necessary assumptions to conduct the study (Flick, 2009).

As research strategy, we used the case study method, which, according to Fiss (2009), is appropriate to understand a phenomenon within a given context and based on a holistic perspective. Furthermore, an exploratory case study is aimed to refine questions to be explored in other subsequent studies (Seuring, 2008). We also used two cases seeking to offer the possibility of more robust analytical conclusions and make comparisons between them (Yin, 2010).

In order to choose the cases to be studied, Yin (2010) recommends the formulation of a set of criteria. In this study, the fundamental criterion is that the company represented a focal role of the supply chain, which, according to Seuring and Müller (2008), usually means to direct or control the supply chain and be responsible for making the product design and establishing direct contact with the end customer. In addition, we identified companies that would show the development of the adoption of a supplier selection process that considered environmental aspects, in order to ensure that the phenomenon become observable. Finally, we gave priority to companies of different sectors in order to privilege the external validity and enrich the discussion of contrasting aspects.

Based on the criteria for choosing the cases, we invited three companies to participate in the research, two of which agreed to participate in the study, Alpha and Beta. Table 2 summarizes some of their characteristics, as well as their representatives interviewed.

Table 2. **Characteristics of the companies studied**

Characteristics	Companies	
	Alfa	**Beta**
Origin	National (Brazilian)	International (foreign)
Sector of operation	Personal hygiene, perfumes and cosmetics	Automotive (automaker)
Main supply chains integrated upstream	Chemical raw materials, natural raw materials, and packaging	Ferrous metals, non-ferrous metals, non-metallic supplies (plastics, rubber and synthetic), glass, electrical and electronic systems, paint/resins/oils, chemicals, parts/components/assemblies
Size	Large (annual gross operating revenues exceeding R$ 300 million, according to BNDES criteria)	
Professionals interviewed	(1) Coordinator of the Supplier Selection and Evaluation Area, of the Procurement department (Interviewee1-Alfa); (2) Responsible for monitoring the social and environmental dimension and the supplier risk management. Had a previous role of financial analyst within the Procurement department (Interviewee 2-Alfa);	(1) Head of the Procurement department (Interviewee 1-Beta); (2) Engineer in the Environmental department (Interviewee 2-Beta).

The interviews were conducted between the months of November and December 2014 and in both companies, the professionals were interviewed simultaneously. Dyadic interviews allow the stimulation of participants to stimulate ideas that would often not be spontaneously recognized or remembered (Morgan, Ataie, Carder & Hoffman, 2013). The fact that the interviews involved both professionals working with procurement or the selection of suppliers and professionals who are involved more directly with environmental issues made the use of the technique even more relevant. The interview at the company Alfa lasted approximately 93 minutes and in the company Beta 55 minutes. They were recorded after the prior consent of the respondents, seeking to obtain a better use in the analysis and interpretation of data, especially because only one of the authors participated in the interview. During the interviews, we used a semistructured script developed based both on the previous literature on environmental purchasing and TCE. The script basically consisted of the initial explanation of the research goals, questions about the role and experience of the respondents, followed by the approach to the issues.

Finally, with the data from interviews and the supplementary documents collected, we conducted a qualitative analysis of the material (Bardin, 2011), seeking to link the empirical evidence required for the presentation and discussion of the results.

After having determined the use of the qualitative analysis, we followed the recommendation of Seidman (2006) to structure the study seeking to prevent the lack of focus and establish the methods and procedures to be used. The preparation of the propositions based on the critical discussion of the revised theoretical framework and the empirical data, in this sense, was particularly relevant. According to Bacharach (1989), a set of propositions is a cornerstone of theorizing because it states the relationship among different constructs about the phenomenon being studied.

PRESENTATION AND DISCUSSION OF RESULTS

In this section, we develop several propositions based both on literature review on environmental purchasing and transaction costs and supported by the exploratory cases. We did this process following the recommendation of "going back and forth between data and theory" (Siggelkow, 2007, p. 22), enacting an interaction between the "empirical world" and "theoretical notions" (Dubbois & Araujo, 2007), in order to build more robust theory in the field of supply chain management and its relationship with social and environmental issues (Toubolic & Walker, 2015).

It should also be noted that, throughout this section, we discuss the characteristics of the supplier selection process according to the environmental purchasing approach adopted by each one of the two companies studied.

Identification of requirements, formulation of criteria and call for tenders

The importance of defining the strategic inputs subject to an environmental purchasing approach is fully justified. Since companies integrate different supply chains (Mentzer et al., 2001) and must establish industry benchmarks in order to evaluate the suppliers – as seen in step four of Figure 2, it generates the need of having a very diverse list of information, in order to establish environmental purchasing criteria with adequate completeness (Noci, 1997). Thus, the company should make the decision about the appropriate environmental criteria considering the transaction nexus of all supply chains it integrates, as proposed by Shook, Adams, Ketchen Jr., & Craighead (2009), seeking to reduce the total transaction cost. This could mean the adoption of common criteria among suppliers of the different supply chains, albeit with differentiated valuation metrics between them.

By analyzing the cases, both companies use uniform environmental criteria to evaluate suppliers from different supply chains they integrate. There is a difference, whether the supplier supplies for the core operations of the focal company, although. Both companies are more stringent with those suppliers.

> "We made no differentiation [between suppliers from different supply chains]. In fact, there is only difference for service suppliers, for which we demand compliance with social criteria, not environmental criteria. For every supplier related to the core operations of Alfa, we monitor its environmental performance.[...] Because for service providers, this is very difficult for us. Sometimes, there are spot purchases. So, the supplier will not waste time filling up a report for us. Besides, once we intend to build a historical record, if the suppliers often change, we cannot do that. So, that is the reason why we

consider only those suppliers important to our core operations, which composes our more stable portfolio of suppliers."(Interviewee 2-Alfa)

"Today, we have an instruction from our headquarters that until 2016 all of our suppliers [either related to the core operations or not related to the core operations] must comply with ISO 14001. [...] This will be a standard guideline for every supplier, since the beginning of selection process." (Interviewee 1-Beta)

Company Beta, however, stated that is more stringent with suppliers of the chemical industry. But, still, following the recommendations of its headquarters with regard to substances restricted by international treaties, even if authorized in Brazil. For the Brazilian subsidiary, there is no significant cost of monitoring these treaties or restricted substances, since its headquarters constantly provides an updated list.

"There is a huge list of substances that the world understand that are polluters, that they offer risks both for the environment and human health and therefore they must be banned [...] Which are those substances? Those substances are forbidden by any international protocol." (Interviewee 2-Beta)

"[...]There is this instruction [about the list of banned substances by international protocol considered by Beta]. However, considering our legislation [i.e, Brazilian Legislation], I cannot blame the supplier [for not complying with all the international protocols], or impose any penalty, because it is complying with our legislation. Nevertheless, this supplier would not be qualified to supply for Beta." (Interviewee 1-Beta)

Based on that, we develop the following proposition:

Proposition 1: *companies use uniform criteria for evaluating suppliers from different supply chain they are integrated upstream, nonetheless their diversity, in order to reduce the cost of formulating environmental purchasing criteria.*

As the number of defined criteria increase, the search for suppliers becomes more expensive, since the probability of finding a supplier that meets the criteria progressively reduces (Stigler, 1961). For this reason, also, the supplier selection process with environmen-

tal criteria, as well as the purchasing in general, is qualifying or based on ranking instead of being eliminatory, regardless of the type of purchasing situation considered (de Boer et al., 2001).

"Actually, there is a score. The supplier [that complies with non-compulsory criteria], usually has an extra score. For example, if this supplier has the same price, we surely would give preference for it over the other tenders." (Interviewee 1-Beta)

"Today, we have many more actions regarding follow-up than the selection itself. In most cases, we oversee the suppliers already performing. Therefore, this is not an eliminatory gate." (Interviewee 2-Alfa)

"We have this distinction between what is essential [related to compliance with Brazilian legislation], which restrain the supplier from supplying, and what is not essential, which we would like them to improve, however it does not restrain them of supplying. In this case, we would follow-up their action plan devised in order to improve the environmental performance." (Interviewee 2-Alfa)

A different situation may occur, however, when assuming that the risk of environmental liabilities related to a certain environmental aspect is very high (Simpson & Power, 2005), then the decision to make it eliminatory comes into question, as the internal policy of company Beta indicates:

"Yes, they are the same [purchasing criteria, for all suppliers]. However, of course, it also depends on what the supplier supplies. If they supply a kind of chemical material that is dangerous, then, there is an extra concern about it. So, Beta oversees it closer. Actually, if this supplier does not present a group of documents, they may not even be able to supply. The Environment department establishes a blockade [into the company internal system], restraining them from supplying". (Interviewee 1-Beta)

For both situations, be it qualifying or eliminatory environmental criteria, we might expect an evaluation of the trade-off between the risk of environmental liabilities originated from the transaction

with the supplier and the level of adequacy of the environmental criteria established with the company's environmental strategy and direction, on the one hand, and the potential opportunity cost of not choosing a supplier who has an excellent performance in the other criteria, on the other hand. This represents, the alluded trade-off between economic and environmental attributes in purchasing decisions (Enarsson, 1998; Handfield, Walton, Sroufe, & Melnyk, 2002; Rezaei et al., 2016).

> "If only the Supply department defends the supplier which has less [environmental] impact, but this is not emphasized when we calculate the impact of the final product, we lose momentum. That is what happens nowadays. It is useless if this impact is not considered when the top management of all departments are gathered in order to make a decision and we do not have a shared goal of carbon emissions, for instance. So this is a process we are working at[…]. Summing up, today, we consider environmental aspects in the main decisions, however, this is an additional element and I would not be able to weigh how much is considered or not". (Interviewee 1-Alfa)

In both companies, the environmental criteria related to the non-compliance with either national or international regulations are the only ones considered as eliminatory, following the trend identified by Winter and Lasch (2016) in the fashion and apparel industry. On the other hand, Alfa poses no requirement for the suppliers to have the ISO14001 certification as an eliminatory factor, while Beta does. As evidenced by one of the managers of the company Alfa, if the certification was an eliminatory factor, the company could incur opportunity cost of losing suppliers with excellent performance in items such as delivery and cost, even having an adequate environmental performance, as measured by the company's own monitoring and audit process.

> "What often happens, in a matter-of-fact, regarding the environmental performance, is that it's not usual to eliminate one supplier that has a good performance in several [traditional] criteria, but poor performance in environmental criteria. However, in this case, we figure out 'why this supplier has such a good performance in everything else but environmental?' So, we will try to support this

supplier in order to improve its environmental performance. This is commonplace." (Interviewee 1-Alfa)

Company Alfa also rewards productive suppliers with relationships exceeding six months and which achieve the best overall performance in six different indicators, such as quality, cost and the environmental aspects monitored, and also for each one of them. The score of each supplier is obtained by weighing the performance of a particular supplier with the comparison with the other suppliers from the same supply chain, bringing therefore the relative performance. The different environmental aspects are also transformed into monetary units from an analysis of the positive and negative externalities based on a proprietary methodology developed by the company with the support from an external consultant. It is a symbolic recognition, but that is qualitatively considered in the negotiation and perpetuity of the relationship with the company. Thus, in the definition of the environmental criteria to be used in the monitoring, the company considers these aspects as qualifiers, somehow managing to align them with its environmental strategy.

> "What we do is compare between suppliers from the same portfolio [industry]. For instance, we collect the data from a supplier, transform them into externalities and divide them for the tonnage they produce. This generates a factor, which is compared between other suppliers from the same portfolio [industry]. (Interviewee 2-Alfa)

> "There is a prize for that supplier that had the best environmental performance and there is a prize for the best overall performance. There is a couple of differentiation; however the prizes are symbolical such as trophies, certificates, etc. Now, we are working to evolve this program in order to transform this recognition into a concrete benefit for the supplier when negotiating with Alfa." (Interviewee 1-Alfa)

> "We take in account several factors when changing suppliers. In fact, this involves policy, relationship, commercial, quality, commitment.[…] So, we know that embraces several factors and, in addition to that, if you decide to add environmental issues, it becomes difficult. So, we came

up with this solution of somehow, monetize everything." (Interviewee 1-Alfa)

Hence, this lead to the following propositions:

Proposition 2*: environmental purchasing criteria are used as a measure to qualify suppliers, not to eliminate them, unless the suppliers are not complying with national or international applied legislation.*

Proposition 2a*: in order to consider the opportunity cost of not choosing a supplier who has an excellent performance in the other traditional criteria, non-compliance with national or international legislation are the only criteria for eliminating a supplier for poor environmental performance.*

Qualification, Final selection and evaluation of supplier performance

Supplier performance on environmental issues is often subject to risks of opportunism without proper safeguards and process of monitoring (Simpson & Power, 2005).

The process of qualification may simply involve the provision of information about the environmental performance by the supplier, a process defined in this study as 'self-assertive', or the qualification via certification by third parties.

The self-assertion may occur through the completion of a specific questionnaire of the buyer or through the participation in voluntary environmental initiatives. A voluntary environmental initiative is regarded as a self-regulation mechanism of the industry and defined as a form of private regulation in which companies get together to establish their own rules to regulate corporate behavior in order to avoid common threats or promote common performance, based on the adoption of a common code of conduct .In general, since the environmental performance is not evaluated, but simply consists of declaring and/or certifying that it develops certain procedures, it is subject to opportunistic behavior (King & Lenox, 2000; Simpson & Power, 2005). If, on the one hand, it may be a mechanism that reduces transaction costs, since the focal company is not required to develop its own pattern of environmental criteria, but require the company's participation in this or that voluntary environmental initiative, on the other hand, it may cause uncertainty in relation to the actual environmental performance of the supplier. Therefore, environmental issues in-

volving the risk of significant environmental liability generated by the supplier may require other more stringent evaluation measures, thus increasing the transaction costs.

By analyzing the cases, both companies use the same criteria and monitoring systems, regardless of the suppliers or the risk of environmental liabilities. In this case, they adopt a process to closely monitor the suppliers who pose a greater risk of environmental liabilities. Company Alfa, through a close monitoring conducted by the supplier selection area and eventually by the risk management area; and company Beta, through more strict requirements for suppliers in the supply chains that pose greater environmental risks.

"How does the environmental data collection [from suppliers] work? We send an Excel sheet and suppliers return it filled up. […]Then, we monthly follow-up how the supplier is evolving, comparing the production, and ask them to justify. […] With this constant follow-up, analyzing and giving feedbacks, one stimulates a more precise and correct data supply. It is different from just asking the suppliers to fill-up with data, store these data and after a long time ask again to see them. Suppliers may inform a figure today, tomorrow inform another figure; they may feel free to make up whatever figure they want." (Interviewee 1-Alfa)

"The thing is: how to oversee if the supplier's plan of action is being effective. For chemical suppliers, every six months, they're automatically blocked in the internal system. Procurement department requires a new assessment to the Environmental department, which consists basically in a recertification, a re-homologation. So the Procurement department follows-up because all licenses [legal environmental licenses and also ISO 14001] expire. In this process, we also oversee whether the action plan agreed in the past between Beta and the supplier has been accomplished by the supplier." (Interviewee 2-Beta)

So, we develop the following proposition:

Proposition 3*: when there is risk of significant environmental liabilities originated from the transaction with a supplier, companies incur in more transaction costs ex-ante and ex-post.*

The environmental certification of the supplier by independent third parties may work as a mechanism to reduce the risks of opportunistic behavior without incurring additional transaction costs for the focal company. Here, it is possible to differentiate the ISO 14001 certification from other certifications focused on environmental performance. This is because the ISO 14001 focuses on the environmental management process and system, while other certifications tend to focus on the environmental performance of the product or production process. The certification bodies, often NGOs engaged in environmental issues, perform audits seeking to attest the environmental performance, not only the existence of an environmental management system. On the other hand, the major drawback of certification systems focused on environmental performance is that they usually have their scope limited to a particular industry or environmental issue and are quite numerous, different from ISO 14001, which has a global standard and for all industries (Vogel , 2008), generating therefore a certain specificity of dedicated assets.

Company Alfa, despite using self-assertive mechanisms, also audits all its production suppliers, thus not being a substitute for the other. Thus, Alfa incorporates the transaction costs by having to perform the monitoring and audit, and the suppliers incorporate occasional costs incurred with collection and the modification of their processes to suit the expectations of the company.

> "In the audit, we have a checklist. This year we included a coherence verification between the informed data in the socio-environmental form and the audited data. For instance, if a supplier informed the use of a certain amount of electricity, the auditor asks the electricity bill for the period and check whether the data matches. [...] That was an evolution we are still working at. [...] Until last year, we trusted on the information that suppliers gave us." (Interviewee 2-Alfa)

Furthermore, in spite of basing the audit checklist on ISO 14001 requirements, Alfa does not demand that suppliers have ISO 14001 certification. By doing that, while they consider a widely accepted pattern of requirements, Alfa also gives its suppliers some discretion on deciding whether adopting ISO 14001 is strategically and financially feasible. Alfa also acknowledges that more costs incur from auditing instead of just demanding ISO 14001 certification from suppliers.

> "Our checklist is designed based on the requirements of ISO 14001, nonetheless, we do not demand the certification. [...] Because, there are suppliers from different sizes, there are even larger suppliers which are not interested, and we may not interfere on their strategy. [...] There are companies that use that as strategy to reduce the number of audits. [...] From the moment you have a certified supplier [with ISO 14001, for instance], you may 'close your eyes, because there is a third part overseeing and checking [the certificated company]. We do not proceed this way. We do not demand. On the other hand, if the supplier has the certification, they are not excused from the audit. Once the supplier has the certification, we corroborate it [performing the audit]." (Interviewee 2-Alfa)

Beta, on the other hand, requires ISO14001 certification and considers it as a proxy for the environmental performance of the supplier. Therefore, it seeks not to incur costs to the company, allocating the transaction costs involved in the supplier selection process with the use of environmental criteria to the suppliers. On the other hand, these suppliers which adopt ISO 14001 might not consider these costs as exclusive of transaction with a single company but with all the companies that require it, reducing the asset specificity.

> "In order to manufacture a final product, you have a process behind it. So, first you assess the product, as the product tells much about the process. So, you have the list of banned substances and the compliance with all regulations regarding that product. Afterwards, we assess the process. Because a company that has an ecological product and a pollutant process makes no sense. However, it is very difficult to oversee the supplier's process. One way to do this is to demand all the required certifications. Then, having ISO 14001 means environmental protection. That is how we oversee it." (Interviewee 2-Beta)

Thus, this lead to the proposition:

Proposition 4: *using ISO 14001 or others broad similar certification systems reduces the transaction costs of en-*

vironmental purchasing both for the focal company and the supplier.

Thus, pursuing certifications that are industry-specific such as the Forest Stewardship Council (FSC) for the pulp-and-paper industry, tend to be a quite viable option to reduce the transaction costs of environmental purchasing only for companies that integrate a single supply chain. Studies such as those of Muradian and Pelupessy (2005) and Klooster (2005) indicate that in commodity industries, seeking industry-specific certifications of this kind is relatively common. The adoption of broader certifications, focused on the process, on the other hand, may be justified to focal companies that integrate several supply chains, such as the automotive industry (Gonzáles, Sarkis & Adenso-Díaz, 2008), seeking to reduce the transaction costs.

Take the case of company Beta. As already mentioned, Beta adopts the ISO14001 certification for all its production suppliers of different supply chains, as it believes that it is a successful way to monitor the performance of suppliers in terms of process, not only with regard to the final product. With regard to the evaluation of the environmental performance of the final product, the company believes that the adoption of international protocols of restricted substances as a minimum compliance criterion is sufficient, considering that some are specific to suppliers of the chemical supply chain. Therefore, Beta believes that simply having a product that has a proper environmental performance is not sufficient, thus requiring that the performance of the supplier's process also meets a minimum a threshold.

> "[…]we always tell suppliers that they have to adapt themselves to our needs. Actually, this is for their own interest. If they do not comply [with the requirements], others [suppliers] will do. So, in a matter of fact, these suppliers would start to lose market share. It is a matter of survival. We say 'you do not have ISO 14001 certification, you are supposed to have until a given date'. Sometimes, we even eliminate a supplier in the pre-qualification [because it not possesses the certification]." (Interviewee 1-Beta)

> "How do we do the homologation [of the supplier]? First item is whether the supplier is selling a clean, ecological product. However, imag-

ine the supplier is a heavy polluter, or they do not comply with regulation.[…] So, we also assess the supplier process. So, one requirement is ISO 14001. Why is that? ISO 14001 is an international standard of environmental protection. We are not able to audit the specificities of a supplier." (Interviewee 2-Beta)

Company Alfa just requires industry-specific certifications from suppliers in very special situations, such as the case of a new line of products labeled as organic. In this case, in order to be considered as 'organic', all the raw materials of the product are supposed to be certified as organic.

> "There was this case, when a perfumery line started to use organic ingredients, including organic alcohol. In this case, this was an essential certification, because it was a product requirement." (Interviewee 2-Alfa)

Based on that, we make the following proposition:

Proposition 5: *companies that integrate more than one supply chain upstream tend to adopt broad certification systems seeking to reduce the transaction costs.*

CONCLUDING REMARKS

Based on the review of the literature addressing the concepts of Supply Chain Management, environmental purchasing and transaction costs, this study discussed the possible transaction costs involved in the supplier selection process with the environmental purchasing approach.

As the main theoretical contributions of this study we present a contribution of general nature and others of specific nature. The contribution of general nature refers to the use of the Transaction Cost Economics in Supply Chain Management studies, and more specifically in the context of environmental purchasing, subjects in which several authors have identified the need of being addressed in the light of organizational theories.

The contributions of specific nature refer to the analysis of the possible transaction costs involved in each stage of the environmental purchasing process and also according to the main transaction elements. As result, five propositions were developed to contribute to the evolution of the knowledge in the field, in the light of two empirical case studies.

By addressing two empirical cases, this study also contributes to the practice by understanding in which situations within the process of green supply chain management, considering the economic and strategic logic, and under which conditions the use of the supplier selection according to the environmental logic is more or less likely to be adopted by the companies. It thus contributes to the discussion proposed by Orsato (2009) and others regarding "When does it pay to be green?".Therefore, it follows the direction of seeking to understand the elements that compel certain types of companies to perform the selection of suppliers with environmental criteria, one way or another. In the cases studied, it became evident, for example, the mediator effect of the environmental strategy, as pointed out by Humphreys et al. (2003), and of the segment of operation and supply chains integrated by the focal company.

However, since these evidences are based on case studies, there are clear limitations with regard to the generalization of the results. Thus, it is first important to enhance the external validity of the results by expanding the research with the study of other cases, particularly addressing companies in other industries. For example, it would be a contribution to replicate the case study in companies that work with commodities or extraction products. By generating more robust propositions, subsequently, the natural path is to perform descriptive studies, using surveys with probabilistic samples seeking to corroborate or refute the hypotheses.

Finally, there are several promising avenues for future research. This study did not discuss more thoroughly the mechanisms that govern the supplier-focal company relationship (Gimenez & Tachizawa, 2012) related to the acquisition of information, notably concerning the hiring of consulting firms, training and hiring of employees, as well as it did not explore asset specificity in deep. Another relevant aspect to be further studied is to understand the adoption of environmental criteria for selecting suppliers according to the purchasing situation and the kind of relationship between buyer and supplier. Whilst we focused the analysis of the first-tier supplier selection only for environmental purchasing, there is room for understand the transaction costs in environmental and social purchasing including second-tier and beyond suppliers, focus which remains understudied (Zimmer, Fröhling and Schultmann, 2016). There is also evidence on the relevance of exploring the different pattern of behavior regarding the environmental purchasing depending on the industry, such as

retail, financial services and automotive (Akhavan & Beckmann, 2016). In addition, there should also be a discussion of alternatives to measure the transaction costs involved in the environmental purchasing process and their validation with empirical studies.

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AN IMPLEMENTATION FRAMEWORK FOR ADDITIVE MANUFACTURING IN SUPPLY CHAINS

ABSTRACT

Additive manufacturing has become one of the most important technologies in the manufacturing field. Full implementation of additive manufacturing will change many well-known management practices in the production sector. However, theo- retical development in the field of additive manufacturing with regard to its impact on supply chain management is rare. While additive manufacturing is believed to revolutionize and enhance traditional manufacturing, there is no comprehensive toolset developed in the manufacturing field to assess the impact of additive manu- facturing and determine the best production method that suits the applied sup- ply chain strategy. A significant portion of the existing supply chain methods and frameworks were adopted in this study to examine the implementation of additive manufacturing in supply chain management. The aim of this study is to develop a framework to explain when additive manufacturing impacts supply chain manage-ment efficiently.

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INTRODUCTION

Due to the global economic slowdown, Latin American countries have faced, like other countries, high commodities prices and demand has faltered, particularly from China (de Barillas, 2014). "It has also implied the substitution of locally manufactured goods by imports, affecting the region's manufacturing capacity and competitiveness" (de Barillas, 2014). This opens a timely opportunity for the adoption of new technologies to enhance customization, lower costs, increase value added and improve value chains.

Appleton (2014) stated that improvements in additive manufacturing technology are growing rapidly. Additive manufacturing has been dramatically developed through the past few years to overcome its technical limitations and limited capabilities. However, manufacturers still underestimate additive manufacturing ability to enhance manufacturing processes or business operations, because additive manufacturing is perceived not as cost effective as repetitive processes of traditional manufacturing especially for large scale of production.

Literature shows a significant expansion in the additive manufacturing market. However, it is not easy for top managers to accept the adoption of this technology in manufacturing (Cohen, 2014). That is because the lack of existence of a clear model in literature to show which business strategy best fits the adoption of additive manufacturing, and/or if additive manufacturing is applicable to all types of products and/or how additive manufacturing can change or re-shape businesses and supply chains. Thus, managers are facing some difficulties to implement this technology in their manufacturing system.

Presently, manufacturers are trying to adopt additive manufacturing technology that is characterized by being efficient in energy and material consumption and, at the same time, being very flexible and very fast with regards to:

1. Following the changes in the market demand and

2. Delivering the product to the customer.

The adoption of this technology requires fundamental changes in the applied business models. Changing production systems in manufacturers has to result in the amendment of the business model's operational strategy. Optimizing operations in manufacturers can be done by focusing on enhancing the main elements of operations which are: 1) decreasing costs, 2) increasing quality, 3) reducing both manufacturing required time and lead time, 4) increasing production flexibility and 5) increasing innovation.

Traditionally, companies are concerned with internal performance improvements and keeping intensive works. However, in this globalized market, customers do not really differentiate a company from its suppliers. Thus, companies have to worry about improvements in their suppliers businesses in order to achieve better performance in the market. The performance of one company directly influences others in the same supply chain. Literature suggests performance improvements through additive manufacturing (Cohen et al,. 2014; Wohlers, 2014; Manners-Bell & Lyon, 2012). In addition, literature shows that additive manufacturing affects the supply chain management. Nyman and Sarlin (2014) argued that additive manufacturing is powerful and makes manufacturing processes easier and customization less expensive. Wong and Hernandez (2012) and Ashley (1991) assured that additive manufacturing products are characterized by presenting higher quality, being lighter, customizable, and stronger, already assembled and having lower costs. Conerly (2014) confirmed that very low volume of raw materials and work-in-process will be in inventory, and no finished goods will be stored in stock. Ugochukwu et al. (2012) stated that additive manufacturing technology helps in delivering the right product, at the right time and at the right price to customers. However, they all suggest a great positive impact on supply chain management; additive manufacturing applications are still not fully expanded to cover the supply chain management, so far.

The research problem is focused on the relationship between supply chain strategies and product types. Attention is particularly given to the specific conditions that would make additive manufacturing applicable. It is because there is lack of contextualized, structured and generalized framework that illustrates the best supply chain strategy and product type manufactured that make the adoption of additive manufacturing applicable. The existing literature has limited developments in terms of the conceptualization of additive manufacturing in supply chain management. In addition, previous studies fail in assessing and consolidating supply chain management and additive manufacturing in terms of efficiency of production and responsiveness to market strategies and to link it with the type of products manufactured.

METHODOLOGY

Due to the exploratory nature of the research, exploratory interviews were adopted in this research.

To better understand the problem, two sets of inductive interviews were held. The first one was conducted with a supply chain optimization consultancy. The aim of this interview is to explore initiatives, practices, problems and guidelines in managing supply chains in general. In addition, to refine the interview questions that were set for the manufacturing companies and to get benefit from their experience in dealing with companies that already adopted additive manufacturing.

The second set of interviews was conducted with three different companies from different industries in several geographical locations. The reason behind this variety is that additive manufacturing became famous in so many fields, such as but not limited to: healthcare, aircraft, automotive, technology, food sector, jewelry, and cloths and footwear.

The criterion followed in selecting the interviewees was based on random sampling. We first checked "All3DP Magazine", a leading additive manufacturing online magazine that ranks the additive manufacturing companies worldwide. Besides, All3DP magazine clusters these companies into different groups according to their geographical areas, industries, printing software, services, etc. From All3DP magazine, we randomly collected contact information of several companies from different industries in different geographical locations and different sizes. Three companies and a consultancy firm specialized in end-to-end supply chain optimization accepted to be interviewed and each suggested a convenient date and time for the interview according to their time schedule. The names of participants and companies are disclosed in the following table (Table 1):

**Table 1:** Interviewees' General Information

Interviewe	Company	Job Title	Industry	Country	Years of Experience
Fraser Gleekie	FERCO Ltd	Senior Consultant	Supply-chain Consultancy	United Kingdom	40
Michael Lee	Shapeways	Vendor Operations Manager	Consumable products	USA	9
Gabriel Asfour	ThreeAsfour	Partner	Fashion	USA	18
Annalisa Nicola	xybag	CEO and Co-founder	Fashion	Italy	16

The interviews were aimed at exploring the guidelines in managing supply chains and exploring how additive manufacturing is applied in these companies. On the other hand, the interviews helped in pointing out and identifying the relevant elements for designing the conceptual framework for adopting the best fit manufacturing method based on supply chain strategies.

The Proposed Research Framework

A conceptual model of factors influencing the implementation of additive manufacturing technologies as a production method is presented in Figure 1. This conceptual framework has been developed from the literature review and a number of exploratory interviews and it is of a closed loop nature to illustrate the interaction and dependency between the supply chain strategy, manufacturing strategy, and manufacturing method that has to be implemented. Next, the theories that ground our framework are presented and propositions behind the framework are explained in detail.

Figure1: Conceptual Framework
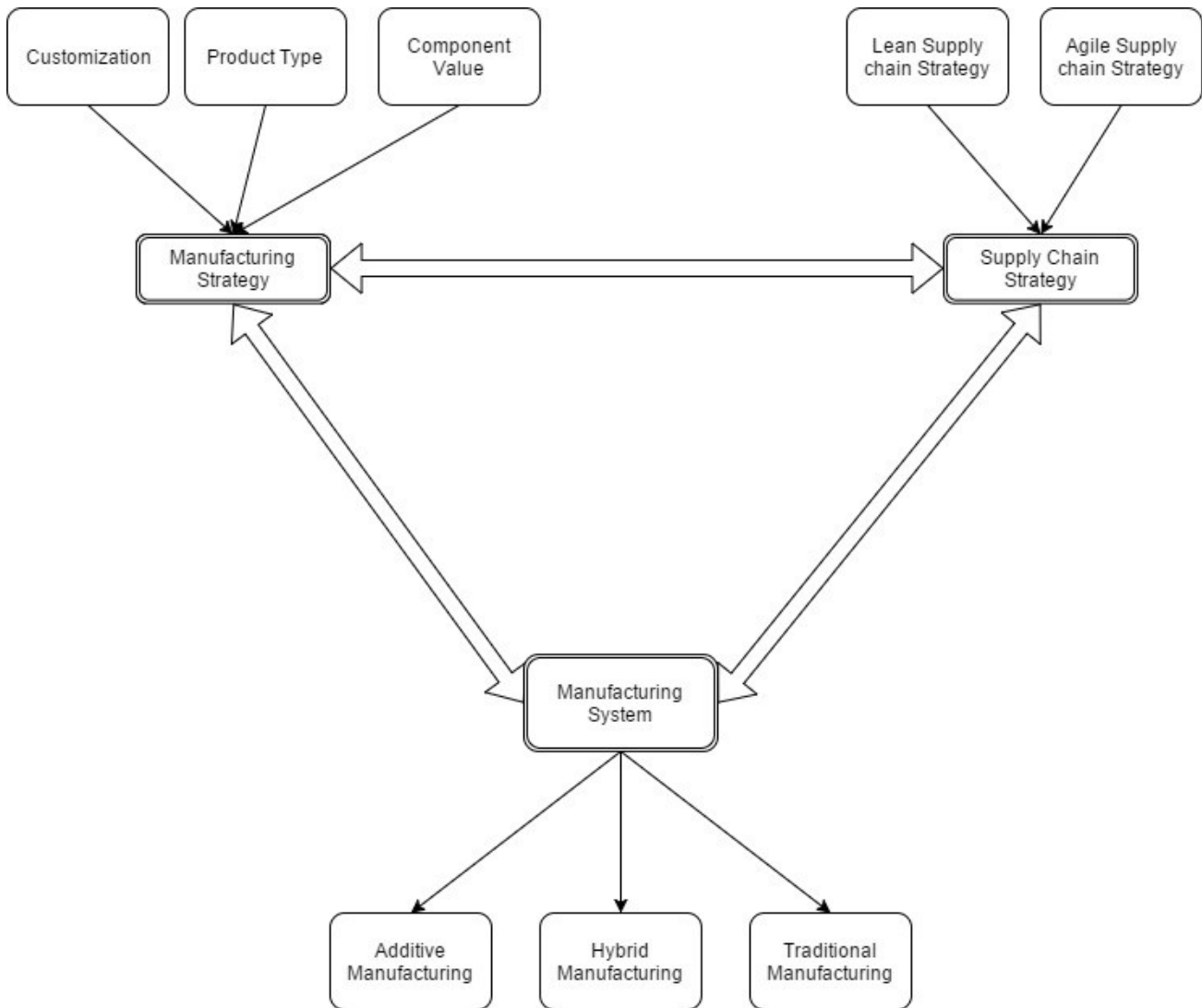
Conceptual Framework Basis

The developed conceptual framework is based on the following theories that are discussed in the literature:

Walter et al. (2004) discussed the effect of additive manufacturing on the supply chain. The authors suggest new solutions for supply chain based on both centralized and decentralized applications of additive manufacturing. In other words, they suggest either implementing additive manufacturing technologies on location or to stick with traditional manufacturing method and outsource the production of some parts through additive manufacturing in locations close to customers. They explained the advantages, as well as the disadvantages of both

centralized and decentralized application of additive manufacturing. According to Walter et al. (2004) implementation of additive manufacturing on location have the advantage of cutting high inventory costs and cutting production lead-times and delivery lead-times, and overcome of batch constraints. They addressed these advantages to the use of additive manufacturing since "it takes too much time and costs too much to produce the required parts on demand using conventional production technologies". The authors also suggest that decentralized application of additive manufacturing technologies can be used to eliminate these costs. However, the authors were concerned with the problem of having enough demand to warrant additive manufacturing

machines on location which let the cost of outsourcing much higher in that case. The authors depended on a case study of an original equipment manufacturer operating in the aircraft industry. From their findings, the authors suggest that to maximize the benefit of additive manufacturing, a hybrid system must be applied but concede that centralized application of additive manufacturing will be the first to be used, due to the significant changes the decentralized manufacture will require. Based on Walter et al. (2004) theory, we consider that additive manufacturing technologies are not suitable in all cases. However, implementation of additive manufacturing will definitely reduce the inventory level.

Besides, we also built our framework on Tuck and Hague (2006) theory, which focuses on the cost effective production of customized products. Tuck and Hague (2006) suggests that additive manufacturing increase the customization level, and thus transport costs are reduced and that the burden of part cost will move from skilled labor operating machinery, to the technology and material. This conclusion is supported by Ruffo et al. (2006). Tuck and Hague (2006) also present and explain that additive manufacturing influences supply chains in terms of lean, agile and leagile supply chains. The authors claim that additive manufacturing enhances lean supply chains as the only requirements for producing a product are the design CAD file and raw material. In addition, Tuck and Hague (2006) also suggest that because additive manufacturing can be used for economic low volume production, there is no need to hold stock in inventory. Therefore, a fully JIT system is applicable. They conclude: "Additive manufacturing could offer the first truly leagile supply chain paradigm, providing goods at low cost through the benefits of lean principles with the fast re-configurability and response time required in volatile markets. The production of goods through additive manufacturing could lead to reductions in stock levels, logistics costs, component costs (through reduction in assembled components) and increase the flexibility of production, through the ability to produce products to order in a timely and cost effective fashion." We base our framework on the two supply chain strategies; lean and agile, according to Tuck and Hague (2006) conclusion. Due to the fact that additive manufacturing technologies are being used for the production of personally customized products, our framework illustrates the necessity to understand the strategy employed by the companies, to integrate additive manufacturing and customization.

Conceptual Framework Factors and the Inter-relationship between Them

The key elements of a successful supply chain strategy are the three Vs; Visibility, Variability and Velocity (Walker, 2005). No matter what the specific competitive priority for the organization is, the goal of the supply chain management is to increase the visibility and velocity while reducing the variability (Narasimhan et al., 2008). The three Vs are defined as follows:

- Visibility is the ability to view information in all parts through the supply chain (Narasimhan et al., 2008). Increasing visibility in the supply chain benefits not only the suppliers and/or the partners, but also, and most importantly, the customers. That is because when visibility is increased, managers in the supply chain can react to change or eliminate unnecessary activities that waste resources and thus focus on enhancing the performance of activities that add value to the product.

- Velocity is the relative speed of all transactions that have to be done along the supply chain (Narasimhan et al., 2008). The higher the speed of transactions, the better; it results in a higher asset turnover for stockholders and quick delivery and response for customers. Velocity is similar to visibility; both are enhanced by supply chain management.

- Variability is the natural tendency of the results of all business activities to fluctuate above and below an average value along the supply chain. Variability measures the fluctuation of average values of time to completion, number of defects, daily sales and production yields (Walker, 2005). Contrary to visibility and velocity, variability decreases with good supply chain management. Supply chain management aims to reduce variability as much as possible.

Supply chain should match the degree of demand uncertainty (Fisher, 1997). Implemented strategies of supply chain can be either Pull or Push systems (Cachon, 2004). The push strategy in the supply chain is typically the method used to save customers' waiting time. Ferguson et al. (2002) called this system an "Early- commitment". Adopting this method, companies try to manufacture and deliver products to the shelves before they get orders from customers, in a way to let the final customers find their needs on

hand. Thus, customers get the product at the exact time when they need it and can immediately have it.

There are three main types of supply chain strategies within push strategy:

1. Stable strategy appropriate for a supply chain which focuses on execution, efficiency and cost performance. With this strategy, only simple connectivity technologies are needed, and real time information is not highly demanded either.

2. Reactive supply chain strategy works well when the supply chain acts to fulfill the demand from trade partner's sales and marketing strategies.

3. Efficient reactive supply chain strategy is the strategy that focuses on efficiency and cost management.

Companies add value to their products in their customers' perspective by saving customer's time of waiting to satisfy their needs. However, push strategy could not be perfect for all types of products and that is because one critical point is missing in this approach. Customization has not been taken into consideration. Innovative and, sometimes, functional products need to be customized according to customers' preferences. Push supply chain does not give the customers the opportunity to customize their goods. However, pull supply chain is the preferable strategy in such cases. Pull supply chain allows the customer to ask first in order to manufacture what he/she wants, and then the product is delivered to them (Iyer & Bergen, 1997). Applying this strategy, however, makes customers wait for some time to get what they ask for.

Additive manufacturing implementation in a supply chain provides the ability to enhance supply chain efficiency and effectiveness in terms of cost reduction, and time saving (Tuck & Hague, 2006).

Even "Efficiency" and "Productivity" terms are sometimes used interchangeably, as in Sengupta (1995) or in Cooper et al. (2000). However, in this research we differentiate the definition of efficiency from productivity. Based on our understanding of the literature, "Productivity" is defined as the ratio between outputs and inputs. While, "Efficiency" is defined as the proximity of a focal organization to its benchmark within its cluster or industry depending on:

1. The minimum cost of production in manufacturing and delivering a final product to a final individual consumer, and

2. The velocity of the supply chain when transforming inputs into outputs and delivering the final product to its final customer. The manufacturing velocity is defined as the ratio of the value added to the total throughout time.

In manufacturing, managers should think about the two main cost drivers: direct and indirect costs, which are summarized in material, labor and overhead. At the same time, they should think about producing goods to satisfy customers' needs. In that sense, an ideal product is one that consumes the least direct and indirect costs of material, labor and manufacturing overhead and, at the same time, satisfies customers' needs and wants (Sun, 2011).

Sun (2011) argues that in order to create a firm uses the minimum possible inputs to produce the maximum possible value for customers, efficiency tool is needed. In his opinion, lean production is that efficiency tool.

In order to be efficient in delivering the right product that satisfies customers' needs, Value Specification suggests that all non-value adding activities have to be eliminated from the process (Gupta & Wilemon, 1990). Eliminating unnecessary steps will accelerate the speed of production process while using fewer resources and so improving both effectiveness and efficiency (Iansiti, 1995b). In addition, Value Stream helps to visualize the sequence of activities in the whole process, thus making it easier to identify and eliminate non-value adding activities. This ensures increased efficiency.

Moreover, many authors, such as Sun (2011), Iansiti (1995a,b), Cordero (1991), Gupta and Wilemon (1990), Rosenau Jr (1988), and Gold (1987) have agreed on the basic idea of increasing and improving efficiency through lean management, which refers to the elimination of non-value adding activities. Therefore, working on purely value adding activities in less time, and with less resources, improves and increases efficiency.

Besides that, and based on what has been discussed earlier, we conclude that lean production is recognized as an efficiency tool, because it focuses on producing outputs with minimum cost by using the least possible resources to deliver products that have the maximum possible value for customers. As con-

sequence, lean production creates firms seeking to add value to their products in all possible ways (Sun, 2011); which means that lean must not be for indoor use only. It must be widespread across the entire process, starting from getting raw materials and continuing until the product is in customers' hands. It means that lean should go beyond production to reach the entire organization, including the supply chain. In that sense, firms that go beyond production in implementing lean thinking can be termed Lean Corporations, which is a more accurate concept to be used (Sun, 2011). Moreover, their activities could be acknowledged as a lean value chain.

In a lean value chain, manufacturers identify each activity to check whether it adds value or it is unnecessary and can be removed. Through lean techniques, managers encounter dispensable activities that create costs and eliminate them. For instance, the JIT technique permits manufacturers to avoid superfluous costs of shipping, receiving, inspection and rework (Sun, 2011).

What is more, lean value chain elevates manufacturers' flexibility in pursuing the market's changes due to demand uncertainty and changing customers' tastes and preferences. JIT lean tool allows firms to change outputs more quickly in response to demand changes, compared to other manufacturing methods.

Lean management is the main bridge that links additive manufacturing with supply chain. Lean management serves as a great linkage that connects both topics by focusing on the efficiency of production. Companies' success or failure depends on getting the right product at the right time, and at the right price to customers (Nyman & Sarlin, 2014). As was clearly visible when reviewing lean management and additive manufacturing literature, both share the following two characteristics:

1. Eagerness to increase efficiency. Many authors, such as Sezen and Erdogan (2009), explained lean as a method used to reduce costs, as well as to increase efficiency and quality. Moreover, Shah and Ward (2007) defined it as a management philosophy. Their definition was perfectly positioned on clear identification and elimination of wastes not only within, but over and above the production process to reach the whole manufacture's product value chain. Nevertheless, from all the reviewed literature, we concluded that all researchers agreed upon one main opinion in defining the objective of lean concepts. This objective is summarized in cost reduction and production efficiency improvement. In addition, researchers and authors in the additive manufacturing field agreed that additive manufacturing methods are able to cut down manufacturing costs and save time. Based on literature review, Wong and Hernandez (2012) proved that additive manufacturing is able to depreciate costs and save time. This has been stated by many other researchers such as: Noorani (2006), Herbert et al. (2005), Cooper (2001) and Ashley (1991). Cost reduction and time saving form the basis of doing things right in terms of what is known as "efficiency."

2. Better responsiveness to market changes in both demand and supply. Globalization and openness to the entire world's markets create rapid changes in natural conditions, technological progress, transport improvements, customers' income, customers' tastes and preferences, and future expectations of both customers and suppliers. In this sense, lean management uses practices and techniques that make the manufacturing process very responsive to these changes (Mohanty et al., 2007; Nightingale, 2005). "Right amount at the right time" practice, "Pull System" tool and "JIT" tool are methods that technically enhance responsiveness to changes in the market. These methods are based on having low amount of raw materials inventory, as well as, work-in-progress and finished goods. Low inventory levels facilitate adapting to new changes in the market easily with minimal inventory costs. Moreover, additive manufacturing is based on producing small production runs pulled from customers' needs, in contrast with traditional manufacturing (Campbell et al., 2011). This feature in additive manufacturing gives it the advantage to be able to quickly adapt to market changes by not holding high levels of inventory on hand.

Based on our previous discussion, we concluded that additive manufacturing has features that makes it able to work well with lean strategy in the supply chain, where it fits perfectly under the following principles:

1. Value Specification: Specifying value, from the end customers' view, involves trying to find out what customers desire from the product (Womack & Jones, 1996a). Thus, in order to

specify the value, a lean practice of realizing customers' needs has to be applied. In that sense, a lean tool has to be put into action in order to translate customers' needs into tangible product. Here additive manufacturing plays a role in transforming the specified value of customers' needs into real products (Nyman & Sarlin, 2014; Wong & Hernandez 2012) because additive manufacturing is a very flexible production tool. Products can be produced to meet customer's exact requirements for the product. Materials used, shapes, sizes and any other features can be adjusted on the spot to meet what the customer requires, with minimal costs of production compared to traditional methods.

2. Identifying Value Stream: Organizations must identify value stream of products at every step of the supply chain, in order to enhance the value added activities and eliminate the non-value adding ones from the process (Womack & Jones, 1996b; Womack et al., 1991). When companies identify the value stream in their supply chain, they will be able to reduce costs which are synonymous with waste (Shah & Ward, 2007; Ohno, 1988). Additionally, additive manufacturing has proven its effectiveness in reducing costs to the minimum by reducing waste from production (Berman, 2012; Sealy, 2012). On that account, additive manufacturing could serve as an effective lean tool to produce and deliver products that hold the maximum value to customers with minimum wastes and costs.

3. Pull Principle: Womack and Jones (1996a) explained the pull principle as "production should be done only when customers demand the product." That consequently explains the Right Amount at the Right Time practice in lean management that calls to produce the needed quantity only when it is needed (Shah & Ward, 2007) because excess in production leads to higher costs in inventory. Based on these principles and practices, we can presume that additive manufacturing perfectly performs the needed duties to be a proper tool in lean management. Based on the fact that additive manufacturing makes it feasible to produce any product required by customers, at the time it is demanded, without the need to change production process or change or retrain

personnel as is often required with traditional machinery. In addition, it allows for product differentiation and customization, because of its ability to flexibly produce any size or shape required (Sealy, 2012).

With additive manufacturing, both customers and businesses can benefit from designing and personally customizing their final products. This new technological manufacturing method makes it possible to modify the functionality of a product, from one side, and physically from the other, in order to fit the needs of the customer, in a way that was not available before. This, of course, has affected the supply chain. Businesses should keep pace with these changes and keep modifying their supply chain to fit the new requirements of the market.

Literature has showed that supply chain is not fixed for all types of products or all types of businesses. Supply chain differs from one production line to another to match the uncertainties in both demand and supply (Lee, 2002). Some businesses are looking to shorten the supply chain by eliminating some activities, while others are interested in having a responsive one and others like to hedge the risks stemming from either supply or demand uncertainties.

When additive manufacturing is applied, the supply chain takes a different shape. This is because traditional manufacturing methods depend mainly on mass production, where products are made in batches and stocked in inventories and have to be distributed to wholesalers and retailers in order to arrive to final customers. With additive manufacturing, responsiveness and the flexibility of both customization and delivery is more easily achieved while eliminating all non-value adding activities such as inventory and distribution.

Lee (2002) argued that agile supply chain is a strategy that makes the supply chain capable of quickly responding to changes in the market and in customer preferences, and diversify the product's functionality to perfectly match customers' needs. In the context of additive manufacturing, agile supply chain is the strategy that is qualified to deliver a perfectly customized product to customers, with the most efficient mode of delivery, at a minimized cost; this is achieved by cutting all unnecessary activities that add no value to the product. In addition, agile supply chain is capable of responding quickly to any changes in customers' preferences while risks are minimized.

Thus, agile supply chain combines the characteristics of efficiency, responsiveness, risk-hedging and customization. Likewise, additive manufacturing is based on the same characteristics, while responding to customers' requirements and perfectly customizing products to fit their needs, cutting costs by reducing waste and eliminating non-value adding activities. In this fashion, implementing additive manufacturing in focal organizations of the supply chain requires the supply chain to take the shape of an agile supply chain.

Previous studies found that technology has the ability to change and reshape businesses as well as implemented strategies (de Jong & de Bruijn, 2014). It is considered to be an internal strong point of the business SWOT analysis when businesses know how to properly employ these technologies to bring opportunities to their side. However, based on the held interviews, interviewees such as Asfour from Three-Asfour and Gleekie from FERCO LTD, claim that additive manufacturing cannot be implemented in businesses to produce all types of products and/or all product components. They suggest that additive manufacturing is more feasible when it is used with high valued components or for complex products.

Additive manufacturing has been applied to low-volume production, and the output can be of higher rank than that of the traditionally manufactured output; that is, additive manufactured products (especially consumer goods and health aids) are characterized by presenting higher quality, being lighter, more customizable, stronger, already assembled and having lower cost (Wong & Hernandez, 2012; Ashley, 1991) than items produced by traditional manufacturing methods. Additive manufacturing has the ability to precisely control the quantity of material used to make the product.

Nyman and Sarlin (2014) argued that additive manufacturing is powerful and makes manufacturing processes easier and customization less expensive for customers. In traditional manufacturing methods, managers forecast future demand. Based on that forecast, a sufficient amount of outputs, that is in accordance with the management's forecast, is produced and stocked in inventory (Lee & Billington, 1992). However, when additive manufacturing is implemented in a manufacturing method, real-time demand manufacturing is set in motion. This feature in additive manufacturing results in shorter lead time from order to delivery and it gives the supply chain more flexibility in responding to changes

in product demand. Additive manufacturing allows manufacturing to become more agile, more flexible, abler to respond rapidly to shifts in market demand, and more capable of introducing new products quickly and inexpensively. As a result, both manufacturing and consumer behavior are affected. It also affects the supply chain; it accelerates the shift from "Push Supply Chains" to "Pull Supply Chains." This is because additive manufacturing makes it possible to store products, parts and components on computer files, with no need to have them physically in warehouses. Each component can be pulled only at the time it is needed. Contrast this with the JIT lean management tool that let managers keep some inventory on hand in warehouses to avoid the risk of shortage (Conerly, 2014). Thus, a very low volume of raw materials and work-in-progress will be in inventory, and no finished goods will be stored in inventory (Conerly, 2014). As a result, overall supply chain management costs will be lower than those of traditional manufacturing supply chains, because of the reduced inventory costs and the reduced waste of outdated products. However, the production cost per one unit in traditional manufacturing methods, where production runs for huge batches, is much lower than in additive manufacturing (Conerly, (2014). Conversely, the opposite is true for small production runs; cost per unit in additive manufacturing for small batches is relatively low when compared to traditional manufacturing. Figure 2 is a hypothetical graph that explains the difference between production cost per unit when using additive manufacturing methods and traditional manufacturing methods, with reference to number of units produced in each method.

Figure 2: Hypothetical Cost per Unit in Both Additive Manufacturing and Traditional Methods of Production
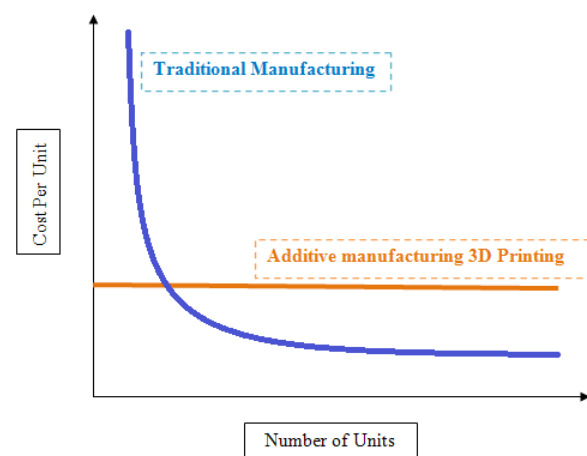
Additive manufacturing has the ability to personalize products to the customer's preferences. Additive manufacturing gives manufacturers the ability to be flexible in creating products based on each customer's requirements (Sealy, 2012; Wong & Hernandez, 2012; Gibson et al., 2010). Thus, in some industries, this manufacturing method delivers a perfectly customized product to customers, which, in turn, is reflected with higher customer satisfaction (Wong & Hernandez, 2012); Noorani, 2006).

In that sense, with additive manufacturing, both final customers and businesses can benefit from designing and perfectly customizing or even personalizing their final product; as is the case in some companies such as Shapeways and XYZBags. This new technological manufacturing method makes it possible to modify the functionality of products, on one hand, and the physical appearance of products, on the other, in order to fit the needs of the customer in a way that was not available before. This, of course, has affected supply chain management. Businesses should keep pace with these changes and continue to modify their supply chain in a way that fits the new requirements in the market.

As a conclusion, cost reduction in manufacturing mixed with fast responsiveness, flexibility and customization make it easier for focal organizations to gain a competitive advantage in the market. That happens due to the ability to reduce prices for final customers, customizing the product to the final customer's preferences and expediting the delivery of products. As a result, customer satisfaction increases. Thus, as a result of increasing agility, flexibility, responsiveness, cost-efficiency, customization and customer satisfaction, the overall profitability of the entity will be increased.

FINAL VIEW OF THEORETICAL FRAMEWORK

Global competitiveness increases the complexity in all activities and processes in any business corporation. Business firms must clearly understand and know how to apply strategies in such a competitive market. Supply chain management is one the most frequent approaches in this global competitiveness. Mabert and Venkataramanan (1998) argued that managing all the activities in the supply chain has become more challenging. That explains why practitioners and researchers paid more attention to this field. Likewise, firms have to strategically manage their supply chain in harmony with the type of products they produce in order to be effective and thus achieve higher financial and operational performance (Christopher & Towill, 2000; Fisher, 1997).

Literature suggests two main strategies for the supply chain: efficiency in production strategy, which is also called lean strategy and responsiveness to market which is also known as agile strategy (Bruce et al., 2004; Yusuf et al., 2004; Christopher, 2000; Christopher & Towill, 2000; Fisher, 1997). Moreover, researchers in supply chain strategies are highly interested in studying the product's type. Based on Fisher (1997) framework that suggests an alignment between supply chain strategy and the type of product manufactured, we proposed our theoretical framework. However, Fisher's framework proposes the two supply chain strategies and attached each of them to one type of product; in our framework, product's type depends on the complexity of the product. We adopted the definition of product complexity from Novak and Eppinger (2001). The authors argue that product complexity depends on the production required knowledge, the difficulty to learn how to produce the product and the required time to produce one unit of the product.

Figure 3 presents the theoretical framework which is basically based on Fisher's (1997) framework. It suggests two fundamental supply chain strategies as in Fisher's: 1) efficiency in production strategy, 2) and responsiveness to market strategy.

Figure 3: Theoretical Framework
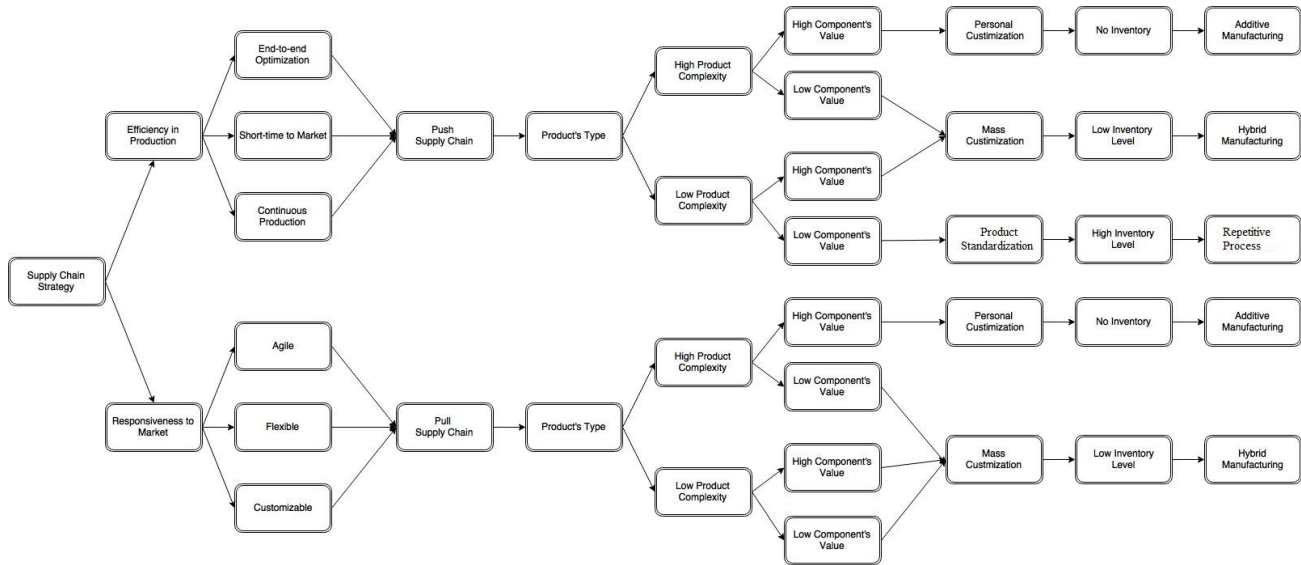
Efficiency in production strategy is characterized by end-to-end optimization, short-time to market and continuous production. Efficiency strategy involves lean production which means eliminating all kind of wastes to reduce cost to the minimum (Womack et al., 1991). Lean production strategy requires a stable product demand which makes it easier to reduce wastes through optimizing end- to-end activities, such as the level of work-in-process and finished goods inventory. In addition, the optimization of the activities creates a stable and continuous production schedule which shortens the lead time, as well. Thus, the main goal of lean production is to reduce cost and increase efficiency by eliminating wastes (Womack & Jones, 1996b). Along these lines, in a stable product demand environment, push supply chain strategy best suits the efficiency in production strategy. On the other hand, responsiveness to market strategy is characterized by agility, flexibility and customization. It provides the business firm with competitive advantage in a rapidly changing environment through offering unique customized features to customers. Rapid changes in customers' tastes and requirements have let the supply chain to respond and act faster in providing the required goods. Agility has got much attention in the literature. Researchers, such as Kidd (1995) have proposed agility as a tool to gain competitive advantage in a dynamic environment. Others have explained it as "the successful exploration of competitive base" (Yusuf et al., 1999). Agility means fast responsiveness and flexibility in responding to customers' requirements. It requires innovation pro-activity and offers higher

quality products. Thus, agility is not limited to a single business firm, but it is expanded to cover all the supply chain (Christopher, 2000). While Christopher (2000) argues that agile supply chain reduces the lead time, Lee (2004) suggests that agile supply chain has the ability to respond faster and more easily to changes in a very short time. Thus, this discussion leads business firms to adopt pull supply chain strategy when the market environment is changing rapidly. Due to the fact that pull strategy is able to respond faster to customers' requirements, it is also able to customize the commodity to their preferences. In general, researchers agreed that firms producing functional products better fit with efficiency in production strategy and thus need push supply chain, while companies that produce innovative products need responsiveness to market strategy and so pull supply chain works better to them.

When the manufacturer decides which strategy to use, the first step is to check the product's type. Products can be classified by their complexity; either high complexity products or products with low complexity. The main element that affects the selection of supply chain strategy is the product's type (Huang et al. (2002). As mentioned before the product complexity depends on the production know-how and the time needed to learn the production process, in addition to the time needed for production (Novak & Eppinger, 2001). After clarifying the product's type, the components value should be recognized. The value of the product's components can be either high value or low value, as well. Products that are combined by high val-

ued components are the ones that can be better customized. In this case, when the components' value is high and the product's type is characterized by high product complexity, personal customization better suits the production method. Thus, dramatically low or even no inventory is required for final goods. However, customization raises the production cost in the tradition manufacturing method. So, additive manufacturing method would be the appropriate method to be used in such cases. On the other hand, when the product is characterized by low product complexity and it is produced by low components' value, mass production and/or mass customization are the best production strategies to be used in this case. As a result, high inventory levels of finished goods will be on hand. Moreover, it is more feasible to use the traditional manufacturing method with low investment in additive manufacturing for prototyping purposes or for the production of some components, only.

CONCLUSION

There have been very few studies focusing on the study of additive manufacturing implementation, and no specific research has focused on supply chain strategies or product types to describe the feasibility of additive manufacturing implementation. In the identification of the research problem in adopting additive manufacturing technologies, the research problem highlights the lack of additive manufacturing implementation studies in the literature, specifically highlighting that top managers face difficulties and the fear of taking the decision of implementing new technologies in the manufacturing process. Nevertheless, there is a high need for lowered cost customized products in Latin American countries, which could grasp the opportunity of the globalized economy's slowdown. As was highlighted in the introduction of this study, additive manufacturing technologies are not successful to all manufacturing businesses. Thus, this study has provided some insight into when firms should implement additive manufacturing as the only production method and when it should be a complementary method to the traditional one based on some characteristics in the product itself and in the management of the supply chain.

In this research, we focused on operative characteristics of supply chain strategies to grab the opportunity of implementing additive manufacturing as an appropriate production method. This study contributes to the field of additive manufacturing research by offering a framework that explains the conditions that make the implementation of additive manufacturing feasible in supply chains. The framework describes two possible supply chain strategies and links each of them to the product types and the value of the product's components to end up with the feasible manufacturing system. Latin American manufacturers can rely on this framework to enhance their supply chains and add value to their manufactured goods.

Our theoretical framework suggests that additive manufacturing can be implemented if the firm is adopting efficiency in production or responsiveness to market supply chain strategies. However, additive manufacturing technology is not always the best manufacturing system to be used when it comes to the product type and the value of its components. Thus, our framework recommends implementing additive manufacturing when the product is complex and is formed by high value components.

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SCANNING INSIGHTS ON SUSTAINABILITY AND SUPPLY CHAIN MANAGEMENT IN BRAZIL

ABSTRACT

This paper aims to analyse how the publications in Brazil are considering the rela- tionship between sustainability and supply chain management. For this end, a lit- erature review was carried out in 120 Brazilian academic journals in which 124 pa-pers were identified, from 2008 until 2013. When considering the Triple Bottom Line approach, the results show that sustainability research in Brazil is focusing on the environmental dimension and SCM research is focusing on the economic dimen-sion. Additional inputs are provided by integrating the governance dimension in the analysis to underline which actions and policies are discussed in Brazil at a corporate level. To support the results a consultation of experts in the field of sustainability in Brazil was fulfilled, and three case examples are presented to explain some of the research results. The findings on publications in Brazil contrast with international studies, particularly on the topic of social performance and management in supply chains. One of the main conclusions is that there are large opportunities to increase publications about sustainability and SCM in the country and that Brazil presents some specificities in the field that researchers and managers shall consider.

KEYWORDS | Sustainability, supply chain management, governance dimension, lit-erature review, Brazil.

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INTRODUCTION

Over the last few years, sustainability-related publications have been increasing around the world (Silvestre, 2016) and are stimulating discussions in different contexts. Despite its recent progress, Baumgartner (2011) believes that the effective benefits for the society occur slowly and need to be more deepened in the academic debate. Considering this idea, some papers highlight that it is necessary to position the role of businesses in bringing sustainability closer to Supply Chain Management (SCM). When these topics are related, it is commonly agreed to talk about "Sustainable Supply Chain Management (SSCM)" (Ashby *et al.*, 2012; Tatticchi *et al.*, 2013). However, according to Pagell and Schevchenko (2014), there is "no future" for the term SSCM and research in this field, because there is no truly Sustainable Supply Chain (SSC) yet. This paper is taking this perspective in the methods applied by studying sustainability and supply chain management in Brazil.

While sustainability and supply chain concepts are being discussed in the mainstream of publications worldwide, Brazilian publications have been following this trend to a certain extent only (Gold, 2016; Silva et al., 2015). However, Brazil can be considered as the most active country in Latin America with regards to sustainability research as well as SCM. Hence, considering globalisation, the overseas expansions of some Brazilian multinationals (Fleury & Fleury, 2011) like Natura (Kaltenecker, 2016; CAF, 2014; Actis, 2013), as well as the growing outsourcing of activities from foreign multinationals to Brazil (e.g. in the automotive industry, Lema et al., 2015), it is interesting to understand which sustainability aspects are the most discussed in the Brazilian literature. This will then allow future research to contrast it with the sustainability aspects that are in the focus of scientific literature on SSCM in other regions of the world and derive recommendations for Brazilian companies and multinationals installed in the country.

According to Jabbour and Jabbour (2014), sustainability and supply chain management is coming as an important research field to Latin America. For Silva et al. (2015), this also happens in the Brazilian context since several actions (e.g. workshops, research projects) have been conducted to increase the focus in both topics. To contribute with a more comprehensive view of Brazilian literature on SSCM the present paper expends the traditional perspective, which is based on the Triple Bottom Line, to a new approach

for the topic considering that three dimensions are not enough to understand the research topic. As presented by Elkington (2014), a management approach should be introduced in the debate and support the development of new research studies. For the purpose of this research the relation between sustainability and supply chain management needs to consider four dimensions, which are the following: social, economic, environmental and governance.

Based on that argument, this paper focuses on answering the following research question: what are the main concerns in Brazilian literature with regards to sustainability and SCM? To answer this question, the paper is structured as follows. The first section presents a brief discussion around the theoretical background of the research. Then, it is explained how the literature review and the expert consultation were used to answer the research question and an overview of sustainability and SSCM approaches is given to justify which sustainability aspects are analysed and how the topics have been linked together. Section 3 demonstrate the methods used in the research. Afterwards, the findings of the literature review and the experts' perspective are presented as well as some case examples from Brazilian research papers. Finally, the findings are discussed and some conclusions are drawn with regards to the status quo of research in the field and future implications.

THEORETICAL OUTLINE

The current discussion about sustainability has been focusing on understanding the impacts of different actors in the society. This occurs because sustainable development is defined as a "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). In this context, Elkington (2002) developed the concept of Triple Bottom Line (TBL) seeking to make sustainability more tangible. For the author, the following three dimensions are necessary to ensure sustainability: economic, social and environmental.

However today, Elkington (2014) claims that these three dimensions are not enough anymore and that a holistic perspective is necessary to make a whole system change and be more sustainable, which involves taking into account a governance dimension. In line with this approach, Fritz *et al.* (2017) and Schöggl *et al.* (2016) propose to analyse sustainability in the sup-

ply chain according to four dimensions, namely: environmental, economic, social, and governance. In this paper we consider this approach in order to provide a more holistic view on sustainability aspects and practices that contribute to creating value for the company and along the supply chain (see Table 1).

Table 1. **Dimensions of Sustainability**

Dimension	Definition	Sustainability aspects
Environmental	To be understood as in the Triple Bottom Line approach.	Hazardous substances; Wastes; GHG and other air emissions; Energy consumption; Environmental-friendly production processes; Environmental-friendly products and services; materials; Water; Environmental preservation; Environmental in general (i.e. abstracts that only mention the word "environment" but no specific aspect).
Economic	To be understood as in the Triple Bottom Line approach.	Competitive advantage; Productivity; Competitiveness; costs management; Flexibility; Profitability; Financial Performance; Efficiency; Economic in general (i.e. abstracts that only mention the word "economic" but no specific aspect).
Social	To be understood as in the Triple Bottom Line approach.	Socially responsible (behaviour); Child labour; Occupational health and safety; employee training; Non-discrimination; Use of conflict minerals; Securing minimum wages; Confidentiality of data; Freedom of association and collective bargaining; Community engagement; Gender awareness; Temporary contracts; Job security; Social in general (i.e. abstracts that only mention the words "social, society" but no specific aspect).
Governance	It highlights aspects that show the organisation's commitment in raising awareness on sustainability and improving its values, strategies and policies towards a better sustainability performance.	Compliance with environmental regulations; Compliance with social regulations; Compliance with human rights regulations; Environmental performance and management; Compliance with product related regulations; Social performance and management; Quality management system; Risk management; Health and safety management system; Information and communication management; Knowledge management; Stakeholders inclusiveness; Expenses for sustainable R&D; Top management involvement towards sustainability; Assessment of suppliers (sustainability) performance; Ethics; Corruption and bribery; Governance in general (i.e. abstracts that only mention words like "sustainable development processes/activities, corporate sustainability" but no specific aspect).

Source: Adapted from Fritz et al. (2017) and Schöggl et al. (2016)

From Table 1, it is clear that to understand sustainability and its relation with SCM these aspects need to be considered and support the analysis from researchers and practitioners in this field. According to Hopwood *et al.* (2005), the way towards sustainability requires to assume a view of transformation rather than maintaining a status quo that is prone to collapse of natural resources or the social tissue (i.e., economic dimension included). Therefore, a set of changes need to occur in both behaviours and practices. When applied to business, companies are challenged to create mechanisms to contribute to sustainability (Peattie, 2007). This further highlights the importance of analysing sustainability and supply chain by including the governance dimension since the contribution of managers and their involvement towards sustainability is

necessary to make changes happen. Thus, governance can be considered as a *sine qua non* condition in the research of corporate sustainability and supply chain.

As presented before, sustainability requires the participation of a set of actors. In the case of organisations these actors can be clustered in inter-organisational relationships, as follow: Alliances, Joint Ventures, Vertical Relationships, Franchising, Cross-sector Partnerships and Networks (Parmigiani and Rivera-Santos, 2011). This paper focuses on the structures and relationships called supply chain. The more widespread definition of SCM was presented by Mentzer *et al.* (2001), but the perspective of supply network can be introduced in several research papers (e.g. Chen and Paulraj, 2004). Therefore, the use of both supply chain management and supply network can contribute to the understanding of sustainability.

According to Ashby *et al.* (2012), the relation between sustainability and SCM is commonly referred to as "Sustainable Supply Chain Management (SSCM)". Taticchi et al. (2013) suggest that many other expressions can also be used, but SSCM is actually the most prominent. The majority of authors working in this field consider sustainability as a synonym for the application of the TBL into supply chain (e.g. Ashby *et al.*, 2012; Carter and Rogers, 2008; Pagell and Wu, 2009; Seuring and Müller, 2008; Wolf, 2011), which increases discussions about the topic and clearly requests a more robust debate. However, other debates may lead to emerging discussions about a different approach to achieve the SSCM, which is more related to a broad viewpoint rather than the traditional view, as proposed in the current paper. Today, the definitions mostly used for SSCM are three presented by Carter and Rogers (2008), Seuring and Müller, 2008, and Pagell and Wu (2009). From a literature review comparing the use of the terms SSCM and Green Supply Chain Management (GSCM), Ahi and Searcy (2013) confirmed the use of these three definitions but show that at least nine more different definitions in relation to SSCM exist.

From these different inputs in defining SSCM it is possible to observe a clear lack of consensus since researchers in the field have not adopted a unifying definition yet. Furthermore, the focus of current concepts is mainly set on sustainability performance without discussing the relationship between sustainability and supply chain, as highlighted by Halldórsson *et al.* (2009), which could be considered as a serious problem. Therefore, Beske and Seuring (2014), and Varsei

et al. (2014) are presenting debates that contribute to analyse the results of sustainability performance into SCM. However, the majority of the discussions are based on conceptual contributions, hence more empirical research studies need to be conducted to discuss the topic better.

In the case of Brazil, besides theoretical and empirical research, the relation between SCM and sustainability is still not clear. For Gonçalves-Dias *et al.* (2012, p.529) "it is necessary to emphasise the country´s reality and highlight the (endogenous) innovations that are genuinely Brazilian [...] and practical initiatives that are not systematically incorporated by academia so far". By interviewing ten organizations, Laquimia and Eweje (2014) found no significant differences in the way Brazilian and New Zealandese organisations manage sustainability, and oganisations in both countries emphasize the importance of collaboration with key stakeholders. In both countries, organisations recognise benefit for knowledge sharing, effectiveness, reputation, supply chain management, and risk management. On the contrary, Delai and Takahashi (2013) show that Brazil as an emerging economy presents some specificities compared to other developed countries. They show that retailers play an important role in the SC to support the shift towards more sustainable consumption and production patterns, although such approaches are rarely studied. They highlight that the eight Brazilian retailers studied intensively focus on socially sustainable practices regarding their relations with employees and communities. Eco-efficiency measures are existing but limited to environment-oriented stores. SSCM is a raising concern as well as consumer awareness. All these sustainability aspects are integrated in the retailers' practices without any specfic management system, they hence occur sporadically and are not being monitored. Community engagement in Brazil is another important aspect highlighted by Hall and Matos (2010) in the biofuel production sector. They particularly show the need for research on how to integrate impoverished farmers and communities as productive supply chain members.

According to Silva *et al.* (2015), the number of publications in the country on sustainability and supply chain management is in general limited. That is why our purpose is to analyse both scientific publications and experts' perspectives in order to enlarge the spectrum and draw a more comprehensive understanding of sustainability and supply chain management in Brazil. The following section will present the methods,

and the findings section will explain the main sustainability and SCM research focuses in Brazil. Then the discussion and conclusion sections will present the main contribution of the paper as well as some reflexions and opportunities to conduct further research in the field of SSCM.

METHODS

This paper is built on a literature review of Brazilian Journals followed by an exploratory bibliometric study based on content analysis. The research was performed in six steps within two phases. In Phase

(a) scientific journals and papers were selected and analysed (see Figure 1), which included steps 1 to 4. In phase (b) a questionnaire was designed and sent to experts on SSCM in Brazil (step 5) and in order to present more real world contributions, some case examples were selected to support the scanning of Brazilian research fields. As presented in Figure 1, the first action was to select the databases that contribute to the research. These were the main Latin-American databases, namely: Scielo (www.scielo.org), Latindex (www.latindex.com), Redalyc (http://www.redalyc.org) and Spell (http://www.spell.org.br, which is specific to Brazil).

Figure 1. **Research design, Source: authors´own illustration**
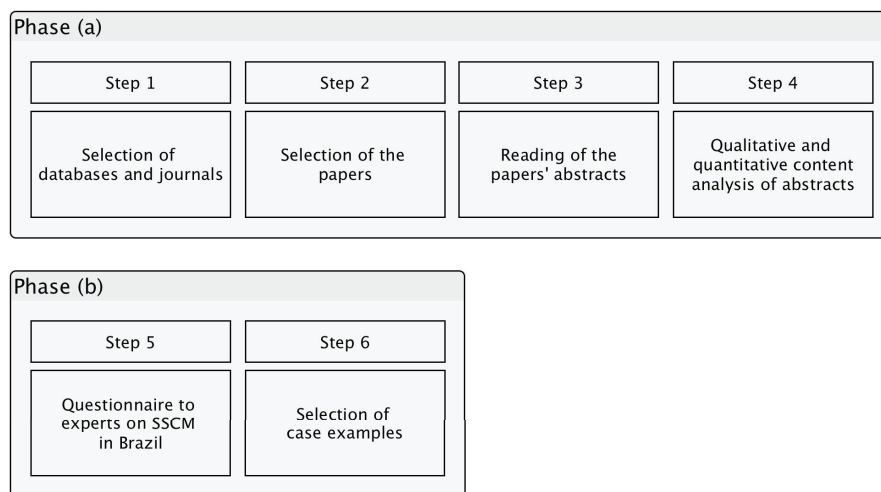
After selecting the databases, we identified the journals that have a publication scope related to our research purpose. For this end, journals were categorized per research field on each of the four databases (see Table A7 in the Appendix). This action resulted in a list of 120 peer-review academic journals. Out of these journals, we defined keywords in Portuguese, Spanish, and English to extract the papers to screen (i.e., *sustent*, *ambient*, *social*, *economic*, *respons*, *cadeia* and *verde*, declined in Spanish and English). Most manuscripts were written in Portuguese, but also in the other two languages. As a result, we obtained a list of 169 papers published from 2008 until 2013 in 54 different journals. We refined this selection by reading each abstract in order to assure that only papers related to sustainability, business or companies were included in our review. Eventually, our analysis counted with 124 papers after the final refinement based on the abstract analysis.

We then performed a qualitative and quantitative content analysis of each abstract according to the methods developed by Mayring (2003) and Neuendorf (2002) in order to identify the main sustainability dimension and the main related sustainability aspect of each paper. A sustainability aspect is here referred as a sub-category of each sustainability dimension (Fritz *et al.*, 2017). We considered that a dimension was a main dimension when the abstract contained most sustainability aspects from this dimension (see Table 1). The coding of sustainability aspects was also based on the dimensions and sustainability aspects identified by Fritz *et al.* (2017) in a context of Sustainable Supply Chain Management (SSCM) research and further adapted to the focus of our research as presented in Table 1. Thus, each paper was analysed based on the 36 sustainability aspects identified in Fritz *et al.* (2017) since these constitute, to our knowledge, the only set of aspects that address the environmental,

social, and governance dimensions of sustainability in supply chains. To these aspects, we added the economic dimension with the economic aspects identified in the content analysis of the abstracts.

In parallel, we designed a questionnaire with open questions (Table A8 in the Appendix) targeting experts in sustainability and supply chain in Brazil. The proposal was to create an overview of the topic in the country and draw specificities of the field from local researchers. The questionnaire was sent out electronically to researchers who met the following three criteria: (1) have at least one publication related to sustainability and/or SCM in Brazil, (2) had finished their PhD on related topic and/or (3) have research projects on the topic. Out of the total of fifteen experts, seven returned the questionnaire filled out, that is to say a 47% participation rate. The questions were related to relevant publications on SCM and sustainability in Brazilian journals, the research field in the country and the relation between academy and enterprises. To select the case examples the

criteria used was a focus on in-depth research, which were based on thesis and master dissertation according to experts' indication. The case examples are all based on case studies following a qualitative approach and have been used to corroborate the results of the present paper. All the results are presented in the findings section of this paper.

FINDINGS

The findings demonstrate that 124 papers are setting their focus on sustainability. Among them, 47 papers are analysing the link between sustainability and SCM in relation to different dimensions (these 47 papers are presented in Table A9 in the Appendix). The selected papers are coming from 54 different journals from the databases mentioned in the method section. Among these 54 journals, Figure 2 shows the 10 most prominent ones in terms of number of papers published between 2008 and 2013.

Figure 2. **Ten most represented Brazilian journals per number of papers analysed (N=54 journals)**
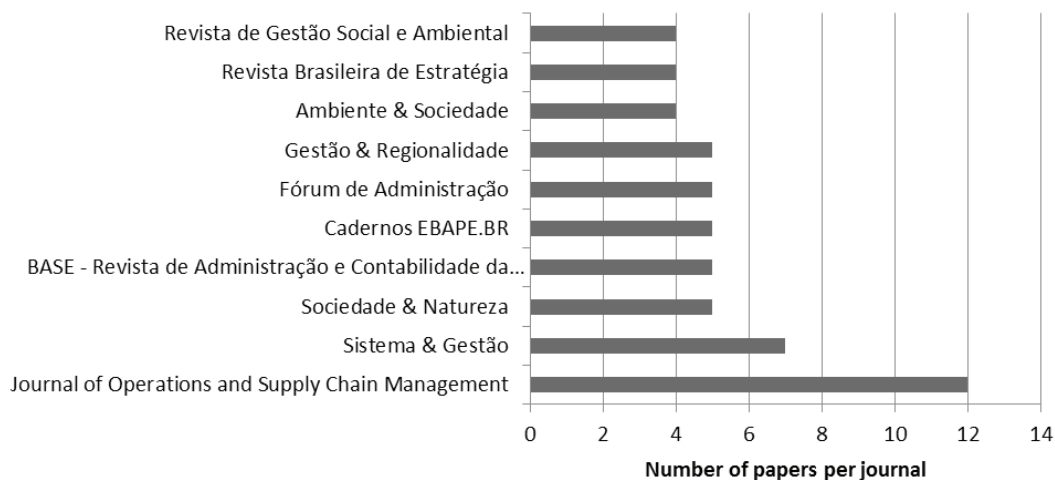
Most of the papers analysed were published in Portuguese, hence sharing knowledge on sustainability and supply chain in Brazil with the Portuguese speaking community. Out of the 124 papers, only 15 were published in English. These 15 articles are originating from the Journal of Operations and Supply Chain (12 papers), the Brazilian Administration Review (2 papers) and the Independent Journal of Management and Production (1 paper). However, it is important to

note that all journals request English abstract. Considering that, it was possible to identify authors from Brazil as well as other countries (e.g. India, Spain, Italy, Argentina and Bangladesh). It is also interesting to highlight that along the years, publications in the country are increasing (see Figure 3). It is hence becoming easier to identify the areas in which the papers have been published and the key sustainability aspects that are being considered.

Figure 3. **Evolution of the number of papers per year (N=124 papers)**
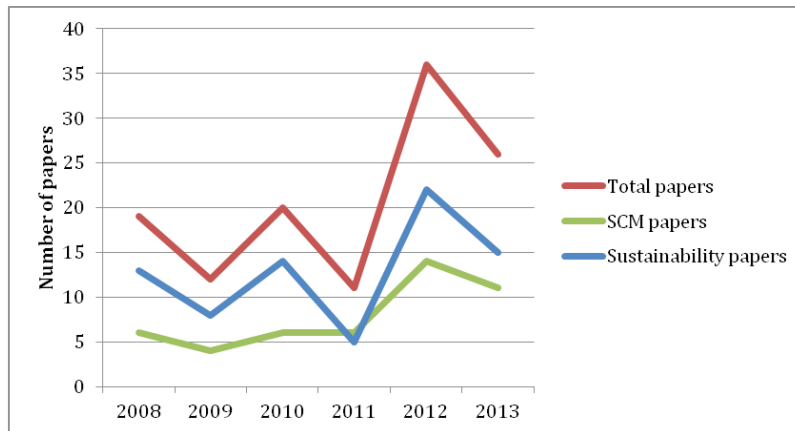
When analysing the 124 selected papers, we can observe that they mostly relate to corporate sustainabilty in general (see blue line in Figure 3). Over the period 2008-2013, 47 papers considered the relationship between sustainability and supply chain management (green line). On the one hand, the interest in sustainability and SCM is constantly growing from 2008 until 2012. On the other hand, papers that do not focus on SCM had also a sharp decrease in publications in 2011 besides the significant decline in 2013.

Comparing these results with the discussion presented by Silva *et al.* (2015), it is possible to observe some correlations as these authors analysed conference proceedings and demonstrate an increase of publications in Brazil. Therefore, the sustainability-relating debate in the country seems to have increased over the past few years. In addition to the total number of papers, it is necessary to understand how the publications relate to the dimensions of sustainability (see Figure 4).

Figure 4. **Main sustainability dimensions for each paper per year (N=124 papers)**
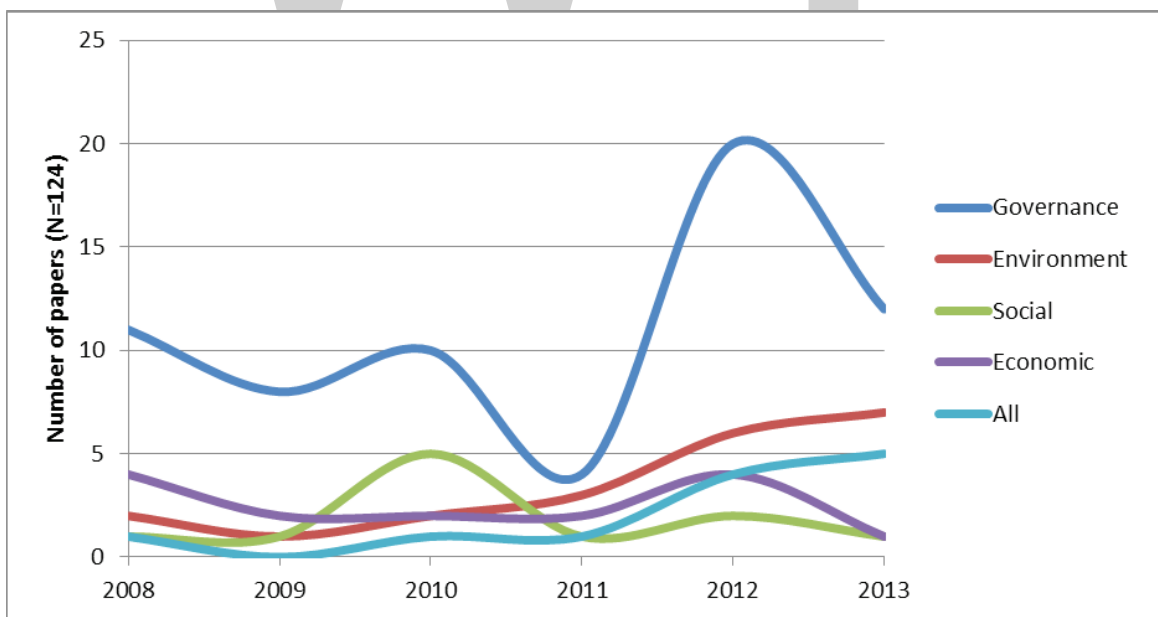
Within the 124 publications analysed, only 12 papers consider all the sustainability dimensions (see Table 6). The governance dimension is the main dimension of the majority of the abstracts analysed with 65 papers. This result might be explained by the fact that the governance dimension contains sustainability aspects related to all dimensions (e.g. environmental performance and management, expenses for

sustainable R&D). Among these 65 papers, several focus on the aspects "Social performance and management" (16 papers), "Information and communication management" (10 papers), "Top management involvement towards sustainability" (9 papers), and "Environmental performance and management" (7 papers). The number of publications focusing on "Social performance and management" corroborates to some extent the fact that social sustainability is an important topic in Brazil (Delai and Takahashi, 2013). Between 2008 and 2013, the research output in the management dimension varied drastically. Small alterations in the years 2008, 2009, and 2010, were followed by a significant decline in 2011. However, the number of papers published rose again to its peak in 2012, and finally, decreased in 2013 when compared to the previous year (2012).

The second most relevant dimension in the studied abstracts is environment. We counted 21 papers with the environmental dimension as a main dimension. Among these 21 papers, the following environmental aspects were the most referred to: "Environmental-friendly production processes" (7 papers), "Materials" (4 papers) and "Environmental preservation" (4 papers). All over the period, the environmental dimension is gaining a growing interest in research. Economic is the third most important dimensions with 15 abstracts identified as having predominant economic focus. However, the interest in the economic dimension is characterised by an almost constant number of publications per year and a slight decrease starting from 2012. In this dimension, "Competitive advantage" was often mentioned (5 papers out of 15) as well as "Productivity" (3 papers). However, several abstracts also considered the economic dimension without mentioning a specific aspect (4 papers).

The social dimension is also the main dimension in a relative constant number of publications (11 in total), except in the period 2009-2011 where the attention on this dimension rose. Most social aspects are related to "Community engagement" (3 papers), "Socially-responsible behavior" (2 papers) and "Gender awareness" (2 papers). Here again, the results are in line with the findings of Delai and Takahashi (2013) who emphasized the importance of socially responsible activities and the engagement of communities for eight retailers in Brazil. But in this dimension several abstracts also consider this dimension in a general way (4 papers). This might be linked to the fact that really little research exist on the social di-

mension of sustainability and due to the fact that it is difficult to clearly define what social sustainability mean (Yawar and Seuring, 2015).

These results are aligned with literature reviews conducted by other authors in other databases and publications from other countries that show that environmental and economic sustainability are in the focus of many publications on corporate sustainability and SCM (e.g. Ashby *et al.*, 2012; Carter and Easton, 2011; Golicic and Smith, 2013; Seuring and Müller, 2008; Wittstruck and Teuteberg, 2012). As presented by Carter and Easton (2011), during the last 20 years this confusion is observed since "sustainability" and "environmental" are considered as synonyms. During the process of content analysis, we could also observe that these results are debatable due to the confusion between environmental sustainability and sustainability as a whole. There is hence a need here to elaborate further on the theories related to sustainability and SCM to define what sustainability and environmental sustainability mean or which existing definitions are the most appropriate. We believe there is a serious need for consensus on these definitions at a global level in order to assure a common understanding of research in sustainability.

As presented in the theoretical outline, many definitions exist and make it difficult to conduct research on the topics. However, some discussions are already solved by using for instance the TBL to understand better sustainability research. Although an overlap among the sustainability dimensions can be considered in the TBL approach, some aspects of these analysis should be used. According to Ashby *et al.* (2012), the main difficulty is to study the social dimension of sustainability because it involves the human nature. Considering these discussions and the need to clarify what is undertood by environmental, social, economic and governance sustainability, the next tables present each sustainability aspect studied.

The number of papers that are focusing on a specific sustainability dimension and/or aspect (when applicable), and the possible influences on supply chains, based on the dimensions and categories of Table 1 are presented in Table 2. Considering the governance dimension, it is possible to observe that many papers focus on this dimension as it covers a wide range of sustainability aspects and many papers were considering sustainability from a management perspective (see Table 2).

Table 2. **Number of papers focusing on governance sustainability and on SCM**

Sustainability aspects of the Governance dimension	Number of papers with governance as main dimension	Number of papers focusing on SCM with governance as main dimension
Assessment of suppliers sustainability performance	2	2
Compliance with environmental regulations	1	1
Compliance with human rights regulations	0	0
Compliance with product related regulations	0	0
Compliance with social regulations	1	0
Corruption and bribery	0	0
Environmental performance management	7	5
Ethics	1	0
Expenses for sustainable research and development	0	0
General	5	2
Health and safety management	0	0
Information and communication management	10	2
Knowledge management	4	3
Quality management	0	0
Risk management	3	3
Social performance and management	16	1
Stakeholders inclusiveness	6	3
Top management involvement towards sustainability	9	1
Total	65	23

As shown in Table 2, out of the total 47 papers focusing on SCM, 23 papers were particularly discussing the sustainability aspects "Environmental performance and management" (5 papers), "Knowledge management" (3 papers), "Risk management" (3 papers) and "Stakeholders inclusiveness" (3 papers). From the data presented in Table 2, it is possible to understand the importance of governance in discussions about sustainability. It is interesting to highlight that the aspect "Social performance and management" is indicated as a the main sustainability aspect for 16 papers, mainly referring to Corporate Social Reponsibility. However, when this is applied to SCM, only one paper studies CSR in supply chain. In addition, it is also interesting to indicate that five papers studied "Environmental Performance and Management" in relation to supply chain.

The data presented before explain several research gaps that may be used by new research studies as the main focus to sustainability as well as SCM. Among them it is possible to highlight, namely: compliance with different regulations, corruption and bribery, management aspects (health and safety, quality), ethics and expenses for sustainable research and development. These types of aspects are possible to be analysed in different contexts, among which in other emerging economy countries. Continuing the analysis, the following Table focuses on the Environmental dimension and its publications.

Table 3. **Number of papers focusing on environmental sustainability and on SCM**

Sustainability aspects of the Environment dimension	Number of papers with environment as main dimension	Number of papers focusing on SCM with environment as main dimension
Environmental preservation	4	0
Energy consumption	1	0

Sustainability aspects of the Environment dimension	Number of papers with environment as main dimension	Number of papers focusing on SCM with environment as main dimension
Environmental-friendly production processes	7	1
Environmental-friendly products and services	1	0
General	1	0
Greenhouse gases and other air emissions	1	1
Hazardous substances	1	0
Materials	4	3
Wastes	1	0
Water	0	0
Total	21	5

The environmental dimension is the second most important regarding sustainability, but only third in relation to SCM with 5 papers. These are mainly discussing the aspect "Materials" (3 papers). From the discussion presented before the environmental sustainability in relation to the other two dimensions from the TBL was the most studied in the publications in Brazil. However, only five papers focusing on SCM are also focusing on this dimension. This can demonstrate some difficulties to study the topic in the country. This also corroborates with the little attention retailers have on environmental aspects as observed by Delai and Takahashi (2013).

Nevertheless, in the governance dimension of sustainability some aspects related to the environmental dimension (but from a management perspective) are also included. When considering these aspects from the governance dimension (especially "Environmen-tal management and performance" with 7 papers) and the environmental sustainability aspects presented in Table 2, the environmental dimension is the leading one in Brazil.

With the analysis carried out several research gap are identified. The most prominent is the aspect Water since no paper presented research in the journals analysed. Regarding the environmental dimension in the SCM these gaps are much more important since few papers were found with this focus. These results are totally different from the economic dimension of sustainability. As presented in Table 4, all the papers identified with the economic dimension as a main dimension (15 papers) are also considering the SCM strategies. Thus, it is possible to deduce that research in SCM is still closely related to the economic dimension, a traditional discussion on the topic of sustainability and SCM.

Table 4. **Number of papers focusing on economic sustainability and on SCM**

Sustainability aspects of the Economic dimension	Number of papers with economic as main dimension	Number of papers focusing on SCM with economic as main dimension
Competitive advantage	5	5
Competitiveness	2	2
Cost management	0	0
Efficiency	1	1
Financial performance	0	0
Flexibility	0	0
General	4	4
Productivity	3	3
Profitability	0	0
Total	15	15

Along the period 2008-2013, the papers focusing on the economic dimension were mainly highlighting the possible competitive advantages that a company could gain with Sustainable/Green Supply Chain Management (5 papers) and the related productivity (3 papers). But several of them referred to the economic dimension only in general (4 papers). The following gaps can instruct future research: cost management, financial performance, flexibility and profitability. This analysis brings relevant information for the debate on the topic since it is not usual to have research papers presenting details for all dimensions,

even for the economic dimension which is to consider as innate to SSCM research. The paper focuses on environmental, and on the social dimension with a broad view. Maybe this is related to the lack of consensus argued before.

In relation to the social dimension of sustainability, few papers are focusing on this dimension. When looking at the link with SCM, it is even more difficult to connect any social aspects as no papers could be identified in this area. This demonstrates a lack of research in the field (see Table 5).

Table 5. **Number of papers on social sustainability and focusing SCM**

Sustainability aspects of the Social dimension	Number of papers with social as main dimension	Number of papers focusing on SCM with social as main dimension
Child labour	0	0
Community engagement	3	0
Confidentiality of data	0	0
Employee training	0	0
Freedom of association and collective bargaining	0	0
Gender awareness	2	0
General	4	0
Non-discrimination	0	0
Occupational health and safety	0	0
Securing minimum wages	0	0
Socially responsible behaviour	2	0
Temporary contracts	0	0
Use of conflict minerals	0	0
Total	11	0

According to Silva and Nascimento (2015), studies on social issues facilitate the development of the reconceptualisation of the supply chain. Considering this view, it is necessary to take into account the "local" level in both the region of the focal company and the creation of strategies in collaboration with the supply chain. This is supported by the results of this analysis as most papers focusing on a specific aspect of social sustainability considered the aspect "Community engagement" (3 papers). But the majority of papers mentioned social sustainability only from a general perspective (4 papers) which may corroborate again the lack of clear definition for this dimension of sustainability.

We can hence say that the social dimension is not yet seriously identified as a source of value creation within supply chains in Brazil. The few evidences on SC activities in the social dimension refer only to retailers (Delai and Takahashi, 2013) and not the whole supply chain which remains hence understudied. However, this is also the case of the majority of studies related to sustainability and SCM as pointed out by several researchers (Ashby *et al.*, 2012; Benoît *et al.*, 2010; Hutchins and Sutherland, 2008). Since the papers found are not focusing on this dimension there are more prominent research gaps in both sustainability side and SCM. One of all the aspects presented in Table 5

that could be highlighted is Child labour which is a topic really important for the country according to some hystorical events and it is not into the research checklist.

Finally, it is necessary to understand the publications in relation to all dimensions of sustainability. As presented in Table 6, only 12 papers were published with all dimension compared to the 124 analysed. This is a result that demonstrates a great opportunity to publish more on the sustainability

topic in Brazil from a comprehensive perspective. According to Silva *et al.* (2015), the major difficulty of Brazilian authors is related to the adaptation of some concepts to their own context. The translation of English papers for example, lacks of precision and differs from the terms that are commonly used at an international level. Thus, sometimes the authors understand the perspective but translate and use it wrong, which influences the final research outputs.

Table 6. **Number of papers in all dimensions of sustainability and focusing SCM**

All sustainability dimensions	Number of papers with all dimensions	Number of papers focusing on SCM with all dimensions
All	12	4

Generally speaking, there seems to be a trend towards a rising number of Brazilian publications considering all dimensions of sustainability since 2012 (see figure 4), but this trend is too recent to draw any conclusions at the moment and the number of papers focusing on sustainability and all dimensions (4 papers) is too low still. From these findings it is possible to highlight so much that sustainability is an emerging topic in the country and this gives large research opportunities for researchers. Considering the research performed with experts, a similar result can be identified since as indicated by one of them:

> "[...] There are few researchers who are publishing in this area in Brazil [...] Thus, there is a broad field to be explored" (Expert 1).

This demonstrates that despite the increasing number of publications, more stimulation is needed for Brazilian researchers to achieve a higher academic impact of publications in both numbers and quality of papers. It should nevertheless be noted that only papers published in Brazil were analysed. Hence, other possible publications from Brazilian authors at an international level might have been omitted. When questioned about the dimension of sustainability emphasised in Brazil, four out of seven experts believe that the focus is environmental, mainly because it is very difficult to study social issues. Additionally, one of the experts pointed out:

> "Research in the country is still very reactive or focused exclusively on the financial discussion" (Expert 4).

Notwithstanding this view, our literature review shows that the economic dimension is not the most important in the papers, which indicates a divergence in this case between expert perception and the actual research output. Concerning the relationship between sustainability and SCM, the experts present some similarities since they consider that a few researches and studies focus on this topic and they think that there is a great opportunity to develop this research field as expressed in the following quotes:

> "There are few studies in Management science, which is in fact a good opportunity for future publications in this area" (Expert 1).

> "The research is very much in its early stages. It is basically done via exploratory research and case studies. A large possibility to publish" (Expert 3).

> "I believe it is growing as an extension of themes such as organisational sustainability and strategy" (Expert 6).

> "To carry research in Brazil is always difficult. To investigate sustainability in the supply chain is no different. We still need to advance a lot" (Expert 7).

According to the last quote from expert 7, it is difficult to conduct research in Brazil. However, some alternatives for that need to be created. Perhaps partnerships with companies, governments and communities can be a possibility to change this trend. Beyond accepting the difficulties, it is necessary to change views, and that was presented by two experts, as follows:

> "[…] the world has interest in understanding Brazil better in its various aspects of business (business environment, business practices, etc.). Thereby, it opens up the possibility of internationalising Brazilian research on various topics of business, including *Sustainability and Supply Chain*" (Expert 1).

> "It is a topic that can make important contributions to the development of more responsible business and concatenated with a new way of thinking in business and in the development of society itself" (Expert 3).

From these discussions, even with a limited number of publications in sustainability and supply chain management in relation to all dimensions of sustainability, a research field on SSCM in Brazil can emerge as an important area of study mainly because with its great diversity, the country has a lot of issues that can be introduced in this discussion. As presented by Griesse (2007), to conduct research in Brazil it is necessary to consider multifaceted characteristics such as geographical diversity or inequalities in socioeconomic issues. Thus, Brazil needs to contribute more with empirical results and proposals that can be used in different countries with the same multifaceted characteristics. Based on that perspective some case examples are presented to stimulate new research on the topic.

Case examples of research on SSCM

In the last few years the research focus on SSCM is increasing, which is represented in thesis and master dissertations since 2012, and some of the related publications. The following summarises different researches carried out in Brazil. It is relevant to highlight that the case examples selected were indicated by experts during the fifth step of the research.

- Natura. This case example integrated the thesis dissertation of André Carvalho. Natura is a cosmetic company founded in 1969 which is based in Bra-

zil, but has activities in different countries of Latin America and France. Regarding sustainability six areas are relevant for the company, namely: biodiversity, Amazonia, GHG, product impacts, quality of relations and education. To perform in all of them the company has some projects and programmes focusing on sustainability. According to Carvalho (2011) the company orientation is based on reducing environmental impacts. There is a clear engagement with the supply chain and other stakeholders as well as the local community in Amazonia. The research was carried out with different members of the supply chain presenting several contributions for the SSCM topic in the country.

- Braskem. This case example is a part of the thesis dissertation of Daiane Neutzling. Braskem is a large company focused on plastics. For Neutzling (2014), Braskem is the largest producer of thermoplastic resins in Latin America. In order to contribute to sustainability the company produces a "green plastic" which is a huge innovation in that sector. The main suppliers are sugar cane and ethanol producers in Brazil (Neutzling, 2014) which support the company to achieve its strategies. The company was founded in 1979 and during the years was receiving investments and pressures to develop new technologies regarding sustainability. According to Neutzling's analysis the company has a strategic orientation for renewable products based on their own engagement for that, since no collaboration on sustainability was identified among the members of the supply chain.

- Mercur. In turn the last case example mentioned by the experts is from the master dissertation of Ana Alves. Different from the other cases, this research focuses on a medium-sized company and its contribution to sustainability. The sustainability for the company is considered in four areas, which are: health, education, coating and handicraft. According to Alves (2014), the purpose of the company is the "well-being" of the society. In order to comply with this main purpose, several responsibilities emerged for the company such as the reduction of business relations with customers that worked with contradictory products (e.g., tobacco). The company was founded in 1924 and sells its products in Brazil and other countries from Latin America. Following Alves' analysis it is a proactive company which has been focusing for many years on introducing the idea of sustainability throughout the supply chain.

When taking into consideration the contributions of other researchers in the field of sustainability and supply chain management in Brazil or the increasing interest of Master and PhD students in the field, it is possible to state that this research field in Brazil presents rich opportunities to those who want to further investigate related research gaps in the country. It is simply necessary that literature reviews and other research studies present these research gaps in order to encourage more empirical and conceptual work in the field. Thus, by having access to this paper, researchers and practitioners could identify more details and deep specific aspects around it and significant knowledge for the empirical field. That section responds to the call of Gold (2016, p.10) when he said that "SSCM researchers in Brazil may live up to their responsibility by engaging in empirical analysis of data collected on the ground that is led by practice-induced problem formulations." Presenting three case studies there are prominent and potential research on the topic for next publications.

DISCUSSIONS

By applying a literature review method to identify what Brazilian journals have published about sustainability and supply chain management, the current paper contributes to research in several ways: (1) different from other literature reviews related to SSCM we added a new dimension to study sustainability and apply it for the supply chain. The governance perspective demonstrates that to study corporate sustainability the triple bottom line approach has several limitations. Thus this new dimension brings new insights and emphasizes particularly the importance of management practices; (2) different from all literature reviews about SSCM we are not limited to identify the sustainability dimensions presented in the papers, we also study in depth each one (four in our case) to figure out which aspects have been studied by researchers in Brazil; (3) this paper presents from all the sustainability aspects several research gaps that could be used by Brazilian researchers, researchers that are in countries with similar characteristics as Brazil, and other researchers interested in conducting research in Brazil. We deliver here an agenda of research that could be applied in various regions and also in other literature reviews that are not only related to supply chain management. Based on these three contributions, we believe that this paper has a significant contribution for the area in both Brazilian context and for other emerging economies

that want to study the same topic. Also, by consulting experts in relation to the outcome of the literature review and by explaining three case examples, it was possible to scan the current perspective of the country comprehensively.

In comparisons with Laquimia and Eweje (2014), our study shows that the practical issues of collaboration with key stakeholders (aspect stakeholder inclusiveness), knowledge sharing (aspect knowledge management), effectiveness (aspect productivity), and risk management are also present in the focus of scientific publications on SSCM in Brazil. The analysis shows that there are also some similarities between Brazilian publications and publications from more developed countries (i.e., Europe and North America) on the topics of environmental performance management and materials that are adressed under the topic of Green Supply Chain Management (e.g., Srivastava, 2007; Seuring and Müller, 2008). Our research highlights the typical lack of research on social issues in the supply chain research too (e.g. Ashby et al., 2012; Carter and Rogers, 2008; Golicic and Smith, 2013; Seuring and Müller, 2008), like the issue of community engagement (Hall and Matos, 2010). There is here an obvious and tremendous gap to fill on all the social aspects for SSCM in Brazil adressed in this paper. However, it is underlined that studies in Brazil also present their own characteristics such as governance since it is presented in the paper that this managerial perspective should be a reference for other studies, mostly for researchers (interested) in emerging economies. This confirms the observations of Delai and Takahashi (2013), Gonçalves-Dias *et al.* (2012, p.529), and we similarly encourage here further empirical studies to reveal these specific characteristics in Brazil and other emerging economies.

As recommended by Silvestre (2016, p.9), future directions for SSCM in Brazil should follow four ways: (i) Sustainable Supply Chain Drivers and Barriers, (ii) Sustainable Supply Chain Genesis, (iii) Sustainable Supply Chains and Innovation, and (iv) Supply Chain Sustainability Trajectories. We believe that this is possible based on all research gaps that we explain in the findings section of this paper demonstrating what has been published and how to follow new directions. That is possible by focusing more on empirical and significant researches that can bring more insights and theoretical advances for the topic. For instance, as presented by Nunes (2016), it is necessary to debate about priorities regarding motivations and pressures based on direct suppliers, and

also to investigate whether the suppliers may have more power of influence to introduce sustainability through the supply chain. From an international perspective, as presented by Gold (2016, p.14) "researchers should continue their efforts of teaming up with colleagues around the world, while keeping their empirical focus on the immediate sustainability challenges on the ground." As indicated by Silva and Nascimento (2015), future research can indeed provide a strong contributions from the Brazilian perspective on the topic worldwide.

CONCLUSIONS

This paper contributes to 1) the analysis of sustainability and 2) the analysis of sustainability in supply chain management in Brazilian scientific publications. It is the first literature review combining the analysis of both sustainability and supply chain management trends in Brazil. The findings demonstrate that publications in Brazil in the field of sustainability and SCM are increasing along the past few years. As identified in other countries, the social issues are not in the focus of most papers as opposed to the environmental dimension that leads the research on sustainability. On the one hand Brazilian publications are aligned with publications from other more developed countries since we observed a focus on economic and green supply chain management aspects and an important gap on all social aspects of supply chain management.

On the other hand, publications in Brazil also present their own characteristics, particularly regarding the governance dimension of supply chain management, which confirms previous studies on social sustainability in Brazil. This shows also that it is necessary to analyse sustainability in supply chains more comprehensively. These main findings are furthermore acknowledged by Brazilian experts in the field. The three case studies presented demonstrate some empirical perspectives, which can serve as local reference for new researchers. However, the cases analysed present results focused on the focal companies and more research is needed to understand the dynamics between direct and indirect supply chain stakeholders and their power of influence to introduce more sustainability throughout the supply chain.

This paper has some limitations since it only considers publications on sustainability and supply chain in Brazilian Journals and some publications relevant to our study may have been omitted due to the categorisation of journals in the online databases used. That is observed in the case of engineering journals that may bring some contributions for the debate. This analysis can be deepened by integrating international databases with papers that also investigated the situation in Brazil. Also, we chose to follow the approach of Fritz *et al.* (2017) and Schöggl *et al.* (2016) to define the sustainability dimensions and aspects to analyse. Hence the results could have been slightly different by choosing another approach or other definitions for the sustainability dimensions and aspects. Indeed, as it can be seen in the literature, there is a harmful proliferation of several terms related to sustainability such as corporate social responsibility (CSR), social business, socially responsible, which puts in jeopardy the research community in reaching a common agreement on these concepts when building a widely accepted and robust academic terminology.

This paper can help practitioners and academic researchers to gain 'rapid' knowledge on the *status quo* of sustainability and supply chain management research in Brazil. Insights for future research about SSCM in Brazil (and in other countries) can be identified through our study, allowing comparability and, eventually, generalisation of our findings. We recommend as a research agenda for SSCM in Brazil (and other countries) more theoretical and empirical studies on: all the social aspects for both sustainability and SCM research (e.g., corruption and bribery, child labour, an important topic for the country according to some hystorical events); the environmental aspect "water"; the specificities of Brazil and how these specificities can serve research in other similar countries or regions (e.g., the role of retailers, focal companies, local/national/international suppliers to integrate more sustainability practices in businesses and society); the analysis of sustainability for full supply chains; the theoretical contributions regarding the meaning of some sustainability aspects in Brazil and comparisons with other definitions (e.g., from North America or Europe) to eventually improve the understanding about sustainability and SCM for both researchers and practitioners and stimulate research for a common understanding.

For instance, the above issues can be translated into broad research questions to be part of the SSCM research agenda in Brazil:

1. How do SSCM practices tackle corruption and bribery in Brazil?

2. What are the environmental challenges that Brazilian domestic supply chains will face in the future?

3. What impact would globalising the supply chain have in both profitability and sustainability performance of Brazilian companies?

4. What are the necessary governance mechanisms to improve management of critical public resources such as water?

Finally since our findings underline that the multi-faceted characteristics of Brazil make it difficult to conduct research in the country, it is necessary to create partnerships with companies, governments and communities inside and outside Brazil to support sustainability research and practices in the country, thereby contributing to the development of more responsible businesses and society and the internationalization of research.

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APPENDIX

Table A7. **Categories used for the selection of journals per topic**

Database	Category (in original language)	Category (English translation)
Scielo	Ciencias Sociales Aplicadas Humanidades	Applied Social Sciences Humanities
Latindex	Ciencias sociales, Multidisciplinarias Administración Ciencia política y administración pública Ciencias sociales y humanidades Derecho laboral Desarrollo económico Ecología Economía Estudios de género Estudios latinoamericanos Estudios locales Ética Humanidades Industria Recursos naturales no renovables Relaciones internacionales Trabajo social	Social sciences Multidisciplinary Administration Political science and public administration, Social sciences and humanities Labour law Economic development Ecology Economy Gender studies Latin-American studies Local studies Ethics Humanities Industry Natural and non-renewable resources International relations Social work
Redalyc	Administración y Contabilidad, Estudios Ambientales Multidisciplinarias Ciencias Sociales, Ciencias, Art y Humanidades	Administration and accounting Environmental studies Multidisciplinary Social sciences, Sciences, Art and Humanities
Spell	Administração, Contabilidade e Turismo	Administration, Accounting and Tourism

Table A8. **Questionnaire for experts in Portuguese and English**

> Q01 - *Qual a sua opinião sobre a realização de pesquisa sobre a relação entre Sustentabilidade e Cadeia de Suprimentos no Brasil?*
> What is your opinion about the research activity in sustainability and supply chain management in Brazil?

> Q02 - *Como você visualiza a aplicação e o valor do conceito Sustentabilidade em Cadeias de Suprimentos por parte das empresas e dos governos no Brasil?*
> How do you observe the applicability and value of SSCM concept by companies and governments in Brazil?

> Q03 - *O Brasil possui estrutura (pessoas, empresas, pressões institucionais) suficiente para avançar no tema Sustentabilidade em Cadeias de Suprimentos?*
> Does Brazil have enough infrastructure (i.e. professionals, companies, institutional pressures) to advance in the theme of SSCM?

> Q04 - *Como você visualiza a abordagem da Sustentabilidade em Cadeias de Suprimentos nas publicações nacionais?*
> How do you evaluate the SSCM approach in the Brazilian publications?

Q05 - *Você poderia destacar alguma publicação sobre o tema no Brasil?*	
Can you please indicate any papers about SSCM published in Brazil?	

Q06 - *Em relação a representatividade, esta(s) publicação(ões) indicada(s) possui(em) nível de relevância para o desenvolvimento de pesquisas no país?*
Are the above papers relevant to develop the field of SSCM in the country?

Q07 - *Estaria o foco das pesquisas brasileiras voltado ao* Green Supply Chain Management*?*
Is the research focus more aligned towards Green Supply Chain Management?

Q08 - *Qual sua percepção sobre a utilização de outras abordagens teóricas para entender o tema Sustentabilidade em Cadeias de Suprimentos?*
What is your perception about the use of other different theoretical approaches to understand the theme of SSCM?

Q09 - *Qual a relevância para as empresas aplicar as recomendações que são realizadas em artigos científicos?*
How relevant are the papers for companies to implement their recommendations and consider their practical implications?

Q10 - *Você poderia citar pelo menos dois casos no Brasil que são trabalhados a partir da relação entre Sustentabilidade e Cadeia de Suprimentos?*
Can you please identify at least two case studies in Brazil that are reference (or exemplar cases) of the relationship between sustainability and supply chain management?

Table A9. **List of the 47 papers analysed**

N=47	Journal	Authors and title of the manuscript
1	Sistema & Gestão	Rodriguez, D.S.S., Silva, L.S., Passos, M., Bertoloto, R., Luís, S., Filho, J.R.F., (2012), A Logística Reversa Utilizada no Gerenciamento da Cadeia de Suprimentos como Instrumento de Vantagem Competitiva, *Sistema & Gestão*, 7(4), 642-656.
2	Sistema & Gestão	Rodrigues, S.C., Peixoto, J.A.A., Xavier, L.S., (2013), Formação de Cadeia Verde de Suprimento a partir da Gestão Sustentável de Resíduos Industriais – Um Exemplo no Setor de Reciclagem, *Sistema & Gestão*, 8(1), 44-57.
3	Sistema & Gestão	Moura, L.L., Silva, R.F., Filgueiras, B.A.G., Correia, J.M.S., (2013), Análise e Intervenção na Gestão do Fluxo de Informações de Uma Cadeia de Suprimentos Hospitalares, *Sistema & Gestão*, 8(4), 416-430.
4	BASE - Revista De Administração E Contabilidade Da UNISINOS	Andrade, M.C.F., Paiva, E.L., (2012), Green supply chain management na agroindústria canavieira: o caso Jalles Machado. *BASE - Revista de Administração e Contabilidade da UNISINOS*, 9(1), 2-12.
5	Cadernos EBAPE.BR	Nakayama, R.M., Teixeira, R.M., (2012), Esquemas interpretativos de dirigentes e fornecedores com relação a estratégias e ações de responsabilidade social: o caso da empresa O Boticário, *Cadernos EBAPE.BR*, 10(1), 82-107.
6	Gestão & Regionalidade	Araújo, G.C., Bueno, M.P., Bueno, V.P., Sproesser, R.L., Souza, I.F., (2008), Cadeia Produtiva Da Avicultura De Corte: Avaliação Da Apropriação De Valor Bruto Nas Transações Econômicas Dos Agentes Envolvidos, *Gestão & Regionalidade*, 24(72), 6-16.

7	Gestão & Regionalidade	Santos, S.M.B., Ferrari, C.E., Filho, G.G., (2008), Responsabilidade Socioambiental Na Cadeia De Suprimentos Do Tabaco No Brasil, *Gestão & Regionalidade*, 24(72), 17-26.
8	Gestão & Regionalidade	Torres Jr., A.S., Ratão, B.P., (2011), Relacionamento Na Cadeia De Abastecimento - Estudo De Caso Em Uma Pequena Empresa Distribuidora, *Gestão & Regionalidade*, 27(79), 4-21.
9	Gestão & Regionalidade	Demajorovic, J., Migliano, J.E.B., (2013), Política Nacional De Resíduos Sólidos E Suas Implicações Na Cadeia Da Logística Reversa De Microcomputadores No Brasil, *Gestão & Regionalidade,* 29(87), 64-80.
10	Revista Gestão & Tecnologia	Patto, A.R., Afonso, B.P.D., (2009), A Cadeia De Suprimentos: A Nova Fronteira Para A Competitividade De Um Atacadista Distribuidor, *Revista Gestão & Tecnologia*, 9(2), 1-20.
11	Revista Gestão & Tecnologia	Afonso, T., Afonso, B.P.D., Santos, V.M., (2013), Avaliando A Integração Em Cadeias De Suprimentos - Um Estudo De Caso No Setor Automobilístico, *Revista Gestão & Tecnologia,* 13(1), 103-126.
12	Gestão E Sociedade	Hansen, P.B., Greice, R., (2008), Cadeia De Suprimentos – Análise De Ações Estratégicas Para Manutenção Da Competitividade: O Caso Do Vale Dos Vinhedos, *Gestão E Sociedade*, 2(4).
13	Gestão.Org	Zamberlan, C.O., Waquil, P.D., Henkin, H., (2013), Interligando A Cadeia Produtiva Na Indústria De Beneficiamento Do Arroz - Linking The Production Chain In The Rice Industry, *Gestão.Org*, 11(1), 186-214.
14	CONTEXTUS - Revista Contemporânea De Economia E Gestão	Oliveira, L.G.L., Ipiranga, A.S.R., (2009), A Inovação Sustentável e a Dinamização do Sistema Local do Agronegócio do Caju Cearense, *CONTEXTUS*, 7(1), 55-68.
15	Produto & Produção	Nodari, F., Teixeira, E.K., Oliveira, M., Zen, A.C., (2012), Facilitadores e barreiras para o compartilhamento de conhecimento em cadeias de suprimentos, *Produto & Produção*, 13(3), 49-62.
16	Produto & Produção	Kobal, A.B.C., Santos, S.M., Soares, F.A., Lázaro, J.C., (2013), Cadeia de suprimento verde e logística reversa - os desafios com os resíduos eletroeletrônicos, *Produto & Produção*, 14(1), 55-83.
17	Journal of Operations and Supply Chain Management - Joscm	Filho, O.V.S., Martins, R.S., Pereira, S.C.F., (2008), Strategic alignment in the Brazilian automotive chain: relationships between first and second tier, *Journal of Operations and Supply Chain Management*, 1(1), 41-56.
18	Journal of Operations and Supply Chain Management - Joscm	Miyake, D.I., Junior, A.S.T., Favaro, C., (2010), Supply chain mapping initiatives in the Brazilian automotive industry: challenges and opportunities, *Journal of Operations and Supply Chain Management,* 3(1), 79-97.
19	Journal of Operations and Supply Chain Management - Joscm	Apte, A.N., (2010), Supply chain networks for perishable and essential commodities: design and vulnerabilities, *Journal of Operations and Supply Chain Management,* 3(2), 26-43.
20	Journal of Operations and Supply Chain Management - Joscm	Rashed, C.A.A., Azeem, A., Halim, Z., (2010), Effect of information and knowledge sharing on supply chain performance: a survey based approach, *Journal of Operations and Supply Chain Management,* 3(2), 61-77.

21	Journal of Operations and Supply Chain Management - Joscm	Dalé, L.B.C., Roldan, L.B., Hansen, P.B., (2011), Analysis of sustainability incorporation by industrial supply chain in Rio Grande do Sul State (Brazil), *Journal of Operations and Supply Chain Management*, 4(1), 25-36.
22	Journal of Operations and Supply Chain Management - Joscm	Miguel, P.L.S., Brito, L.A.L., (2011), Supply Chain Management measurement and its influence on Operational Performance, *Journal of Operations and Supply Chain Management*, 4(2), 56-70.
23	Journal of Operations and Supply Chain Management - Joscm	Okino, D.A., Junior, O.C., (2011), Assessment of the Brazilian cash operation through the approach of sustainable supply chains, *Journal of Operations and Supply Chain Management*, 4(2), 71-85.
24	Journal of Operations and Supply Chain Management - Joscm	Martins, R.S., Filho, O.V.S., Pereira, S.C.F., Di Serio, L.C., (2012), Strategic alignment in the brazilian automotive chain, *Journal of Operations and Supply Chain Management*, 5(1), 16-30.
25	Journal of Operations and Supply Chain Management - Joscm	Mishra, R.K., (2012), Measuring supply chain efficiency: a DEA approach, *Journal of Operations and Supply Chain Management*, 5(1), 45-68.
26	Journal of Operations and Supply Chain Management - Joscm	Kress, N., Wisner, J., (2012), A Supply Chain Model for library quality and service improvement, *Journal of Operations and Supply Chain Management*, 5(2), 40-53.
27	Journal of Operations and Supply Chain Management - Joscm	Corrêa, L.H., Xavier, L.H., (2013), Concepts, design and implementation of Reverse Logistics Systems for sustainable supply chains in Brazil, *Journal of Operations and Supply Chain Management*, 6(1), 1-25.
28	REBRAE - Revista Brasileira de Estrategia	Alves, A., Silveira, V.A., Tortato, U., Silva, W.V., (2008), Gestão estratégica da cadeia de abastecimento: relacionamento entre demanda e estoque no setor de autopeças, *REBRAE*, 1(3), 297-306.
29	REBRAE - Revista Brasileira de Estrategia	Welgacz, H.T., Tortato, U., Corso, J.M., (2010), Vulnerabilidade na cadeia de suprimentos de processamento e exportação da madeira tropical brasileira, *REBRAE*, 3(2), 171-180.
30	REUNA (Online)	Almada, S.R., Abreu, M.C.S, Cunha, L.T., Filho, J.C.L.S., (2011), Desafios para a Formação de Cooperativas Agrícolas na Cadeia de Suprimento de Biodiesel no Estado do Ceará, *REUNA*, 16(4), 13-26.
31	Revista Brasileira de Administração Científica	Rocha, A.C., Rosa, L.B., Camargo, C.R., Zamberlan, J.F., Gomes, C.M., (2013), Gestão Da Cadeia De Suprimentos E Sustentabilidade: Um Estudo Bibliométrico Da Produção Científica Na Base Web Of Science, *Revista Brasileira de Administração Científica*, 4(1), 155-170.
32	Revista Gestão Ambiental e Sustentabilidade	Taderka, G., Riedner, L.N., Bertolini, G.R.F., (2013), Responsabilidade Social: A Postura Das Empresas Agroindustriais Com Seus Fornecedores, *Revista Gestão Ambiental e Sustentabilidade*, 2(1), 26-44.
33	Revista Innovare	Sasaki, F.A., Oliveira, G.H.C., Pacheco, E.O., Cardoso, P.A., Araujo, H.X., (2009), Gerenciando Uma Cadeia De Suprimentos Utilizando A Dinâmica De Sistemas, *Revista Innovare*, 1-10.
34	Revista Gestão Industrial	Lopes, L.J., Neto, M.S., Spers, V.R.E., (2013), Diferenças e Complementaridades Entre a Logística Reversa, Iso 14000 e o Green Supply Chain Management, *Revista Gestão Industrial*, 235-253.

35	Revista Eletrônica De Ciência Administrativa	Santos, M.S., Padula, A.D., (2012), A Transação Como Fator Estruturante Da Cadeia De Suprimento Do Biodiesel No Rio Grande Do Sul, *Revista Eletrônica De Ciência Administrativa*, 11(2), 178-192.
36	Revista Economia & Gestão	Ladeira, W.J., Marconatto, D.A.B., Estivalete, V.B., (2012), Controlar Para Confiar? Uma Análise Do Risco Percebido Em Relacionamentos De Uma Cadeia De Suprimentos, *Revista Economia & Gestão*, 12(29), 98-123.
37	Revista De Negócios	Moori, R.G., Benedetti, M.H., Farias, O.O., (2012), Alinhamento Estratégico Na Cadeia De Suprimentos: Uma Análise De Empresas Do Setor De Bens De Capital A Partir De Suas Prioridades Competitivas, *Revista De Negócios*, 19(1), 82-100.
38	Revista Administração de Empresas	Cunha, V., Zwicker, R.E., (2009), Antecedentes do relacionamento e da performance em empresas da cadeia de suprimentos:estruturação e aplicação de modelos de equações estruturais, *Revista Administração de Empresas*, 49(2), 147-161.
39	Revista Administração de Empresas	Brito, R.P., Berardi, P.C., (2010), Vantagem competitiva na gestão sustentável da cadeia de suprimentos: um metaestudo, *Revista Administração de Empresas*, 50(2), 155-159.
40	Revista de Administração da Unimep	Pozo, H., Tachizawa, T., Souza, J.H., (2011), Supply chain management nas micro e pequenas empresas (MPE): uma estratégia competitiva para redução de custos e fortalecimento das empresas, *Revista de Administração da Unimep*, 9(3), 114-136.
41	Revista de Administração da Unimep	Morais, R.R., Shibao, F.Y., Santos, M.R., (2012), Fatores mais valorizados pelos clientes na Gestão da Cadeia de Suprimentos de um distribuidor de produtos de Telecomunicações, *Revista de Administração da Unimep*, 10(3), 90-109.
42	Revista de Administração da Unimep	Vivaldini, M., (2012), O Papel de Operadores Logísticos em Ações de Sustentabilidade, *Revista de Administração da Unimep*, 10(1), 55-79.
43	Revista de Administração da Ufsm	Carvalho, A., Junior, F.H., (2012), A Sustentabilidade Na Indústria Automobilística: Vantagem Competitiva Ou Um Sonho Distante?, *Revista de Administração da Ufsm*, 5, 785-798.
44	**REAd - Revista Eletrônica de Administração**	Martins, R.S., Filho, O.V.S., Pereira, S.C.F., (2012), Alinhamento Estratégico Nas Cadeias De Suprimento Da Indústria Automobilística Brasileira, *Revista Eletrônica de Administração*, 18(3), 581-606.
45	Revista de Administração e Inovação	Sampaio, M., Csillag, J.M., (2010), Integração Da Cadeia De Suprimentos Da Indústria Farmacêutica, *Revista de Administração e Inovação*, 7(1), 109-130.
46	Revista de Administração e Inovação	Carvalho, A.P., Barbieri, J.C., (2013), Inovações Socioambientais Em Cadeias De Suprimento: Um Estudo De Caso Sobre O Papel Da Empresa Focal, *Revista de Administração e Inovação*, 10(1), 232-256.
47	Revista de Administração Contemporânea	Cerra, A.L., Maia, J.L., (2008), Desenvolvimento de produtos no contexto das cadeias de suprimentos do setor automobilístico, *Revista de Administração Contemporânea*, 12(1), 155-176.

VEIN TO VEIN: EXPLORING BLOOD SUPPLY CHAINS IN CANADA

ABSTRACT

There is not yet any substitute for human blood which remains a scarce resource in many countries. Effective and efficient management of blood supply chains (BSCs) is utmost important in the healthcare industry. This paper gives an overview of the BSC and how blood products are used at hospitals to provide life-saving services to patients. Factoring in the blood types and their receipt compatibility, a simple inventory model is proposed. Using secondary data, the model is illustrated by way of a small case study in Nova Scotia, Canada. We highlight that due to both demand and supply uncertainties, and due to its perishable nature, inventorying blood prod-ucts is not straightforward and brings with it many logistical and management chal-lenges in the BSC.

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INTRODUCTION

Supply chain management plays an important role in the healthcare industry. In particular, hospitals facilitate and provide life-saving services for patients. The supply chain is applied to both urban and remote locations, as well as sites of natural disaster. Thus there is an importance on the overall optimization of the blood supply chain.

One of the critical components of hospital operations is the supply of blood. Currently, there is no substitute for human blood and in many countries blood is considered a scarce resource. In Canada, blood donation is voluntary and the system is managed by Canadian Blood Services (CBS). There are specific standards and policies around blood testing, storage, and treatment mandated by the World Health Organization to ensure the quality of the blood, but some countries have different standards and regulations around blood testing and treatment.

CBS is a non-profit organization responsible for managing the blood supply across all the provinces and territories in Canada (excluding Quebec). It has 36 permanent sites across Canada and conducts approximately 14,000 mobile clinics annually. It collects and tests blood from the donors to ensure its safety before it is transfused into patients. Furthermore, CBS conducts research on blood and stem cells to improve quality and knowledge (CBS, 2017a).

A human body contains five litres of blood. During the blood collection procedure, one unit of blood (approximately 450 millilitres) is collected from the donor (CBS, 2017b). The human body takes up to 40 days to replenish the red blood cells, which limits the number of times an individual can donate to six times annually. Each donation can save up to three lives, and thus if an individual donated to the full potential, one individual could "improve the quality of life of as many as 18 people" in one year (CBS, 2017a).

Blood has many applications in hospitals. For example, a major surgical procedure may require a transfusion to compensate for blood loss. Transfusions are often needed for victims of severe accidents or natural disasters; it can take up to 50 units of blood to save a single car crash victim (CBS, 2017c). Furthermore, blood transfusions are needed for those with blood illnesses and disorders, including liver disease, where the liver cannot properly produce components of blood, illnesses that causes anemia (deficiencies in red blood cells) such as kidney dis-

ease or cancer, and from the use of medicine or radiation treatments (Balentine, 2016).

A perishable (time-sensitive) product is defined as a one with a limited lifetime or shelf life. Blood is perishable because its components are short-lived, which will be discussed later in the paper. Common challenges of a time-sensitive supply chain include maintaining the quality of the product by minimizing delivery time and controlling the environment, e.g., temperature and humidity (cf. Thron et al., 2007; Blackburn & Scudder, 2009; Schiavo et al., 2015).

This paper explores the details of a Blood Supply Chain (BSC), from donor to recipient or until the blood is stocked in hospitals. It identifies the level of safety stocks needed for inventory management. It is important to analyze the components of the blood and identify perishability thresholds. This will be applied in the model that addresses the demand for each blood type. In supply chain management, there are always trade-offs. The trade-offs present in the BSC are identical to those in the perishable supply chain: cost and time. However, as blood is a life-related product, there is less emphasis on cost savings. There are also trade-offs in the blood unit inventory management, namely, having excess or insufficient stock, resulting in wastage and stockouts, respectively.

The paper proceeds as follows. In the next section, we provide a closer examination of blood. Then, the inner workings of BSCs are given along with a related literature review. As a small case, in the following section, we provide a blood inventory management model and apply it to Nova Scotia. Finally, provided are conclusions and future research avenues.

BACKGROUND ON BLOOD AND BLOOD PRODUCTS

There are four types of blood: A, B, AB, and O. Each is further categorized by the rhesus (Rh) factor, either positive (Rh+) or negative (Rh-), to denote the presence of a surface antigen. A surface antigen is a protein found on the surface of cells that elicits an immune response to foreign substances in the body. For example, Rh- blood will have an immune response to Rh+ blood because Rh+ blood cells have the Rh antigen, which will be identified as a foreign substance in the body. However, Rh+ blood will not have an immune response to Rh- because the Rh- blood cells are lacking the antigens.

Therefore, there are a total of eight blood types, taking Rh factors into consideration. As a result, blood compatibility is based on the blood type and the Rh factor because each blood type produces unique surface antigens and antibodies against blood antigens. The presence of antigens and antibodies is shown in Exhibit 1. Blood also produces certain types of antigens, A and B. For example, blood type A contains A antigens, which produce antibodies against the B antigen (Anti-B). Blood type AB produces both A and B antigens, and thus does not produce any antibodies as both A and B antigens are accepted. On the other hand, blood type O lacks any antigen, and therefore produces antibodies against both A and B antigens.

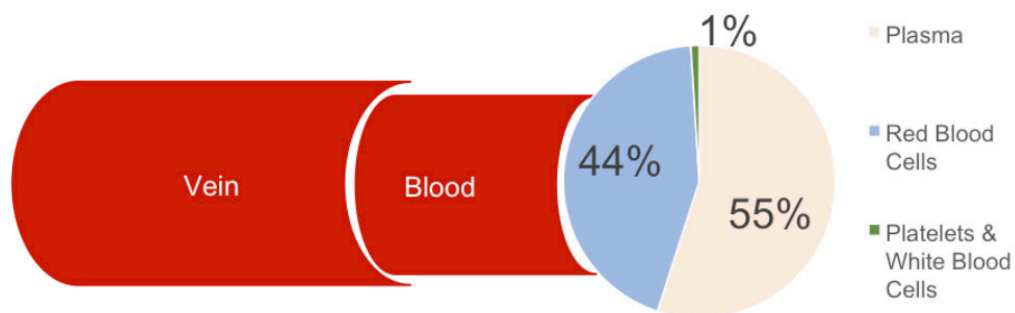**Exhibit 1. Blood types, and their antigen and antibodies**

Blood Type	Antigens Produced	Antibodies Produced
A	A antigen	Anti – B
B	B antigen	Anti – A
AB	A & B antigens	N/A
O	N/A	Anti – A & B

Figure 1. Components of blood (CBS, 2017d)

The most common blood type in Canada is O+ found in 39% of the population while AB- is the least common blood type, found in only 0.5% of the population. Moreover, blood type O- is a universal donor (7% of the Canadian population), where AB+ is a universal recipient, the 2.5% of the population (CBS, 2017d).

Blood Components

In humans, blood is produced in the bone marrow and has four components: red blood cells (RBCs), white blood cells (WBCs), platelets, and plasma (see Figure 1). Each component has different uses. RBCs are mainly used during surgery and for those undergoing cancer treatment. Platelets are used for cancer patients and those with bleeding disorders. Plasma is used during extensive surgery, for trauma patients, and for those with liver disease. Lastly, WBCs are not used for transfusion as they are part of the body's immune system and would not be accepted by a different immune system.

The function and capabilities of individual blood components (red blood cells, white blood cells, platelets, and plasma) is shown in Exhibit 2.

Exhibit 2. Components of Whole Blood and Their Functionality (CBS, 2017d)

Red blood cells (RBC)	RBCs, also known as erythrocytes are responsible for carrying oxygen to tissues and accounts for 40 - 45% of the blood volume. A gas exchange occurs in the capillaries in the alveoli (air sacs) in the lung. Carbon dioxide diffuses out of the bloodstream and oxygen is attached to the RBC to yield oxygenated RBC. Carbon dioxide is eliminated from the lungs with exhalation and oxygen is obtained by inhalation. WBCs, also known as leukocytes are part of the body's immune system and provide protection against infectious disease and foreign invaders.

White blood cells (WBC)	WBCs account for 1% of the total volume. In order to prevent the donor's white blood cells from suppressing the recipient's immune system, WBCs are isolated and removed from whole blood samples.
Platelets	Platelets or thrombocytes are responsible for blood clotting to help stop bleeding. It is a small component of the blood volume, accounting for less than 1% of the blood volume.
Plasma	A majority of the blood is made of plasma, which is a fluid accounting for 55% of the blood volume. The plasma is composed of 92% water and 7% vital proteins. Cryoprecipitate is a component of plasma, which is rich in clotting factors (The American National Red Cross, 2017).

A survey of blood supply chain and related literature

In this section, we look at how a BSC works and identify challenges related to its management, including determination of the optimal level of blood stocks. The related key literature is included.

How does a BSC work?

Much like any supply chain, the one for human blood involves many bodies, each responsible for a value-added task. There are complexities that accompany each stage of the BSC, often termed the 'vein to vein chain' (CBS, 2014).

Upon demand for human blood, blood banks engage in volunteer donor recruitment to generate adequate supply. In Canada, CBS performs this task as well as the collection phase of the chain. The scope of this study considers hospitals as the customers for blood and responsible for communicating demand to CBS (the supplier). Fig. 2 illustrates the BSC chain.

Figure 2. BSC stages from the origination of demand to patient transfusion (CBS, 2017c)
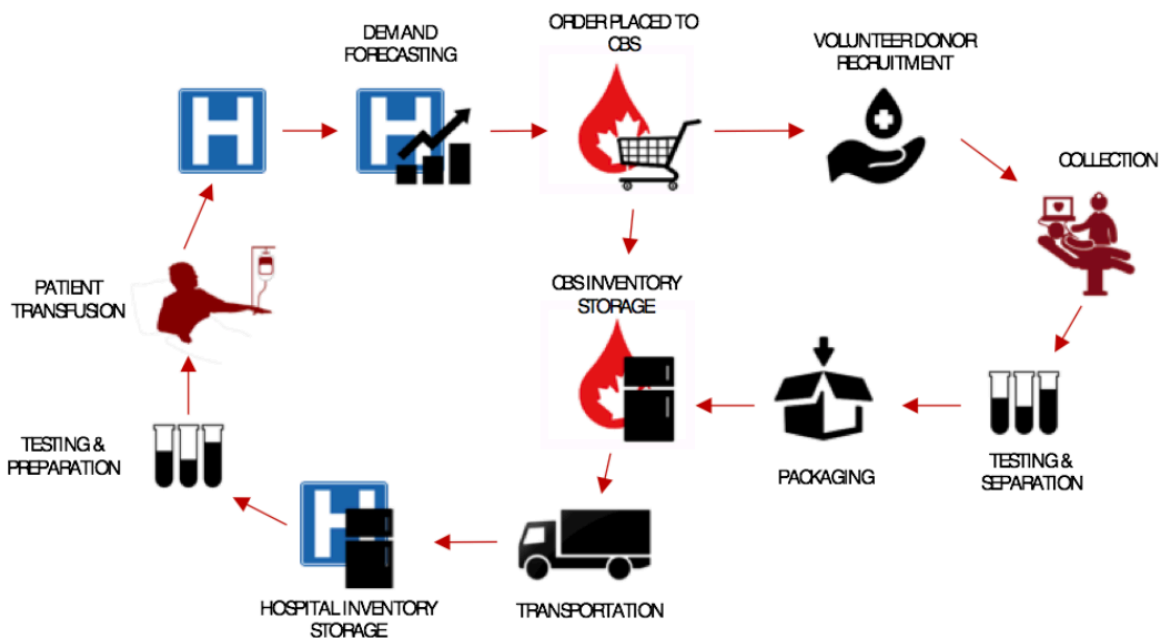
Inappropriate donors are filtered out during the collection phase, which involves iron level testing and a thorough questionnaire that identifies healthy individuals with no history of blood-threatening disease. This process maximizes the likelihood of usable samples and works to minimize the number of unusable collections. The entire collection process from start to finish takes about one hour, and includes the extraction of one unit of blood, and four test tubes of blood that are used for the testing phase. During the testing, the whole blood sample is separated into RBCs and plasma, and each is tested individually. The tests

performed include blood group typing, RBC antibody screening, RBC antigen screening (phenotyping), and infectious disease testing (including HIV, hepatitis, HTLV, syphilis, West Nile, and Chagas disease).

The packaging phase of the BSC involves labelling and packaging in plastic bags. There are many factors in the transportation phase, including the use of a tamper-evident device that makes any form of tampering immediately visible. CBS uses a variety of shipping container and ice-packing configurations, depending on the shipping temperature required. The temperature requirement differs for the different components of blood, and must be maintained throughout the entire transportation route. Before transfusion, the blood is defrosted/warmed from its chilled state, mixed, and undergoes pre-transfusion testing. This testing involves extracting a sample from the intended recipient for ABO and Rh blood typing and antibody screening. A test for compatibility between the extracted sample and inventory blood RBCs is done, as well as cross-matching between inventory and patient plasma.

The last stage of the supply chain is blood transfusion, during which the end user receives the required blood collected from donors.

Hospitals are responsible for their own inventory management, which entails estimating demand, selecting safety stock volumes, and minimizing wastage. Hospitals utilize different inventory systems, however few use sophisticated models to dictate replenishment policies and instead rely on employee opinions and past trends (Williamson & Devine, 2013). When hospitals reach their reorder points, they place an order with a blood bank, which for this report is CBS. CBS in turn sends the hospitals the stock they do have, and then engages in donor recruitment to replenish its own inventory.

Complexities within the BSC

Several complexities that exist in the supply chain pose challenges to minimizing cost and time. As there is no alternative to meeting the demand for blood, and there is no substitute for human blood, the utmost care and thoroughness must be applied to ensure minimal waste. Efficient and effective blood banking is an essential part of health services and has a direct impact on the success of medical treatments (Pierskalla, 2005). Some of these complexities include expiry time, temperature and trans-

portation requirements, extensive testing, and the potential for testing errors.

Whole blood, which is the original collection from donors, has a shelf life of 21–35 days depending on the type of anticoagulant used prior to its components being separated (ANRC, 2017). RBCs must be stored at 1–6 degrees Celsius and have a shelf life of 42 days (CBS, 2016). Plasma must be stored at -18 degrees and has a shelf life of 12 months (CBS, 2015). Platelets have a shelf life of up to 5 days, and must be stored at 20–24 degrees (room temperature). Lastly, cryoprecipitate (a component of plasma) has a shelf life of 12 months when kept below -18 degrees (BCA, 2017). Once any of the packaging has been broken or the component has been thawed, all must be used within 24 hours (cryoprecipitate in 4–5 hours).

These various storage requirements pose extreme challenges for inventory and replenishment management, as one transfusion recipient may require more than one blood product, which requires the management of all products with different storage periods. While many recipients require known and predetermined products scheduled in advance (for surgery for example), an increased risk of supply shortage exists for emergencies and unexpected events.

Supply uncertainty in BSC

Most significant, though, is the uncertainty of demand and supply, which pose serious challenges for distribution network requirements and inventory management. The preparation of the different components of whole blood results in significant costs because component has a different storage requirement and shelf life.

Given that the supply of blood comes from volunteer donors, the quantity is unknown and can be considered a random variable. Soliciting efforts by blood banks are not guaranteed to generate stable or substantial supply. Supply levels are becoming increasingly difficult to attain because of the number of viruses and conditions that must be screened out. A study of daily donation volumes in Chicago blood banks showed that, day to day, the number of units collected ranged from zero to 1,100, exhibiting the high variability and difficulty in predicting supply (Pierskalla, 2005). Donor recruitment strategies used in Canada and the UK include online marketing efforts, telephoning previous donors, allowing donors to fill out the health checklists at home prior

to their appointment to reduce the time of the visit, and mobile collection clinics. Although recruitment has increased in recent years, still only 4% of eligible Canadians donate while on average 7% of Canadians require blood products each year (McGinn, 2017). Furthermore, while an individual can donate up to six times per year, most Canadians who donate only do so twice per year (CBS, 2017a). Another struggle with retaining donors is donor well-being following donation, which has become more complex due to iron deficiencies, increased fainting, and dehydration (Osorio et al., 2017). While Canada has now implemented screening systems to reduce these occurrences, this also limits the supply because donors who are deemed ineligible to donate once are less likely to return. These supply deficiencies pose serious health risks, including surgery cancellations.

Uncertainty of demand for blood types

There exists uncertainty inherently in demand for blood. Although hospitals can track historical demand rates, in the case of demand for blood, historical trends are not always accurate at predicting future demand, which is subject to the influence of uncontrollable factors such as natural disasters or weather that results in more accidents. Common demand-forecasting techniques used by hospitals include an analysis of historical and seasonal trends, environmental scans, clinical volume trends, patient-specific future plans (e.g., surgeries), and discard and wastage data (CBS, 2014). Demand forecasting for blood banks is also complex, and challenges often result from asymmetric information. Changes to hospital policies or transfusion protocols

and the introduction of new treatments, for example, can greatly increase the demand for blood and a lack of communication with blood banks can lead to supply deficiencies (Pierskalla, 2005). Increased pressure to solve the issue of matching supply with demand is stemming from the growing aging population in Canada. It is estimated that overall demand for blood will increase by 10% between 2013 and 2023 due to cancer treatments in elderly patients, the growing population of elderly patients, and violent trauma in younger people (Williamson & Devine, 2013).

Current research on BSC management

Most of the research performed on the mismatch of supply and demand concludes that it is quite challenging to optimize the gap between the two because both are uncertain. Most research on optimal management of the BSC therefore focuses on two components of the supply chain that are less uncertain but equally difficult to optimize: network optimization and inventory management. While the model presented in this report concerns inventory management, it is important to review the impact that network has on lead time and therefore inventory replenishment policies.

The BSC consists of many players in the four echelons or stages of the chain – collection, production, inventory, and distribution – that together make up the BSC network. Network optimization assesses the policies and decisions connecting all four stages, the effectiveness of which is most easily assessed by the number of stock-outs experienced (Fig. 3 provides a flow chart of these stages).

Figure 3. Flow chart of the four BSC echelons/stages (based on Osorio et al., 2017)
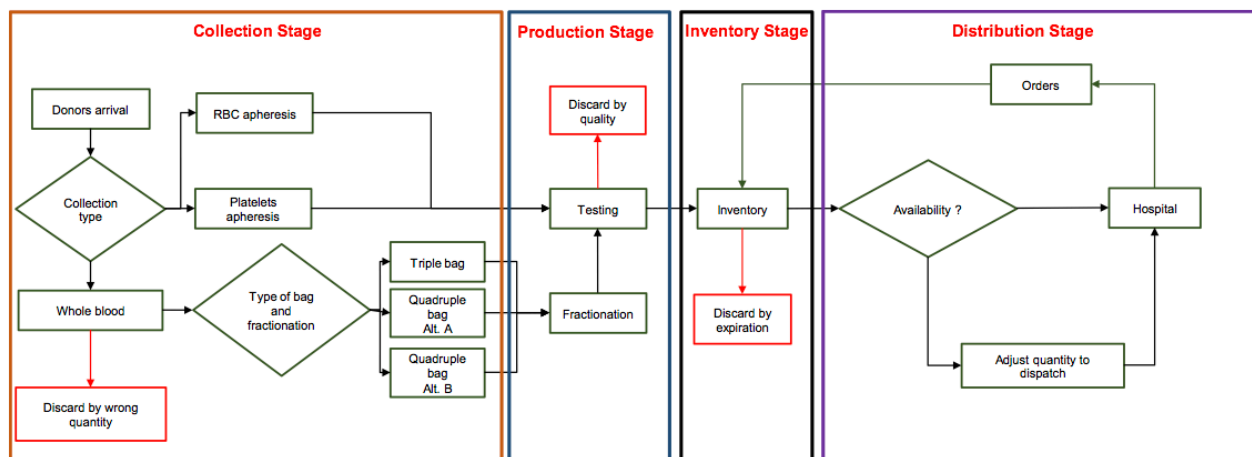
Research on network optimization uses cost minimization as the main driver. Costs often include wastage, spoilage, and stock-out costs, rather than traditional supply chain optimization costs such as transportation, storage, and routing methods. The various models used in recent research assess the most effective network policies and decisions that minimize the damage and disposal of blood units.

One study in particular focuses on regionalized blood banking systems. Nagurney et al. (2012) develop am algorithmic model that measures the perishability of blood using arc multipliers, discarding costs resulting from wastage, demand uncertainty, and shortages and quantifies the risk of supply issues. The model provides an equation for total operating costs that can be minimized, factors in the cost of perishability at each node of the chain, and presents an optimal path flow. In theory this model can be applied to any blood bank network by substituting the corresponding inputs, but does not offer an optimal network design applicable to most scenarios.

Simulation models are also popular because they allow for random variables and ranges of variables that mimic the uncertainty of demand and supply at each stage of the chain. A simulation model represents the daily behaviours of the BSC system, the optimization of which supports decisions around the number of required donors, and collection and production methods that minimize overall costs. Such simulation models can be utilized by hospitals to manage short-term demand forecasting; however, challenges with uptake involve complexity in estimating the value ranges of the various variables involved.

MANAGING INVENTORY IN BSC

Inventory management of blood supplies requires hospitals to make decisions about optimal inventory levels, reorder points, quantities, shipment and distribution policies, and waste/repurpose policies. Demand is the sum of all individual orders (planned and emergency), but as both demand and supply are unknown, hospitals are faced with balancing the trade-offs between wastage due to excess inventory and shortages due to insufficient inventory. Inventory systems are periodic, where one period is one day and a first-in/first-out system is used to keep track of and minimize wastage of blood products.

Beliën & Forcé (2012) and Osorio et al. (2015) present a review of literature for the inventory and supply chain management of blood products, the former focusing on those quantitative models in BSCs. Current research most commonly focuses on four types of inventory management analysis: simulation and regression, Markov chain analysis, dynamic programming, queueing theory. Simulation and regression model research includes scenario generation for various compositions of storage supplies (by size of unit and age of blood). Especially in health care chains where resources are scarce and the problems complex, simulation may be a powerful tool in better decision making (Rytilä & Spens, 2006; Kopach et al., 2008). This simulation also models ordering, issuing, and cross-matching policies to identify the option resulting in least wastage. Research using Markov chain analyses applies to perishable supply chains and assesses how issuing policies are affected by inventory size and age of the blood supply. Dynamic programming research from the 1980s concludes that increasing inventory stocks is more advantageous for perishable products, but limited research using dynamic programming has been done since then. Lastly, queueing theory simulations have been developed that facilitate decision-making around the use of blood products at various demand rates. Synchronizing strategic and operational decisions, Or & Pierskalla (1979) present models to optimally determine how many and where to locate blood banks, the allocation of the hospitals to the banks, and the optimal routing of the periodic supply operation, so that both the total of transportation costs (periodic and emergency supply costs) and the system costs are minimized.

Research on hospital blood inventory management dates back to the 1960s, and consistently measures performance based on shortages, outdates, waste, and the cost of information and transportation (Stanger, Yates, Wilding, & Cotton, 2012). That literature review and study concludes that proper inventory management supports significant reduction in hospital wastage of red blood cell products in particular. The study also indicates that effective human resource training to increase awareness about the proper planning based on historical stock levels and order patterns, and increased transparency of inventory policies and procedures are key elements to improving inventory management practices. Electronic cross-matching has also become a common practice for transfusion management in larger hospitals whereby expiry dates and storage times are tracked by an electronic system to increase service levels and reduce the time required to select products (JPAC, 2016).

While there has been substantial research done on how to manage and optimize inventories of blood, both at the hospital and blood bank level, all the research reviewed refers to blood all together and does not discuss differences in demand for the different blood types. The proposed model in the next section fills this gap by assessing how reorder point and safety stock inventory policies may differ for the various levels of demand for each blood type.

Model development

Before calculating demand, it is important to understand substitutability in blood types, namely, someone of a certain blood type being able to accept a different blood type. The substitutability combinations are shown in Exhibit 3.

Exhibit 3. Blood type substitutability

Following the rows horizontally, we observe that a unit of blood type A+ can be used by patients of blood types A+ and AB+. The inventory demand (units of donor blood) for one blood type, thus, is a function of the demands that can accept it. Therefore, inventory of A+ is the sum of the A+ and AB+ demands, as these are the two blood types that can accept it. The average of this sum is then taken because the donor blood is compatible with other blood types. This leads us to redefine demand for each of the eight blood types using the following equations:

$$D_k = \sum_{i \in K} d_i \quad \text{and} \quad \sigma_k = \sqrt{\sum_{i \in K} \sigma_i^2 + 2 \sum_{i > j} \rho_{ij} \sigma_i \sigma_j}$$

(1)

where k is a specific blood type and K is the set of blood types with which it is compatible. Our proposed model assesses the safety stock levels of each blood type that hospitals should maintain to ensure stock-outs are avoided at the allowable risks. To measure this, the classical safety stock (sk) equation is adapted from Bagchi et al. (1984). It follows as

$$s_k = z \sqrt{\overline{T} \times \sigma_{D_k}^2 + \overline{D_k}^2 \times \sigma_T^2}$$

(2)

where z is the safety factor set by management, is the expected supply lead time, is the expected demand per period during the lead time, and are the standard deviation of demand per period and the standard deviation of supply lead time, respectively. Safety stocks in BSCs are especially important as they may be vital in absorbing uncertainty in demand for blood products (cf., Perera, Hyam, Taylor, & Chapman, 2009). Our proposed safety stock calculation factors in the compatibility of the blood types; therefore it pools the inherent variations.

Eq (2) is applied to all eight blood types in order to inform hospitals of how many units of product per blood type should be kept on hand at all times. It is important to note that the inputs for demand and standard deviation will depend on the geographic location of a hospital and the size of its catchment area. Additionally, because the eight blood products are used for different scenarios and purposes, variation will occur depending on which blood products are being stocked. It is recommended that hospitals calculate safety stock inventories by blood type and by their by-products together in order to minimize the number of stock-outs.

A numeric illustration: application to Nova Scotia, Canada

To better understand the model, the optimal safety stock level of each blood type is assessed using a case study of the province of Nova Scotia (NS), Canada. This study shows the estimated population for each blood type using the Canadian averages. The overall demand for blood type per replenishment period of RBCs are also explored.

The population of Canada as of July 1, 2016, was 36.3 million. NS accounts for 2.6% of the total, or 942,926 persons. The percentage of individual blood types in Canada and the corresponding estimates in NS are displayed in Table 1. NS numbers are estimates based on percentage of the Canadian population.

Table 1. Blood Donor Type Estimates

		% in Canada	# estimate in NS
A	+	36.0%	339,453
	-	6.0%	56,576
B	+	7.6%	71,662
	-	1.4%	13,201
AB	+	2.5%	23,573
	-	0.5%	4,715
O	+	39.0%	367,741
	-	7.0%	66,005

NS was chosen because it has nine post-secondary institutions, over half of which are in Halifax, the largest city in NS. Thus, the Halifax Regional Municipality is a good representation of Canada because there is a sizable influx of students from all over the country and from other nations.

Blood demand and safety stock are demonstrated by applying the model in NS. According to CIHI (2016) data, between 2014 and 2015, the age-standardized rate of hospitalization per 100,000 due to trauma was 592 in NS, which equates to 55,821 individuals. There are assumptions applied to the model for estimating blood safety stock and demand. One assumption is that one-third of the individuals hospitalized due to trauma-related injuries require blood transfusions. Therefore, it is estimated that annually 18,576 people in NS require blood transfusion. Further, the model focuses on RBC transfusion only to illustrate the number of RBC units that should be kept in hospital inventory. It is also assumed that the trauma patients in question require RBC transfusion due to a lack of oxygen and loss of blood volume.

RBCs have a shelf life of 42 days, roughly 1.5 months, and therefore require eight replenishment periods per year. As a result, the total demand for RBCs per replenishment period has been calculated as 2,322. The overall demand for blood types in Nova Scotia per replenishment period of RBCs is shown in Table 2.

The cycle demand is calculated using the demand equation. The cycle inventory has been averaged because the donor blood is compatible with other blood types as mentioned earlier with blood type substitutability. The lead time used in this study is one day, as stated by CBS. This is a conservative measure as CBS has locations in major cities, is able to deliver blood to the hospitals as required, and is known to do multiple runs in a day. A standard deviation of 10 was used for blood demand (inventory). Moreover, the model assumes a 99% safety factor as stock-outs are not acceptable for blood.

Table 2. Overall demand for blood types in NS per replenishment period of RBCs

A	+	836
	-	139
B	+	176
	-	33
AB	+	58
	-	12
O	+	906
	-	163
	Total	**2,322**

The total inventory (2,374), as shown in Table 3, is greater than the overall demand for the blood types (2,322), as shown in Table 2, indicating that there will be sufficient inventory for the anticipated demand. The cycle inventory and safety stock numbers based on the overall demand for blood types in NS per replenishment period of RBCs are shown in Table 3.

Table 3. Cycle inventory and safety stock of blood types based on overall demand for blood types in Nova Scotia per replenishment period of RBCs

		Cycle Inventory	Safety Stock	Total Inventory
A	+	447	152	598
	-	261	89	350
B	+	117	40	157
	-	70	24	94
AB	+	58	20	78
	-	35	12	47
O	+	494	167	661
	-	290	98	389
			Total	**2,374**

We also conducted a sensitivity analysis for cycle inventory and safety stock of the blood types based on the overall demand for blood types in NS per replenishment period of RBCs (see Table 4). A sensitivity analysis is used to determine the circumstances of the model under different inputs. Thus, the lead time and standard deviation of the safety stock equation have been changed to illustrate how sensitive the model is to these changes.

For this sensitivity analysis, the lead time has been reduced by 25% from 1 day to 0.75 days. In addition, the standard deviation of the overall demand has been increased by 10% from 10 to 11. The calculation with these inputs shows that both the safety stock and inventory decrease with a reduction in lead time and increase in standard deviation of the overall demand. In this scenario, the total inventory of blood types is below the demand for RBCs per replenishment period with 1% variance. The total inventory of blood under the sensitivity analysis has been calculated to be 2,294, where the demand of red blood cells per replenishment period is 2,322.

The case of Nova Scotia has been used with the model to determine the optimal safety stock levels of each blood type. The model focuses on the population that requires blood transfusion per replenishment period for RBCs. Total inventory exceeds the overall demand for blood types in NS, where there will be enough inventory to meet anticipated demand for blood and accommodate unexpected spikes in demand.

Table 4: Sensitivity analysis for cycle inventory and safety stock of blood types based on overall demand for blood types in Nova Scotia per replenishment period of red blood cells, where lead time has been reduced by 25% and standard deviation of demand increased by 10%

		Cycle Inventory	Safety Stock	Total Inventory
A	+	447	131	578
	-	261	77	338
B	+	117	35	152
	-	70	21	90
AB	+	58	17	75
	-	35	11	46
O	+	494	145	639
	-	290	85	375
			Total	**2,294**

CONCLUDING REMARKS

Our model is generalizable as it can be used by hospitals in both urban and remote areas if population numbers, average accident rates, or historical data on transfusion numbers for the geographic area they serve are available. It is very likely that this information is available to hospitals; Statistics Canada provides detailed information on population in cities and towns, and hospitals can track historical data on the number of transfusions that occur annually. There is also the possibility that this model can be applied to research and clinical studies that are required to use blood products.

As the case study of Nova Scotia shows, the blood type that hospitals should stock most is of type O- because it can be accepted by every other blood type. In times of donor shortages of other blood types, hospitals should replenish those blood types with O-. This in turn puts direct pressure on blood banks such as Canadian Blood Services to focus their attention on O- donors.

There is the opportunity for hospitals to forecast demand for the different blood products by calculating demand for all different scenarios that require each blood type. Examples of the most common reasons for blood transfusion include liver disease, illnesses that cause anemia, bleeding disorders, surgery, and cancers in the kidney, blood, spleen, or bone marrow (Mayo Clinic, 2017).

In recent years there has been significant discussion about private organizations disrupting the blood bank industry and providing financial compensation for blood donations. Several studies have shown that financial compensation incentivizes potential donors and is effective at increasing donation rates. Most of the plasma products Saskatchewan's hospitals use come from the U.S. To counteract this, one clinic in Saskatchewan has started paying plasma donors $25 per visit (Rienzi, 2013). Many Canadians disagree with the principle of financial incentives out of ethical concerns about exploiting Canada's poorer citizens, as well as the increased costs to perform more thorough tests because paid donors might be incentivized to lie about their health history, which poses risks to transfusion patients.

Within the Operations Management and Supply Chain Management literature, there remains much room for research on BSCs and their management. On a broader sense, the uncertainties inherent in both supply and demand sides in BSCs pose challenges in developing and executing agile supply chain networks (Lee, 2002). Due to its rare, scarce, and perishable nature, human blood and its byproducts require special inventory management models to be used at the blood banks in BSCs. Besides, giving a detailed portrayal of how BSCs operate, our supply aggregation model for blood types may be incorporated in single-period (perishable) inventory management models with supply uncertainty (cf., Käki et al., 2015) and also in developing operating characteristics for continuous review systems for perishables (e.g., Tekin et al., 2001). Furthermore, our model can feed into the current literature in which generally incorporates only demand stochasticity in BSC network optimization such as in Nagurney & Masoumi (2012), and in Jabbarzadeh et al. (2014). In the setting of BSCs, how stochastic and substitutable supply, along with demand uncertainty, impact optimal design of supply chain networks? How do geographical demand characteristics impact the network design of a BSC? How does supply of blood change over time? How can it best matched with demand varying over time? From a closed-loop SC perspective, discarding of potentially hazardous blood packaging and waste, warrants further research.

Last but not least, incorporating the donor behavior (e.g., Ülkü et al., 2015) and its implication on the optimal inventory allocation policies for blood types and products, along with quality and traceability issues (Bentahar et al., 2016) pose challenges. Add to this, compensating blood donations, lends itself as a new research venue on ethical issues and their impact on supply uncertainty in BSCs.

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The contributors of this book come from diverse backgrounds, making this book a truly international effort. This book will bring forth new frontiers with its revolutionizing research information and detailed analysis of the nascent developments around the world.

We would like to thank all the contributing authors for lending their expertise to make the book truly unique. They have played a crucial role in the development of this book. Without their invaluable contributions this book wouldn't have been possible. They have made vital efforts to compile up to date information on the varied aspects of this subject to make this book a valuable addition to the collection of many professionals and students.

This book was conceptualized with the vision of imparting up-to-date information and advanced data in this field. To ensure the same, a matchless editorial board was set up. Every individual on the board went through rigorous rounds of assessment to prove their worth. After which they invested a large part of their time researching and compiling the most relevant data for our readers.

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