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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 products is not straightforward and brings with it many logistical and management challenges in the BSC.

KEYWORDS | Healthcare operations, blood products, supply chain management, inventory control, donor behaviour .

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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 disease 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 stock-outs, 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

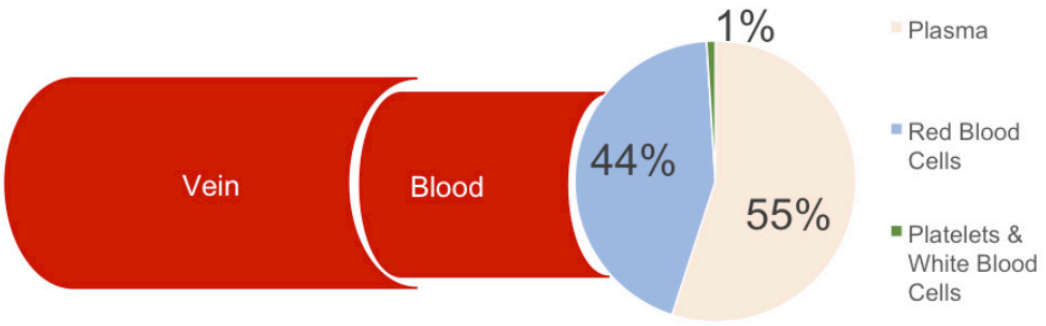
Blood Type	Antigens Produced	Antibodies Produced
A	A antigen	Anti – B
B	B antigen	Anti – A
AB	A & B antigens	N/A
O	N/A	Anti – A & B

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.

Figure 1. Components of blood (CBS, 2017d)



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

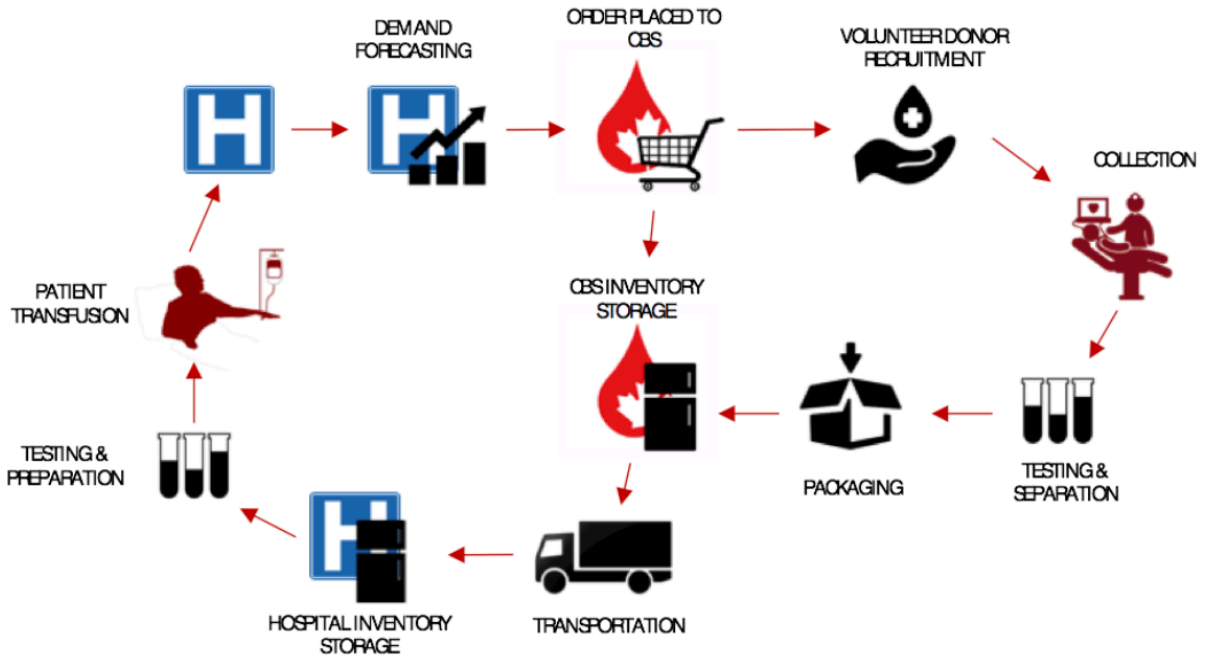
In this section, we look at how a BSC works and identify challenges related to its management, including determination of the optimal level of blood stocks. The related key literature is included.

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 transportation 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

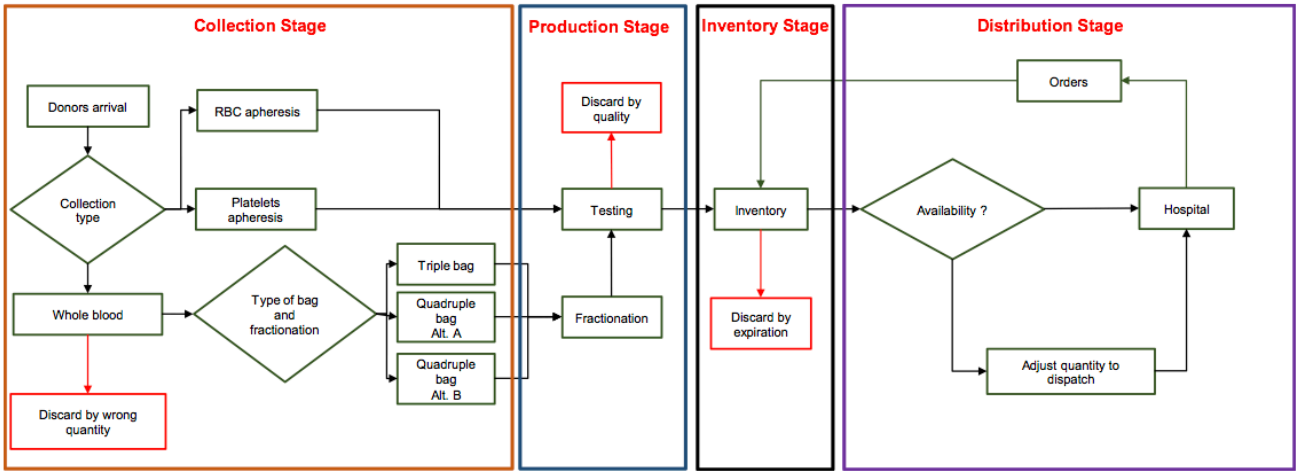
There exists uncertainty inherently in demand for blood. Although hospitals can track historical demand rates, in the case of demand for blood, historical trends are not always accurate at predicting future demand, which is subject to the influence of uncontrollable factors such as natural disasters 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

			RECIPIENT							
	Blood Type		A		B		AB		O	
		Rh Factor	+	-	+	-	+	-	+	-
DONOR	A	+	✓				✓			
		-	✓	✓			✓	✓		
	B	+			✓		✓			
		-			✓	✓	✓	✓		
	AB	+					✓			
		-					✓	✓		
	O	+	✓		✓		✓		✓	
		-	✓	✓	✓	✓	✓	✓	✓	✓

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:

$$D_k = \sum_{i \in K} d_i \quad \text{and} \quad \sigma_k = \sqrt{\sum_{i \in K} \sigma_i^2 + 2 \sum_{i>j} \rho_{ij} \sigma_i \sigma_j} \tag{1}$$

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

$$sk = z\sqrt{\bar{T} \times \sigma_{D_k}^2 + \bar{D}_k^2 \times \sigma_T^2} \tag{2}$$

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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ARTICLES

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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 management (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.

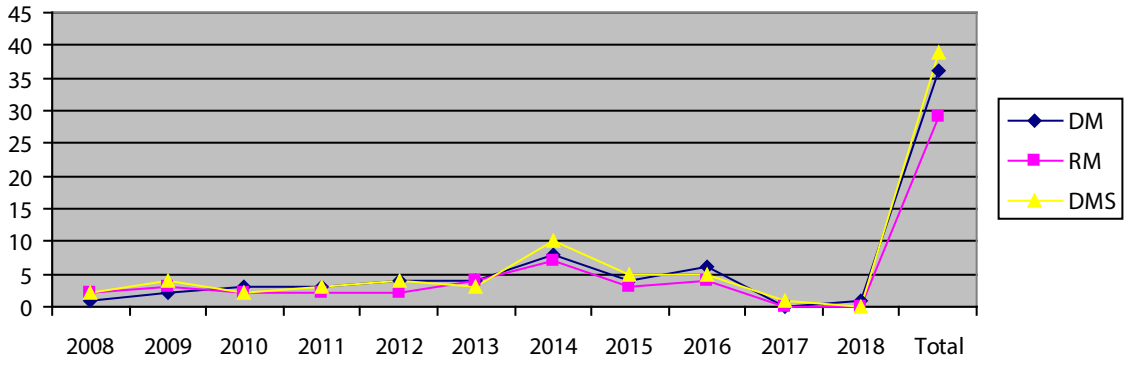
Exhibit 1. List of key Journals referred for Sampling

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.

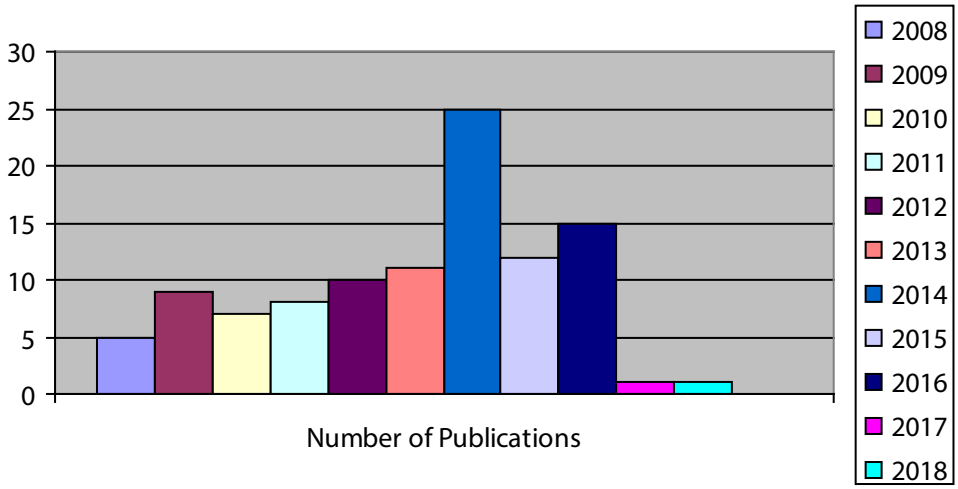
Figure 1. Subject-wise Classification



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 coordinated 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

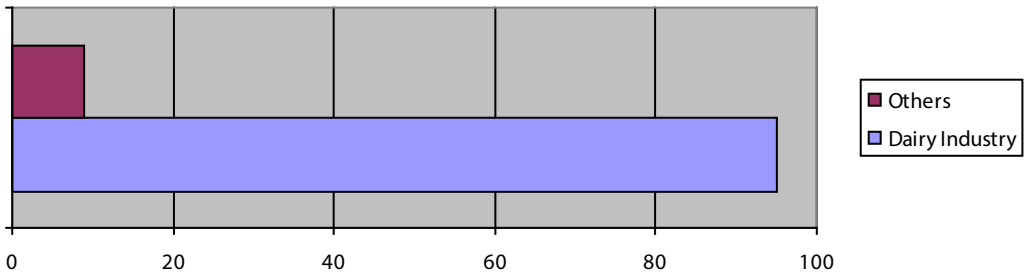


Prakash and Pant (2013) suggested that the importance of balance scorecard approach in India is different from the developed countries due to infrastructural issues, variable milk production, poor breed of cattle, poor sourcing, unavailability of cold infrastructure and poor information systems. Prasad 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 non-parametric 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 stimulate 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 publication 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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ARTICLES

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AIRPORT ECONOMIC EFFICIENT FRONTIER

ABSTRACT

Studies about airport operational efficiency models generally disregard the correlation between operational efficiencies and economic drivers. The goal of this study is, firstly, to isolate and detail the key economic drivers and then find their efficient frontier. The methodology employed was Data Envelopment Analysis (DEA) as a non-parametric and linear programming model. It provides relative measures of efficiency using multiple inputs and outputs for a given Decision-Making Unit (DMU) without requiring a prior production function. The number of variables in this study was limited in function of the DMUs analyzed, which consisted of the following Brazilian airports: Congonhas Airport (CGH), Guarulhos International Airport (GRU) and Viracopos International Airport (VCP). Two of the airports, GRU and VCP, were found to be efficient considering this study's combination of very limited variables, meaning that theses airports, from this isolated standpoint, are maximizing their commercial, passenger parking and marketing revenues, given their terminal area and the number of yearly passengers.

KEYWORDS | Airport planning, Brazilian airports, competitiveness, decision making unit, operational.

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INTRODUCTION

Although various studies have examined airport operational performance or efficiency, fewer authors have focused on determining an efficient frontier that combined operational efficiencies and economic drivers. For these reasons, the present study aims to isolate and detail the key airports economic drivers and then find their efficient frontier, as well as their operational efficient frontier. It is expected that this study will provide a basis for a comprehensive analysis of airport economic value drivers. It complements previous research focusing on operational efficiency and aspects related to broad economic efficiency measuring, such as total airport revenues and costs.

Rather than absolute figures, financial ratios such as Return on Assets and EBITDA Margins can be a natural solution to the problems of limited number of airports in the sample and their significant differences in terms of physical and economic dimensions and operation profiles. In this respect, Brazilian airports were analyzed (Fernandes, Pacheco and Braga, 2014) concerning a broad measure of profitability against their number passengers and the potential of their cities.

Fasone, Maggiore and Scuderi (2014), for instance, analyzed the ownership structure of 25 Italian airports against key financial ratios such as return on equity (ROE), return on investment (ROI), return on sales (ROS), asset turnover (AT), equity on debts (ED), operating income per workload units (WLU) and operating income per air transport movement (ATM). This study determined the relationship between size/structure and key financial ratios.

With regard to the methodology used, Data Envelopment Analysis (DEA) is a non-parametric, linear programming model that has been extensively used in efficiency or performance evaluations. It provides relative measures of efficiency, using multiple inputs and outputs for a given Decision Making Unit or DMU without requiring a prior production function.

AIRPORT KEY ECONOMIC VALUE DRIVERS

The output of most efficiency frontier models has revolved around yearly number of airplanes, passengers and cargo, while inputs have commonly included runway length, passenger terminal area, number of employees and apron area. Also Lotti and Caetano (2018), when considering the variables for the choice of airports for the exportation of products, consider different airport costs, such as the costs of managing the cargo and airport charges, as well as the time of processing the cargo, related to the distance from the origin of the product to the airport. Barros (2008), Tovar and Cejas (2009), Coto-Milla et al. (2014) and Tsui et al. (2014) used those characteristics; however, Tovar and Cejas (2009) used a modified distance function instead of the most common Data Envelopment Analysis (DEA). Wanke (2014) expanded the input variable range to include figures for runways, aircraft parking spaces and vehicle parking spaces. In a word, the main goal of the aforementioned studies was to investigate operational efficiencies; they did not examine economic or financial efficiencies, which are the focus of the present study, with the purpose of adding a new dimension to those previous studies.

An even smaller number of studies have focused on determining an efficient frontier that combined operational efficiencies and economic drivers. Assaf (2010) kept the usual output profile while using labor price and capital price as inputs, as well as a Bayesian estimation method. Gitto and Mancuso (2012) divided their model so as to create what they called a physical model, which isolated airside activities, and a monetary model which also covered landside activities. Therefore, they innovated by defining their input model to include labor cost, capital invested and soft costs, whereas aeronautical and non-aeronautical revenues were defined as the model's output.

Labor cost, capital invested and operational costs were used as inputs by Barros and Dieke (2008) in their model. However, in their search for efficiency determinants, they used Simar-Wilson procedures. Additionally, Martin, Deniz and Dorta (2013) introduced and focused primarily on a key economic driver, i.e., cost, using an estimation of Stochastic Cost Frontiers. They tested cost flexibility in an economic downturn context and determined a cost frontier. Since results varied by geographic region, external variables on individual airport cost flexibility metrics were regressed against a common set of variables.

Malighetti et al. (2011) conducted regressions to deal with the revenue side of the efficiency equation, with the following coefficients: airport size, return on assets, leverage, passenger growth, airports within 100km, age and aviation revenues share. This particular study introduced ROA and debt into the equation. Table 1 lists the literature addressing operational efficiency and economic driver efficient frontier.

Table 1: Key Drivers Identified in the Literature

Authors	Index	Variables	Metrics
Assaf (2010)	Cost Efficiency	Input	Price of Labor
			Price of Capital
		Output	Number of Passengers
			Aircraft Movement
			Total Cargo
Barros (2008)	Technical Efficiency	Input	Labor
			Runways
			Airport Ramp
			Passenger Terminal Area
		Output	Number of Planes
			Number of Passengers
			Cargo
Barros and Dieke (2008)	Efficiency Determinants with Simar-Wilson procedure	Input	Labor Cost
			Capital Invested
			Operational Cost excluding labor cost
		Output	Number of Planes
			Number of Passengers
			General Cargo
			Receipt Handling
			Aeronautical Sales
			Commercial Sales
Fasone, Maggiore and Scuderi (2014)	Financial Analysis	Financial Indicators	Return on equity
			Return on investment
			Return on sales
			Asset turnover
			Equity on debt
			Operating income per WLU
			Operating income per ATM
		Efficiency Indicators	Cost of services per WLU
			Cost of services per ATM
			Cost of labor per WLU
			Cost of labor per ATM

Gitto and Mancuso (2012)	Technical Efficiency	Physical Model - Airside Airport Activities	Input: number of employees, runway area and airport area
			Output: Number of movements, passengers and cargo
		Monetary Model - Airside and Landside	Input: labor cost, capital invested and soft costs
			Output: aeronautical and non-aeronautical revenues
Malighetti et al. (2011)	Value Determinants	Size ROA Leverage Passenger growth Airports within 100 km Age Aviation revenues share Low-medium income country Upper-medium income country High income country	Financial Information
			Non-Financial Information
			Ownership Structure
			Industry Specific Regressors
Martin, Deniz and Dorta (2013)	Short-run cost Frontier	Variable Costs	Labor
			Materials
		Outputs	Domestic/international Passengers
			Air transport movements
			Average landed MTOW
			Metric tons of cargo
			Non-aviation revenues
		Fixed Factors	Gross floor area in terminal buildings
			Total runway length
			Total number or boarding gates
			Check-in desks
			Warehouse area
		Other	Time
			Full-time equivalent employees
			Index of airline traffic shares
			Share of charter traffic
			Share of low-cost traffic
			Ownership form

Millan et al. (2014)	Technical and scale Efficiency	Input	Number of employees
			Airport surface area
			Number of gates
		Output	Aircraft Movement
			Average Aircraft Size
			Share of non-aeronautical revenue in total airport revenue
Tovar and Cejas (2009)	Distance Function	Input	Number of employees
			Airport surface area
			Number of gates
		Output	Aircraft Movement
			Average Aircraft Size
			Share of non-aeronautical revenue in total airport revenue
Tsui et al. (2014)	Operational Efficiency	Input	Number of employees
			Number of runways
			Total runway length
			Passenger terminal area
		Output	Aircraft Movement
			Air Cargo volumes
			Air passenger numbers
Wanke (2014)	Efficiency Analysis	Input	Airport area
			Apron area
			Number of runways
			Total runway length
			Number of aircraft parking spaces
			Terminal area
			Number of parking places
		Output	Number of passengers
			Express cargo throughput
			Number of landings and take-offs

Source: research data

According to Table 1, it is possible to see that although scholars have been analyzing airport efficiency for decades, few studies have focused on the economic value driver aspects of these efficient frontiers.

DATA COLLECTION, ANALYSIS AND CLUSTERING METHODOLOGY

In the present study, the Data Envelopment Analysis (DEA) has been used, which is a non-parametric, linear programming model that has been extensively utilized for efficiency or performance assessments. It provides relative measures of efficiencies, using multiple inputs and outputs for a given Decision Making Unit (DMU) without requiring a prior production function. Charnes, Cooper and Rhodes introduced the DEA concept in 1978, and several studies, particularly in 1984 and 1999, further developed the method into its current, widely used form. Emrouznejad et al. (2008) provided a comprehensive list of more than 4,000 papers covering DEA and its multiples forms from 1978 to 2007. A comprehensive introduction to and analysis of DEA can be found in the studies of Thanassoulis (2001) and Zhu (2003).

Revenue as a single output was used by Barros and Dieke (2008), Tovar and Cejas (2009), Martin, Deniz and Dorta (2013), Gitto and Mancuso (2012), and it was already a development from the traditional operational efficiency frontier analysis. However, since it is a wide-ranging value driver – like operating cost and capital –, it is decided to include a second layer in this study. Ideally, each value driver should be further categorized according to their short, medium and long-term impacts, but these has not been a factor on this study.

This second layer was the main challenge in the study as it involved breaking the wide-ranging revenue value driver down into individual components. For example, the overall revenue had to be broken down into aeronautical and non-aeronautical revenues, and even further into vehicle parking, concessions fees, fuel fees and any other significant revenue sources, including real estate initiatives.

The key data sources were balance sheets, income and cash flow statements and, in a relevant way, management comments on financial reports. These data sources were the most used in the studies listed in Table 1. However, none of them looked into the individual components and used financial report top lines; in this respect, The study investigated the individual revenue components, thus providing a refined efficient frontier.

A second and indirect data collection method used consisted of finding key airport suppliers and searching their financial reports for the revenue derived in the airports studied.

One of the expected contributions of this study is to provide a basis for a comprehensive analysis of airport economic value drivers.

The restricted number of DMUs initially limited the number of variables in this study, as studied by Pedraja-Chaparro et al. (1999), Golany and Roll (1989), Banker et al. (1989), Friedmand and Sinuany-Stern (1998) and Cooper et al. (2007). Table 2 shows the recommended number of DMUs and variables for each author. On the other hand, Khezrimotlagh (2014) demonstrated in his study that a Kourosh and Arash Model (KAM) approach yields satisfactory results even when the number of DMUs in comparison with the number of variables does not follow the rules of the aforementioned studies.

Table 2: Number of DMUs (n) in relation to inputs (m) and outputs (p)

Pedraja-Chaparro et al. (1999)	n / (m + p) should not be small
Golay and Roll (1989)	n > 2 * (m + p)
Banker et al. (1989), Friedman and Sinuany-Stern (1998) and Cooper et al. (2007)	n > 3 * (m + p)
Dyson (2001)	n > 2 * m * p

Source: Khezrimotlagh (2014)

According to Table 2, the number of DMUs should be at least twice and up to three times the number of inputs and outputs combined.

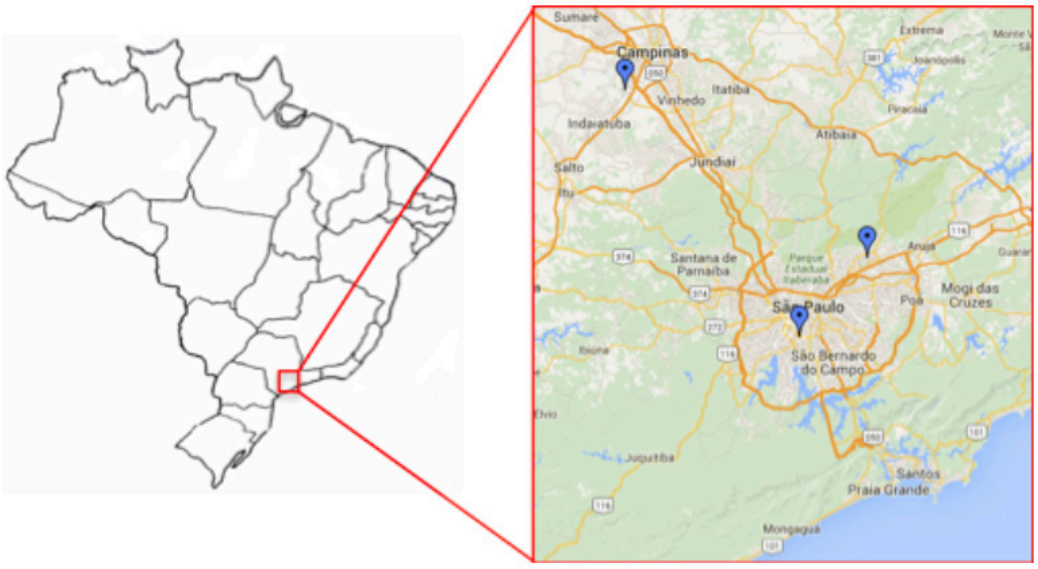
Data Envelopment Analysis results

Publicly available data has been used from several sources, using two different methodologies. Direct data was collected from airport operators such as Infraero and private operators at the recently concessioned airports; Agência Nacional de Aviação Civil (ANAC) and Secretaria de Aviação Civil (SAC) databases were also researched. These sources were also used by Rocha et al. (2016), Wanke (2012) and Fernandes et al. (2014).

The following Brazilian airports were analyzed: Congonhas Airport – CGH, in the city of São Paulo; Guarulhos International Airport - GRU (Sao Paulo's international airport); and Viracopos International Airport – VCP, in the city of Campinas, as shown in Figure 1. The availability of data varied by airport, ranging from the past 18 months up to the last 5 years, and included the items listed in Table 3.

For reference, GRU is ranked number one in Brazil in number of passengers, having reached approximately 39.5 million in 2014. CGH and VCP are ranked second and sixth, respectively, with 18.1 million and 9.8 million passengers in the same year (Infraero, 2015).

Figure 1: Airports analyzed (from left to right): VCP, CGH and GRU.



Source: adapted from Google Maps (2016)

Figure 1 shows the location of the airports analyzed, while Table 3 lists the variables analyzed.

Table 3: Main variables analyzed

Terminal area (m^2)	Concessions area (m^2)
Vehicle parking spaces (n)	Number of commercial concessions (n)
Apron and number of aircraft parking spaces (n)	Commercial revenue (BRL)
Cargo revenue (BRL)	Rent revenue including hangar spaces (BRL)
Fuel flowage fee (BRL)	Vehicle parking revenue (BRL)
Aeronautical revenue (BRL)	Marketing revenue (BRL)
Labor cost (Land- and Air-side) (BRL)	Administration costs (BRL)
Maintenance costs (BRL)	

Source: research data.

The initial set of DMUs included GRU, VCP and CGH, and all data corresponded to fiscal year 2014, except for CGH's airport terminal data, where 2015 data was used. The initial set of DMUs leaves sufficient room for future studies as 98% of the total number of passengers, around 199 million in 2014, used 65 airports. The selected inputs were Terminal Area, Number of Passengers per year and Operational Costs. For the first scenario, all outputs were financial and included Commercial Revenue, Passengers Vehicle Parking Revenue and Marketing Revenue.

Table 4 lists all data collected. However for the sake of confidentiality, an index was created so that the numbers listed therein are multiples of the original data.

Table 4: collected data

2014	A	B	C
Terminal Area	23,333.3	159,616.7	53,815.8
Area for Commercial Concessions (m^2)	5,566.7	-	9,111.6
Number of Passengers	8,205,710.8	32,947,500.0	15,112,306.7
Number of Car Parking Spaces	2,500.0	6,954.2	2,845.0
Number of Commercial Stores	-	189.2	60.8
Apron Area (m^2)	72,481.7	600,091.7	64,434.2
Number of Aircraft Parking Spaces	30.8	50.8	24.2
Commercial Revenue (million)	64.3	469.1	133.2
Cargo Revenue (million)	234.0	-	-
Fuel Flow Fee (million)	5.3	-	4.7
Car Parking Revenue (million)	17.4	86.0	6.5
Aeronautical Revenue (million)	86.9	-	128.8
Marketing Revenue (million)	3.9	46.9	13.2
Area Rental Revenue (million)	33.8	-	126.9
Other Revenue (million)	1.0	15,009.6	-
Non-Regulated Revenue (million)	-	910.7	-
Regulated Revenue	-	853.1	-
Operational Expenses (million)	217.7	179.7	-
Personnel Expenses (million)	108.8	-	70.5
Maintenance Expenses (million)	79.4	106.1	44.9
Other Operational Expenses (million)	29.5	148.6	12.3
Administrative Expenses (million)	-	95.8	2.3
Governmental Fee (million)	-	185.1	-

Source: research data

Table 4 lists all data collected and illustrates the wide range of financial reporting methods employed by the airport operators and the difficulty in extracting accurate and consistent data. Microsoft Excel Solver was used, through the LP Simplex engine, as this is recommended for linear problems. The following reports were generated for GRU, VCP and CGH, respectively.

Table 5 shows the inputs and outputs used for GRU's DEA, and since the efficiency index resulted in 1.00, that means that GRU is just as efficient as the other DMUs for this particular combination of variables. It shows that the airport is, given the limited number of common variables used, maximizing commercial, passenger parking and marketing revenues for its terminal area and number of yearly passengers, or minimizing its related costs.

Table 5: GRU' DEA

Name	Cell Value	Status	Slack
Passenger Terminal Area LHS	191,540.0	Binding	0
Number of Passengers Year LHS	39,537,000.0	Binding	0
Operational Cost LHS	148,600,000.0	Binding	0
Commercial Revenue LHS	562,860,000.0	Binding	-
Passenger Parking Revenue LHS	103,191,000.0	Binding	-
Marketing Revenue LHS	56,286,000.0	Binding	-
Weights Constraint LHS	1	Binding	0

Source: research data

In addition to being just as efficient as the other airports, Table 5 shows that all variables have zero slack, meaning that with this particular combination of variables, GRU could efficiently minimize inputs or maximize outputs in order to achieve total effectiveness. A slack number lower than 1.00 would mean that even if GRU acted to minimize inputs or maximize outputs, it would not achieve the efficiency level of the most efficient DMU.

Table 6 shows the inputs and outputs for VCP's DEA. Despite being almost four times smaller than GRU, it also had an efficiency index of 1.00, meaning that the airport is efficient for this combination of variables. It shows that the airport is maximizing its commercial, passenger parking and marketing revenues, given its terminal area and the number of yearly passengers, as well as minimizing its respective costs, again, given the limited number of common variables used.

Table 6: VCP's DEA

Name	Cell Value	Status	Slack
Passenger Terminal Area LHS	191,540.0	Binding	0
Passengers Yearly LHS	39,537,000.0	Binding	0
Operational Cost LHS	148,600,000.0	Binding	0
Commercial Revenue LHS	562,860,000.0	Binding	-
Passenger Parking Revenue LHS	103,191,000.0	Binding	-
Marketing Revenue LHS	56,286,000.0	Binding	-
Weights Constraint LHS	1	Binding	0

Source: research data

Table 6 also shows that all variables have zero slack, meaning that for this particular combination of variables, VCP could efficiently minimize inputs or maximize outputs in order to achieve total effectiveness.

With regard to CGH, Solver could neither find an optimal solution nor generate a feasibility report, meaning that the constraints can not be simultaneously satisfied. This is a common issue with models using significantly different scales, as is the case of this particular DMU. The difference in scale will trigger the model's instability as it tries to overcome accuracy requirements. Future analysis should try to rescale the variables and include a combination of other variables to avoid this situation.

As far as The results are concerned, similarly to Barros (2008) and Barros and Dieke (2008), who found significant variances in efficiencies in both studies mainly due to scale and location, the present study also indicates the need for a clustered DEA approach and further statistical analysis. Gitto and Mancuso (2012) also found similar results, indicating a greater sensitivity toward non-aeronautical revenues, which were the focus of this study.

The present study builds on the studies of Tsui et al. (2014), who also found that non-aeronautical revenues are key for an airport's efficiency, and, particularly, of Fernandes et al (2014), who also identified the need for a component-by-component analysis.

This study shows that, unlike previous studies focusing mainly on operational efficiencies, it is possible to examine whether an airport is maximizing its commercial, passenger parking and marketing revenues, given its terminal area and number of yearly passengers, using DEA methodologies. This study also provides the basis for various enhancements in efficient frontier analysis, including data selection, statistical tools and a DEA correlation analysis.

Recent developments in the Brazilian recently concessioned airports analyzed, mainly concerning their ability (or the lack thereof) to reach the expected Return on Investment (ROI), reached a bottom when both Campinas International Airport (VCP) and the Rio de Janeiro International Airport (GIG) virtually failed to pay their annual concession fees, while Guarulhos International Airport (GRU) formally asked for a payment reschedule.

What seems to be an inconsistency in this study reveals that the then short-term market outlook was largely overoptimistic. That outlook drove an extremely high winning bid, with annual concession fees, cost structure and mandatory investment schedule inconsistent with the situation of the enterprises and the economy. In other words, from a purely operating profit standpoint, this study is consistent with the fact that airport operators are mainly pointing to concession fees and mandatory investments as the underlying drivers of their financial performance as they are constantly adjusting their cost structure.

This is not directly explained by DEA, so the reader should to take into account that The analysis is a picture, rather than a dynamic present value study.

CONCLUSIONS

Airport operational efficiencies have been studied extensively, and although they are useful for indicating asset use patterns, previous studies do not take any economic or financial aspect into account. The present study recognizes that there are tradeoffs and, particularly, that an optimal balance has to occur between operation efficiencies and profitability, assuming that quality and safety are Pareto optimal.

In sum, this study used data for a few Brazilian recently concessioned airports, isolated their key financial-economic drivers, and employed an initial DEA methodology to build an introductory economic efficient frontier. We found several aspects which can be improved in future studies, from data collection and clustering to the statistical analysis. We chose DEA primarily because it is a deterministic and non-parametric methodology. Moreover, it can handle multiple inputs and outputs, even when they are presented in different units. DEA provides a relative measure of efficiency, which is the primary goal of this study, and has been used in a number of papers that examined operational efficiencies.

The main challenge to this deterministic DEA study was using different sources, thus possibly compromising the quality of collected data; in addition, the number of observations was limited, since Brazilian airport operators have different reporting standards. Enhancing this initial DEA methodology through Stochastic DEA, bootstrapping and frontier analysis should be considered for future studies.

The initial set of DMUs – i.e., CGH, GRU and VCP – provided a first look into economic efficient frontier, despite the limited number of variables. Two of the airports, GRU and VCP, were found to be efficient using this study's very limited combination of variables, meaning that theses airports are, from this standpoint alone, maximizing their commercial, passenger parking and marketing revenues, given their terminal area and number of yearly passengers. CGH analysis´ constraints could not be simultaneously satisfied. This is a common issue with models using significantly different scales, which was the case in this particular DMU. The difference in scale will trigger the model's instability as it tries to overcome accuracy requirements. Future analysis should try to rescale the variables and include a combination of other variables to avoid this situation.

Future studies should also expand this analysis on three distinct fronts: a) increasing the number of DMUs and cluster them by volume or location; b) conducting further statistical DEA analysis using bootstrapping, correlation adjustments and, perhaps, other stochastic elements; and, most importantly, c) examining and determining correlations yet to be studied between previous DEAs analysis focusing on operational efficient frontiers and this study's new economic efficiencies perspective. It is suggested the use of this methodology on ports and bus terminals to compare different results on transportation sciences.

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ARTICLES

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AGGREGATE PLANNING FOR PROBABILISTIC DEMAND WITH INTERNAL AND EXTERNAL STORAGE

ABSTRACT

This paper presents three approaches to support decision-making for production planning, sales and inventory problems. They work in a situation with: non-stationary probabilistic demand; production capacity in regular hours and overtime; shortage leads to lost sales; limited internal storage space; and ordering costs resulting from machine preparation are negligible. In the first approach, we consider the problem as linear and deterministic. In the second, safety inventories are used to fill a probabilistic demand, but the possibility of stockout is not considered. The third approach estimates shortage resulting from demand uncertainty. The last two approaches use iterative processes to re-estimate unit holding cost, which is the basis to calculate safety inventories in each period of the horizon. Using Microsoft Excel Solver, with linear programming and nonlinear search functions, a hypothetical example (but strongly based on real-life companies) and some scenarios permit concluding that developing more realistic and complex models may not provide significant benefits.

KEYWORDS | Inventory, non-stationary probabilistic demand, aggregate production planning, sales and operations mathematical models, no ordering costs.

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NTRODUCTION

Aggregate Production Planning, or Sales and Operations Planning, represents an intermediary level of planning in companies, between strategic, in which the company defines its production structure for future years, and operational, which defines the processing sequence of production orders based on the resources available. Buffa and Sarin (1987) present the main concepts about this subject.

In aggregate planning, companies should define how to use their resources to reach their operational goals (maximize operational profit, usually). Overtime work may be considered, as well as having additional shifts, outsourcing part of production, not meeting part of demand, or building inventories in periods of low demand to use them in higher demand periods. The texts analyzed present two approaches for the sizing of safety inventories in each period in the planning horizon, necessary in situations of demand uncertainty. The first approach results from the arbitrary definition of a proportion of replenishment cycles without shortage (for example, 95%) or a demand proportion to be met without shortage, which leads to the identification of a safety coefficient to meet demand (usually, based on normal distribution). The second approach considers product holding and shortage costs to establish this safety coefficient. This approach is more adequate when the intention is to minimize total operation costs. This paper addresses a problem not addressed elsewhere in the literature: due to storage constraints in the company's own facilities (refrigerated environment, for example), unit holding costs depend on making seasonal and safety inventories for periods of high demand, which would require an iterative planning process, as the safety inventory is defined by the relationship between holding costs and shortage costs.

This proposed iterative planning process will be compared to others, simpler, to assess the benefit of a more complex process. One should always bear in mind that people will be carrying out processes in companies and, if these people find the process too complicated for an uncertain return, this process will be left aside. A relevant number of companies have similar problems in aggregate planning, and comparing aggregate planning models may be quite useful for them, as it will guide their decisions of which model the company should use.

The rest of the text is organized in the following way: after presenting method and literature review, I describe the aggregate planning problem to be solved by the models presented next. The first formulation corresponds to the deterministic linear model for nonstationary demand with internal storage constraints and the option to use overtime. The second formulation corresponds to the linear model proposed for the probabilistic demand problem, while third formulation is used to solve the nonlinear model with probabilistic demand and shortage, thus allowing for the comparison among models and guidelines for their use in companies, made next. Finally I present the conclusions and limitations of the study.

METHOD

The analysis of the related literature mentioned in the references of books about operations and papers found after search in databases (Science Direct, Scopus and Web of Science, among others) provided the approaches that could be useful to deal with the problem addressed herein.

This is not a case study. A fictitious company was created to permit the comparison between the mathematical modelling approaches to solve problems of aggregate planning with probabilistic demand and production and storage constraints. The initial information about the fictitious company, like the behavior of demand and unit costs involved in operations, were obtained from real-life companies, and combined to create a dataset representing a valid and realistic problem.

The mathematical models were populated into Microsoft Excel® spreadsheets and solved by the add-in optimization software Solver, by Frontline Systems Inc.

The performance comparison of the test models was based on the total margin resulting from the operations of the fictitious company. The total margin is a result of the difference between the revenues from product sales and direct production costs (materials and energy), overtime costs, onsite storage costs and contracted offsite storage costs. Due to considering monetary values resulting from operational decisions (production, sales, shortage, and internal and external storage), the total margin would be a better performance indicator than reaching arbitrary goals for utilization of the installed capacity or fill rate.

Different scenarios were tested to validate conclusions. In each one of this six scenarios, costs or demand pattern were changed (one change each time)

in relation to original values. An increase of 50% was made to unit holding cost due to internal storage, unit holding cost due to external storage and unit sale revenue. A decrease of 50% was made to original value of internal storage capacity; an increase of ten times was made to unit labor cost in overtime; a greater variation of demand along horizon, with same average, was applied in the last scenario.

LITERATURE REVIEW

Buffa and Sarin (1987), Thomé, Scavarda, Fernandez, and Scavarda (2012) and Silver, Pyke, and Peterson (1998) present the most usual techniques to solve aggregate planning problems. The simplest ones contemplate simplified models of companies, only considering the main resources, usually implemented through electronic spreadsheets and simulation, whose equations permit evaluating the feasibility of a suggested plan, without result optimization. Tenhiälä (2011) suggests that companies underuse more sophisticated models that use linear programming and mixed linear programming techniques (the later considers binary variables used to represent resource consumption—and associated costs—when equipment is prepared in an intermittent production environment). Hierarchical models may also be used, with optimization in each detailing level of production and sales plans. Günther (1982) used simulation to compare the performance of linear programming models and linear decision rules in situations of demand uncertainty, indicating that the more uncertain the demand, the latter produces better results than the former; however, he does not develop a specific model to deal with the issue of uncertainty. Li, Wang, Yang, Guom, Qi (2013) present a technique (*belief-rule-based inference*) for conditions of demand uncertainty, in which plans are evaluated in scenarios with different probabilities.

Literature search revealed a set of papers (Wang & Liang, 2005; Hsieh & Wu, 2000) about aggregate production planning in situations of uncertain cost coefficients, demand and production capabilities suggesting their resolution by "possibilistic" linear programming, where uncertainties are defined by triangular distributions (minimal, most likely and maximum values). Their concern is different from this paper's, because those authors do not try to calculate safety inventories, but rather to define deterministic decisions that are appropriate to a scenario of uncertainties. A similar approach is observed in "robust optimization models" or stochastic linear programming, in which scenarios with different probabilities of occurrence are built based on possible values of initial parameters (RahmanI, Ramezanian, Fattahi, & Heydari, 2013; Sen & Higle, 1999).

Mula, Poler, García-Sabater, and Lario (2006) conducted an extensive survey of production planning models under uncertainty, but the part about aggregate planning does not provide relevant contributions for this article as they only mention studies using fuzzy logic.

Working with heuristics, Ketzenberg, Metters, and Semple (2006) analyze the problem of aggregate planning with several products, non-stationary probabilistic demand, and common capacity restraints. Marginal analysis heuristics, which allocates production capacity both in limited capacity periods and in advanced production, according to each product's economic return, provided better results than others tested (balanced (fair share), proportional and fixed allocation). The results of the winning heuristic were compared with optimal results, obtained with the use of dynamic programming. The study ignores preparation costs and calculates safety inventories based on storage costs and lost sales costs, like prosed by this work, but without considering the possibility of overtime and external storage.

Pauls-Worm, Hendrix, Alcoba, and Haijema (2016) analyze the situation of perishable products with probabilistic demand and limited demand proportion met (defined arbitrarily, and not based on the relationship between storage and shortage costs), comparing an optimizing approach (mixed integer nonlinear programming) with an approximate approach (mixed integer linear programming). They conclude that linear approximation is adequate when ordering costs make appropriate a replenishment cycle for the next product life period.

Martínez-Costa, Mas-Machuca, Benedito and Corominas (2014) say, based on an extensive review, that there are few studies addressing simultaneously strategic capacity management and production and inventory management, although they emphasize that capacity and inventory are substitutes: the more installed capacity, the smaller the needs of inventory. This separation occurs in a base company (one of the companies used to create the fictitious company of this study), in which strategic capacity planning (with a horizon of several years and annual detail of decisions) is done without analyzing the detailed consequences for long term production and inventory management. These are left for the production and sales

planning process, with a horizon close to one year and monthly detail. In the first problem, the base company adopts a solution based on demand tracking strategy, in which the company's regular capacity should meet average demand. As suggested by Olhager and Johansson (2012), differently from the anticipation strategy, in which there is always installed capacity to meet demand increases (with major idleness), and demand-following strategy, in which capacity is only installed after demand occurs (with potential demand losses), the tracking strategy leads to situations in which inventories are formed to cover periods of high demand. In the case of our base company (and the fictitious one), there is still the possibility of overtime work (on weekends).

Bookbinder and Tan (1988) present basic cases, both deterministic and probabilistic, of production planning with non-stationary demand, assuming unlimited capacity of production and storage, and ignoring shortage costs. In the deterministic case, there would be no reason for them to exist, as there is unlimited capacity. In the situation of demand uncertainty, however, they simplify reality because they would consider that the minimal service level required by the company would take shortage as little significant. Service level would be measured by the proportion of replenishment cycles without stockout (also called as cycle service level), and values usually adopted would be equal or greater than 90%. The basic issue of Bookbinder and Tan's study would be to define how to calculate production lots to balance ordering and storage costs.

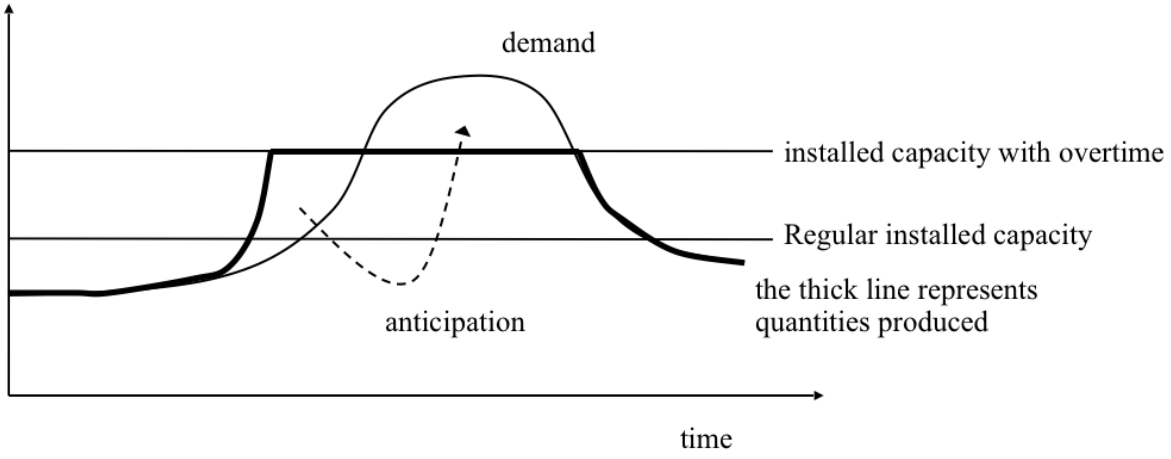
Having the same objective in mind, i.e., minimizing total costs that include ordering and storage, the most common solving techniques are Complete Enumeration, Wagner-Whitin Algorithm, Silver-Meal Algorithm, Mixed Simulation, and Linear Programming. Assuming quadratic costs in some cases, another solving technique is Linear Decision Rule, obtained from the HMMS model (Holt, Modigliani, Mutt and Simon), as Buffa and Sarin (1987), Tarim and Kingsman (2004), and others indicate.

Mixed linear programming was Bookbinder and Tan's option, as well as Tarim and Kingsman's (2004 and 2006). Choudhary and Shankar (2015) used Tarim and Kingsman's 2004 formulation to analyze the benefit of using VMI (Vendor-Managed Inventory) in relation to the "simple" information sharing between companies. In their 2006 paper, Tarim and Kingsman incorporate shortage cost in the analysis, and calculate shortage as the function of an item demand probability distribution for the time interval the purchased lot would last. To use linear programming, Tarim and Kingsman (2006) suggest piecewise linearization for the cost curve as a function of stocked and late quantities. They also calculate maximum errors in relation to the values that would be obtained from the non-linear curve (more realistic), and these errors depend on the number of segments adopted. In the studies identified in this paragraph, capacity constraints of production and internal storage are not considered.

DESCRIPTION OF THE PARTICULAR PROBLEM OF PRODUCTION, INVENTORY AND SALES PLANNING

As mentioned before, the fictitious company herein presents an installed capacity that permits meeting total annual demand using overtime and/or early building of inventories for higher demand periods with production in lower demand periods. Figure 1 presents the situation described.

Figure 1 – Demand for the product family, installed capacity, and production (developed by the author).



The company's items are sufficiently similar, in terms of raw materials and production process, for us to safely assume that they would all be part of a single family. However, the formulas of the mathematical models designed consider that average unit processing time for the item family and production capacities are expressed in hours (not in product units). In this manner, it would be relatively simple to incorporate more general situations, with several products competing for the same production capacities. A similar transformation could be made to consider storage constraints for the several products; in this case, product units by product space.

Widely worked in many of the papers mentioned above, the issue of deciding if an item will be manufactured or not in each period of the planning horizon is not relevant for this situation, because it would be necessary to prepare machines even if the same item continued to be manufactured. The justification for the almost daily preparation of production lines is the fact that the items of this paper's base company are foods: regular cleaning of machines is fundamental for product quality. In this manner, the company planning problem is not to decide when to produce each item (because all of them may be produced in any month, without additional setup costs), but to decide if it is better to produce with overtime in higher demand months or to use seasonal inventories for that purpose, in addition to defining safety inventories for each period in the horizon.

There is limited production capacity both for regular work hours (for which there are not additional labor costs, because this labor in regular hours is already included in the company's fixed payroll) and for overtime production (that could be on weekends, and would lead to additional costs). There is also limited internal product storage capacity (in refrigerated environment). If necessary, the company may hire outsourced space, more expensive than the company's own space. If there is stockout, this will lead to lost sales.

The problem is probabilistic in nature because of demand uncertainty. The behavior of costs as a function of decision variables (particularly, in the case of product inventories and shortage) is nonlinear. The fact that unit holding cost depends on how much external storage is used increases even more the complexity of the situation. However, simpler approaches may be tested to solve this problem, as suggested, in a different situation, by Beale, Forrest, and Taylor (1980, *apud* Feiring & Sastri, 1990).

The deterministic linear model, which allows solving by linear programming and regards safety inventories unnecessary, was the first tested in this study. Next, the probabilistic linear model with iterations is presented; it calculates safety inventories as a function of the relationship between holding and shortage costs (as suggested by Tarim & Kingsman, 2006) and uses an iterative process to refine the final result. This iterative process is necessary because unit holding cost, initially used to calculate the safety inventory, change after calculating production, inventory and sales decisions, because external storage is more expensive than internal storage. Last, the probabilistic nonlinear model with iterations is presented; unlike the previous one, it calculates expected shortages as a function of demand uncertainty. The last model is the most faithful to reality, but the order of presentation chosen, from the simplest to the most complex model, should facilitate understanding the increasing difficulty to operationalize the models. The economic margin function, criterion for comparing results, fails to present a linear behavior, requiring optimization by search algorithms, in addition to the use of an iterative process.

At the end, we analyze if the calculation of expected shortage and the use of an iterative process to refine unit holding cost, methods that are more time-consuming and laborious, are offset by significantly better results, or if, to the contrary, simpler planning methods may be used without relevant losses in company performance.

DETERMINISTIC LINEAR MODEL

In the deterministic situation, in which demand is known without uncertainties, there would not be stockout, as the company's policy is to seek to always meet customer needs.

The decision variables are:

V_t sale (quantity to be sold) in period t (independent)

P_t production (quantity to be produced) in period t (independent)

EF_t inventory (quantity to be stored) at the end of period t (dependent)

EFI_t internal inventory at the end of period t (dependent)

EFE_t external inventory at the end of period t (independent)

HN_t regular hours used in period t (dependent)

HXt overtime used in period t (independent)

The initial parameters necessary (and their values) are:

EF_0 final inventory at instant 0 (1204 t)

LN_t normal capacity in period t (600, 570, 570, 590, 560, 590 and 600 h/month)

LX_t overtime capacity in period t (120 h/month)

LEI internal storage capacity (2000 t)

p unit processing time (0,0667 h/t)

v unit sale revenue (3000 $/t)

m unit direct production cost excluding labor (500 $/t)

x unit labor cost in overtime (40 $/h)

e unit holding cost due to internal storage (400 $/t/month)

o unit holding cost due to external storage (800 $/t/month)

D_t forecast demand for each period t (7000, 6000, 7000, 11000, 12000, 11000 and 8000 t/month)

The formulation of the deterministic linear model would be:

Objective function: maximize margin,

margin = revenue minus variable costs of production, holding and overtime work

$$M = \sum_t \left[(v \times V_t) - (m \times P_t + x \times HX_t + e \times EFI_t + o \times EFE_t)\right] \quad (1)$$

constraints:

mass balance: $EF_t = EF_{t-1} + P_t - V_t$; t = 1...T (2)

no shortage: $V_t = D_t$; t = 1...T (3)

time worked: $HN_t = p \times P_t - HX_t$; t = 1...T (4)

regular hours limit: $HN_t \leq LN_t$; t = 1...T (5)

overtime limit: $HX_t \leq LX_t$; t = 1...T (6)

total storage: $EFI_t = EF_t - EFE_t$; t = 1...T (7)

internal storage limit: $EFI_t \leq LEI$; t = 1...T (8)

variables ≥ 0 (9)

Table 1 presents the example based on the hypothetical company. A horizon of only seven months was used to limit the size of problem and permit its resolution by the MS Excel add-in Solver. Shortage cost is not being considered because in a deterministic situation is not necessary to have shortage, as there is always capacity to meet demand with production in periods of lower demand. Pt, EFEt and HXt are the independent variables.

Table 1. Results of the deterministic linear model (developed by the author).

t	1	2	3	4	5	6	7
P_t	5796.0	6000.0	9515.7	10644.7	10194.9	10644.7	8000.0
D_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
V_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
EF_t	0.0	0.0	2515.7	2160.4	355.3	0.0	0.0
EFE_t	0.0	0.0	515.7	160.4	0.0	0.0	0.0
EFI_t	0.0	0.0	2000.0	2000.0	355.3	0.0	0.0
HN_t	386.6	400.2	570.0	590.0	560.0	590.0	533.6
HX_t	0.0	0.0	64.7	120.0	120.0	120.0	0.0

Margin ($)	153,301,954

One may note that part of the demand of months 4 to 6 is filled with early production of month 3, and with overtime production of months 3 to 6. The internal storage limit is reached in months 3 and 4, which required contracting external space. Inventory at the beginning of the planning horizon, of 1204 t, was used to fill part of the demand of the first period.

PROBABILISTIC LINEAR MODEL WITH ITERATIONS

In a more realistic situation, in which demand is considered uncertain, the company should have safety inventories. Bookbinder and Tan (1988), Feiring and Sastri (1990) and Tarim and Kingsman (2004) use the proportion of replenishment cycles without stockout (cycle service level) as a parameter to establish this safety inventory. This work uses Tarim and Kingsman's (2006) logic, which considers unit shortage and holding costs for this purpose. The relationship f/(f+e), with both costs having end of the month basis, permits calculating the best cumulative probability of fully meet demand in the month. Through the inverse function of cumulative probability in the standard normal distribution, one may find the safety coefficient to fill demand (z). Multiplying z by the standard deviation of demand in the month (dp), we may find the safety inventory (ES) and, lastly, the minimal initial inventory wanted for the month (EImin), which is equal to average demand plus the safety inventory for the month. These calculations are made for each month in the planning horizon, which require using the "t" index for the parameters.

In the cases of unit holding cost and safety coefficient z, values will have to be estimated again in future iterations, as upon the need to use external storage space, the unit holding cost will increase. This higher holding cost will suggest a smaller safety coefficient, thus indicating the need of an also smaller safety inventory. The unit holding cost in the second iteration is calculated as a weighted average, resulting from quantities stored onsite and offsite in the previous iteration.

It is important to highlight that, although demand was considered uncertain in the calculation of the safety inventory, such uncertainty is not considered to calculate possible stockouts. In this linear version of the probabilistic problem, demands would still be fully filled. The following section, which presents a more complete model, considers the possibility of stockout.

In addition to the parameters presented in the initial model, the following are necessary:

dp_t standard deviation of demand in period t (1000 t/month, in all months)

f unit shortage cost (includes lost sales plus possible additional shortage costs (f_{ad}), resulting from contract penalties or other penalties) (3100 $/t)

e_t unit holding cost per period t

zt	safety coefficient per period t
F(zt)	cumulative probability function corresponding to coefficient z
ESt	safety inventory for period t
EImint	minimal initial inventory for period t

In this case, the additional shortage cost was estimated to be 600$/t. As the unit sale price is 3000$/t and the direct production cost excluding labor is 500$/t, unit shortage cost was estimated at 3100$/t. Normal demand distribution is assumed, independent along time.

The formulation of the probabilistic linear model would be:

Objective function: maximize margin,

margin = revenue minus variable costs of production, holding and overtime work

$$M = \sum_t \left[(v \times V_t) - (m \times P_t + x \times HX_t + e \times EFI_t + o \times EFE_t) \right] \quad (10)$$

constraints:

mass balance: $EF_t = EF_{t-1} + P_t - V_t$; t = 1...T (11)

no shortage: $V_t = D_t$; t = 1...T (12)

time worked: $HN_t = p \times P_t - HX_t$; t = 1...T (13)

regular hours limit: $HN_t \leq LN_t$; t = 1...T (14)

overtime limit: $HX_t \leq LX_t$; t = 1...T (15)

total storage: $EFI_t = EF_t - EFE_t$; t = 1...T (16)

internal storage limit: $EFI_t \leq LEI$; t = 1...T (17)

cycle service level: $F(z_t) = \frac{f}{f + e_t}$; t = 1...T (18)

safety coefficient : z_t = *inverse of standard normal distribution* $(F(z_t))$; t = 1...T (19)

safety inventory: $ES_t = z_t \times dp_t$; t = 1...T (20)

minimal initial inventory: $E\,\mathrm{Im}in_t = D_t + ES_t$; t = 1...T (21)

variables ≥ 0 (22)

Table 2 presents the results for the problem considering safety inventory constraints.

Table 2. Results of the probabilistic linear model in the first iteration (developed by the author).

t	1	2	3	4	5	6	7
P_t	7000.0	6000.0	9515.7	10644.7	10194.9	10644.7	8000.0
D_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
dp_t	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
f	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0
e_t	400.0	400.0	400.0	400.0	400.0	400.0	400.0
$F(z_t)$	0.886	0.886	0.886	0.886	0.886	0.886	0.886
z_t	1.204	1.204	1.204	1.204	1.204	1.204	1.204
ES_t	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0
$EImin_t$	8204.0	7204.0	8204.0	12204.0	13204.0	12204.0	9204.0
EI_t	8204.0	7204.0	10719.8	14364.5	13559.4	12204.0	9204.0
V_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
EF_t	1204.0	1204.0	3719.8	3364.5	1559.4	1204.0	1204.0
EFE_t	0.0	0.0	1719.8	1364.5	0.0	0.0	0.0
EFI_t	1204.0	1204.0	2000.0	2000.0	1559.4	1204.0	1204.0
HN_t	466.9	400.2	570.0	590.0	560.0	590.0	533.6
HX_t	0.0	0.0	64.7	120.0	120.0	120.0	0.0

Margin ($)	148,365,361

One may note that production decisions are the same as those of the deterministic linear model, except for the first period, because the inventory available at the beginning of the horizon corresponds to the safety inventory. The margin is smaller because of the safety inventories required, 1204 t each month.

In this case, as the safety coefficient is defined by the relationship $f/(f+e_t)$, an iterative calculation process may be used, as the unit holding cost, resulting from weighting internal and external holding costs, becomes bigger than the value initially considered. In a problem of limited internal storage capacity, in which safety inventory was calculated as the function of an imposed cycle service level, similar to Bookbinder and Tan (1988) and Tarim and Kingsman (2004), such iterative process would not be necessary, because the coefficient would be the same, even if the unit holding cost have changed.

In the example analyzed, the unit holding cost of period 3 would increase to 584.9$/t/month, result of the weighing (2000×400 + 1719.8×800)/(2000 + 1719.8). A similar re-evaluation occurs for period 4. Table 3 presents the results of the second iteration of the probabilistic linear model.

Table 3. Results of the second iteration of the probabilistic linear model (developed by the author).

t	1	2	3	4	5	6	7
P_t	7000.0	6000.0	9515.7	10644.7	10194.9	10644.7	8000.0
D_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
dp_t	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

f	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0
e_t	400.0	400.0	584.9	562.2	400.0	400.0	400.0
$F(z_t)$	0.886	0.886	0.841	0.846	0.886	0.886	0.886
z_t	1.204	1.204	1.000	1.021	1.204	1.204	1.204
ES_t	1204.0	1204.0	999.7	1021.5	1204.0	1204.0	1204.0
$EImin_t$	8204.0	7204.0	7999.7	12021.5	13204.0	12204.0	9204.0
EI_t	8204.0	7204.0	10719.8	14364.5	13559.4	12204.0	9204.0
V_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
EF_t	1204.0	1204.0	3719.8	3364.5	1559.4	1204.0	1204.0
EFE_t	0.0	0.0	1719.8	1364.5	0.0	0.0	0.0
EFI_t	1204.0	1204.0	2000.0	2000.0	1559.4	1204.0	1204.0
HN_t	466.9	400.2	570.0	590.0	560.0	590.0	533.6
HX_t	0.0	0.0	64.7	120.0	120.0	120.0	0.0

Margin ($)	148,365,361

One may note that, in the example given, the cost increase is insignificant, thus suggesting that the iterative process only would be necessary if the quantities stored offsite were a lot greater than quantities stored onsite and/or if the costs of offsite storage were a lot greater than those of onsite storage. Even in these situations, the iterative process is unlikely to be necessary, because, although the safety inventory and minimal initial inventory may be smaller, the initial inventory of the period in which this reduction occurs results in a value higher than the minimal because of the required anticipation of production.

PROBABILISTIC NONLINEAR MODEL WITH ITERATIONS

In the previous models, shortage was considered null, which would be reasonable in the hypothesis of deterministic demand (first model), but a simplification in situations of probabilistic demand. This section complements the previous model, considering the possibility of shortage. The expected shortage for each period in the horizon is calculated after the reevaluation of safety coefficient z. In the periods of lower demand, the minimal initial inventory, calculated as the sum of average demand plus safety inventory -suggested by the safety coefficient resulting from the relationship f/(f+e)-,becomes the initial inventory for each period. However, in the periods immediately before higher demand, in which production occurs ahead of time, the initial inventory of the period results in a value greater than the minimum. With this, it is possible to calculate a final safety coefficient (zf_t):

$$zf_t = (EI_t - D_t)/dp_t \quad (23)$$

As demand was assumed to have a normal behavior, average loss (F_t) may be estimated for each period in the horizon based on normalized average loss, given by the loss integral of the standard normal distribution at point z, I(z):

$$F_t = dp_t \times I(zf_t) \quad (24)$$

In Microsoft Excel®, the I(z) value may be obtained with the use of the functions available: I(z) = f(z) - z * (1 - F(z)), in which f(z) is the probability density function of the standard normal and F(z) is the cumulative probability function of the standard normal.

The function of this loss integral is not linear, a fact that would require adopting a search software or the piecewise linearization technique, which was chosen by Tarim and Kingsman (2006). This study uses the Microsoft Excel® add-in Solver, which also has the search function. As there would be the expected shortage, the expected sale would not be period's demand, but the difference between this and expected shortage:

$$V_t = D_t - F_t \quad (25)$$

Such shortage would lead to a shortage cost that was not present in the previous models. Part of this shortage cost would result from the margin loss (unit

revenue minus unit direct production cost excluding labor) and another share, of an additional penalty, whose unit value is f_{ad}.

We should clarify that the results found for sales, shortage and inventories at the end of periods are average values resulting from the same decisions for many years of the company's operations. In a same period of the same year, there cannot be simultaneously shortage and inventory, because either one or the other would occur.

The formulation of the probabilistic nonlinear model would be:

Objective function: maximize margin,

margin = revenue minus variable costs of production, holding, shortage and overtime work

$$M = \sum_t \left[(v \times V_t) - (m \times P_t + x \times HX_t + e \times EFI_t + o \times EFE_t + f_{ad} \times F_t)\right] \quad (26)$$

constraints:

mass balance: $EF_t = EF_{t-1} + P_t - V_t$; t = 1...T (27)

time worked: $HN_t = p \times P_t - HX_t$; t = 1...T (28)

regular hours limit: $HN_t \leq LN_t$; t = 1...T (29)

overtime limit: $HX_t \leq LX_t$; t = 1...T (30)

total storage: $EFI_t = EF_t - EFE_t$; t = 1...T (31)

internal storage limit: $EFI_t \leq LEI$; t = 1...T (32)

initial cycle service level: $F(zi_t) = \frac{f}{f + e_t}$; t = 1...T (33)

initial safety coefficient: z_t = *inverse of standard normal distribution* $(F(z_t))$; t = 1...T (34)

initial safety inventory: $ES_t = zi_t \times dp_t$; t = 1...T (35)

initial minimal inventory: $E\,\mathrm{Im}in_t = D_t + ES_t$; t = 1...T (36)

final safety coefficient: $zf_t = \frac{EI_t - D_t}{dp_t}$; t = 1...T (37)

expected shortage: $F_t = dp_t \times I(zf_t)$; t = 1...T (38)

expected sales: $V_t = D_t - F_t$; t = 1...T (39)

variables ≥ 0 (40)

Table 4 presents the results of the first iteration of the probabilistic nonlinear model.

Table 4. Results of the first iteration of the probabilistic nonlinear model (developed by the author).

t	1	2	3	4	5	6	7
P_t	7000.0	5947.9	9429.6	10644.7	10194.9	10644.7	7944.4
D_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
dp_t	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
f	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0
e_t	400.0	400.0	400.0	400.0	400.0	400.0	400.0
$F(zi_t)$	0.886	0.886	0.886	0.886	0.886	0.886	0.886
zi_t	1.204	1.204	1.204	1.204	1.204	1.204	1.204
ES_t	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0
$EImin_t$	8204.0	7204.0	8204.0	12204.0	13204.0	12204.0	9204.0
EI_t	8204.0	7207.6	10692.4	14337.1	13532.1	12204.0	9204.0
zf_t	1.204	1.208	3.692	3.337	1.532	1.204	1.204
$I(zf_t)$	0.056	0.055	0.000	0.000	0.027	0.056	0.056
F_t	55.6	55.2	0.0	0.1	27.2	55.6	55.6
V_t	6944.4	5944.8	7000.0	10999.9	11972.8	10944.4	7944.4
EF_t	1259.7	1262.8	3692.5	3337.2	1559.4	1259.7	1259.7
EFE_t	0.0	0.0	1692.5	1337.2	0.0	0.0	0.0
EFI_t	1259.7	1262.8	2000.0	2000.0	1559.4	1259.7	1259.7
HN_t	466.9	396.7	570.0	590.0	560.0	590.0	529.9
HX_t	0.0	0.0	59.0	120.0	120.0	120.0	0.0

Margin ($)	147,517,656

The second iteration of the probabilistic nonlinear model is presented in Table 5. As in the situation of the probabilistic linear model, the second iteration changed very little the results of the first one.

Table 5. Results of the second iteration of the probabilistic nonlinear model (developed by the author).

t	1	2	3	4	5	6	7
P_t	7000.0	5947.9	9429.6	10644.7	10194.9	10644.7	7944.4
D_t	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
dp_t	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
f	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0
e_t	400.0	400.0	583.3	560.3	400.0	400.0	400.0
$F(zi_t)$	0.886	0.886	0.842	0.847	0.886	0.886	0.886
zi_t	1.204	1.204	1.001	1.023	1.204	1.204	1.204
ES_t	1204.0	1204.0	1001.2	1023.4	1204.0	1204.0	1204.0
$EImin_t$	8204.0	7204.0	8001.2	12023.4	13204.0	12204.0	9204.0
EI_t	8204.0	7207.6	10692.4	14337.1	13532.1	12204.0	9204.0
zf_t	1.204	1.208	3.692	3.337	1.532	1.204	1.204
$I(zf_t)$	0.056	0.055	0.000	0.000	0.027	0.056	0.056
F_t	55.6	55.2	0.0	0.1	27.2	55.6	55.6

V_t	6944.4	5944.8	7000.0	10999.9	11972.8	10944.4	7944.4
EF_t	1259.7	1262.9	3692.5	3337.2	1559.4	1259.7	1259.7
EFE_t	0.0	0.0	1692.5	1337.2	0.0	0.0	0.0
EFI_t	1259.7	1262.9	2000.0	2000.0	1559.4	1259.7	1259.7
HN_t	466.9	396.7	570.0	590.0	560.0	590.0	529.9
HX_t	0.0	0.0	59.0	120.0	120.0	120.0	0.0

Margin ($)	147,517,656

As expected, the total margin on the horizon is smaller than in the previous models, because uncertainty does not only require a safety inventory, but also leads to stockout. Shortages are relatively modest (less than 1% of demand), which is expected because its cost is significantly greater than holding costs. In the periods preceding higher demand, building inventories reduces shortage, because inventories are bigger than the minimal inventory for the period.

EVALUATION OF PROBLEM-SOLVING APPROACHES

Table 6 presents the results arising from the decisions of the probabilistic linear model entered in the calculation of the probabilistic nonlinear model. One may note that, as the former does not consider shortage, decisions would lead to a slightly bigger inventory, and the same would occur with sales. The total margin, however, would be slightly smaller (0.2%).

Table 6. Results of entering the decisions of probabilistic linear model into the calculations of the probabilistic nonlinear model (developed by the author).

t	1	2	3	4	5	6	7
Pt	7000.0	6000.0	9515.7	10644.7	10194.9	10644.7	8000.0
Dt	7000.0	6000.0	7000.0	11000.0	12000.0	11000.0	8000.0
dpt	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
f	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0	3100.0
et	400.0	400.0	400.0	400.0	400.0	400.0	400.0
F(zit)	0.886	0.886	0.886	0.886	0.886	0.886	0.886
zit	1.204	1.204	1.204	1.204	1.204	1.204	1.204
ESt	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0	1204.0
EImint	8204.0	7204.0	8204.0	12204.0	13204.0	12204.0	9204.0
EIt	8204.0	7259.7	10825.0	14469.7	13664.7	12329.3	9372.0
zft	1.204	1.260	3.825	3.470	1.665	1.329	1.372
I(zft)	0.056	0.050	0.000	0.000	0.020	0.043	0.039
Ft	55.6	49.6	0.0	0.1	19.9	42.8	39.0
Vt	6944.4	5950.4	7000.0	10999.9	11980.1	10957.2	7961.0
EFt	1259.7	1309.3	3825.0	3469.8	1684.6	1372.0	1411.0
EFext	0.0	0.0	1825.0	1469.8	0.0	0.0	0.0
EFint	1259.7	1309.3	2000.000	2000.000	1684.6	1372.0	1411.0
HNOt	466.9	400.2	570.0	590.0	560.0	590.0	533.6
HEXt	0.0	0.0	64.7	120.0	120.0	120.0	0.0

Margin ($)	147,187,454

Table 7 presents comparison of margins, fill rates and relative margins (to the second iteration of non linear approach) among approaches for the basic scenario and six other different scenarios, as explained in Section 2. Scenario 2 uses unit holding cost due to internal storage of 600 $/t/month. Scenario 3 uses unit holding cost due to external storage of 1200 $/t/month. Scenario 4 uses unit sale revenue of 4500 $/t. Scenario 5 uses internal storage capacity of 1000 t. Scenario 6 uses unit labor cost in overtime of 400 $/h. Scenario 7 uses forecasted demand for each period of 4900, 4200, 4900, 12650, 13800, 12650 and 8900 t/month, respectively.

Scenario	Basic Scenario	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Margin Decisions of Probabilistic Linear 1st iteration in Non Linear ($)	147,187,454	145,486,162	145,869,545	239,532,078	145,572,831	147,034,562	138,118,108
Margin Decisions of Probabilistic Linear 2nd iteration in Non Linear ($)	147,187,454	145,486,162	145,869,545	239,532,078	145,844,602	147,034,562	138,118,108
Margin Non Linear (first iteration) ($)	147,517,656	146,024,604	146,305,778	239,748,479	146,078,407	147,367,175	138,348,607
Margin Non Linear (second iteration) ($)	147,517,656	146,024,722	146,305,778	239,954,580	146,474,864	147,367,175	138,348,607
Fill rate Decisions of Probabilistic Linear 1st iteration in Non Linear (%)	99.67%	99.52%	99.67%	99.77%	99.67%	99.67%	99.76%
Fill rate Decisions of Probabilistic Linear 2nd iteration in Non Linear (%)	99.67%	99.52%	99.67%	99.77%	99.61%	99.67%	99.76%
Fill rate Non Linear (first iteration) (%)	99.60%	99.37%	99.60%	99.74%	99.60%	99.60%	99.73%
Fill rate Non Linear (second iteration) (%)	99.60%	99.37%	99.60%	99.71%	99.51%	99.60%	99.73%
Relative margin Linear first iteration (%)	99.78%	99.63%	99.70%	99.82%	99.38%	99.77%	99.83%
Relative margin Linear second iteration (%)	99.78%	99.63%	99.70%	99.82%	99.57%	99.77%	99.83%
Relative margin Non linear first iteration (%)	100.00%	100.00%	100.00%	99.91%	99.73%	100.00%	100.00%

Table 7 shows the small differences in the margins (less than 1%), even in the situation with half of original internal storage capacity (scenario 5). Fill rates are slightly greater when simplifications of more complete model are used.

In addition to the small benefit resulting from the use of the nonlinear model, we should also remember that the iterative calculation process to refine the value of unit holding cost did not show to be necessary either. With this, the conclusion is that the use of a deterministic linear model adopting several minimal inventories for each period (equivalent to each period's safety inventories) may be enough for good decision-making. This model is equivalent to the probabilistic linear model without iterations.

With results very close to optimal, this model would clearly be simpler to execute than the other ones.

FINAL CONSIDERATIONS

After presenting the results of the three models, deterministic linear, probabilistic linear, and probabilistic nonlinear, one may note that, for the hypothetical company analyzed and related scenarios, the application of the most complex model would not provide significant benefits, although it is conceptually more appropriate. Similar results are expected in other situations, possibly except for those in which internal storage capacities are very small and/or unit costs of external storage are much higher than internal storage and as stockout may be intentional (and not only resulting from demand uncertainties), situations that were not analyzed in this study.

For situations with many products and longer planning horizon, the quantity of variables and constraints would increase proportionally. Moreover, considering the problem as nonlinear would require using the piecewise linearization technique (a simplification that requires more constraints for the mathematical model) or using nonlinear optimization software (based on search algorithms, without guarantee of identifying optimal global results and with longer processing times).

We should weigh, therefore, the complexity of the model and its processing time with the potential benefits of its use. With regard to the problem of meeting non-stationary demands with constraints of internal storage and production capacity in regular hours and overtime, the approaches herein provided quite similar answers.

A natural complementation of this study would be to compare the approaches analyzed in other situations, particularly those in which the ordering cost would not be negligible, with the company making several products whose manufacturing processes shared production and storage resources. It would also be interesting to use data from several real-life situations to validate the approach and the conclusions of this study.

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INTERNATIONALIZATION PATTERNS AND THEIR EFFECTS ON COMPANY PERFORMANCE

ABSTRACT

The goal of this article is to identify internationalization patterns and analyze their effects on company performance. This is a quantitative study with a sample of 343 Brazilian companies that have had export operations for more than three years. Results indicate that companies choose between two distinct paths to internationalization. In the first group are firms that seek to enter the global market proactively. They are present in more countries, have an in-house department of internationalization and a better economic-financial performance. The second group consists of companies that approach internationalization reactively. They outsource part of the process, succeed only in entering markets that are less demanding and do not perform as well as the first group.

KEYWORDS | Internationalization, strategies, export, performance, Brazil.

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INTRODUCTION

Since the technological-economic paradigm change involving information technology and the internet (Freeman & Perez, 1988), competition has become global, as well as operation ways, consumer demandingness and institutional requirements, among other factors that have influenced the business world. Thus, the opening of markets which were previously protected for political-economic reasons has become easier for companies from many countries.

Thus, innovation has become a condition for survival in a globalized, highly competitive world (Freeman & Soete, 2006). Therefore, seeking to differentiate from competition by using specific knowledge that can yield solutions both feasible in technical and economic terms and capable of meeting even more demanding requirements has demanded of companies a series of prerequisites that only the fittest can achieve. In addition, increased operation levels due to companies' entering new markets allowed them to increase their earnings. Therefore, companies' internationalization process has become easier because of the opening of several markets to foreign businesses, real-time information exchange, safer economic transactions and a more efficient and relatively cheaper logistics capacity.

In order to enter new markets, and considering markets' demandingness, firms are expected to change how their production factors combine (Schumpeter, 1912) to create a solution that can meet the expectations of new consumers in other markets. Thus, innovation is likely a condition for a company to succeed (Freeman and Soete, 2008), and internationalization is likely a process that can validate a solution beyond the company's domestic boundaries (Kafouros et al., 2008).

Therefore, this article aims to identify internationalization patterns and analyze their effects on company performance. This is a quantitative study with a sample of 343 Brazilian companies that have export operations for more than three years. The article is organized in four parts, in addition to this introduction. The next section presents the review of the literature on internationalization, among other correlated subjects. Then, we address the method used, considering the goals of the study. Results are presented in the third section, and we close the article by presenting our final considerations, as well as subjects for further research.

LITERATURE REVIEW

This section presents the main the literature sources which guide our study. The first subsection discusses internationalization and its various currents. The second subsection addresses the effects of internationalization on firms.

Companies' Internationalization

Internationalization is the process through which companies from a given country start developing activities outside their country of origin (Deresky, 1994). Such activities can range from the relationship with suppliers and customers to the physical presence of production units abroad. The liberalization of markets, the growth of globalization and the advances in information technology, particularly in the Internet, have increased companies' speed, scope and degree of access to foreign markets (Yip, 1989; Yeniyurt, Cavusgil, & Hult, 2005). Internationalization provides a number of benefits for companies in international markets. Caves (1971) says that establishing operations in other countries allows the company to develop specific knowledge that might give a competitive edge to the company's activities.

The form and degree of a firm's international presence can vary according to its entry strategy into different markets. According to Root (1994), the way firms enter a foreign market is an institutional arrangement through which they seek to introduce products, technology, human skills, management or other resources into nations other than where they are based. The different internationalization strategies encompass different objectives, goals, policies and resources that will guide companies' actions during a certain period in order to achieve the expected growth.

The process of internationalization allows companies to reach other markets so they can generate new business activities in order to achieve extraordinary profits. In addition to its financial benefits, internationalization allows companies to aggregate new knowledge arising from their presence in other countries for later dissemination in other sectors of the organization (Zahra, Ireland, & Hitt, 2000; Castellani & Zanfei, 2004; Frenz et al., 2005).

Companies are known to differ and have distinct results and processes even in the same industry (Nelson, 1991), since knowledge basis, technologies and even products certainly vary from company to company. Therefore, it is to be expected that companies

seeking to reach new markets will do so in different ways and under different conditions. In other words, internationalization process goals, form and results can vary from company to company, since it is necessary to consider factors such as industry, product type and complexity, distribution channels, internationalization strategies and interests in a global positioning, as well as the role of internationalization in the company's value chain (Guan & Ma, 2003; Barber & Alegre, 2007) and Kafouros et al. (2008) and Abecassis-Moedas et al.

As concerns how foreign markets can be entered into, there are different ways a company internationalizes which can be divided in: direct foreign investment (FDI) with the creation of a branch, acquisition or merger with a local company; joint venture; direct or indirect export; and being represented by third parties through licensing, franchising and cooperation agreements (Root, 1994). For each of these forms, it is necessary to consider several factors to understand the internationalization process, such as: size, position in the value chain, industry standard, type of technology and firm innovation capacity. According to Banalieva and Eddleston (2011), the way the firm is going to enter a foreign market is one of the most important decisions to be made concerning internationalization. Su (2013) says that internationalization processes can vary according to these factors: internationalization strategies, the company's operational capacity and customer relationships. Therefore, in considering how to enter a foreign market, companies need also to consider such internal aspects of the organization.

The main theories regarding the process of internationalization of companies are basically divided in two parts. On the one hand, the behavioral approach assumes that companies will seek to develop their international activities in an incremental way (Johanson & Vahlne, 1977), based on the experience they have gained during the process (Rocha, 2002). On the other hand, the economic approach, which encompasses theories such as the eclectic paradigm and transaction costs, assumes that firms seek the internationalization process in a more planned and structured way (Gao, 2004; Whitelock, 2002). Since economic theories consider that corporate decision makers have all the information they need to decide in the best interests of the company and that they always do so rationally – which in practice is not always the case – and because such theories focus mainly on the internationalization of large multinationals, in this study we chose to use behavioral theory to explain firms' internationalization processes.

On the behavioral side of internationalization theories, the Uppsala school (Johanson & Vahlne, 1977) starts by assuming that internationalization is a process guided by organizational learning. Thus, entering international markets is seen as a consequence of corporate growth (Rocha, 2002). This school affirms that companies initially export to countries with a small psychic distance. As experience increases, the firm starts serving markets with greater barriers to entry. In other words, it is only as the company grows that more distant markets become accessible (Johanson & Vahlne, 1977; 2009). Psychic distance is defined as the set of factors that distort the information flow in the internationalization process, i.e., factors such as language, culture, education and political system differences (Melin, 1992). However, this model does not accept that companies may, through their own strategies, skip steps in the internationalization process, e.g., going straight for direct foreign investment (Rocha, 2002). Nor does it consider determinants such as the effect of the market, competition and products marketed in the internationalization process. The Uppsala model and its more contemporary approaches have been widely used, particularly to explain the internationalization process of Small and Medium Enterprises (SMEs) in the export sector.

Effects of Internationalization on Firms

The relationship between internationalization and performance was explored in the study of Lu and Beamish (2001) in the context of Japanese small and medium export companies. Their findings indicate that firms with direct foreign investment performed better than export ones. According to Lu and Beamish (2001), the relationship between internationalization and business performance can be described by a U-shaped curve. In the initial phase of internationalization, it has a negative impact on performance, as the company needs to take risks and invest to develop new knowledge and resources. However, a greater degree of internationalization where the company has already developed such knowledge and resources, will have a positive impact on performance (Lu & Beamish, 2001).

The U-shaped relationship between internationalization and performance was also identified by Ruigrok and Wagner (2003); however, they point out that the U-shape of the curve may vary. This may

be due to differences in the opportunities for international expansion that emerge when entering different countries. Ruigrok and Wagner (2003) show the importance of knowledge acquisition in the internationalization process, as well as its impact on company performance. Similar results were found by Contractor et al. (2007), who examined the impact of internationalization on the profitability of 291 Indian companies from 1997 to 2001, and by Capar and Kotabe (2012), who analyzed data from 81 German companies in the service industries.

Several studies about the influence of internationalization on firm innovation have been developed in recent years. Kotabe (1990) was a precursor of empirical research on the direction of the internationalization-innovation relationship, publishing results that indicate improvements in companies' innovation capacity due to internationalization. The study of Kumar and Saqib (1996) shows that companies' export activities can positively impact R&D investments. Along the same lines, Hitt, Hoskisson and Kim (1997) show the positive relationship between international expansion and technological innovation.

Considering another perspective, Zahra, Ireland and Hitt (2000) present the effects of internationalization on technological learning, as well as the strong relationship between them. Likewise, Filippetti, Frenz and Ietto-Gillies (2013) suggest that exports increase the scope of learning and the need to innovate.

According to Filipescu (2010), there are strong arguments suggesting that increased international activities can lead to innovation. Because of internationalization, according to Kafouros et al. (2008), in addition to enriching its knowledge sources, the company can capture new ideas from diverse markets and cultural perspectives, and these factors allow an increase in organizational learning. The same authors argue that international diversification provides access to vast scientific knowledge which can be integrated into an internationalizing firm, thus increasing its innovation capacity.

Similarly, Castellani et al. (2016) provide a new conceptualization of the relationship between multinationality and productivity. They investigate the potentially differential effects of the breadth and depth of multinationality on business productivity, as well as the mediating (and not moderating) role of R&D. Their results show that multinational depth has a direct positive effect on productivity, while an increase in multinational breadth is associated with lower productivity. In contrast, both multinational breadth and depth are positively correlated with R&D investments, although the relationship is stronger for multinational breadth.

RESEARCH METHOD

The present work is a quantitative cross-sectional study with Brazilian export companies. We used the database from a study titled *Grau de internacionalização e desempenho inovativo de empresas exportadoras* ["Export Companies' Degree of Internationalization and Innovative Performance", translator's note.] developed at the Federal University of Rio Grande do Sul (UFRGS) for academic purposes with the support of funds from a federal government agency.

The database had 350 respondent companies. Of the total of questionnaires answered, six were excluded: two for being insufficiently answered for the study, and four for being repeated for the same companies. In the case of repeated responses for the same organizations, we decided to use the questionnaires containing the most complete answers. Thus, the final sample we used for our statistical analysis had 344 companies. The study included companies located in several Brazilian municipalities and states, represented by the heads of foreign trade departments.

Research Instrument

The data collection instrument consisted of six blocks with different statements in a 1 to 5 Likert scale, eleven (11) dichotomous/categorical questions, seven (7) nominal questions and a categorical question with ten options, with the possibility of multiple answers.

The first block of questions aimed to identify the main environments where innovation originates. The second block aimed to identify the companies' degree of international performance.

In turn, the third block of questions sought to determine the importance of several actions for companies considered as internationalized. As to the fourth block, it sought to identify the importance of several factors for companies' internationalization process.

The fifth block measured the satisfaction of firms about the main outcomes of their internationalization process. Finally, the sixth block sought to understand the effects of internationalization on the company's performance.

In the first two blocks, respondents were encouraged to answer whether they disagreed completely (answer 1) until whether they completely agreed (answer 5). The next two blocks asked what the importance of certain factors was, with 1 being not important and 5 very important. Block 5 measured the degree of satisfaction, 1 being totally dissatisfied, and 5 totally satisfied. Finally, block 6 aimed to measure the effect of internationalization on the companies' innovative performance, 1 being no effect, and 5 a very positive effect.

Statistic Procedures and Data Analysis

The first statistical phase of the study consisted of organizing the database and adapting it to the requirements of the software we would use for the analysis. For the sake of practicality, we decided to use *Microsoft Excel* software to carry out preliminary data organization. For statistical analysis, we used the *Statistical Package for the Social Sciences* (SPSS) version 20.

Initially, to characterize the sample, we conducted descriptive analyzes so as to allow analyzing the general characteristics of the database. After this characterization, a chi-square test and a mean comparison test (ANOVA) were performed to analyze the dependence relationship between the variables and the level of significance of the mean difference for the variables in question.

Subsequently, we conducted a factor analysis test on the performance block to summarize the information we had for many variables into a smaller number of variables or factors, in order to facilitate understanding the data by identifying underlying factors or patterns (Hair et al., 2005). Finally, we performed a cluster test which allowed us to characterize the differences between the companies concerning their internationalization strategies and where these firms export to, and then show if there were economic-financial differences between the firms.

RESULTS

This section was organized in three parts. Firstly, we present the sample characteristics. Then, we describe the process of factorial analysis to assess performance. Finally, we present the cluster analysis and the formation of company clusters.

Sample Characteristics

Initially, we sought to identify general characteristics about the sample formed by 343 valid questionnaires for companies that have had export operations for more than three. The study population comprised four (4) Brazilian states: Rio Grande do Sul, Santa Catarina, Minas Gerais and Pernambuco. We chose these states because they were ranked intermediate among Brazilian states in terms of exports. Due to this selection, the sample has a predominance of companies based in the states of Rio Grande do Sul (47%) and Santa Catarina (26%), totaling 73% of firms in the southern region of Brazil.

With regard to size, the companies were divided in turnover groups according to their classification by the Brazilian National Bank for Economic and Social Development (BNDES). Being an optional question, only 146 companies provided information about their turnover. Figure 1 shows that 56% of the companies in the sample are classified as Medium-Large (31%) and Large firms (25%). This can be explained by the fact that larger companies have more financial and human resources, as well as greater economies of scale (Wagner, 1995). Likewise, these companies are less affected by the risks of operating globally as they can dilute those risks within all activities of the firm (Leonidou, 1995; Pla-Barber & Alegre, 2007; Cavusgil et al., 2013).

Figure 1. Company size classification by turnover (n=146)

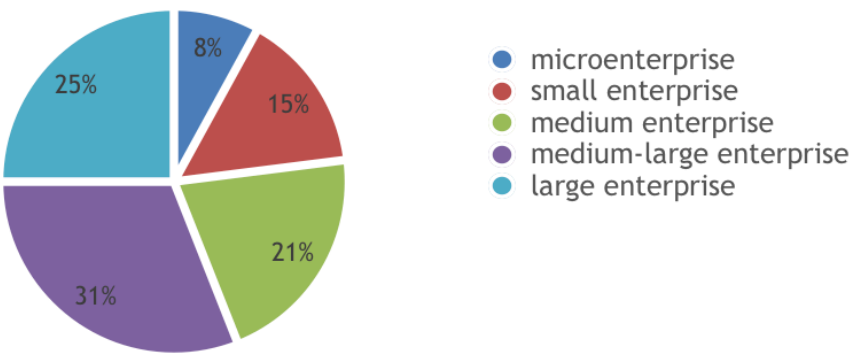

Table 1 presents information describing the age of companies, their experience in the international market and their participation in other countries. The sample has companies aged from four to 176 years old, i.e., it is diverse in terms of both size and age. The average age of the companies is 44 years old. With regard to their presence in foreign markets, some firms started operating internationally three years ago, while others started 144 years ago, with an average of 25 years. The average number of countries where companies have a stake is 19 different nations and the share of income from international operations is, on average, 36%. The company with the largest global presence operates in 150 countries.

Table 1. General characteristics of the export companies

	No. of Companies	Minimum	Maximum	Mean	Standard Deviation
Year of internationalization	329	1872	2012	1990.90	17.754
No. of countries to which it exports	342	1	150	19.42	22.612
Year of establishment	342	1840	2012	1971.71	31.195

Of the companies studied, around two-thirds have an in-house department dedicated to internationalization activities (Table 2). Although these are the majority, it is clear that many Brazilian companies still outsource their internationalization process to contracted firms. This is evidenced by the fact that roughly 40% of respondents said that export operations occurred through third parties (trading companies and agents). Among the continents where the companies operate, the most common destination is South America, which can be explained by the geographical and cultural proximity, as well as the small psychic distance (Johanson and Vahlne, 1977).

Table 2. Existence of an internationalization-dedicated department

		No.	Percentage (%)
Existence of a sector (in-house department) dedicated to internationalization	Yes	227	66.2
	No	116	33.8
	Total	343	100.0

According to Table 3, of the 343 valid responses, 67.6% of the companies invested in product and process research and development activities. Of the firms that invest, the average percentage of turnover invested is 6%.

Table 3. Investment in R&D

		No.	Valid Percentage (%)
Investment in new product and process research and development	Yes	232	67.6
	No	111	32.4
	Total	343	100.0

Based on the characteristics analyzed, we found a considerable diversity among firms concerning size, operation in the market and international experience.

Factor Analysis

To achieve the goal of this article, we conducted a factor analysis of the variables about the effects of internationalization on the performance of the export firms (Table 4). Data adequacy was analyzed using the Kaiser-Meyer-Olkin Measurement of Sampling Adequacy (KMO) and Bartlett's sphericity tests, which produced satisfactory results, presenting optimal (Pestana & Gageiro, 2003) and significant correlations (Hair et al., 2010).

Table 4. Factor Analysis of the effects of internationalization on performance for the last 3 years

		Components	
		1	2
Economic-Financial Performance	Company total turnover	.482	.766
	Company profitability	.557	.741
	Market share	.557	.600
Operational Performance	Client satisfaction	.692	.468
	Development of new trade channels (agreements and partnerships)	.641	
	Increase in the company's knowledge base	.780	
	Use of new firm management tools	.690	-.323
	Change in production processes	.751	-.390
	Internal process enhancement	.745	-.357
	New product development	.816	
	Collaborators' qualification	.808	-.306
	Cost reduction	.774	-.322

Based on the factor analysis, one can infer that two dimensions must be considered to assess firm performance. The first is the economic-financial factor expressed by turnover, profitability and market share figures which we use to indicate the performance of the company in relation to its industry. The second factor was denominated operational performance as it aggregates variables related to internal development, operations, management and trade processes.

Based on this differentiation, two new variables were created to indicate both the economic-financial and the operational performance. The first variable was calculated from the arithmetic mean of the first three variables (total company turnover, company profitability and market share). For the second variable, we also calculated the mean of the other nine variables (Customer satisfaction, Development of new trade channels, Increase in the company's knowledge base, Use of new firm management tools, Change in productive processes, Internal process enhancement, New product development, Collaborators' qualification, Cost reduction).

Using these two new variables, we can analyze whether companies will perform differently, considering their internationalization strategy, the continent they export to and a dedicated department or the lack thereof.

Cluster Analysis

To identify firm internationalization patterns so as to infer and analyze the configurations and behaviors that show similarities and differences between the companies, and thereby determine how they will perform, we conducted a cluster analysis. This test helped divide the companies in the sample through statistical calculation, which grouped together the ones with similar variances among the variables chosen.

To determine which variables to choose and in how many clusters the model would be most adequate, we performed a preliminary test with 20 variables, 18 of which being nominal with two categories, while the other two were the mean of the 1-5 Likert scale variables relating to the performance block that was divided in two factors, as described in the previous section.

This preliminary cluster division provided an important configuration in which the internationalization mode relation was evidenced. All companies analyzed responded that they only carry out "direct export to customers, without intermediaries". Thus, we conducted a new test in order to improve the Cluster test quality by removing the questions with negative answers for the different operation regions. After decreasing the number of variables from 20 to 14, a new Two-Step Cluster test was performed which improved cluster quality; the total number of valid companies also increased from 234 to 273.

The companies were evenly distributed between the clusters, with 136 companies (49.8%) in Cluster 1, which we denominated 'Consolidated Internationalization Companies', and 137 companies (50.2%) in Cluster 2, which we called "Developing Internationalization Companies, totaling 273 firms. The difference between the total sample and the number of companies in the test is due to our decision to only include in the clustering test the firms that had answered all questions chosen. Thus, after this test, we reached the final division of clusters (Table 5).

Table 5. Cluster Test

Variables	Cluster	
	Consolidated Internationalization Companies	**Developing Internationalization Companies**
Is there a sector (in-house department) dedicated to internationalization?	Yes	No
Was direct export to clients, without intermediaries, the internationalization mode your company chose?	Yes	Yes
Does the company operate in North America?	Yes	No
Does the company operate in Central America?	Yes	Yes
Does the company operate in South America?	Yes	Yes
Does the company operate in Eastern Europe?	Yes	No
Does the company operate in Western Europe?	Yes	No
Does the company operate in Africa?	Yes	No
Does the company operate in Oceania?	Yes	No
Does the company operate in East Asia?	Yes	No
Does the company operate in the Middle East?	Yes	No
Does the company operate in Central Asia?	Yes	No
Mean Economic-Financial Performance *	4.11	3.54
Mean Internal Activities Performance*	4.19	3.59
No. of Companies	136	137

*At 0.001 significance level (ANOVA Test)

From these results, we can infer the existence of two types of companies: those that have an internationalization-dedicated sector, are present in a greater number of continents and whose economic-financial and internal activities performance is significantly better than those that have no internationalization-dedicated department and a more limited geographical scope.

DISCUSSION

Based on the sample characteristics, it is worth stressing that the companies have a turnover above the national average and they have been operating for some time in the global market. This corroborates Rocha's (2002) affirmation that entering international markets is seen as a consequence of corporate growth and that it is a process related to organizational learning. At the same time, firms consider internationalization important so they can have a world-class corporate image, access to funds and raw materials, use new distribution channels and dilute risks over more markets, which is in line with Cavusgil et al. (2013).

With regard to the internationalization process, the great majority of the firms fulfill orders from abroad

through indirect exports, since few firms in the sample have subsidiaries, offices or contracts with other companies abroad. According to Root (1994), internationalization through indirect exports is a less risky form of operating internationally and may therefore be more interesting for smaller companies with less international experience. In contrast, large firms, usually multinationals, tend choose internationalization methods with higher risks, such as direct foreign investment and greenfield investment (Cavusgil et al., 2013), which is characterized by the construction of new units without, for example, buying an existing plant. Larger firms find it more important to be pioneers in new markets as well as participate in larger markets. For smaller companies, these factors are significantly less relevant.

With regard to the continents where the firms operate, the most common destination is South America, which can be explained by the geographical and cultural proximity, as well as the small psychic distance (Johanson & Vahlne, 1977). One can infer that the companies that export to more demanding countries with possibly numerous legal, political, economic or cultural constraints, must have a department dedicated to conducting direct exports to customers without intermediaries. Moreover, since they are able to export to such countries, these companies with well-structured internal activities achieve superior economic and financial performance. This conclusion corroborates the study of Castellani et al. (2016) as it indicates that multinationality implies opportunities to access new sources of knowledge and engage in new learning processes.

The results of the cluster test corroborate studies related to the Uppsala school (Johanson & Vahlne, 1977; 2009) since we may infer that companies without an in-house department dedicated to foreign trade do not have the necessary capabilities to enter markets at a greater psychic distance such as the North American, European and Asian markets. In addition, results indicate that a lower economic performance internationally is also related to international presence. This result reinforces that developing an international process is a consequence of organizational growth and development (Rocha, 2002). Therefore, companies without a department to deal specifically with those activities inherent in an internationalization process can only reach customers psychically close and with lower barriers to entry.

FINAL CONSIDERATIONS

The goal of this article was to identify firm internationalization patterns and analyze their effects on performance. To that end, first we sought to present the characteristics of the internationalization process of firms, as well as their strategies to enter foreign markets. In the second part of data analysis, we examined the relationship between different internationalization patterns and company performance.

Based on our results, we can say that the export firms in the sample consider two fundamental characteristics for their internationalization strategies, which concern their market credibility and their need to increase market share by entering new markets. The goal of both strategies is financial return, but the actions taken by the firms in each case are significantly different. In the former, the image and the relationship with the market are priorities. In the latter, increasing and diversifying the production to serve new markets is a priority. Therefore, the motivation for internationalization is linked first to economic and financial performance and then to internal issues related to development, operation, management and marketing.

Results also indicate that there are two types of export companies: those that have a sector dedicated to internationalization and are able to be present in more continents, and therefore, concerning their economic-financial results and internal activities, have a performance that is significantly superior to the other type, i.e., those that do not have a department dedicated to internationalization. In other words, companies exporting to developed countries with more demanding consumers and possibly many legal, political, economic or cultural constraints when compared to other, less developed countries, require a specialized department to carry out direct exports to customers without intermediaries. In addition, because they are able to export to such countries, these companies must have well-structured internal activities, therefore, they can achieve superior economic and financial performance. Thus, in line with previous research (Lu e Beamish, 2001; Capar and Kotabe, 2003; Ruigrok and Wagner, 2004; Contractor, et al, 2008), the results of the present study reinforce that a greater investment and risk in internationalization can lead to a better performance.

As a managerial implication, these findings show that internationalization will have a greater impact on the economic and financial performance of companies with a greater degree of internationalization. To that end, a greater investment in the internationalization structure and in the development of inter-

national markets at a greater psychic distance, may also bring greater economic gains to the firm.

Concerning the limitations of the present study, we point out that the sample companies were concentrated in the Southern region of Brazil and considered the domestic market as their main market. Moreover, the present study did not consider certain qualitative data, such as type of product and type of contract with the client, which could provide a more accurate analysis about export companies. In this respect, further research could investigate in depth companies with different internationalization patterns.

Thus, we suggest that future studies assess the impact of innovation for each type of company and whether this is a determining factor in exports to a particular type of country. Likewise, it is important that future studies analyze the impact of each cluster analysis variable on the internationalization process of companies.

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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 supply 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 competitors) 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 significant. 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

Source: Research Data

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 fertigation 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 structuring. 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)

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

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.

NOTE FROM THE EDITOR

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INFLUENCE BETWEEN INDIVIDUAL ENTREPRENEURIAL ORIENTATION, SERVICE STRATEGY AND BUSINESS PERFORMANCE

ABSTRACT

In today's competitive business environment, the influence of strategies is directly linked to the demands of the market, particularly through individual performance, whether concerning customers or suppliers of products and services. The goal of this study was to investigate the influence between individual entrepreneurial orientation, service strategy and business performance. To that end we conducted a descriptive quantitative study with a sample of 250 respondents in the hospitality industry in Brazil. We used a conceptual model with hypotheses which we tested through the modelling of structural equations, using Smart PLS 3.0 software. The theoretical and practical implications obtained from our field research indicate that the latent variable Individual Entrepreneurial Orientation has a greater impact on service strategy, followed by a small influence of service strategy on business performance. For future research, we recommend investigating the relationship between individual entrepreneurial orientation and business performance.

KEYWORDS | Individual entrepreneurial orientation, service strategies, business performance, structural equations, hospitality.

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INTRODUCTION

In today's fiercely competitive business environment, the services industry stands out when it comes to consumers' demands. The services industry is huge and it is considered as key for social development (Gronroos, 2009). According to Service Brazilian Support to Micro and Small Enterprises (Sebrae 2015), the services industry has grown across the country to branch out into various segments, unveiling new business horizons where some opportunities were explored and others expanded. In this respect, companies' performance depends on a number of factors, but the personal characteristics of the individuals who lead them are essential (Hill, Jones, & Schilling, 2014). Therefore, theoretical and practical studies seek to understand the relationships and the degree of influence between the individual characteristics of managers, the service strategies they adopt and how both factors impact business performance.

Thus, competition indicates that the ability to innovate and develop new products and services becomes an even greater challenge to organizations, leading them to take risks and achieve a significant economic growth constituted by the opportunities developed both in the country and globally. Therefore, this article aims to investigate the influences related to individual entrepreneurial orientation (IEO), the adoption of service strategies and business performance. Our study covered services provided in the hospitality industry, a term used by Brotherton (1999) to designate those who host travelers by providing them with lodging and food in order to generate effects of entertainment. From this perspective, managers' mission is to turn the needs of customers into the comfort and warmth of a personalized hospitality for each individual (Camargo, 2015).

However, when Bolton and Lane (2012) replicated a study on Entrepreneurial orientation (EO) at the individual level, of the five EO dimensions, they only found three: innovation capacity, proactivity and risk-taking. Therefore, organizations are increasingly interested in initiating their activities with well-planned, well-defined service strategies, seeking a competitive edge through innovation valuable to the client – in other words, service strategy emerges as the guiding principle for proposing goods and services, adding value to the firm's main product (Gronroos, 2009; Johnston & Clark, 2010; Lovelock & Wright, 2001; Nóbrega, 2013). Given the above, the study's main question emerges as follows: What are the influences between Individual Entrepreneurial Orientation, Service Strategy and Business Performance?

THEORETICAL REFERENCE

Individual Entrepreneurial Orientation

Individual Entrepreneurial Orientation (IEO) emerged with the in-depth investigation conducted by Lumpkin and Dess (1996) on studies of entrepreneurship (ES) in organizations. Bolton and Lane (2012) examined studies on EO and found that only organizations had been surveyed. Therefore, human individual participation in organizations was not being addressed by research. Thus, they developed a research tool and used it with 1,100 MBA students in the USA in order to test the dimensions studied by Lumpkin and Dess (1996) at the individual level. The former found that the proactivity dimension resembles competitive aggressiveness, thus allowing to merge these into a single dimension. Also noteworthy, of the 52 factors used in the study, only 10 were confirmed as characteristics of individuals in the three dimensions (i.e., risk-taking, innovation capacity and proactivity).

The characteristics of individuals are directly related to their involvement with the organization (Levenburg & Schwarz, 2008; Raposo, Paço, & Ferreira, 2008; Harris & Gibson, 2008). Entrepreneurial actions, along with individual characteristics, are highlighted by individuals' personality and attitude which can be affected by external and social influences (Zahra, 2005; Lumpkin & Dess, 1996). The authors have shown that EO can impact company performance both directly and indirectly, depending on the different environments in which they operate. Hughes and Morgan (2007) believe that the different ways of describing entrepreneurial orientation may have caused divergent results concerning the construct studied with organizational performance, since a few authors found positive correlations, while others found none (Bolton & Lane, 2012; Hughes & Morgan, 2007; Lumpkin & Dess, 1996; Miller, 1983; Wiklund & Shepherd, 2005).

Stewart, Castrogiovanni, and Hudson (2016) consider that if the characteristics of the entrepreneur (individual) are associated with an entrepreneurial orientation (organization), this combination can achieve gains regarding the strategies adopted by the firm. Consequently, the stream of future profits of strategic operations seek prospective business opportunities, observing competitors' moves (Lumpkin & Dess, 1996). Given the above, our theoretical proposition was developed on solid scientific foundations. Therefore, we raise the following hypothesis: H1 – Individual entrepreneurial orientation positively influences the adoption of the service strategy.

Service Strategy

Service strategies have been part of various business activities since the very beginning of business administration until contemporary business administration. Therefore, measuring them or choosing the best strategic alternatives is not an easy task. Exhibit 1 shows the interfaces between the main theoretical models on Service Strategy.

Exhibit 1: Interfaces between the main theoretical models on Service Strategy

Variables	Authors
Access	Corrêa and Caon (2010); Nóbrega (2013)
Attitude	Johnston and Clark (2010)
Capacity	Lovelock and Whight (2001)
Competence	Corrêa and Caon (2010); Hoffman (2009); Lovelock and Whight (2001); Nóbrega (2013); Teboul (1999); Zhang and Bruning (2011)
Communication	Corrêa and Caon (2010); Heskett (2002);
Competitors	Corrêa and Caon (2010); Fitzsimmons (2010); Groonros (2009); Jhonston and Clark (2010); Lovelock and Whight (2001); Nóbrega (2013); Heskett (2002); Contador and Meireles (2004); Zhang and Bruning (2011).
Reliability	Groonros (2009); Teboul (1999); Contador and Meireles (2004); Slack and Lewis (2003); Gebauer (2005);
Comfort	Corrêa and Caon (2010); Heskett (2002);
Knowledge	Corrêa and Caon (2010); Groonros (2009); Nóbrega (2013);
Consistency	Corrêa and Caon (2010); Victorino et al (2005);
Creativity	Slack and Lewis (2003); Gebauer (2005); Zhang and Bruning (2011) and Ketchen et al (2007);
Performance	Heskett (2002); Slack and Lewis (2003); Gebauer (2005); Zhang and Bruning (2011) and Ketchen et al (2007)
Differentiation	Corrêa and Caon (2010); Fitzsimmons (2010); Groonros (2009); Hoffman (2009); Jhonston and Clark (2010); Lovelock and Whight (2001); Nóbrega (2013); Zeithaml (2012); Slack and Lewis (2003);
Service Availability	Lovelock and Whight (2001); Nóbrega (2013); Heskett (2002); Slack and Lewis (2003); Contador and Meireles (2004); Victorino et al (2005);
Esthetics	Corrêa and Caon (2010);
Flexibility	Corrêa and Caon (2010); Grönroos (2009); Slack and Lewis (2003);
Integrity	Corrêa and Caon (2010); Jhonston and Clark (2010);

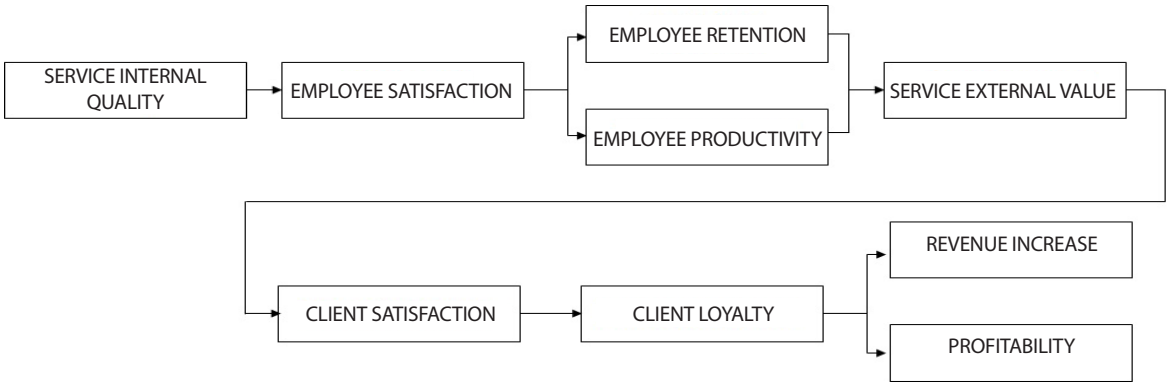
Cleanliness	Corrêa and Caon (2010); Jhonston and Clark (2010);
Opportunity	Corrêa and Caon (2010); Groonros (2009); Jhonston and Clark (2010); Lovelock and Whight (2001); Nóbrega (2013); Heskett (2002); Contador and Meireles (2004); Slack and Lewis (2003); Victorino et al (2005); Zhang and Bruning (2011);
Deadline (response time)	Contador and Meireles (2004);
Price (cost)	Corrêa and Caon (2010); Contador and Meireles (2004); Groonros (2009); Zeithaml (2012);
Perceived Quality	Corrêa and Caon (2010); Groonros (2009); Zeithaml (2012);
Quality of goods	Corrêa and Caon (2010); Contador and Meireles (2004); Slack and Lewis (2003); Gebauer (2005);
Security	Corrêa and Caon (2010); Jhonston and Clark (2010);
Speed	Corrêa and Caon (2010); Nóbrega (2013); Slack and Lewis (2003);

In this context, studies say that individual entrepreneurs are more likely to show innovation capacity. In contrast, individuals who work in a more competitive environment tend to be more cautious and follow field/industry rules (Zhan, Bruning, 2011). Thus, it is necessary to develop more than one "weapon" or service strategy for simultaneous use through the following characteristics: competitiveness through the price of goods and services; customer care; image; or delivery deadline (Contador & Meireles, 2004). According to Johnston and Clack (2010), service strategies must be appropriate and continuous, since companies become aware that by improving the service they provide they will achieve greater gains and, therefore, a better business performance. According to a service strategy conceptualized by Victorino, Verma, Plaschka, and Dev (2005), the factor that influences hotel industry services most is innovation, which is attractive to clients while facilitating business management processes, thus improving business performance. Thus we raise the following hypothesis: H2 – Service strategy has a positive influence on business performance. Given the above, service strategy is the way an organization sees itself and sets about offering services to its clients (Nóbrega, 2013, p.33).

Business Performance

Business performance is usually measured by financial variables. However, obtaining that information is not an easy task; in fact, it is a difficulty that may render a study invalid (Perin & Sampaio, 2004). Therefore, we analyzed firms' strategic decision-making, as well as their marketing and financial performance measures and operational indicators (Vij & Bedi, 2016). Thus, the present study uses two perspectives related to business performance: Balanced Scorecard (BSC) and CSL. BSC's dimensions are as follows: a) Financial: Economic Value Added (EVA), Return on Investment (ROI) and Earnings Before Interest, Taxes, Depreciation and Amortization (EBTIDA); b) customer: customer satisfaction and retention; c) internal processes: operations, innovation and after-sales service; d) learning and growth: training and employee satisfaction (Kaplan & Norton, 1997). According to Zattar, Silva, and Silva (2014), BSC is a model that is able to convey the company's raison d'être by means of its strategy and of performance indicators related to effective strategic management. The service-profit chain (SPC) is based on financial performance, which is associated with a "mirror effect" between employee and customer satisfaction and loyalty (Heskett, 2002).

Figure 1: Model Service Profit Chain (CSL) – adapted (HESKETT, 2002)



METHODOLOGICAL PROCEDURES

The present study is descriptive and exploratory in that it addresses the combination of three latent variables (i.e., IEO, service strategy and perception of business performance) to propose a conceptual model. With regard to our approach to the problem studied, data collected were treated quantitatively. For our review of the literature on individual entrepreneurial orientation, service strategy and business performance, we searched a few databases, such as: Emerald, Scielo and Scopus. Thus, we searched theses, dissertations, books, among others. We chose a statistical technique consistent with our initial purposes, considering the types of relationship between theory and data collection, as well as the nature of the variables. In structural equation modeling, one of the basic characteristics is the possibility to test the causal relationship between a set of variables.

The population consisted of 250 Brazilian entrepreneurs or managers of both genders (male or female) aged 18 to 65 or older, in the hospitality industry (bars, hotels and restaurants) in Brazil. Data were collected from August to December 2016. The sampling was determined by accessibility and convenience, rather than probabilistic sampling techniques in the hospitality industry. For sample calculation, we followed Hair Jr et al. (2005), who say the number of respondents must be 5 to 10 times the number of variables of the largest construct or latent variable. In our case, the largest construct has 25 variables; therefore, the sample consisted of 250 respondents. We used partial least squares structural equation modeling (PLC-SEM) with Smart PLS 3.0 software. Below, the meaning of abbreviations presented in Figure 2: IEO – Individual Entrepreneurial Orientation; SS – Service Strategy; and BP – Business Performance. This multivariate statistical analysis method was the most adequate to our study as it allows investigating how well predictors can explain the dependent variable (criterion) and which predictor variable is the most important. Regression, too, could be used for these purposes, though one must consider that there can be more than one dependent variable in a single model (Maruyama, 1998).

Figure 2: Hypothesis Model

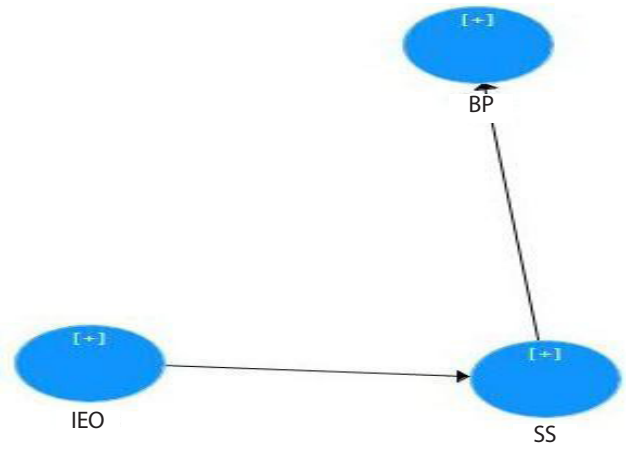
The conceptual model we propose includes latent variables and observable variables. Thus, we used partial least squares which determine the latent variable that gets the greatest number of arrows or a greater number of predictors by means of the causal relationship (a path coefficient between latent and observed variables) studied (Ringle, Silva, & Bido, 2014).

The hypotheses we identified in the literature were: H1 – Individual entrepreneurial orientation positively influences the adoption of the service strategy; and H2 – Service strategy has a positive impact on business performance.

RESULTS: PRESENTATION AND ANALYSIS

In this section, we present the analyses we carried out in this study using Smart PLS 3.0 software. Figure 3 shows the conceptual model we proposed for the constructs.

Figure 3: Conceptual model proposed (Smart PLS)



Source: Search data (2016).

Sample Profile

The sample consisted of 250 respondents of our online questionnaire, thus meeting the minimum required for the sample, at a confidence level of 97.5% and with a sampling error of 2.5%, as shown in Exhibit 2.

Exhibit 2: Sample Profile

DESCRIPTION		QUANTITY	PERCENTUAL
INDUSTRY SECTOR	Hotels	55	22.00%
	Bars	53	21.20%
	Restaurants	122	48.80%
	Bars/ restaurants	20	8.00%
	Total	250	100.00%
GENDER	Male	148	59.20%
	Female	100	40.00%
	Male / Female	2	0.80%
	Total	250	100.00%
AGE	18 to 25	51	20.40%
	26 to 35	115	46.00%
	36 to 49	63	25.20%
	50 or older	21	8.40%
	Total	250	100.00%
EDUCATION	Primary Education	20	8.00%
	Secondary School	123	49.20%
	Higher Education	93	37.20%
	Graduate Education	14	5.60%
	Total	250	100.00%

SERVICE TIME	Up to 2 years	65	26.00%
	3 to 6 years	88	35.20%
	7 to 10 years	52	20.80%
	Up to 10 years	45	18.00%
	Total	250	100.00%

Source: Research data (2016).

Data processing

Table 1 shows the Variance Inflation Factor (VIF), which was 1.00.

Table 1: Variance Inflation Factor (VIF)

	BP	SS	IEO
BP			
SS	1.000		
IEO		1.000	

Source: Research data (2016).

Our study had a mean estimated VIF of less than 3.3. According to Kock (2015), the value of VIF should be less than 3.3, corroborating Ringle et al. (2014), to whom variables with a small multicollinearity index generate reliable results. Tables 2 and 3 show the composite reliability and Cronbach's alpha.

Table 2: Compound Reliability

BP	0.945
SS	0.925
IEO	0.835

Source: Research data (2016).

Table 3: Cronbach's Alpha

BP	0.922
SS	0.907
IEO	0.765

Source: Research data (2016).

Table 4: Factor loading after model adjustment

	BP	SS	IEO
BP-01	0.911		
BP-02	0.941		
BP-03	0.898		
BP-04	0.849		
SS-07		0.714	
SS-09		0.778	
SS-12		0.745	
SS-14		0.725	
SS-22		0.813	
SS-23		0.817	
SS-24		0.839	
SS-25		0.786	
IC-04			0.592
IC-07			0.579
PRO-08			0.712
PRO-09			0.799
PRO-10			0.842

Source: Research data (2016).The results presented in Table 4 show the variables that remained after the adjustments. The

AVE must have acceptable results. Therefore, in order for the desired results to be adequate, adjustments were made to the model. The variables excluded from the study were: RST-01, RST-02, RST-03, IC-05, IC-06, SS-01, SS-02, SS-03, SS-05, SS-06, SS-08, SS-10, SS-11, SS-13, SS-15, SS-16, SS-17, SS-18, SS-19, SS-20, and SS-21. Table 4 shows the variables that remained after the adjustment. It shows that most of the data show a factor loading equal to or greater than 0.7. However, results for the variables IC-04 and IC-07 were smaller than the established standard.

Therefore, despite the loads for variables IC-04 and IC-07 are small, these variables should not be excluded since they belong to a construct that has been validated by previous research, and because they have no AVE-related problem.

To be acceptable, the threshold for the average variance extracted (AVE) must be ≥ 0.5 (Bido, Silva, Souza, & Godoy, 2010; Kock, 2015a). The latent variables were well explained by the variables observed, as shown in Table 5, therefore, all AVE values are within acceptable limits.

Table 5: Average Variance Extracted (AVE) after adjustment

	AVE
BP	0.810
SS	0.606
IEO	0.508

Source: Research data (2016).

Discriminant validity is an additional component in the model validation process. By comparing the individual AVEs in Table 5 with the AVE square roots for each construct in Table 6, we found that the AVE values were smaller than the square root. Thus, data proved acceptable, without interference by the other variables, and the model's discriminant validity was confirmed (Kock, 2015).

Table 6: Discriminant validity

	BP	SS	IEO
BP	0.900		
SS	0.336	0.778	
IEO	0.081	0.378	0.713

Source: Research data (2016).

Note: The square root of the average variance extracted (AVEs) is on the diagonal.

Table 7 shows that R^2 values for this model after regression are 0.521 and 0.215 for a $p < 0.001$. In the field of social and behavioral sciences, R^2 = 2% is of small effect, R^2 = 13% is of medium effect and R^2 = 26%, of great effect (Cohen, 1988). Therefore, they were explained with small and medium effect for the model proposed.

Table 7: R^2 coefficient

	R^2	R^2 adjusted
BP	0.113	0.109
SS	0.143	0.140
IEO		

Source: Research data (2016).

R^2 values for this model after the regression are 0.109 and 0.140 for a p <0.001. Though these are not poor results, a good explanation of the construct in the model requires a minimum 0.4973. However, all constructs in the model have at least 4 variables, thus contributing to a significant solution (Cohen, 1988; Reinartz, Haenlein, & Henseleret, 2009). Table 8 shows that the path coefficients have positive values closer to +1, which is considered acceptable to validate the hypotheses.

Table 8: Path coefficient (Beta)

	BP	SS	IEO
BP			
SS	0.336		
IEO		0.378	

Source: Research data (2016).

The Cohen factor (f^2) is analyzed according to the size of the effect it provides for the model path; thus, with regard to construct effects, 0.02 is considered of small, 0.15 of medium and 0.35 of great effect in social sciences. This means that the variables chosen for each construct are the most adequate for the fit of the model. As shown in Table 9, factor 0.287 is of medium effect; however, factor 0.626 is of great effect for the path, according to the parameters used (Hair Jr. et al., 2014). Therefore, all indexes were accepted for the model path.

Table 9: Cohen factor (f^2)

	BP	SS	IEO
BP		0.626	
SS			0.472
IEO	0.287		

Source: Research data (2016).

Table 10 shows values above the established threshold of 1.96 (Hair Jr et al., 2014), therefore, the paths between the constructs are significant for the structural model adjusted.

Table 10: t-value

	t – value
IEO -> SS	7.177
SS -> BP	5.337

Source: Research data (2016).

DISCUSSION OF RESULTS

Figure 4 shows the adjusted indices in the model for the latent variable (IEO) and the observed variables (SS and BP).

Figure 4: Hypothesis Model Adjusted – Smart PLS

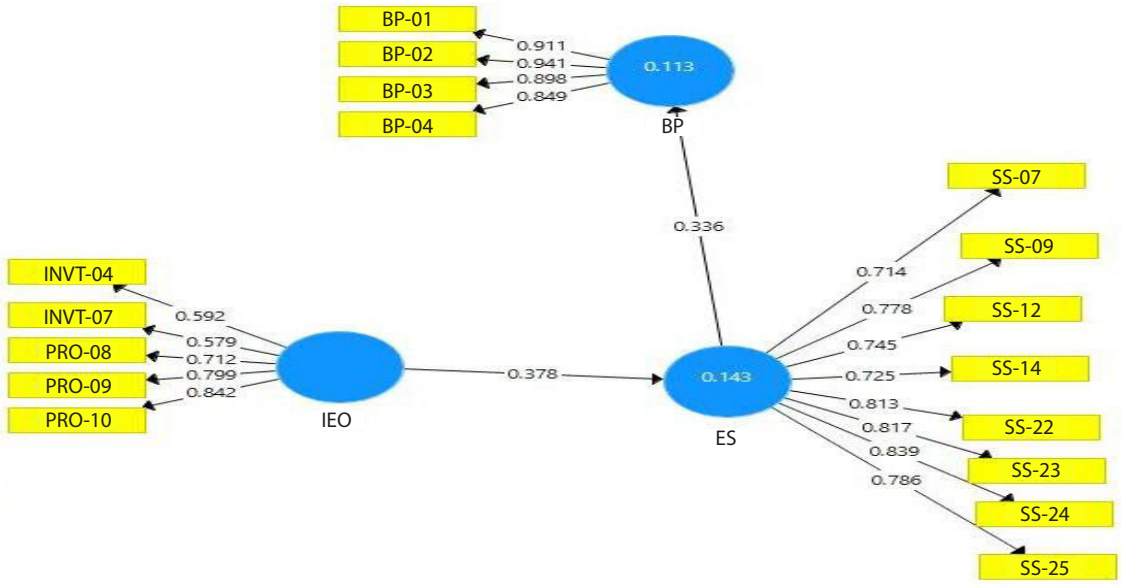


Figure 5 shows the Student's t coefficients.

Figure 5: Hypothesis Model with Student's "t" coefficient

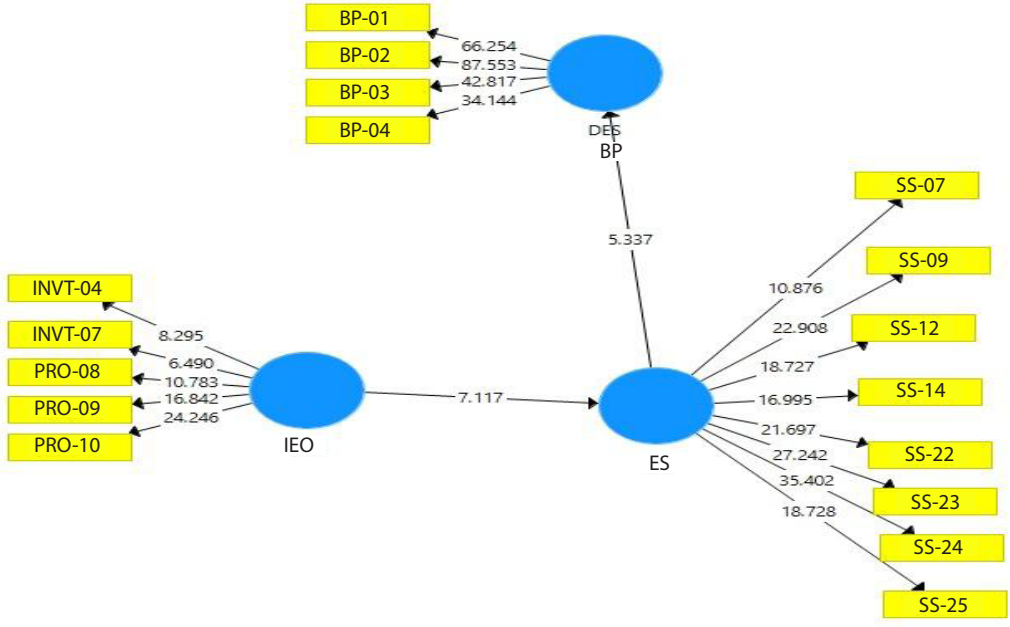


Table 11 summarizes the results for the model after the adjustment, using partial least squares structural equation modelling, which harmonizes the analysis and assessment of the hypotheses we proposed in this study.

Table 11: Summary of Data after Adjustment

	BP	SS	IEO	Criteria	Authors
VIF	1.000	1.000	-	VIF < 3.33	Ringle et al. (2014)
AVE	0.810	0.606	0.508	AVE > 0.50	Bido et al. (2010) Kock (2015)b
Composite Reliability	0.945	0.925	0.835	CC>0.70	Bido et al. (2010) Hair Jr et al. (2014)
Cronbach's Alpha	0.922	0.907	0.765	AC>0.70	Bido et al. (2010)
Discriminant Validity	0.900	0.778	0.713	AVES square roots > than the correlations between the constructs	Kock (2015) Hair Jr et al. (2014)
R^2	0.113	0.143	-	R^2 = 26% R^2 (mean)= 14%	Cohen (1988) Reinartz et al. (2009)
R^2 adjusted	0.109	0.140	-	R^2 = 26% R^2 (mean)= 14%	Cohen (1988) Reinartz et al. (2009)

Exhibit 3 shows that the hypotheses were analyzed and confirmed. Table 8 shows the path index found. Thus, our study confirmed hypothesis H1, which postulated that individual entrepreneurial orientation positively influences the adoption of the service strategy, corroborating Stewart et al. (2016), who say that if the characteristics of the entrepreneur (individual) are associated with an entrepreneurial orientation (organization), this combination can achieve gains regarding the strategies adopted by the firm. On the other hand, we also confirmed hypothesis H2, which postulated that service strategy positively influences business performance, corroborating Victorino et al. (2005) who say that the factor that influences hotel industry services most is innovation, which is attractive to clients while facilitating business management processes, thus improving business performance.

Exhibit 3: Hypotheses Results

Hypothesis	Relationship	Path Coefficient	Results
H1	IEO influences the adoption of service strategy.	0.336	Not rejected
H2	Service strategy influences business performance.	0.378	Not rejected

The values found for the adjusted R^2 coefficient show that the business performance and service strategy constructs have a small explanatory power for the model proposed, since they were, respectively, 0.109 and 0.143 – i.e., about 11% and 15%, which are poor indicators. However, even though the values found are below the parameter established by the literature, the hypotheses were not rejected because they are statistically significant, consistent with what the study proposes, and show an influence relationship between the constructs.

The IEO construct helps explain the model proposed, though to a lower degree. While its path coefficient is not high, the hypothesis is confirmed, since the construct has been validated by Bolton and Lane (2012). Hypothesis H1 is also confirmed, however, by presenting a medium path coefficient, thus corroborating the studies of Lumpink and Dess (2001) according to which these personality factors (innovativeness and proactivity) can influence organizations – just like, one might argue, proactivity can arise from extraversion, need for realization and openness to experience; it can also be influenced by extraversion, internal control and consciousness.

Other researchers, such as Covin and Slevin (1989), argue that there is a mix of variables in studies on entrepreneurs' individual characteristics; however, the IEO-organization relationships are confirmed. Curiously, although risk-taking is a relevant characteristic of managers, we found no significant result for it in our study; we removed all analytical variables from the model since their coefficients were not sufficient to justify their permanence, corroborating the study of Zahra (2005) according to which managers often run firms on their own, without paying attention to risks coming from the market. Businesses that are run by experienced managers aim to acquire, assimilate and transform other financial resources into exceptional organizational resources, as well as human capital to support both family and business growth needs (Yong & Panikkos, 2010).

Service strategy has a small influence on business performance, with a path index of 0.336. Although its f^2 is of small effect for the model path, it remains a matter of discussion, corroborating the study of Johnston and Clark (2010), service strategies must be appropriate and continuous, since companies become aware that by improving the service they provide they will achieve greater gains and, therefore, a better business performance.

According to the findings of this study, which consisted of investigating the influences between individual entrepreneurial orientation, service strategy and business performance, there are such influences between the constructs in the model proposed, although the indicators have a small explanatory power. Business performance was the construct that was best represented through our data, showing an influence by the adoption of a good service strategy, which therefore improves business performance, corroborating the study of Vij & Bedi, (2016), according to which it is necessary to analyze firms' strategic decision-making, as well as their marketing and financial performance measures and operational indicators. However, entrepreneurial individual orientation shows how significant service strategy is, and data indicate that individual characteristics (innovativeness and proactivity) positively influence the adoption of the service strategy. This corroborates the study of Zhang & Bruning (2011), according to which entrepreneurs working in an environment with many growth opportunities are more likely to show innovation capacity. In contrast, individuals who work in a more competitive environment tend to be more cautious and follow field/industry rules

CONCLUSIONS

The goal of this study was sought through the proposed model, which allows investigating the influences between the constructs. We found that the IEO construct has a greater influence on service strategy, followed by a small influence between service strategy and business performance. This corroborates the study of Yong and Panikkos (2010) according to which entrepreneur individual characteristics appear in several critically important roles in terms of behavior and company performance.

This study provides contributions such as the model we propose for the influence relationship between the constructs presented, since no similar conceptual model was found in the literature reviewed that addressed the industry we investigated. Another relevant finding was that manager individual characteristics positively influence the adoption of service strategies and, therefore, business performance; in other words, based on our theoretical framework, our results suggest that organizations should choose their managers based on individual characteristics that are relevant to the model of strategic management adopted, and observe business performance through financial data.

The theoretical implications are related to the fact that only three latent variables (service strategy, IEO and business performance) were considered. One limitation is that the IEO influence on business performance was not addressed in the model proposed. Another theoretical implication was the limitation regarding national and international articles, books and electronic databases. Thus, we recommend further research to investigate the relationship between IEO and business performance. We also recommend further research aimed at replicating the results obtained in this study in other contexts, i.e., testing the structural model proposed here in other industries. Another recommendation is to determine whether the influences between the constructs service strategy and business performance (SS->BP) can generate financial gains for organizations. Therefore, we may conclude that more studies are necessary to understand, explain and analyze both the theoretical and practical aspects of the influences between the constructs IEO, service strategy and business performance.

As a managerial implication of this study, we recommend pursuing further insights into IEO in the services industry in Brazil, as well as the development of good practices for the hospitality industry. On the other hand, a better understanding of IEO dimensions can help researchers explore further the influences between the constructs studied and other factors of interest.

The findings of this study are scientific, and the study helped to advance the knowledge about individual entrepreneurial orientation, service strategies adopted and the perception of managers regarding business performance in the hospitality industry in Brazil. It also helped explain and disseminate advanced statistical techniques and analyzes such as structural equation modelling, which are still scarce in management research published in Brazil. It is worth noting that the study was conducted with 250 Brazilian managers in a particular industry (hospitality) and their individual entrepreneurial characteristics were identified using an instrument that has been validated in the United States by Bolton and Lane (2012).

NOTE FROM THE EDITOR

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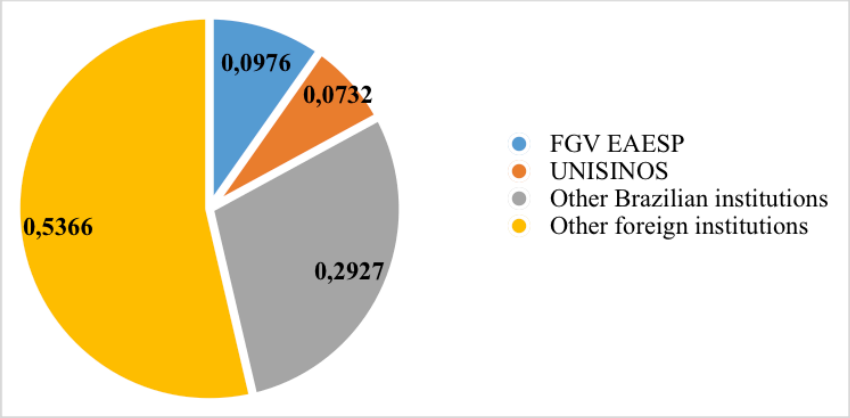

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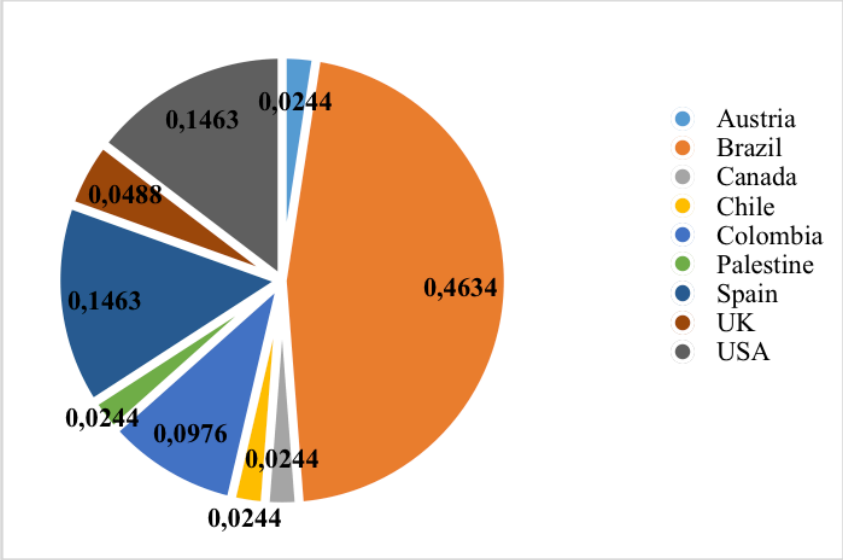

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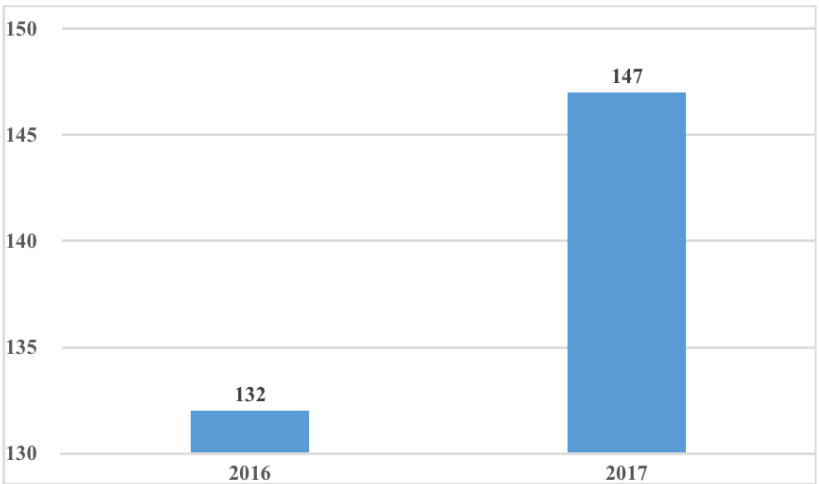

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