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Information Technology Framework for Pharmaceutical Supply Chain Demand Management: a Brazilian Case Study

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ABSTRACT

The paper aims at proposing an information technology framework for demand management within a dyad on the supply chain pharmaceutical industry. The paper adopts the exploratory study as research method, involving a producer of generic drugs and its main distributor. Data was collected by semi-structured interviews. In pharmaceutical supply chain, sharing information boosted by information technology translates into greater flexibility and reliability, lower costs, obtained through more reliable forecasting, and lower inventory requirements. There are few initiatives involving Information Technology (IT) applied to demand management in pharmaceutical supply chains available in the literature. It was found that the IT framework proposed in this research is adherent to the demand management of the focused pharmaceutical dyad. Other assumption was that, if partners processes integration exist, better supply chain performance is achieved. It was found that, by means of proposed tools and solutions, such as RFID and involved partners applications integration, this goal could be achieved. Because of the chosen research approach, results may be restricted to these specific dyadic processes. Further application of the proposed IT framework have to be tested. The paper identifies demand management strategic and operational processes that can reach a better performance by using the proposed IT framework. Based on the literature, were identified which IT requirements should be met to demand management processes optimization. Additionally, were applied questionnaires and interviews to the focused dyad personnel, to corroborate the data identified in the literature. Answers found in the case study link literature elements with those stated by respondents. Finally, based on this, was conceived an IT framework composed of three elements: 1. One specific for infrastructure, to enable data and systems interoperability among SC participants, considering a virtualized infrastructure environment (Cloud); 2. An information system solution to integrate partners applications, based on the reference component model structure (CORBA / CCM – Common Object Request Broker Architectures / Corba Component Model); 3. One element responsible for logistics operations, formed by fourth and fifth pieces: a tool to streamline the logistics flow, and to obtain prompt inventory data, provided by a RFID (Radio Frequency Identification) solution; and another to provide information about production and logistics lead times, applied to demand forecasts elaboration and to streamline the order fulfillment

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process, based on OEE (Overall Equipment Effectiveness) solution. This paper covers a field that is not widely researched that is IT solution application into pharmaceutical demand management processes, and related performance improvements.

Keywords: Demand management. Information technology. Pharmaceutical industry. RFID (Radio Frequency Identification). Supply chain management.

1 INTRODUCTION

Hilletofth (2009) states that, in the beginning of globalization, companies could develop economies of scale for the production and distribution of large volumes of goods, thus reducing costs, increasing competition. Such competition points towards the establishment of structures that allow value addition processes and customer retention, namely, supply chains (LAMBERT; COOPER, 2000; RAINBIRD, 2004; CHRISTOPHER, 2011).

Effective demand management is a key element for the strategic coordination of SC (JUTTNER *et al*., 2007; WALTERS, 2008). It provides a competitive advantage in SC operations because there are reductions on the negative effects of demand amplification (CROXTON *et al*., 2008; HILLETOFTH, 2009). The configuration of and integration among SC participants are critical to performance and competitive success of these SCs, fact that has been addressed in the literature by various researchers (FROHLICH; WESTBROOK, 2002; VICKERY *et al*., 2003; ZHAO *et al*., 2008; FLYNN *et al*., 2010).

This paper discusses the roles of and presents a set of tools for information technology (IT), organized into a proposed framework, and applied to demand management within supply chains. It also considers the producer-distributor dyad, represented respectively by a drug manufacturer and its largest distributor within the pharmaceutical industry, focusing specifically on the generic drugs into Brazilian market.

In the case of Brazil, the Febrafar (2013) states that drugstores are main distribution channel for drugs for the Brazilian population. The country is the fourth largest market for drug consumption and first in number of pharmacies, over sixty thousand units for attendance of one hundred and seventy million inhabitants. There is a ratio of 3.34 pharmacies per ten thousand inhabitants (WHO - World Health Organization recommends a pharmacy for every ten thousand inhabitants).

Farina (2009) explains that if there are delays on drugs delivery by the distributor, there is revenue losses for pharmacies and drugstores, since the customer usually does not wait by the product availability and search the drug elsewhere. Furthermore, such pharmacies rely on the distributor fast delivery, both for replenishment of their stocks, and for communicating promotions and new releases.

Carneiro (2005) states that about $ 8 billion annually are moved by pharmacies and drugstores in Brazil, considering, besides the drugs, products for personal care and cosmetics.

The hypothesis is that this information technology (IT) framework can collaborate effectively with demand management in SCM, especially in the acquisition, processing, and sharing of data. Thus, the relevant gap identified by the survey can be stated by the question: "*What solutions can jointly and in an organized manner, supporting the process of demand management of distribution channels in the pharmaceutical industry, the producer-distributor dyad?*"

Demand management in SC, although it is a subject addressed by several authors such as Mentzer (2005), lacks approaches that relate to IT processes and, especially, specific studies for the pharmaceutical industry. For decades, the pharmaceutical industry has been one of the most profitable industries, primarily due to the unsaturated markets and mechanisms for patent protection (HERACLEOUS; MURRAY, 2001). Regarding Brazilian case, public health systems and private organizations exerted pressure on drug prices in recent years, and made possible the entry of generic products, partly caused by the reduction of the period of patent protection (DANESE *et al*., 2006). Additionally, there is extensive specialization in the industry, and frequent introduction of products that are refinements of existing drugs (GARAVAGLIA *et al*., 2012). To respond to this scenario, several companies searched for scale economies in their production processes, synergy with other companies in research and development (RD), opportunities for mergers and acquisitions in the sector, and changes in their SC (DANESE *et al*., 2006).

Demand information sharing along the SC has been increasingly recognized as an effective approach to reduce distortions of demand along the SC, and fundamental for improving the entire chain performance (JUTTNER *et al*., 2007; BAILEY; FRANCIS, 2008; CROXTON *et al*., 2008; HILLETOFTH, 2009).

1.1 METHODOLOGY AND RESEARCH DESIGN

The focus of this study is the use of IT to support the management of demand in the pharmaceutical industry. The paper adopts the exploratory study as research method, which converges with the nature of the problem investigated, and the current state of available knowledge, as suggested by McCutcheon and Meredith (1993), Yin (2014) and Eisenhardt (1989).

The following elements justify case study method selection:

- The focus of this study is the use of information technology in supporting demand management in the pharmaceutical industry. The literature on this topic is scarce;
- The available knowledge level is in the early stages of the development of the research. So, case study proves to be the most appropriate approach for this survey because, as suggested by McCutcheon and Meredith (1993), Yin (2014) and Eisenhardt (1989), it is typical in the early stages of the development of theory, whenever events or phenomena research have little, or no cataloged knowledge;
- There is no precise idea of which information technology variables directly affect the pharmaceutical demand management performance. Thus, these elements would become clear during the research process, with continuous comparisons between the case evidences and the available literature. As a result, the problem of this research will be refined during the study (EISENHART, 1989);
- Research of IT solutions applied to pharmaceutical demand management requires the researcher to place the events in a chronology, to determine their causal connections. By doing so, the case study becomes the initial basis for such causal references (YIN, 2014).

This simple case study involves a producer of generic drugs and his main distributor for the aftermarket. Data collection was obtained through semi-structured interviews application, which was base for Information Technology Framework generation. This research execution was supported by a formal protocol, as recommended by Seuring (2008) for SC researches, and also by Tranfield *et al.* (2003), composed of: (1) plan for literature review; (2) execution of literature research and; (3) results presentation.

The IT framework components and layers were selected based on business needs and on technological similarities, which were put together to address and solve demand management problems, applied to this dyad.

2 SUPPLY CHAIN (SC) AND SUPPLY CHAIN MANAGEMENT (SCM)

Lambert and Cooper (2000) consider the supply chain as a network of companies with multiple business activities and relationships, in which each link provides facilities so that the product gains value along the chain. Supply chain management (SCM), however can be defined as the integration of business processes upstream and downstream along the chain that produce value for the end customer (LAMBERT; COOPER, 2000). For the Global Supply Chain Forum (GSCF), SCM is the integration of key business processes of involved partners that provides products, services, and value-added information to customers and other stakeholders (CROXTON *et al*., 2008; LAMBERT; COOPER, 2000; LAMBERT *et al.*, 1998).

For the Council of Supply Chain Management Professionals (2013), SCM encompasses the planning and management of activities related to the purchase and supply goods, as well as processing and logistics management, which includes coordination and collaboration with logistics partners.

2.1 SUPPLY CHAIN DEMAND MANAGEMENT

The supply chain management model proposed by GSCF (Global Supply Chain Forum) comprises eight key processes: (1) managing relationships with customers (CRM - Customer Relationship Management); (2) managing relationships with suppliers (SRM - Supplier Relationship Management); (3) customer service management; (4) demand management; (5) order processing; (6) manufacturing flow management; (7) development and marketing of products; (8) management of returns (LAMBERT *et al.*, 1998; CROXTON *et al.,* 2008).

Croxton *et al.* (2008) argue that the goal with demand management is the quick and correct adaptation of needs from the market, balancing the demand with the operational capacity in the supply chain. Chopra and Meindl (2009) consider that distribution, a component of customer service processes, impacts directly SC competitiveness, especially with respect to costs (which can be 20% higher than the manufacturing costs), and the customer service level. Potvin *et al.* (2006) add routes optimization and transportation schedules as keys to reducing such distribution costs. In addition communication and integration of business processes are affected positively by the use of IT (LAMBERT; COOPER, 2000; MENTZER *et al*., 2001; WANKE, 2010).

Fang *et al*. (2013) indicate three alternatives for improvements in supply chain management: demand variability reduction (LEE *et al*., 2000) supply variability reduction, (ZHANG *et a*l., 2006), and reducing both simultaneously

From the perspective of Croxton *et al.* (2008), there are six main processes related to strategic dimension: determination of objectives and strategies related to demand management, definition of procedures to make estimates, planning, information flows, defining synchronization procedures, development of management systems contingencies, and developing a model of metrics. Also, based on Croxton *et al*. (2008), under the operational aspect are the following processes: obtaining data and information, making estimates, synchronization, reducing variability, providing greater flexibility, and performance measurement.

The creation of demand as well as its attendance are coordinated in order to generate synergy and competitive advantage for organizations (JUTTNER *et al*., 2007; RAINBIRD, 2004; WALTERS, 2008).

Croxton *et al.* (2008) claim that finding ways to reduce demand variability contributes to an increased accuracy of the design, thus reducing costs, while increasing the flexibility helps the SC to respond quickly to internal and external demands.

Also, Simatupang *et al.* (2004) agree that demand management and stock controls processes along Supply Chains should be formal and structured, as basis for decision making and operations within this SC.

Demand variability amplification along the supply chain is known as "bullwhip effect" (BWE), which is responsible for serious inefficiencies in the chain, being subject of study, both academic and also entrepreneurial (KELEPOURIS *et al*., 2008).

Lee *et al.* (2004) complement, indicating that the BWE occurs when purchase orders to suppliers present greater variation that sales of the downstream link (closer to the end customer), causing a distortion in demand, which propagates upstream chain.

As a way to mitigate these variations impacts, many companies adopt inventories maintenance solution (LIN; LIN, 2006; Lee *et al*., 2004).

Croson and Donohue (2003) conducted experiments sharing data from point of sales and inventory information among participants and, consequently, achieved a BWE reduction.

Kelepouris *et al*. (2008) and Lee *et al*. (2000) cite imprecise demand forecast, low capacity utilization, excess inventory and poor quality of customer service as sources for: (1) increased levels of safety stocks; (2) the need for additional production capacity; (3) increased use of space; (4) additional investment costs.

Lee *et al.* (2004) cite as four major causes of the BWE: incorrect planning and execution of the demand perception; batch orders production; products rationing / shortages;

price variations; and long lead times. Zhang and Zhang (2007) indicate the lack of information sharing as responsible for BWE, and cites as elements of this phenomena mitigation: shared decisions, lead times reductions, and the use of a single customer forecast shared among chain participants.

Kelepouris *et al*. (2008), on the other hand, contend that the modeling of behavioral parameters that determine the replenishment inventory policies of inventory replenishment is a key activity in supply chains.

New technologies, however, allow the sharing of information along the chain, which is one of the main actions to minimize the BWE (Bullwhip Effect), because it enables the visibility of demand, inventory, and the supply chain in different stages (LEE *et al*., 2000). Sanders *et al.* (2011) and Tokar *et al.* (2011) argue that firms participating in a SC need to share information, and collaborate in an integrated manner.

Some authors argue that Information Technology (IT) is one of the enablers for the emergence and establishment of supply chains over the past two decades (HULT *et al*., 2004), not only to support and sharing information, but also to help the coordination of competitive initiatives (WU *et al*., 2006; AUTRY *et al*., 2010; HALL *et al*., 2012; HAZEN; BYRD, 2012).

Among the benefits identified in the literature by the use of IT in SCM, several include: lower costs, reduced TTM (Time to Market) in product development, shorter lead times in the cycle order fulfillment, and greater flexibility and agility in the SC processes (RADJOU, 2003; HULT *et al*., 2004; FAWCETT *et al*., 2008; LAO *et al*., 2010).

3 INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ON SUPPLY CHAIN MANAGEMENT SCM)

Hugos (2011) and Sambharya *et al*. (2005) explain that the appropriate use of IT can increase both the efficiency and the level of customer responsiveness, although the initial capital investment and other IT resources can be, for many small and medium size companies, prohibitive. In this sense, the construction of a digital platform, according to Weill and Ross (2009) and Banker *et al.* (2006), aims the sustainable growth, obtained by the process agility and lean flow from operations.

3.1 CLOUD COMPUTING

The Internet, due to its processing power with low-cost, open technology usage, and low investment in IT infrastructure needs, is widely recognized as a major enabler of business collaboration, allowing agile and flexible solutions (CHEN *et al*., 2007;. LIU; ORBAN, 2008; ASMAD *et al*., 2012).

Armbrust *et al*. (2010) and Buyya *et al*. (2009) argue that, although there are many practical development initiatives of Cloud Computing in industry, little research and academic studies in the context of supply chains were found.

Cloud computing can be defined as a technology that uses a set of virtualized resources, such as software, infrastructure or platform, facilitating connectivity, being dynamically reconfigurable to support multiple levels of organizational requirements, enabling the optimal use of resources (IBM 2009; IBM, 2011; VAQUERO *et al*., 2008, CEGIELSKI *et al*., 2012).

In comparison to traditional computing systems, cloud computing facilitates the scalability of computing power, rapid delivery of solutions, and reduced infrastructure support, with lower costs (IBM, 2011). Additionally, the technology is not limited to a specific supplier or configuration, or even for a particular use. Thus, it can be applied in different contexts, to support members of different organizations, which makes the technology useful for SC collaborative contexts (IBM, 2011).

Ahmad *et al*. (2012) also cite network components reuse as an added benefit, since it simplifies these devices maintenance, reducing operational costs. Autry *et al.* (2010) agree with this, and consider cloud computing as an IT tool that serves as an essential component of technical infrastructure to facilitate communication, coordination and collaboration among the systems of the participating companies of the SC.

One of the main issues to consider in relation to Cloud Computing technology is security, a key element in designing the architecture (IBM, 2011; AHMAD *et al*., 2012). To mitigate these risks, several technology alternative are adopted, like the use of a security certification entity (Trust Provider), model proposed by Ahmad *et al.* (2012); or a layered based infrastructure, such as the IBM model, called the Common Cloud Management Platform (IBM, 2011).

Ahmad *et al*. (2012) explain that cloud computing environments can be implemented in various models: SaaS (Software as a Service); PaaS (Platform as a Service); IaaS (Infrastructure as a Service); CaaS (Communications as Service): MaaS (Monitoring as a Service).

3.2 APPLICATION ARCHITECTURE

Recent studies suggest that electronic supply chain systems (eSCMS) can facilitate the development of more efficient SC (BOYER; HULT, 2005; GIMENEZ; LOURENCO, 2008; WANG *et al*., 2006).

Several exploratory studies have been done with the focus on using IT to integrate the SC (NARASIMHAN *et al*., 2008). Banker *et al*. (2006), for example, studied the effects of mediating processes IT Just-in-Time (JIT) as well as in other activities involving interactions with providers.

One of the technical architecture evaluated in this case study was the CORBA (Common Object Request Broker Architecture), sourced by OMG (Object Management Group).

This architecture is composed by a system of objects, which is defined by OMG (2008) as "a set of objects that isolates the service requesters (clients) of the suppliers of these services, a well-designed interface encapsulation, isolating those customers with specific aspects related to implementations of these services, as representations of data or executable code".

The OMG is an international consortium of companies, universities and research institutions in the field of computing, for setting standards in the area of distributed objects, which allow interoperability and portability of distributed applications, formed in 1989 (BARROS, 2003; OMG, 2008, 2012). In 2012, the OMG, based on contributions from its consortium members, including Oracle and SAP, created the CORBA 3.3 specification. (OMG, 2012).

The CORBA model is abstract in the sense of not being directly carried by specific technology. At the same time, a concrete model because it can be added to or removed from parameters that are specific to particular implementations (OMG, 2008, 2012). Therefore, the CORBA object model describes the concepts, which are meaningful to customers, such as object creation and identity, requests and operations, types and signatures. This model then describes the concepts related to the implementations of objects, and concepts such methods, mechanisms, and activation (OMG, 2008, 2012).

3.3 RFID (RADIO FREQUENCY IDENTIFICATION)

Zhu *et al*. (2012) note the radio frequency identification (RFID) as an emerging technology increasingly used in SCM logistic processes, RFID provides accurate and real-time information for producers, suppliers, distributors, and resellers. RFID technology is used for physical distribution and planning, including inventory control (ZHU *et al*., 2012), material handling (HUANG *et al*., 2007), and order processing (PHILIPS; IBM, 2004).

Thiesse *et al.* (2011) clarify that the identification event is done by transponders located on these objects, with no contact access, done via wireless interface between the scanner and the tag antenna. Transponders can be built on different formats, operating under several radio frequencies.

Pramatari (2007) explains that EPC (Electronic Product Code) became the technical foundation for several RFID initiatives, specially for big dealers, as the case of Walmart with Novartis.

Zhu *et al*. (2012) list several potential benefits of the proper use of RFID, including: reduction of time for order fulfillment, increased accuracy of inventory information (which helps in reducing shortages of materials and needs inventory recounting), and technology support programs for rapid response in SCM. Thiesse *et al.* (2011) points out that, although the benefits of the adoption of RFID technology result from the replacement of manual labor, reducing costs, and simplifying monitoring and control activities, the value of the computerization of the process is dependent on the skill and efficiency with which IT can collect, store, and distribute data.

Zhu *et al.* (2012) explain that RFID can be used in logistic processes, in particular, to identify and track the location of containers and shipped items such as books, equipment, and medications, both inside the warehouse and en route.

Martinez-Sala *et al.* (2009) consider RFID technology one of the most effective because it has distinctive features such as multiple simultaneous readings, without signal line, greater memory capacity and robustness, which streamline the process of reading and data collection, with high level of accuracy. Shepard (2005) complements that RFID is operational under harsh environments.

In this sense, Thiesse *et al.* (2011) consider the existence of flexible infrastructure fundamental to be able to integrate, with low cost, a broad number of reader devices.

4 CASE STUDY: BRAZILIAN PHARMACEUTICAL COMPANY

The pharmaceutical company, focus of this study and named here as company A, was established in 2003 and operates in the Brazilian market with a target on the generic drugs market segment, in twelve therapeutic classes: antibiotics, antidepressants, antidiabetics, antihypertensive, anti-lipemic, antihistamines, anti-mycotic, anti-infective, analgesics, anti-inflammatory, glucocorticoid and relaxing mix. The company sells, on its portfolio, 59 medicines. It is a brazilian company, with no international invested capital (BRAINFARMA, 2013).

This drug manufacturer is on the 15th place regarding sold units volume. Between 2005 and 2006, the company had a growth of 56% in revenues, and increase of 50% on sold units. The enterprise has an contractual agreement with an Indian firm, the Ranbaxy Laboratories Ltd, one of the largest generic drugs manufacturers in the world, Finished goods are distributed throughout all the Brazilian territory, being present in major pharmacies and drugstores (BRAINFARMA, 2013).

Because generic drugs are the foundation of the company's product portfolio, and due the fact that products be delivered using the same chain used to personal care market, by specific distributor, it was selected as the focus distributor company for this research, being named here as Company B.

Company B is also a former Brazilian company, was founded in 1976, in Goiás State, and it is present in 97% of the country, being the leader in drug distribution. The company currently holds a 15% share of the domestic distribution market, and has thirteen distribution centers, as well as support from various regional offices (PANARELLO, 2013).

The Company B has, as suppliers, more than 200 national and multinational pharmaceutical companies, with a portfolio of 35 000 clients, representing thousands of points of sale throughout Brazil. The Company B transports daily 1 million units, with deliveries in periods of 24 hours. Since 2009, Company B belongs to a controlled distributor called American Pharma, in conjunction with a German group, called Celesio (PANARELLO, 2013).

The production process for generic drugs in Company A is represented by activities described in Figure 1.

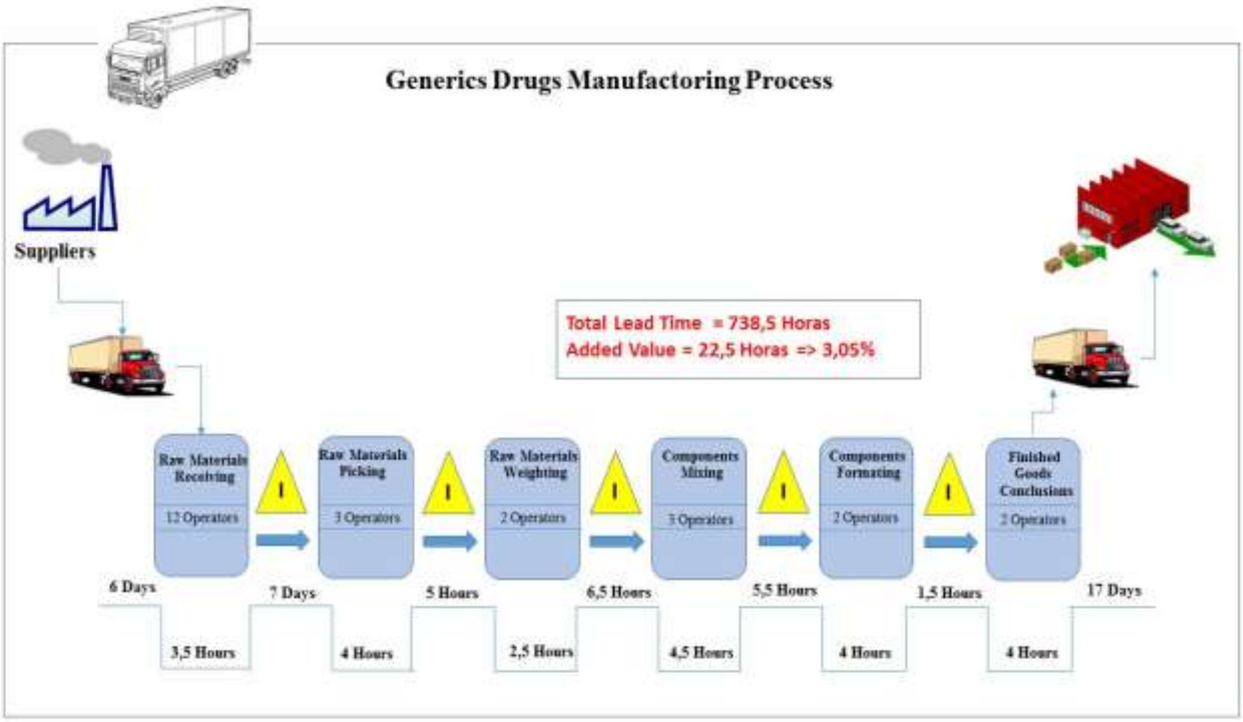

Figure 1 – Company a Manufacturing Process

The drug production process is composed of the following steps:

- Raw Material Reception: done with support of an existing program in the company's ERP (SAP), supported by bar coding reading;
- Raw Materials Picking: Based on the batches production schedule generated in SAP, is created a picking list;
- Raw Materials weighing: which is done on electronic machines, linking each production order with raw material consumed batch;
- Component Homogenization: which takes place by means of mixer process, under reactors. These component batches are associated with a specific production order, for which both the production and consumption should be reported;
- Components formatting: which corresponds to the blistering, also done automatically and without manual contact;
- Finished Goods Conclusion: which corresponds to the warehousing of the finished goods.

To define which IT components would better support this dyad processes, was applied a structured survey, composed of seventeen questions, classified into three groups, and described on Table 1.

TARGET		QUESTIONS	TOPICS RELATED TO LITERATURE REVIEW
Understand how is the process of strategic alignment between the manufacturer and distributor of generic drugs	1	What is the strategy of the manufacturer with respect to drug distributors?	- Supply Chains; - Capacity Management, constraints and market characteristics; - Executive Management Involvement; - Alignemnt Level between manufacturer and distributor; - Sales Plan Development.
	2	How are made sales forecasts to distributors?	
	3	Who are the stakeholders (organizational areas / positions) in sales forecasting process for generic drugs?	
Understand how is the process of demand planning between generic drugs manufacturer and its distributor	4	What activities are carried out in the sales planning process for generic drugs?	- Supply Chains; - Capacity Management, constraints and market characteristics; - Executive Management Involvement; - Alignemnt Level between manufacturer and distributor; - Sales Plan Development. - Demand Management; - Demand Variability; - Information Technology applied to Supply Chain Management.
	5	What information is shared? How are they shared? Is there any systemic integration? Are there any IT tools and solutions involved?	
	6	When demand management plannig for generic drugs is done?	
	7	How often demand estimates for generic drugs are reviewed?	
	8	How the generic drugs demand planning is formalized and shared?	
	9	What are the main identified problems in the demand management for generic drugs?	
	10	What tools / IT solutions could be applied to address problems encountered in managing the demand planning of generic drugs?	

Table 1 – Applied Survey

TARGET		QUESTIONS	TOPICS RELATED TO LITERATURE REVIEW
Understand how is the process of demand attendance between generic drugs manufacturer and its distributor	11	How is the process of generic drugs demand attendance?	- Supply Chains; - Capacity Management, constraints and market characteristics; - Executive Management Involvement; - Alignemnt Level between manufacturer and distributor; - Business Practices applied on Supply Chain Management; - Demand Management; - Demand Variability; - Information Technology applied to Supply Chain Management; - Supply Chain Performance Measurements.
	12	Are there alignment meetings with distributors? In what situations? How often?	
	13	Are there performance indicators? If so, what are they?	
	14	Which IT elements are present in generic drugs demand attendance?	
	15	What are the main problems in demand attendance for generic drugs?	
	16	Which IT tools can be used to minimize / resolve detected problems?	
	17	What is the importance of the IT use in the relationship between generic drugs manufacturer and distributor?	

Table 1 – Applied Survey (continued)

Surveys were sent to 32 participants, both from Company A and B, involving participation of IT staff (7 surveys) and of business areas (internal processes (3), finance (2), production planning (3), logistics (10), marketing (5), purchasing (2)), during October of 2012 and January of 2013. Respondents of the survey considered were Directors, Managers and Coordinators, all owning operational and strategic information about demand management processes. From 32 questionnaires sent, were returned 12 (37,5%). Additional meetings with interviewees was required, mainly to clarify technical aspects of the questions.

4.1 CASE STUDY RESULTS

Of the total respondents, seven (58.3%) stated that the strategy, as both for the manufacturer and the distributor, rely in the integration of the operations, especially for the demand forecast processes, in order to improve this forecast assertiveness.

Among the responses, was mentioned large distortion between the actual demand and production plans, since about 30% of the inventories of manufacturers are with short shelf life (less than six months to expire).

Additionally, was identified frequent distributor requests for sales estimates changes (10 respondents, 83.3%), as a result of demand change from the pharmacies and also due to the manufacturer constraints, caused for lack of finished goods, and also by production constraints.

Service level was also one of the impacted results, as nine respondents cited complaints as lack of shared information (75%), six cited logistical problems as the main causes of the complaints (50%). Among the identified logistical problems, delays in delivery were the most significant (4 cited this element, which corresponds to 33% of the total), followed by incomplete applications (3 respondents, 25%), and incorrect product delivered (1 respondent, 8.3 %).

Question 10 seeks to identify the main problems identified in the demand planning processes. As it is an open question, was accepted more than one answer per respondent, as stated: delays (10 of 12), rework (9 of 12), lack of relevant information (8 of 12), lack of knowledge (8 of 12), many manual tasks (7 of 12), and incorrect information (3 of 12).

Regarding delays, main causes are, according to seven respondents (58.3%), the time required to obtain the necessary data, which requires the participation of several areas. Related to rework, respondents pointed out the poor quality of information (3 respondents, 25%), the constant changes in the plan (four respondents, 33.3%), and lack of support systems (2 respondents, 16.7%) as key causes for this rework.

The lack of information is seen as the third leading cause (8 respondents, with 66.7%), along with the lack of knowledge of the people in the business areas (also cited by 8 respondents). In this sense, the assumption is that lack of knowledge is caused by high employees turnover, particularly in the areas of logistics, sales and production of the manufacturing company (mentioned by 4 respondents, or 33.3%).

In the case of excessive manual activities, seven respondents (58.3%) cite many manual tasks to prepare the demand forecast. In addition, five respondents (41.6%) cite lack or inadequacy of information systems as its cause.

Lastly, incorrect information was cited by three respondents (25%), being appointed by them as probable cause the fact that data is stored in several sources, like department spreadsheets, causing information distortions.

Based on the survey results, the benefits cited as results of information technology application are: better stock visibility (7 of 12), forecast demand updated in on-line basis (7 of 12), centralized application (6 of 12), automation of planning processes (5 of 12), faster IT solution deployment (5 of 12).

So, based on the survey findings, and founded on the existing literature, was proposed an IT framework to be applied to this case.

5 IT FRAMEWORK FOR SCM DEMAND MANAGEMENT

An adherent IT solution to SC demand management business processes is proposed, as an IT framework, which includes an infrastructure communication layer, being addressed with cloud computing paradigm; an application layer, fulfilled by CORBA (Common Object Request Broker Architecture) and CCM (CORBA Component Model); and a logistics operational layer, supplied by RFID technology, as illustrated in Figure 2.

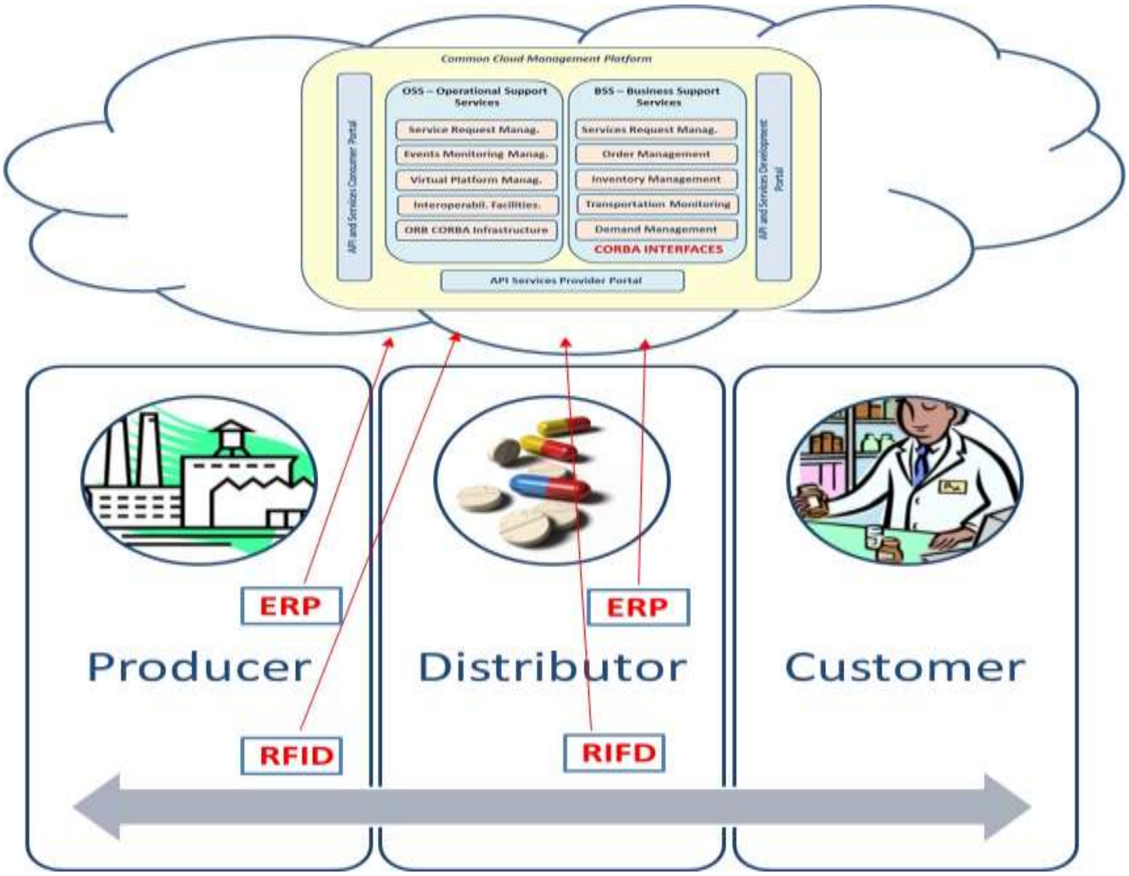

Figure 2 – IT Framework for Supply Chain Demand Managment

The proposed IT framework aims to support the processes of strategic and operational management of demand, proposed by Croxton *et al.* (2008). This framework considers several elements of distinctive competitive advantage: agility, quality, and reliability. Additionally, while addressing IT solutions usage to reach identified key elements: the need for accurate information, as data shared with partners in this SC. Additionally, these IT elements are addressed to solve the major issues identified in the present case study, as shown in Table 2.

IT Frameworks elements	**SCM Benefits**	**Authors**	**Demand Management Related Processes (Croxton et al. 2008)**	**Application on Identified Case Study Issues**
IT Infrastructure – Cloud computing	Scalability of IT capacity, flexibility, lowers costs.	Cegielski *et al.* (2012); Boyer e Olson (2002); Gimenez e Lourenco (2008); Olson e Boyer (2005); Wang *et al.* (2006).	Collect data, preparation of estimates, synchronization, reduced variability and increased flexibility.	Delays, unavailability of information.
Applications – Corba / CCM	Integration, collaboration, information sharing, inventory levels lower, shorter cycle.	Lee *et al.* (2002), Hendricks *et al.* (2007), Moller (2002), Weston (2003), Ndede-Amadi (2004); Loh *et al.* (2006).	Collect data, preparation of estimates, synchronization, reduced variability and increased flexibility.	Lack of integration between the manufacturer and ERP systems distributor.
Operations – RFID	Sharing and exchange of information, reduced stock shortage, increase in the level of services.	Lee *et al.* (1997); Saygin *et al*. (2007); Mills-Harris *et al.* (2007); Hardgrave *et al*. (2005); Lee *et al*. (2004); Sarac *et al.* (2010).	Collect data, preparation of estimates, synchronization, reduced variability and increased flexibility.	Delays, requests forwarded with errors, mistakes and discrepancies in inventories.
Operations – OEE	Higher profitability, better quality of machine capacity information, lower production times, reduced TTM (delivery time).	Hansen (2001); Bamber *et al.* (2003); Braglia *et al*. (2009); De Ron e Rooda (2005).	Collect data, preparation of estimates, synchronization, reduced variability and increased flexibility.	Production delays, delays in delivery time, materials with short shelf life.
Performance System – Model of Slack and Lewis	Increased process maturity level, higher level of	Simatupang e Sridharan (2004); Lockami e	Determine the objectives and demand management	Production delays, delays in delivery time, materials

	service, lower operating costs.	McCormack (2004); Cohen e Roussel (2004); Trkman *et al.* (2007); Cooper *et al.* (2007); Beamon (1999); Lee *et al.* (2000); Mentzer (2001).	strategies, development of contingency system, development of performance metrics framework.	with short shelf life.

Table 2 – IT Framework Elements for the Case Study

Thus, through the IT architecture, aimed supply is a feasible systemic alternative, readily applicable and reconciling technology with performance objectives, promoting agility, reliability, coordination and collaboration, with lower costs among the SC members (OLSON; BOYER, 2005; WANG *et al*., 2006). Under the applications dimension, one recommendation is to have a scalable solution that is independent of technology and can, with little investment and time, connect enterprise management systems of the members of the chain, in order to consolidate important information for operations of the SC. This need for greater integration and competitiveness in SC makes the traditional suppliers of enterprise resource planning solutions (ERP) develop additional Web-based modules for SCM applications and, in order to support inter-organizational collaboration, the authors appoint ERP-II (MOLLER, 2005). Weston (2003) considers that ERP-II contains the entire scope of ERP, plus the existing functionality in CRM or SCM. Moller (2005) also considers modular ERP-II, with e-business and collaboration in SC. Thus, ERP-II aims to integrate the SC through inter-organizational collaboration. Such applications present such benefits as shorter cycle times and lower inventory levels, thus contributing to lower operating costs (NDEDE-AMADI, 2004).

On the operational side, the recommendation of using both RFID (Radio Frequency Identification) for immediate measurement of inventories and goods in transit. This technology is applicable to hostile environments and allows data collection without manual intervention with great precision. Saygin *et al.* (2007) consider that the implementation of RFID technology increases visibility throughout SCM, especially covering a space between the shop floor operations and upper level processes. According to the Materials Handling Management (2005), with the adoption of RFID, Walmart experienced a 16% reduction in absences of materials in stock after this implementation. Sarac *et al.* (2010) concluded that the greatest potential benefits of using RFID in SCM are obtained when technology is applied to solve problems of inaccuracy, inventory replenishment policies, and minimization of the "bullwhip effect," these also being the main areas of research. Thus, the choice of RFID technology to support the processes of demand management in supply chains is relevant to supply chain field of research.

5.1 IT COMMUNICATION INFRASTRUCTURE LAYER FOR SCM

Cegielski *et al.* (2012) argue that cloud computing technology has applicability in SCM for the advantage of flexibility that technology offers. Therefore, flexibility is considered a key competence of SCM (SWAFFORD *et al*., 2006). Byrd and Turner (2000) are more specific with respect to flexibility, defining it in terms of compatibility, being "the ability to share information between any types of technology platforms."

In this work, IBM's model will be used, called CCMP – Common Cloud Management Platform (IBM, 2011). The choice of this architecture is based on the following criteria: 1. Possibility of integration with CORBA/CCM models (chosen as application development infrastructure SCM), 2. Be an open solution, 3. Implementation of additional services, 4. Offer scalability, security, persistence and high degree of integration in heterogeneous environments. In this architecture, according to IBM (2011), the component operational support services (OSS) defines the set of management systems that can be used by developers of cloud services. Among these areas of management are the managing of incidents and problems, provisioning, monitoring and event management, and asset management and IT licenses, among others.

Additionally, another important component consists of the business support services (BSS), which IBM (2011) defines as the capabilities required to deliver business management to one or more cloud services. For example, in an infrastructure as a service (IaaS) environment, the component responsible for service charging the BSS can be used to perform the billing of consumption of machine resources, such as virtual memory (IBM, 2011). Thus, in a SaaS model, the SCM application can be made available for collaboration, integration, and data sharing between the members; for the purposes of this paper, the architecture used CORBA/CCM as a reference model. The CCMP model is shown in Figure 3.

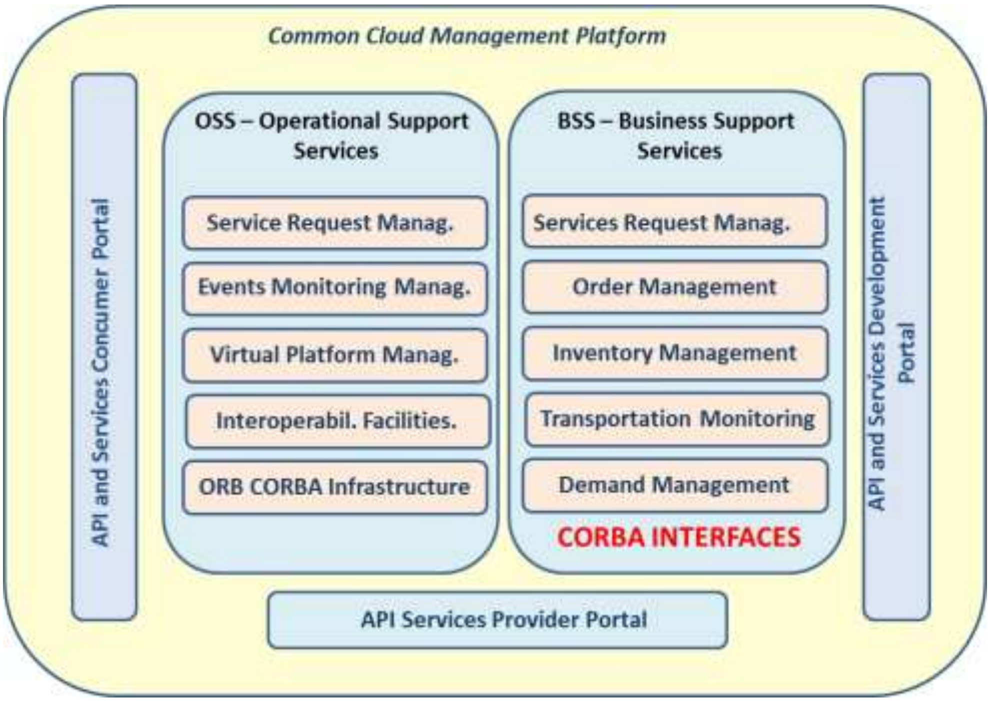

Figure 3 – CCMP Architecture
Source: IBM Adapted (2011)

As both the model CCMP for Cloud Computing and the model CORBA/CCM applications are based on layers, separating aspects of infrastructure on the application can be combined to generate a systemic solution, backed by support services operating in distributed environment. From this perspective, the common facilities of the CORBA model, as well as the properties of business objects, can be managed within the scale of OSS (Operational Support Services), whereas the features relating to the implementation of the CORBA model can be made available within the dimensions of BSS. For this paper's purpose, the CCMP model is adopted as a solution for communication infrastructure layer, based on SaaS model for information system within SCM, and modality IaaS services for security, persistence, transaction control, and monitoring, among others. Its solution is feasible and suitable as a component of the IT model for supporting the processes of demand management in the SC of the pharmaceutical industry. Additionally, because it is not directly linked to the manufacturing process of the drug, there is no need for qualifying infrastructure or system validation by ANVISA (Associação Nacional de Vigilância Sanitária), a necessary condition for quality assurance within the processing cycle of the product.

5.2 IT APPLICATION LAYER FOR SCM

The structure lies in the CORBA Reference Model, and defined in Architecture OMA (Object Management Architecture) from OMG (SOLEY; STONE, 1995), consisting of layers called the objects (ORB), Object Services, common facilities, and application objects.

The CORBA architecture allows applications to make requests to objects in a transparent and independent of language, operating system, hardware, or consideration of location (MASTELARI, 2004).

Thus, according to OMG (2008), the ORB is the basic mechanism by which objects transparently make requests and receive responses from other systems located on the same server, or outside the network.

The OMG specification originated the BOCA (Common Business Object Architecture), aiming to support the construction of an infrastructure layer on the CORBA model, configurable environment. Based on BOCA, and in order to provide additional functionality for the development of SI in distributed environments, the OMG released the CCM (CORBA Component Model). CCM complements the CORBA object model by defining services for the implementation, management and configuration of components (OMG, 2002). The CORBA component model is an extension and specialization (target-type) of the object model. In addition, the CCM (CORBA Component Model) supports the division of the life cycle of components in two mutually exclusive phases, phase configuration and operation (OMG, 2002a).

5.3 RFID TECHNOLOGY TO SUPPORT LOGISTICS WITHIN SCM

For the purposes of this paper, RFID technology is considered part of the IT framework for SC demand management within the pharmaceutical industry, being considered for both the control of inventory levels in an automated manner and for monitoring of in-transit medicines via road transport. Likewise, these data can be used to form ATP (Available to Promise) information, increasing accuracy and agility in the demand planning process, with real-time information. Thus, the inventory information of these medications can be obtained automatically and immediately. As a result, efforts for obtaining information and rework are eliminated, making the processes of planning and meeting demand leaner.

6 CONCLUSIONS

In this work, the concept of SC proposed by Lambert, Cooper, and Pagh (1998) was adopted, which focuses on a specific company and comprises all the organizations with whom this company has direct and indirect relations. Additionally, this work focused on the model of demand management by Croxton *et al.* (2008), particularizing it to the producer-distributor dyad in the pharmaceutical chain.

One of the assumptions of this study was that, in a supply chain, especially in the pharmaceutical industry, the sharing of information was a condition for better performance, which translates into greater flexibility and reliability, lower costs obtained from reliable estimates, lower inventory requirements, and increased reliability of deliveries. It was found that information sharing, boosted by the application of information technology, achieves these because of collaboration.

Another assumption was that, if the processes of the partners involved were integrated, there would be better performance. It was found that by means of tools and solutions, such as RFID and information systems that enable simpler integrations, this goal can be achieved with lower costs, generating optimization and quality enhancement for greater reliability, and accessibility and availability of information.

Thus, the purpose of this paper was, based on the literature: identify IT requirements that must be met for optimization of the demand management processes. Based on these requirements, we applied questionnaires and interviews, and it was concluded, based on the respondents' answers, that there is a positive correlation between the findings in the literature and the answers of respondents.

After the research was conducted, we see that the designed framework of IT consists of two elements. One relates to infrastructure, to enable inter-operability of data and systems from different SC partners. For this purpose, infrastructure virtualization environments (cloud computing) was considered as a solution. The choice is based on the fact that companies participating in the SC have IT environments tailored to their needs, and the choice would be a time investment and the development of a particular solution for each integration partner. Thus, the technology showed mature and stable support of the requirements identified. The CCMP (Common Cloud Management Platform) model was adopted for the purpose of this paper.

For the second component of the information system, the CORBA/CCM reference model was adopted, under which applications can be built. The choice of this technology was due to the fact that this displays independence from the computing environment and has the concept of layers and shared services, isolating the application layer specifics for support services. In addition, it adheres to different patterns of existing systems, and is convergent with the CCMP model.

Thus, the proposed framework can be applied for other SC industries, as well as other relationships within the SC studied.

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