SUPPLY CHAIN AUTOMATION IN COLOMBIA: LITERATURE REVIEW

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ABSTRACT

THE EMERGENCE OF INCREASINGLY RAPID TECHNOLOGICAL ADVANCES, THE COVERAGE OF INFORMATION AT ALL LEVELS, INDUSTRIAL AND CONSUMER PRODUCTS CREATING SUBSTITUTES FOR ANY TYPE OF NEED, AMONG OTHER CHANGES IN THE WORLD OF TODAY, MAKES IT NECESSARY THAT ANY COMPANY SEEKING TO STANDOUT OR REMAIN IN THE ACTUAL MARKET SHOULD BE UPDATED WITH TECHNOLOGY TRENDS IN ITS INDUSTRY AND ESPECIALLY FOCUS EFFORTS TO SATISFY CUSTOMERS WHO ARE MORE INCREASINGLY INFORMED AND SEEKING SOLUTIONS BEYOND OBTAINING A PRODUCT.

IN THIS LITERATURE REVIEW, WE TAKE THE MAIN CONCEPTS DEVELOPED BY THE AUTHORS ABOUT THE IMPLEMENTATION OF AUTOMATION TECHNOLOGIES IN THE SUPPLY CHAIN AND MAKE A CLASSIFICATION ACCORDING TO THE LOGISTIC PROCESS IN WHICH THEY CAN BE APPLIED; ITS MAIN CHARACTERISTICS AND HISTORICAL EVOLUTION OF THESE CONCEPTS AND TECHNOLOGIES HAVE HAD IN RECENT YEARS.

AFTER PERFORMING THIS CLASSIFICATION, WE REVIEWED THE CURRENTLY USED TECHNOLOGIES IN THE INDUSTRY IN COLOMBIA AND MAKES RECOMMENDATIONS ON GLOBAL TRENDS THAT CAN BE IMPLEMENTED BY THE COLOMBIAN INDUSTRY.

KEY WORDS

Automation, Supply Chain Management, Information Technology, Logistic Processes

INTRODUCTION

In the literature review we found that automating logistics processes of organizations has been an important link for growth in the market and making a difference in the service that accompanies the sale of any product. Colombian industry is still in the learning process, but gradually different sectors in the economy have understood the importance of optimizing their processes throughout technology and have adopted more flexible positions before implementation. (PORTAFOLIO, 2013)

The supply chain is the set of operations performed to meet the requirements of customers of a product or service (Casati, Dayal, & Shan, 2001), and is altogether a business should see its logistical process and likewise design strategies and targets to ensure that this integration is the answer the company's mission (Fawcett & Magnam, 2002).

The first industrial revolution was the mechanization of production using water and steam power; it was followed by the second industrial revolution which introduced mass production with the help of electric power, followed by the digital revolution, the use of electronics and IT to further automate production. (Cutler, 2013)

In the last century the main aim of all industrial developments has been the automation of processes, from the automation of the production line at the beginning of the century, to support systems decision making and integration of existing information integration, (Viswanadham, 2002), the study and practice of physical distribution and logistics emerged in the 1960s and 1970s, when the costs of worldwide logistics process varied between 15 and 25% of gross domestic product of industrialized nations. (Ballou, 2007). It was an immediate need for further industry growth in this field and embarks on a path toward improving processes, unifying and find areas through the planning and execution of logistics activities, the level of costs and services that help you stay in the market.

In recent decades, has increased significantly the need to optimize costs and response times through specifically logistics processes, ranging from the supply to reverse logistics , both type of companies goods producing and services supplying in order to stay in the market and achieve real competitive advantage.

During the 2000s, the systems approach has been used to provide a framework for understanding SCM. Current interest in differing units of analyses continues as SCM research aims to provide analytical depth and implementation models for SCM practice (Gundlach, Bolumole, Eltantawy, & Frankel, 2006). Apart from differing units of analysis, SCM research has encompassed a range of analysis levels including tactical, operational, strategy and strategic orientations.

In response to these needs, initiates the generation of models that integrate the Supply Chain Management, the goal of integration and collaboration along the supply chain is to synchronized with demand, this is due to the approach of optimizing individual processes does not necessarily lead to the optimization of the chain as a global concept. (Nickl, 2005).

The challenge on global supply chain level becomes integrating all elements of a supply chain. The material flow, the information flow, and the value flow need to be synchronized (Ehm, Ponsignon, & Kaufmann, 2011). For an automation looking company, the value flow managed in all aspects is one of the key enablers in order to always fulfill custom and financing requirements and for taking full benefit of the globalization.

Logistics processes automation uses control systems and informatics technology to reduce human intervention in a process. An automatized supply chain increases production, reduce costs and generate large benefits to minimize risk to the operator. (García M. N., 2012) They offer full control of the process, which means product traceability at any time, with data points as location, weight, dimension, input, output, and above all, accurate and detailed control of the inventory at any time, among other details.

Colombian industry has seen the need to take these trends and have slowly come to understand the importance of implementing technological advances, both in software and hardware; with these advances de SC may provide the market infrastructure, from offering specific solutions to provide comprehensive services that meet the expectations of its customers. And most importantly, this allows organizations to consolidate a more efficient use of infrastructure and human resources and the creation of value in their processes (PORTAFOLIO, 2013).

The lack of information systems and methodology to adequately assign the right transport mode and storage the products makes operating expenses are increased between 10% and 30% per year in Colombia (García P. , 2013), that's why in the last few years, the Colombian industries adopted the global applied technologies, systems and models for automation of all the administrative, productive and provider/customer relationship processes.

Many organizations became early adopters, while other postponed implementation, to allow new system to further mature. (Fernandez, 2004). As these organizations ready themselves for new systems, they might benefit from lessons learned by early adopters.

The logistics went from being a storage and distribution concept to a transversal strategy that touches all areas of the company (Jin, 2013), for that reason, companies have been more technical your collection points to be more competitive in the global market.

This trend has been recorded since about five years now, when it has presented a change of mentality of entrepreneurs who saw them modernize this area brought a significant impact on their organizations (Lydon, 2011).

So they have made several changes to implement in their facilities layout designs, which address how to locate the goods in a distribution center based on the behavior of the movement thereof (Worker, 2010).

They went from having a human resource to implement trucks carrying conveyor belts for this purpose and are now palletized deliveries to ride and unload goods. In transport, they have been concerned with improving the loading of trucks by technologies that enable them to measure the cubic space used in the vehicle (Heinze, 2006). They are also using route optimization models in delivery of goods, enabling the design of truck loading plan.

Also been using satellite tracking technology for the vehicles that allows them to calculate fuel consumption and identify location to find high-risk areas , therefore , the customer can check the status of your order in real time (Bajaj, Ranaweera, & Agrawal, 2002).

This allowed them to have a high quality system with intelligent integrated processes, right technology, where information flows in real time and there is visibility across the supply chain logistics provider with extensive expertise and coverage.

With all these elements, companies can improve the terms of response between 5 and 25 percent, which translates into savings of time and money (Kärkkäinen, 2003).

Similarly, a warehouse automation process can be reduced by 25 percent maintenance costs related to inventory; compliance increases orders by 76 percent with the same staff, due to productivity activities. (Lee, 2002)

These also reduced, by 64 percent, the time of execution of orders and the same percentage improvement in the ability to meet the specific requirements of customers. (Piramuthu, 2005)

The efficiency plays a key role in the logistics of distribution, therefore, the information and communication technologies that generate visibility of information about product movement and availability, as data synchronization processes are the key to deal with the quality and speed required demand increasingly difficult to determine (Tajima, 2013).

Likewise, the use of identification technologies such as bar codes, are important to know what happens to the property in each point of the supply chain.

The latest automation supply chain tools help companies avoid problems, or deal with them quickly if they do occur, to minimize damage to their brands. (Anderson, 2009)

By automation system facilitates storage and transport and centralized overall control of the processes, achieving a higher efficiency in the production of business, reducing production costs and profiting on a significant increase in productivity. Also, by implementing security systems reduce the risk of accidents and failures in the chain systems.

Most industrial processes are highly technical and complex logistical elements with increasingly high requirements arise technological options market seeking greater efficiency at lower cost.

It can be said that the elements of the supply chain and logistics process are pervaded, to a greater or lesser extent, by technology and high degree of automation and systematized tools (Power, 2005).

Automation is not a momentary trend, not justified automate for automation. There are different automation levels that give the opportunity to harness a sustainable plan for improvement. Automate is in many cases a necessity, but first requires a serious study of the process in which the details are considered and analyzed the largest number of possibilities from the standpoint of technical and economic feasibility of defining and as the degree to which it must be implemented. (Chan & Chan, 2005)

Table 1 shows the main areas in which those companies are investing to create added value through automation and technological implementation. (PricewaterhouseCoopers LLP, 2013).

Table 1. Leaders are investing in a number of differentiating practices

Supply chain value driver	Top three differentiating practices of Leaders
Maximum delivery performance	1. Collaboration with key customers on planning (e.g., effective forecasting) 2. End-to-end supply chain planning and visibility 3. Vendor-managed-inventory direct-replenishment model
Minimized costs	1. Best-cost country sourcing 2. Differentiated order-to-delivery time 3. Differentiated service level, including potential reduction
Maximum volume flexibility and responsiveness	1. Internal capacity flexibility 80%-120% 2. Flexible shift models/payment structure 3. Regional supply chain set-up
Minimized risks	1. Multiplication of sources and sole-sourcing avoidance 2. Regular review of suppliers' financial risk and mitigation through risk-sharing partnerships 3. Visibility and regular monitoring of main suppliers' operational indicators

Complexity management	1. Development of multi-skilled employees to cope with complexity 2. Late-stage product customization 3. Use of distributors and other channel partners
Sustainability	1. Agreement with supply chain partners to adhere to highest ethical standards 2. Responsible supply chain partner footprint and procurement framework 3. Internal carbon footprint optimization and improvement
Tax optimization and efficiency	1. Manufacturing and assembly optimization (toll manufacturing) 2. Localization of inventory ownership in tax-efficient countries 3. Localization of procurement organization in tax-efficient countries (e.g., Singapore, Switzerland, Cayman Islands)

Source: PwC, *Global Supply Chain Survey 2013*

Unquestionably automating supply chain represents a significant change for the company, which brings multiple benefits have been analyzed by experts in the field.

Following are some of the benefits to which we referred to earlier (Zonalogística, 2013):

- Automated load during the processes related to it. The load can be labeled enters barcode to be examined and identified, then are moved on conveyors and automated cranes to be located at the place assigned by the system.

- Automated extraction of products for enlistment orders. After receiving the order, the computer system located articles and take the place in which they are located.

- Automated process of shipment. Mix the knowledge of all orders placed in the automation system and assigns the merchandise in shipping units.

1. METHODS AND RESOURCES

A search in the Emerald, IEEE Explore, ProQuest and Ebrary databases and specialized magazines Revista de Logística and Zona Logística, was performed in November 2013. All papers containing the terms ‘Supply Chain’, ‘Automation’, ‘Logistics Processes’ in the title or abstract were identified. The abstracts of these

studies (n = 65) were then inspected to ascertain whether they contained information about Supply Chain Automation.

The following information was gathered: the trending technologies identified by logistic process, the correlation between the technologies and their implications in processes efficiency and costs.

The main objective of this review is limited to a cross-section of the literature in Supply Chain Automation; and does not, attempt to be a deep study of the complete research and investigation on this area, but a compilation of the most specific, trending and applicable works.

2. ANALISYS AND RESULTS

According to professionals, a complete system of logistics automation significantly reduces the amount of labor. (Zonalogística, 2013).

Industry is on the threshold of the fourth industrial revolution. Driven by the Internet, the real and virtual worlds are growing closer and closer together. In the becoming years, the goods and services production will be conducted by the increasingly personalization of those, with the conditional to provide an extremely flexible and efficient production system, the large integration of informed and demanding customers and business providers in business and value-added processes, and the linking of production and high-quality services leading to the called hybrid products. (Cutler, 2013)

Current key trends in logistics for application in the near future include e-business supported supply chain management (Skoett-Larsen, 2000). Information technology has helped the industry to improve it responsiveness to customers (Auramo, Kauremaa, & Tanskanen, 2005).

Most of the authors agreed describing to the ERP systems, as the larger advance in technology of information for the supply chain automation.

The concept was introduced in the 1990s by Gartner as an evolution of "Planning Resources" or MRPII, the name of the previous group of applications that companies use to manage information throughout the company and its operations. (Pairat & Jungthirapanich, 2005)

This software has its beginning in the 1950s and 1960s with the development of processors and applications to manage inventory and develop plans Material Requirements (MRP). The primary functions were the foundation upon which additional tasks were added: control of production and purchasing, planning, finance and costs, which make up the group of integrated multi - functional applications (Gibson, Holland, & Light, 1999). ERP is a new name that shows the continued

development of MRP and MRPII in a technology that addresses all processes and includes issues such as customer relationship management, after-sales services and guarantees use, distribution planning, data collection production, management of supplier relationships, online collaboration, e-commerce and more. (Leopoulos, Kirytopoulos, & Voulgaridou, 2005)

To define an ERP system should be aware that the software is built around a single management system relational database with analytical tools and a management information system. (Shuai, Su, & Yang, 2007). ERP versions offer a variety of user interfaces, access control based on user roles and high security and protection of information and easy integration, with common tools and commercial business.

It is worth noting that the term is being applied to ERP application sets out the manufacturing market. Service providers, hospitals, offices and other general business license can now comprehensive integrated software packages that are marketed as ERP solutions. (Ge, Wenge, & Tianyong, 2006)

Taking the ERP systems such as the overall framework of automating supply chain, we can find other technologies, software and systems applied to macro processes on supply chain, which complement and make applicable ERP systems, depending on the type of organization and production system.

In order to further develop understanding the underlying mechanism to how automation investment benefits supply chain management and as a result of this literature review, we classified the most common and trending concepts in Information Technology applied to the main macro logistics processes, as we present on the following table:

Table 2. IT Systems per Supply Chain Process

LOGISTIC PROCESS	TECHNOLOGY	DEFINITION	AUTHORS
PLANNING	Advanced Planning and Scheduling (APS)	Advanced planning and scheduling (APS) is a type of system that tracks costs based on the activities that are responsible for driving costs in the production of manufactured goods. An APS allocates raw materials and production capacity optimally to balance demand and plant capacity.	. (Chen & Chen, 2002)
			(Shan, 2010)
PROCUREMENT	Vendor Managed Inventory (VMI)	The manufacturer receives electronic data (usually via EDI or the internet) that tells him the distributor's sales and stock levels. The manufacturer can view every item that the distributor carriers as well as true point of sale data. The manufacturer is responsible for creating and maintaining the inventory plan. Under VMI, the manufacturer generates the order, not the distributor. VMI does not change the "ownership" of inventory. It remains as it did prior to VMI.	(Weiguo & Xue, 2011)
			(Suo, Wang, & Jin, 2004)
			(Wang & Yu, 2009)
	Collaborative Planning, Forecasting and Replenishment (CPFR)	Collaborative Planning, Forecasting and Replenishment (CFPR) is a business model that takes a holistic approach to supply chain management and combines the intelligence of multiple trading partners in planning and fulfilling customer demand by using common metrics, language and firm agreements to improve efficiency for all participants. CFPR links sales and marketing best practices – category management, supply chain planning and execution processes to increase availability while reducing inventory, merchandizing, transportation and logistics costs.	(Yaxin, Xuejun, & Zhuojun, 2007)

	E-Procurement	In simplest terms, electronic procurement defines the automation of an organization's procurement processes using web-based applications. Unlike enterprise resource planning (ERP) systems that enable businesses to automate their internal processes, e-procurement enables widely dispersed buyers and suppliers to come together, interact, and execute purchase transactions directly over the Internet.	(Chang, 2008)
PRODUCTION	Master Production Schedule (MPS)	A Master Production Schedule is a Schedule of the completions of the end items and these completions are very much planned in nature. Master production schedule acts as a very distinct and important linkage between the planning processes. With the help of this schedule, one can know the requirements for the individual end items by date and quantity. In companies, MPS are generally produced in order to know the number of each product that is to be made over some planning horizon. This schedule forms a very unique part of the company's sales program which deals with the planned response to the demands of the market.A master production schedule is also in management language referred to as the master of all the schedules as this schedule provides the production, planning, purchasing & top management, the most needed information required for planning and control of the whole manufacturing process or the operation.	(Arbon, Mally, Osborne, Riethmeier, & Tharrett, 1994) (Shujuan, Yan , & Yong, 2006)
	Material Requirements Planning (MRP)	Material requirements planning (MRP) is a type of planning focused on the management of processes in manufacturing industries. MRP looks at the availability of materials for production and other related metrics.	(Kim & Funk, 1990) (Orlicky, 2002) (Xinjian & Qihua, 2009)

	Manufacturing Resource Planning (MRP-II)	Successor to the material requirements planning (MRP), it integrates planning of all aspects (not just production) of a manufacturing firm. MRP-II includes functions such as business planning, production planning and scheduling, capacity requirement planning, job costing,	(Jiang & Han, 2009)
			(Leng, 2005)
			(Frew, 2006)
DELIVERY	Distribution Requirement Planning (DRP-I)	Systematic process for determining which goods, in what quantity, at which location, and when are required in meeting anticipated demand. This inventory related information is then entered into a manufacturing requirements planning (MRP-I) system as gross requirements for estimating input flows and production schedules.	(Lei, Liu, Ren, & Wang, 2001)
			(Xin, 2008)
	Warehouse Management System (WMS)	A software application which supports the daily operations of a warehouse. The software application allows for a system of centralized management of warehousing tasks including inventory control, tracking, and the location of stock items. WMS may work on their own as a single application or be an integrated part of a larger system. Current WMSs are capable of being highly complex and handle significant amounts of data many companies will allocate an entire staff to the operation of the software.	(Harper, 2010)
			(Liu, Yu, & Liu, 2006)
			(Shen & Wang, 2010)
	Yard Management Systems (YMS)	A yard management system (YMS) is a software system designed to oversee the movement of trucks and trailers in the yard of a manufacturing facility, warehouse, or distribution center. YMS provides real-time information on the location of trailers in the yard and allows yard employees to move trailers from staging to docks to fill	(Park, Oh, Cheong, & Lee, 2006)

		orders in an efficient manner.Help prioritize shipment arrivals, identify trailer contents, manage yard jockey activity, standardize yard processes, reduce the time needed to allocate vehicles to loads, and avoid unnecessary vehicle movements.	(Zhang, Ryu, Hong, & Park, 2010)
	Transportation Management System (TMS)	A Transportation Management System (TMS) is a subset of Supply Chain Management (SCM) software focused on transport logistics. TMS systems facilitate interactions between an Order Management System (OMS) and the Warehouse or Distribution Center (DC).	(Oh, Kang, Yang, & Kang, 2009)
INVERSE LOGISTICS	Efficient Consumer Response (ECR)	System for replenishing merchandise based on actual consumer demand. Prior methods of inventory replenishment were order driven, relying on retailers and wholesalers to predict demand. ECR is demand driven, initiating the manufacture and shipment of goods based on consumer purchase activity. ECR reduces the cycle time from purchase to replenishment, reduces the cost of warehousing excess inventory, and assists retailers, wholesalers, and manufacturers in determining the optimum product mix. ECR predicts the impact of a product promotion on retail demand and production requirements. ECR is dependent upon the efficient and timely sharing of data along the supply chain beginning with sales information collected at a point-of-sale terminal. Given thin margins on average transactions and significant expenditures on warehouse space, some food and drug retailers resist manufacturers' ECR initiatives.	(Kurnia, Johnston, & Dare, 2006)

CONCLUSIONS

The main supply chain automation objective is to develop specific processes, measure results and improve the lead times, involving thought the process the staff, since they are whom understand the operation. Companies that wish to have a complete production system, which involved suppliers and distributors, will have to focus efforts on advancing through the automation of all the links in your supply chain to focus efforts and implement key actions for the growth of your business.

Goods flows and data streams can no longer be considered as an independent matters and areas. Business and commercial interchange by globally networked companies can be more efficient and productive conducted with the most updated, specialized and business core-applicable IT systems.

Logistics is taking on its latest challenges with increased automation; a better informed decision making on supply chain planning results in greater logistics operational efficiencies and yields significant cost savings.

The customers' requirements being placed on a supply chain plan are continuously rising: as a result of factors like growing variety, increasing product personalization, reduced vertical integration and quickly changing production, storing, transport and distribution processes, those difficulties can be reduced through the use of automated systems and equipment, whether on the hole supply chain or some of the key process.

With those conditions and parameters, a balanced material and information flow system is one that reaches a break point between flexibility, autonomy and automation. Final client's requirements are to be directed to the larger extent possible and the technological and infrastructure advances of automation are to be exploited.

For the Colombian case, the companies has a long way to catch up with the global tendencies, starting with the country landscape infrastructure, keep going with the needing of expert managers and technician. The current mass applied technologies are those related with product identification (RFID), and the path for trucking, cargoes and transport tracing and tracking began a few years ago with the biggest companies, but the small ones and the independent contractors has been reacted to assume this kind of costs for their operation, that's mean the massive implementation for any type of system or technology will take longer.

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