The use of information technology and communication: workflow system for greater integration of supply chain

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Abstract
The global competition has imposed challenges to Supply Chain (SC) integration, mainly, during the process of obtain information to make Demand Management decisions. This paper proposes an integrated model for data collection, analysis and results dissemination in the SC, contributing to research and alternatives for "The Bullwhip Effect" issue.

Keywords: Supply Chain Management; Workflow System; Bullwhip Effect.

INTRODUCTION

The global competition has imposed increasing challenges for enterprises, mainly due to the lower profit margins and the decreasing technological advantages over their direct and indirect competitors. In this sense, the organizational paradigms need to be reviewed in regards of all organization management aspects. The complexity of Supply Chain (SC) integration process is partly due to the difficulty of obtaining data integration between companies: during the process of meeting market demands many issues arise regarding the service times, the correct production amounts and the business profitability.

Electronic data interchange (EDI) let all stages of the supply chain hear that customer's voice and react to it by using flexible manufacturing, automated warehousing, and rapid logistics. Nonetheless SC itself has the inability to predict demand (Fischer, 1997). These issues gain relevance because the costs associated with the management system had become crucial to maintain or enhance the competitive advantage of companies in the global competition. In this sense, it is necessary to discuss the integration of Supply Chain Management (SCM) systems and the functionality in ERP - Enterprise Resources Planning and others systems that could be integrated with ERP to enlarge their scope over the chain of immediate supplies.

This paper seeks to establish new alternatives in order to get improvements before solving local and specific problems. In search of global gains, it will be proposed a model that extends the scope of the integrated systems management in use in the market, presenting an alternative to integrate companies through workflow system, using the internet with means of integrating data between system generations and different technologies. In conclusion The purposes of this paper are: examining the traditional concepts of management of SC, production and processes; proposing an integration model, which realizes the data collection, analysis and dissemination of results in a quickly and accurate way for each member of the SC; providing information for better decision thanks to the awareness of inventory vision and demand behavior on different levels of the SC.

RESEARCH BACKGROUND

Supply Chain Management (SCM)

There are several interpretations of logistics understanding and its definition as an academic discipline. The activity was elevated to the category of strategic capabilities of an organization (Hamel and Prahalad, 1995). Accordingly to the “Council of SCM Professionals”, SCM was coined as *integrated logistics* and this definition has been adopted by above-mentioned council, associating the term with the following description: "SCM is the integration of industrial and commercial processes, starting from the final consumer to the initial suppliers, creating products, services and information that add value for the customer ".(Novaes, 2007).

There are different views in relation to logistics and SCM. This difference does not compromise the result of the adoption of one rather than the other; the main issue is to understand the implications of integrating all players. (Viagi et al., 2010). The *demand management* is important, where the customer service level will set the amount of inventory needed to ensure the meeting of the needs. Thus, the better the information from the SC further the downstream, the smaller will be the variations between the forecast and the reality, reducing the standard deviation and therefore the safety stock required to ensure the level of service. (Azevedo and Bremer, 2006)

In this way, the demand management is one of the critical factors for the SCM, because it will affect the level of inventories along the chain as a whole, also influencing the lead time and product cost (Lambert, Cooper and Pagh, 1998). Therefore, the goal is to manage the demand and the inventory levels in an integrated manner within the SC, reducing the multiplier effect of demand due to the uncertainty of each chain member. This multiplier effect was named by Forrester, in 1958, as "Bullwhip Effect" (BE). (McCullen and Towil, 2002, Mackelpranga and Malhotra, 2015). Figure 1, illustrates how the uncertainty influences the generation of rising inventories along the supply chain.

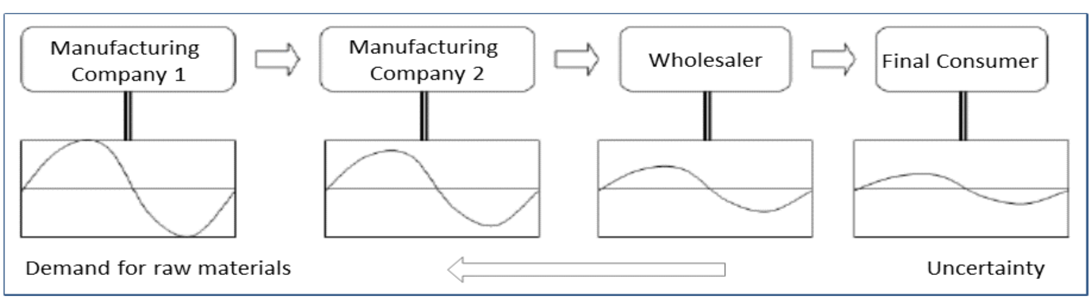

Figure 1: Demand Amplification or Bullwhip Effect - Adapted from Taylor (2005

Without attempting to exhaust all the nuances relevant to the study of SCM, we can conclude that it is an emerging issue and its importance is growing every year. For this reason, the main focus for business is on meeting the customer needs, as a basic condition of competitiveness, and surviving in the global market.

Cooper, Lambert and Pagh (1997) and Lambert, Cooper and Pagh (1998) list the business keys processes, highlighting the importance of the demand management and integrated stocks and trying to balance the customers' needs with the production capacity in order to reduce the uncertainty, minimize the bullwhip effect and create an effective flow of material throughout the SC. Infact, "ERP systems were never designed just to support SCM. Their architectural advantage of being fully integrated for one firm becomes a strategic disadvantage in this new business environment, where modular, open and flexible IT solutions are required" (Akkermans et al. 2003)

Another important evidence from the Bose et al. (2008) is that in ERP systems, material, capacity and demand constraints are considered separately. Kobayashi et al. (2003), declare that in traditional production systems, where product demand is relatively stable, it is sufficient to study local optimization only for such isolated tasks as sales, manufacturing, logistics and finance but now the challenge is other. It is difficult to adapt to radical changes in demand using only local optimization.

Information and Communication Technology (ICT) in the SCM

It is important to know how and in which extent the SCM has been influenced by the Information and Communication Technology (ICT). The motivation for the development of integrated systems was due to the necessity of a better management of the material, human and financial resources, utilized in the production process. The joint development between the evolution of the management concepts and the ICT systems makes clear that one would be less important without the other and vice versa.

Information Technology (IT) comprises disciplines that study the equipment (hardware), programs (software) and application programs. IT changes the operations, information access and, consequently, the relations strength between redesign of structures and work processes; promoting a significant change in the way of being an organization. Some processes are directly changed, for instance: the planning and production control, enterprise resources planning, supply chain management, purchase, sales strategy, customer relationship management and business intelligence systems (Di Serio and Vasconcellos, 2009).

The search for management solutions and integration intensifies the adoption of – ERP systems, helping the development of ICT solutions, incorporating features to address issues that are *outside* the company walls and relationships with its direct partners. The ERP systems are usually developed as individual standalone monolithic applications or modular separable tools assembled in a suitable structure for all individual business needs and web-access has been severely facilitated by recent advances in telecommunications and network technology, their web-based ERP system utilizes workflow engine that manages the entire business process task flow across the enterprise. For this, web services offer two crucial advantages: ease of integration and cost reduction. In conclusion the authors state that WS and ERP web-based systems can contribute to solve SCM and Logistics problems. (Tarantilis et al.,2008)

Cagliano et al. (2006) identify two ways of integrating supply chain processes. The first type of integration requires a closer coupling of the production systems between the customer and the supplier, and even the co-location of plants. As a result, often the integration of physical flows is closely related to purchasing practices such as supply base leveraging and rationalization. The second type of integration mechanism is aimed at leveraging information from the counterpart to improve internal activities and operations management. For the authors the implementation of ERP, both in production and in supply management, aims at improving internal efficiency, but it does not increase the information exchange with suppliers. The ERP implementation is an important step to integrate the SC. However, the ERP has mainly focused on management of internal and immediate SC players, being poorly functional integrated with other members of the SC. It emerges that the functionality for the integration of overall SC has not been identified and/or developed yet. (Kelle and Akbulut, 2005; Viagi et al., 2010),

Kelle and Akbulut (2005) list some relevant statements from the following articles:

- Although ERP packages strive to integrate all the major processes of a firm, customers discover that some essential functionality is lacking (Scott and Kaindl, 2000)
- Traditional ERP infrastructures failed to support an extended business model across the supply chain (Edwards et al.,2001)
- The challenge is to figure out what, how, where, who, when, and why manufacturing operations can feed the ERP beast (Harrold, 2001)
- Since ERP philosophy is process based, rather that function based, it necessitates disruptive organizational changes (Hong and Kim, 2002)
- ERP systems mostly adopt a myopic view of planning, based on pure deterministic planning methods (Landeghem and Vanmaele, 2002)

The most important application for SC management is the Advanced Planning and Scheduling – APS. However, Santos (2010) makes a critical analysis highlighting the difficulty of integrating APS with many ERP systems and obtaining the necessary information to plan and schedule SC activities (Taylor, 2006).

Simchi-Levi *et al.* (2003) define that for the integration of heterogeneous ERP systems, the APS operation should occur through an internet portal for the management of business processes. Figure 2 shows the integration of APS with multiple ERP, as proposed by Santos.

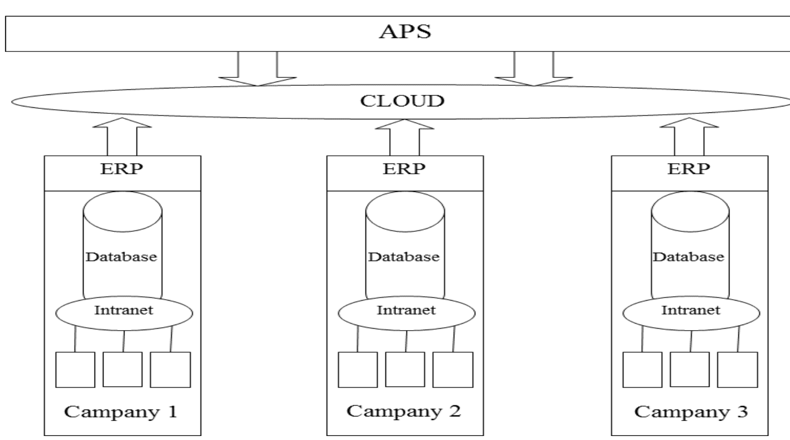

Figure 2: APS Integrating Multiple ERP - Adapted from Santos (2010).

Besides the problem associated with data collection coming from SC members to demand management, there is also another limitation of ERP systems. The systems needs to be *fed* continuously by operators and managers, without a control system to keep the pace of work and point to the discontinuity problems timing to ensure on the dot decisions and avoid delays and failures in meeting the demand.

Gianni (2004, 2005) classifies ERP systems as *modular* when they are composed by modules with specific features. He points out that, in the 1990s, emerged *procedural* ERP systems, which used the concept of workflow, allowing the registration and monitoring of transactions during their realization as an *on-line* process. These systems were also able to rise the alarm if the process was not completed within the established limits. In some applications, it is now possible to establish the path that a work order should follow and to stress, through alarms, evident delays and "forced" the correction of deviations. The proposal of the procedural systems is to use the functionality of ERP system as materials management, human resource management and others, in combination with the business process management (BPM) and workflow control, through the functionality of the WS.

BPM is the way in which key activities are managed and continuously improved to ensure consistent ability to deliver high quality standards of products and services (Zairi, 1997; Lee and Dal, 1998, Trkman, 2010). As shown in this step, the WS creates work routine and tasks control implementation, in order to ensure the real integration of the activities performed by different people, controlling the execution time and generating alerts across the hierarchy.

PROPOSED MODEL OF THE SUPPLY CHAIN INTEGATION

The proposal consists in using the concepts of advanced planning system (APS) combined with WS in a cloud system. The APS simulation tools are sustained with demand forecast. At this first stage, the demand forecast is the primary information to evaluate the effective demand of the overall SC. This information is obtained thanks to map the data collection process of each client in each layer of the SC, it should be controlled by a WS installed in the cloud. The difficulty of this purpose is to achieve the information sharing between various companies, and to ensure that the rules for the actions execution, described in the WS, are executed by any members of SC. In this case, it is necessary to identify the critical players for the SC success, and to identify the responsibilities and benefits by the improvement of SC performance. The model predicts that when there is the necessity of data related to other SC members, the WS installed can be used to request this data, to control this process and to provide the results through the distribution of information to all SC players.

According to the common interest among the SC members, the data exchange integration, even for ERP system developed with different technology and database, can be achieved by the integration of protocols for data conversion and by the access via cloud system. The most important aspect is that the WS has performance indicators to assess the efficiency of any SC players, allowing an immediate action when a problem arises impeding the progress of flow.

There are a large number of possible applications for such integration and one of them was tested in case study and a third one in the theoretical field, the data collection for Demand Planning. Figure 3 illustrates this proposed in a simplified and schematic form.

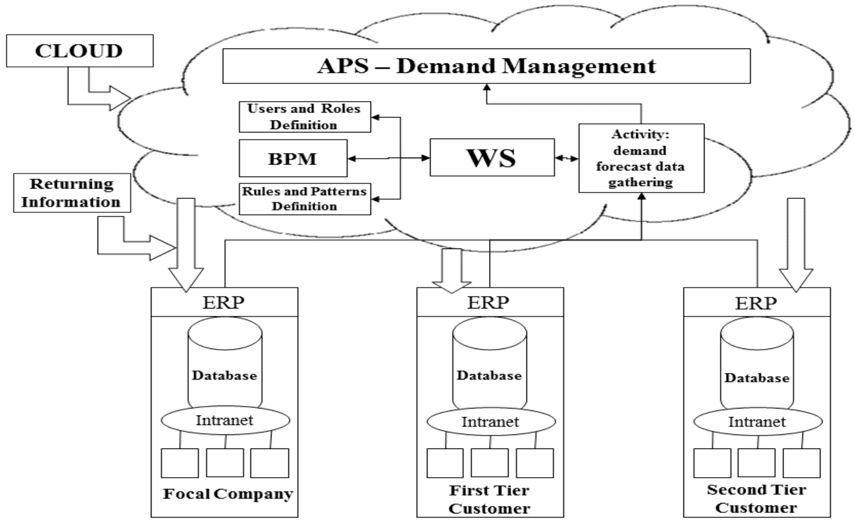

Figure3:Proposal for ERP and APS integration, with Workflow on the Internet - Viagi (2011)

Data collection for the preparation of Demand Planning

In this case, the WS was used to collect data form each SC players and, after processing the sales forecast and the inventory, it returns as result to these players the *plausible* demand accordingly to this relation:

$$Dp(i) = f((Fr(i+1) \times ((D(i+1));(I(i+1)))\sim Fr(i+2) \times ((D(i+2));(I(i+2)))\sim...\sim Fr(i+n) \times ((D(i+n));(I(i+n))))) \quad (1)$$

And:

D(i) = Plausible Demand - Focal Company

D($i + n$) = Demand - Customer Tier (i+n)

I($i + n$) =Inventory - Customer Tier (i+n)

Fr (i+1) = Correction factor – Customer Tier (i+n); $0 < Fr < 1$, for the focal company

D ($i + n$) → D(real),... , >> n

$$\text{Lead-time (LT)} = \frac{\sum_{m=1}^{n} I(i+m)}{D\text{ (real)}} \quad (2)$$

Where our objective is to minimize LT (2) in order to reduce the level of stock along the SC and increase the speed to satisfy the market demand. Figure 4 shows the logical scheme of this activity:

- The focal company starts the demand planning process, implementing the projected inventory data request and the sales forecast for the SC players;
- The focal company uses the WS to send request and control the information collection and the deadlines
- The WS, according to the rules system, is configured to send alert mails and putting pressure to avoid later information the deadline;

- Finally, when the information is complete, the demand planning (1) is performed and the result is returned via WS to the players, in order to define their master plan.

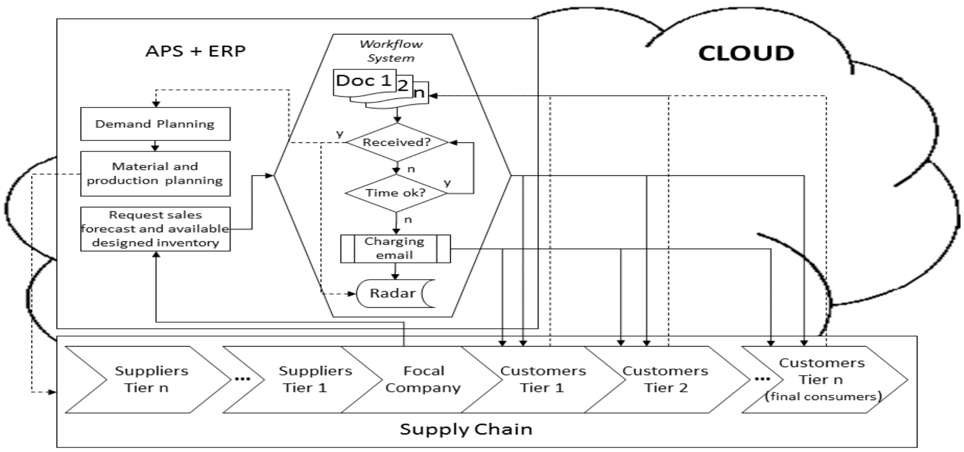

Figure 4 – Demand Management and Production Planning - Viagi (2011)

In Figure 4, the radar element is a metaphor for the information flow control in WS, it represents a visual control system.

CASE STUDY

To test the effectiveness of the proposed model, a case study was analyzed in Pulp and Paper industry, specifically in a relevant branch of special thermo- and carbon-paper firm. This case involves: the major suppliers of cellulose, the paper company (focal company), a large paper distributor and a retail responsible for delivering the product to the customer. It was observed that, the high inventory level of finished goods and offset paper for coating was due to a variety of formats of finished products and the manufacturing of products with different characteristics. It was also found that the product family volume sale forecast has 70% of accuracy, compared to historical data, but this accuracy is not reliable in term of product mix.

The team responsible for model implementation negotiates a reduction in the lead-time, it would be challenging and meaningful for the application of the proposed method. The proposed target is to reduce about 500 tons of paper stock among all players of the SC: impacting on capital employed approximately for US $ 600,000.00, reducing the occupied space by WIP and finished products. In this way, the risk of obsolescence and handling damage is also reduced and the overall competitiveness increases thanks to all benefits mentioned above. Table 1 presents the proposal to reduce the lead-time from the current state.

Table 1 - Lead-time proposed - Viagi (2011)

PLAYERS	**LEAD-TIME (Days)**	
	Current	**Proposed**
Pulp producer	**28**	**28**
Paper producer	**117**	**102**
Distributor	**15**	**13**
Graphical producer	**5**	**5**
Retail	**2**	**2**
Total	**167**	**150**

And,

Table 2 – Sample SC Data

Average Demand	**≈ 880 t/month**
LT ~ 1 day	**≈ 29 t**
Total inventory (current)	**≈ 4850 t**
Total inventory (proposed)	**≈ 4350 t**

The reason why we take into account the lead-time for our case is that: in SCM, lead-time is an indirect measure of stock and WIP entity, as a function of demand. For this reason, the reduction of lead-time is a consequence of stock reduction. We highlight that our model implementation aims at this objective.

RELEVANCE AND CONTRIBUTION

After five months from the beginning of the implementation, the Lead-time reduction obtained was equal to 6.6%, it was considered promising for the team and company representative. Another relevant result observed was the integration of all SC main players thanks to meetings, information exchanges and demand and inventory data analysis. This result is prerequisite for the implementation of future development of our model. The Table 3 presents the partial results of lead-time reducing applying the implementation method

Table 3 - Lead-time partial result – Viagi (2011)

PLAYERS	**LEAD-TIME (Days)**	
	Current	**Partial Result**
Pulp producer	**28**	**28**
Paper producer	**117**	**107**
Distributor	**15**	**14**
Graphical producer	**5**	**5**
Retail	**2**	**2**
Total	**167**	**156**

And,

Table 4 - Sample SC result

Total inventory (partial)	≈ 4524 t

The results were satisfactory considering the short time implementation, in spite of conflicts with other daily priorities of team members and the limitations of the early stage system. The figure 5 shows the current state and the partial results in terms of total inventory and LT for the SC of our firm sample.

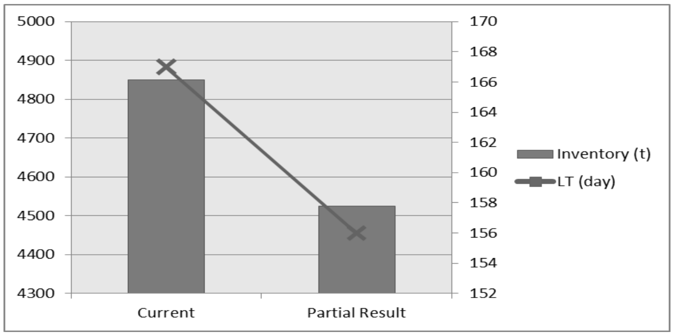

Figure 5 – Current State and Partial Result

Regarding the objective proposed to support the research, the model represents an alternative using of current technology and the results observed in the case study corroborate the possibility of structuring a model to hold up the SCM, with the support of ICT. In this configuration, it is possible to contribute to increase the SC productivity with the direct improvement of demand management, improve the information collection and keep the sales forecast system, resulting in an effective inventory and lead-time management.

There is the opportunity of advantages arising from the integrated SCM, thanks to the great influence of the demand variation in the definition of safety stocks at every stage of SC. The challenge is to overcome the traditional way of SC where the relationship of a large number of suppliers is based on price. When a buyer gives detailed technical specifications, the communication is limited and the information exchange is not complex. This kind of relationships has some advantages for thebuyer, such as: easy switching between different suppliers, lower costs, having the supplier as the excess stock absorber and not sharing the confidential information. From the point of view of suppliers disadvantages are greater than advantages. (Kelle and Akbulut, 2005)

The optimal policy for the buyer is to have frequent small-size shipments and it results in a large loss for the suppliers. Similarly, the large lot sizes and shipment sizes, preferred by the suppliers, result in large loss for the buyers. However, the integration in the proposed model with others approaches like lean management can also be analyzed, broadening the research scope with a preliminary SC mapping; it would support the understanding of changes adoption by the SC managers.

FUTURE RESEARCH

Some alternatives are identified in order to lead the future studies on this subject. In our opinion the most important are:

- to study the use of ICT in combination with Radio Frequency Identification (RFID), in order to develop a model of integrated SCM for controlling stocks and real-time demand
- to investigate the possibility that the WS is used to aims at placing the Vendor Management Inventory in practice and provide to the suppliers the information related to the necessity of replacement of the stock, or order fulfillment, with the possibility that this information is shared by the SC demand manager based in the main company (focal).

Finally, it can be concluded that this paper gives an effective contribution, by proposing a method that aims to integrate the SC, improving the inventory management and other aspets of business management.

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