

# Supply Chain Management Optimization within Information System Development

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**Abstract** The supply chain concept has become a concern due to global competition and increasing customer demand for value because the Companies try to improve their industrial performance in terms of cost, delays, adaptability, variety and traceability. Thus, the information must be available in real time across the supply chain and this can not be achieved without an integrated software system for supply chain management. Supply chain members have to collaborate, sharing information for improving customer's satisfaction. The purpose of this paper is to present what is the impact of the information system in performance of SCM in which a framework is based on Model Predictive Control (MPC) combined with a forecasting module was presented, so, this article is dealing with studying the relationship between information system and supply chain management (SCM) optimization. For this objective, we develop a new model based in model predictive control when is nowadays recognized as a standard methodology for the control of industrial and process systems. In addition, this article attempts to clearly describe the relation between the supply chain management and information system. The proposed framework will be determinate the efficiency of the method and the impact of forecast accuracy on overall control performance of the supply chain.

**Keywords:** *supply chain management, optimization, information system*

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## 1. Introduction

Supply Chain Management (SCM) is an integral part of our daily life. Today it influences more than ever a large number of human and economic activities. SCM has been considered as a competitive strategy for integrating suppliers and customers with the objective of improving responsiveness and flexibility of manufacturing/service organizations. The optimal design of a supply chain is therefore an urgent and critical issue for SCM researchers and practitioners. As it is essential to treat the supply chain as an integrated system with physical flow of materials, manufacturing planning and control, as well as physical distribution, the development of models and approaches towards the optimization of supply chain priorities has become a challenging task for SCM. Nowadays, Companies have consistently tried to enhance their business efficiency and effectiveness by reassessing their internal business operations such as purchasing, warehousing, materials management and distribution. Supply chain management (SCM) is an approach that has evolved out of the integration of these considerations. SCM is defined as the integration of key business

processes from end user through original suppliers that provides products, services, and information and hence adds value for customers and other stakeholders (Lambert et al., 1998).

Supply chain (SC) systems are nowadays entering the age of adaptive and intelligent supply chains, a new generation of networks that features collaboration and visibility features across the different partners to deal with the system dynamics, such as supplier failures or demand uncertainty. Supply chains systems are a set of separate and independent economic entities more interested in their local objectives than in the global system performance. Therefore, centralized management approaches, where a single partner such as the logistic center optimizes the global performance, are becoming less realistic and being replaced by decentralized management approaches, where each member optimizes its own performance, albeit knowing that collaboration with other partners can improve the individual and global performance. In any case, the key issue is to align the members' objectives and coordinate their decisions to optimize the supply chain performance, but this is particularly more difficult to attain with a decentralized management approach. There are numerous articles on the strategies, techniques and technologies for the design and development of SCM.

Also, several literature survey papers which include taxonomy of SCM, and modeling and analysis of SCM (e.g. Tan, 2001). However, there is a very few literature survey article that deals with IT in SCM. However, it is impossible to achieve an effective supply chain without IT. Since suppliers are located all over the world, it is essential to integrate the activities both inside and outside of an organization. This requires an integrated information system (IS) for sharing information on various value-adding activities along the supply chain. IT is like a nerve system for SCM. Companies have consistently tried to enhance their business efficiency and effectiveness by reassessing their internal business operations such as purchasing, warehousing, materials management and distribution. These processes commit huge time and financial resources and therefore companies are continually striving to make them more effective in order to improve their financial standing and market positions.

## 2. Supply Chain Management

Bechtel and Jayaram (2007) define the Supply Chain Management as a recent movement in logistics research that has been defined in various ways. The Global Supply Chain Forum defines SCM as “the integration of business processes from end-user through original suppliers that

provides products, services, and information that add value for customers” ([Lambert, D., Stock, J., and Ellram, L.,(1998) p. 504 ]. Following Cavinato (1991), Kotzab and Schnedlitz (1999) define SCM as a special form of strategic partnership between retailers and suppliers, with positive effects on the overall performance of the channel. The key element of SCM is activity integration. In fact, Bechtel and Jayaram (2007) present an integration-continuum between “pure awareness” and “pure integration” of supply chain activities. They champion the view of SCM as a “seamless demand pipeline” with the end-user as the driving force in the entire system.

Chandra and Grabis, (2007) defines a supply chain as a set of suppliers, manufacturers, warehouses, distributors and retailers who, through coordinated plans and activities, develop products by converting raw materials to finished goods.

Kotzab (1999a) goes further and places SCM in the “metalogistical” level of business logistics. The “metalogistical” level includes all possible forms of cooperation between economic organizations [Pfohl, H.-C (1996)].And, according to Ihde (1987), this cooperation occurs between institutions of different levels within a channel and can be either short or long-term in orientation. Inspired by Cooper, Lambert and Pagh (1997), Kotzab (1999a) presents a schematic of an SCM model.

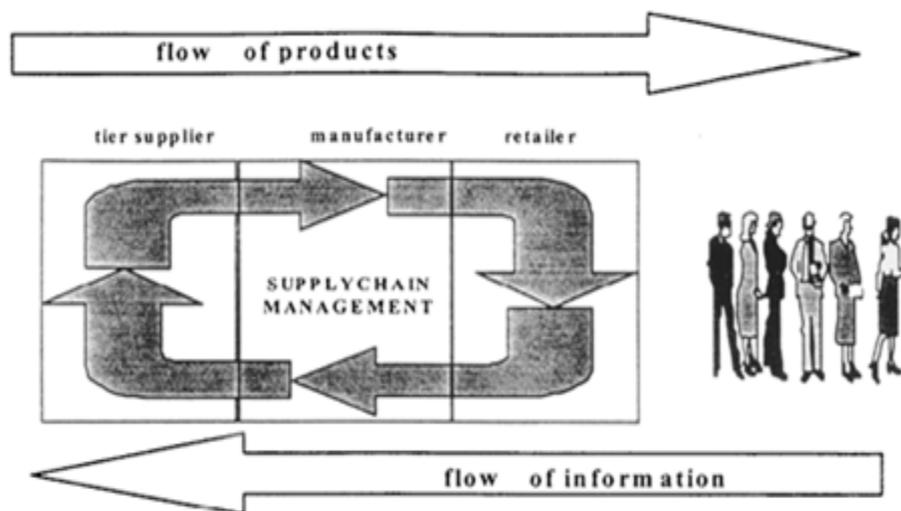


Figure 1. Basic supply chain management model

It is important to note that the basic SCM model in Figure 1 suggests the orchestration of activities at the inter-organizational level as well as the departmental level. Instead of focusing on the management of inter-firm inventory and transportation capacities, SCM aims to integrate the activities of an entire set of organizations from procurement of material and product components to deliver completed products to the final customer ( Schary, P., and Skjtt-Larsen, T.(1995)).

Scott and Westbrook (1991) and New and Payne (1995) describe supply chain management as the chain linking each element of the manufacturing and supply process from raw materials through to the end user, encompassing several organizational boundaries. According to this broad definition, supply chain management encompasses the entire value chain and addresses materials and supply management from the extraction of raw materials to its

end of useful life. Baatz (1995) further expands supply chain management to include recycling or re-use. Supply chain management focuses on how firms utilize their suppliers' processes, technology, and capability to enhance competitive advantage (Farley, 1997), and the coordination of the manufacturing, logistics, and materials management functions within an organization (Lee and Billington, 1992).

## 3. Evolution of Supply Chain Management

In the 1950s and 1960s, most manufacturers emphasized mass production to minimize unit production cost as the primary operations strategy, with little product or process flexibility. New product development was slow and relied exclusively on in-house technology and

capacity. Sharing technology and expertise with customers or suppliers was considered too risky and unacceptable and little emphasis appears to have been placed on cooperative and strategic buyer-supplier partnership. The purchasing function was generally regarded as being a service to production, and managers paid limited attention to issues concerned with purchasing (Farmer, 1997). In the 1970s, Manufacturing Resource Planning was introduced and managers realized the impact of huge WIP on manufacturing cost, quality, new product development and delivery lead-time. Manufacturers resorted to new materials management concepts to improve performance within the four walls of the company. The intense global competition in the 1980s forced world-class organizations to offer low cost, high quality and reliable products with greater design flexibility. In the fast-paced JIT manufacturing environment with little inventory to cushion production or scheduling problems, manufacturers began to realize the potential benefit and importance of strategic and cooperative buyer-supplier relationship. The concept of supply chain management emerged as manufacturers experimented with strategic partnerships with their immediate suppliers. In addition to the procurement professionals, experts in transportation and logistics carried the concept of materials management a step further to incorporate the physical distribution and transportation functions, resulting in the integrated logistics concept, also known as supply chain management.

The evolution of supply chain management continued into the 1990s as organizations further extended best practice in managing corporate resources to include strategic suppliers and the logistics function in the value chain. Supplier efficiency was broadened to include more sophisticated reconciliation of cost and quality considerations. Instead of duplicating non-value-adding activities, such as receiving inspection, manufacturers trusted suppliers' quality control by purchasing only from a handful of qualified or certified suppliers (Inman and Hubler, 1992). More recently, many manufacturers and retailers have embraced the concept of supply chain management to improve efficiency across the value chain. Manufacturers now commonly exploit supplier strengths and technology in support of new product development (Ragatz et al., 1997; Morgan and Monczka, 1995), and retailers seamlessly integrate their physical distribution function with transportation partners to achieve direct store delivery or cross docking without the need for receiving inspection (St. Onge, 1996). A key facilitating mechanism in the evolution of supply chain management is a customer-focus corporate vision, which drives change throughout a firm's internal and external linkages.

#### 4. The Strategic Importance of Supply Chain Integration

Over the past decade there has been a growing consensus concerning the strategic importance of integrating suppliers, manufacturers, and customers (Reck and Long, 1988; Leender and Blenkhorn, 1988; Bowersox et al., 1989; Freeman and Cavinato, 1990; Syson, 1989; McGinnis and Kohn, 1993; Morris and Calantone, 1991; Cammish and Keough, 1991; Eloranta and Hameri,

1991; Burt and Doyle, 1992; Clinton and Closs, 1997). As Carothers and Adams (1991), Langley and Holcomb (1992) and Shapiro et al. (1993) convincingly argued, the once narrow subject of logistics has become a comprehensive topic that now spans the entire value system from suppliers to customers. Reinforcing this point, Ragatz et al. (1997) noted that the "effective integration of suppliers into product value/supply chains will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive". For practitioners, the strategic importance of integration is similarly reflected in the Supply Chain Council's popular Supply Chain Operations Reference (SCOR) model that assumes all businesses include sourcing, making, and delivering processes strategically linking suppliers and customers to manufacturers (see [www.supply-chain.org](http://www.supply-chain.org)).

Many of the theoretical arguments for closely integrating operations between manufacturers and suppliers and customers come from the process reengineering literature (Hammer and Champy, 1993; Hammer, 1996; Fliedner and Vokurka, 1997; Burgess, 1998). Typically the goal is to create and coordinate manufacturing processes seamlessly across the supply chain in a manner that most competitors cannot very easily match (Anderson and Katz, 1998; Lummus et al., 1998). As Birou et al. (1998) pointed out "the opportunity to use process integration across functional boundaries is now considered a key to competitive success". Davis (1993), Dyer and Ouchi (1993), Eisenhardt and Tabrizi (1994), and Littler et al. (1995) similarly echoed the importance of integrating suppliers and customers into supply chains for developing new products and processes.

#### 4.1. Supply Chain Integration Tactics

At the tactical level, the literature suggests that there are two interrelated forms of integration that manufacturers regularly employ. The first type of integration involves coordinating and integrating the *forward* physical flow of deliveries between suppliers, manufacturers, and customers (Saunders, 1997; Trent and Monczka, 1998). Many of these proponents of supply chain integration fall under the banner of just-in-time (Chapman and Carter, 1990; Chen and Chen, 1997; Landry et al., 1997; Grout, 1998; Narasimhan and Carter, 1998; Tan et al., 1998; Sakakibara et al., 1997; White et al., 1999). Others have pointed out the importance of delivery integration in terms of implementing product postponement and mass customization in the supply chain (Lee, 1998; Lee and Tang, 1998; Van Hoek et al., 1998; Pagh and Cooper, 1998) or for exploiting third-party logistics (Saunders, 1997; Gattorna, 1998; Marvick and White, 1998). The other prevalent type of integration involves the *backward* coordination of information technologies and the flow of data from customers to suppliers (Martin, 1992; Trent and Monczka, 1998). Information technologies allow "multiple organizations to coordinate their activities in an effort to truly manage a supply chain" (Handfield and Nichols, 1999). Integration using information technologies includes electronic data interchange (EDI) (Sheombar, 1992; Walton and Maruchek, 1998; Jayaram and Vickery, 1998; Narasimhan and Carter, 1998) as well as sharing data from traditional planning and control systems (Bowersox and Daugherty, 1995; Lewis and Talalayevsky, 1997; Van Hoek et al., 1998).

## 4.2. The Arc of Integration

If this need to develop shared operational activities is accepted, then the strategic issue becomes one of direction and degree in which direction (towards customers and/or towards suppliers) and to what extent (degree of integration) should such shared activity be developed? Taking this pair of decisions as the key dimensions for representing a strategic position we can illustrate them graphically as an arc, with the direction of the segment showing whether the firm is supplier or customer leaning, and the degree of arc indicating the extent of the integration. This has more visual immediacy than a plot on a line graph for this type of investigation. Hence, in this paper we characterize the strategic position of each respondent with respect to supply chain development as that firm's "arc of integration". All manufacturers implicitly make strategic decisions concerning the extent of upstream and downstream integration that they want to undertake. Some manufacturers decide to engage in relatively little integration with suppliers or customers and thus have a relatively narrow arc of integration. Other manufacturers extensively integrate their organizations with upstream suppliers and downstream customers by pursuing a strategy with a broad arc of integration.

Growing evidence suggests that the higher the level of integration with suppliers and customers in the supply chain the greater the potential benefits (Stevens, 1989; Lee et al., 1997; Metters, 1997; Narasimhan and Jayaram, 1998; Lummus et al., 1998; Anderson and Katz, 1998; Hines et al., 1998; Johnson, 1999). Tan et al., (1998) noted that when companies "integrate and act as a single entity, performance is enhanced throughout the chain". Others have pointed out the inherent hazards of not fully integrating with upstream suppliers and downstream customers (Lee and Billington, 1992; Hammel and Kopczak, 1993; Armistead and Mapes, 1993). Fisher et al. (1994) highlighted the critical role of balancing supply and demand across the supply chain. Handfield and Nichols (1999) argued that now manufacturers must not only manage their own organizations but also be involved in the management of the network of upstream and downstream firms. Hale (1999) similarly pointed out that those firms "who have traditionally been structured as independent businesses will increasingly have to configure operations on a shared basis". By extension, manufacturers with the broadest arcs of supply chain integration should have the highest levels of performance improvements

## 5. Literature Review of Supply Chain Performance

Many works seek how to improve the performance of the supply chains. Authors try through their models and hypothesis to reinforce collaboration and cooperation devices that contribute to company or supply chain performance. Collaboration and information exchange between partners becomes essential within any supply chain. We find various strategies and contributions based on information technologies, information exchange, information sharing, supply chain practices, inter-organizational communication and collaboration.

Paulraj et al. (2008) consider inter-organizational communication as a critical factor for strategic collaboration between companies. They define the inter-organizational communication as a relational competence, which can provide a strategic advantage for the partners of the chain and thus improve their performance. Focused on the collaboration and the use of the information technology, Chen et al. (2007) use the CPFR (Collaborative Planning Forecasting and Replenishment), a collection of practices which aims to radically reduce stocks and expenses and also tries to increase the customer service, to simulate four scenarios of collaboration between a retailer and a supplier. The authors show that the use of the IT cannot alone ensure that partners can gain. Mutual trust plays an essential role in achieving this goal.

Seggie et al. (2006) explore information technology (IT) alignment and inter-firm system integration between supply chain partners as supply chain specific IT facilitators of brand equity. However, there could be more supply chain facilitators of brand equity including inter-firm coordination, inter-firm information exchange, partner flexibility and inter-firm integration of supply chain activities. The improvement of brand equity influences positively on market and financial performance.

More generally and while always seeking to improve the performance of the company, Sander (2007) aims to extend knowledge on how the use of e-business technologies impacts organizational collaboration, and organizational performance. The author proposes a model of the relationship between organizational use of e-business technologies, organizational collaboration, and organizational performance. Indeed, the growth of Information Technology and especially the Internet and the Web may have had the most profound impact on business integration and collaboration. This study confirmed that e-business technology use have a significant direct impact on both intra and inter-organizational collaboration. Another important finding is the significant impact of intra-organizational collaboration on performance. Hence, companies should invest in strategies that promote cooperation and integration across the functions of the organization. New concepts appeared with Yang et al. (2008). The authors test the links between relational capital, relational commitment, relational stability, and alliance performance. The cooperation in the form of alliance enables firms to share financial risk, improve service quality, increase productivity, and reduce cost. This study shed light on the importance of managing relationships in supply chain alliances in terms of ensuring relational commitment, trust of suppliers, and relational stability to lead the performance.

Other types of performance are considered in the literature such as delivery performance, supplier performance, customer performance, etc. Zhou et Benton (2007) investigate the integration of information sharing and supply chain practice in supply chain management. This study focuses on three aspects of information sharing - information sharing support technology, information content, and information quality - and considers three categories of supply chain practice: supply chain planning, just in time (JIT) production, and delivery practice. On the other hand, this research takes an interest in the delivery performance defining by on-time delivery, perfect order fulfillment rate, and delivery reliability/dependability. The

result of this study shows that both effective information sharing and effective supply chain practices are necessary to achieve improvement in supply chain performance, and have significant influence on delivery performance. Other works are interested in testing the influence of other types of practices on the supply chain performance.

Li et al.(2006) define supply chain management practices as the set of activities undertaken by an organization to promote effective management of its supply chain, and propose five dimensions of supply chain management practices: strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement. These practices influence positively the financial performance, the market performance and create a competitive advantage for the company in terms of price, quality, reliability, product innovation and time to market. Chowa et al. (2008) add others practices like communication, integration and customer service management, supply chain concerns, information sharing and specify that even if these practices are different geographically, they influence always positively the total performance of the chain.

Among all the practices studied in the literature, the information exchange and the information sharing remain the most involved practices. Many authors such as Gaonkar, R., Viswanadham, N., (2001), Laux, J., Hung, G., Mak, K., (2004), Liu, E., Kumar, A., (2003), Sahin, F., Robinson, E. P., (2005), Shore, B., (2001), Llerena, D., Duvallet, J., Lemarié, S., Penz, B., (2006), Gruat-La-Forme, F.-A., (2007) and Botta-Genoulaz, V., Gruat-La-Forme, F. A., Millet, P. A., Seville, M., Boucher, X., Derrouiche, R., Llerena, D., Neubert, G., Pellegrin, C., (2005) have sought to identify information that may be shared and to evaluate the impact and the profit of these exchanges. We can so release six kinds of information to be exchanged in the supply chain: products, resources, stocks, delays, demands and planning information.

In practice, to improve supply chain performance, executives often choose to implement either effective information sharing or effective supply chain practices because limited resources usually prevent firms from pursuing both simultaneously. As a solution, Zhou and Benton (2007) proposes the standardization of supply chain processes. The standardization of supply chain processes tends to help companies to take better advantage of the information shared among supply chain partners. Information sharing is a means to capture the supply chain dynamics and thus reduce uncertainty in external and internal environments. When coupled with the standardization inherent in effective supply chain practices, this uncertainty reduction allows performance improvement.

Klein, R., (2007) examines supply chain management relationships between service providers and clients, and focuses on the impacts of the provider's information exchange behaviour and both parties' level of trust. Trust has been established as core component of persistent business partnerships and strategic alliances [Ganesan, S., (1994) Gulati, R., (1995)]. Trust influences cooperation and teamwork within organizations characterized as mutually beneficial initiatives. The relationship between service providers and clients is also based on the level of client customization of integrated supply chain functions through outsource service providers' e-business applications and solutions.

Fynes, B., Voss, C., Seán, d. B., (2005) study the nature of supply chain relationships with the aim of improving customer satisfaction. The authors define the supply chain relationship quality as the degree to which both parties in a relationship are engaged in an active, long-term working relationship, and using indicators of communication, trust, adaptation, commitment, interdependence, and co-operation. The mutual interest of the works presented above is that they try to improve the supply chain performance while following several strategies or models. The use of information technologies, information exchange, and sharing, inter-organizational communication, trust, cooperation and intra- and inter-organizational collaboration form essential factors of supply chain performance. However a company must be able to clearly define its requirements in performance in order to identify which are the best practices meeting these needs. In the next paragraph, we are going to present more precisely the information system of supply chain management which we could gather and which lead their importance in supply chain. Thus, many societies needs an improvement for their objectives, so, it's necessary to use the information system for many reason: firstly the market environment is exchange and any societies must survive, secondly societies can increase their competitiveness and performance.

## 6. Information System

Nowadays companies focus on satisfying customer needs and capturing customer loyalty. Businesses depend on strategic relations with their customers and suppliers for creating value systems that will provide a competitive advantage in the market. Companies trade with suppliers and customers over the Internet in real time. This requires a real time automation of business processes between business partners using a variety of information systems inside the company and among supply chain member organizations. In order to inform customers about products, services, transactions twenty four hours a day, companies have to integrate their information systems with those of their suppliers and customers.

After studying the business environment, we have noticed that e-business integration increase company performance by supporting business success: faster design and market of new products and services; better service; sales growth; lower costs with production, inventory. E-business brings complexity to business applications regarding security, reliability, fault tolerance, government regulations, as well as technical aspects: B2B requirements, online customer and supplier connections, and networks, Web technologies (Roşca, 2004). A complex information system for supply chain management should execute the following operations: centralized coordination of information flows, cross-functional and cross organizational decision-making; logistic management; customer fulfillment systems; inventory management; global sourcing, inter-organizational information access; data transmission through wireless communication; data capture - tracking an order status to the end customer.

ERP applications are complex; they are expensive and difficult to implement such as Oracle, SAP, People soft, Edwards. J.D examining the existing information systems for supply chain in the software market and implemented

in different Romanian companies, we concluded that enterprises may benefit from implementing even isolated modules or applications for supply chain. Many ERP systems include modules for supply chain management which use information from different sources: current inventory and order status, cost accounting, sales forecast and customer orders, manufacturing capacity, new product development, CAD drawings, product and quality specifications, supplier capabilities, transportation rates, benchmark analysis.

Organizations store data from different systems in data warehouses for enabling data mining for decision-making applications. Some systems use on-line analytical processing - OLAP for reports generations executed on-line from any remote location. Due to the complexity of SCM, software companies introduced decision support systems in their information systems which provide reports on relationships and performance across the supply chain (Ilieş, 2003).

These supply chain decision support systems use huge volumes of static information such as: production rates, capacities, bills of material, routings and dynamic information about forecasts, orders, and deliveries. Technologies used for building a decision support system include: SQL interface for direct links to common relational database; expert system rules; scheduling algorithms; linear programming capabilities; scheduling for production, inventories, demand centers; graphical user interface; user definable database using object oriented approach, demand management etc (Turban and Aronson, 2001). "There are different models in the scientific literature for the configuration of such a system like: statistical models, knowledge based models, optimization models, simulation models and hybrid models" (Chandra and Grabis, 2007).

More than ever before, today's information technology is permeating the supply chain at every point, transforming the way exchange-related activities are performed and the nature of the linkages between them (Palmer and Griffith, 1998). A more recent perspective on linkages within the supply chain considers the role of inter-organizational systems, which are sophisticated information systems connecting separate organizations (Kumar and van Dissel, 1996). The strength of inter-organizational systems has been particularly crucial with respect to enabling the process transformation needed to create effective networks (Holland et al., 1994; Venkatraman, 1994; Holland, 1995; Teng et al., 1996; Kumar and van Dissel, 1996; Greis and Kasarda, 1997; Christiaanse and Kumar, 2000). Information technology also enhances supply chain efficiency by providing real-time information regarding product availability, inventory level, shipment status, and production requirements (Radstaak and Ketelaar, 1998). It has a vast potential to facilitate collaborative planning among supply chain partners by sharing information on demand forecasts and production schedules that dictate supply chain activities (Karoway, 1997). In particular, the goal of these systems is to replace inventory with perfect information. Thus, the indicators of this construct are conceptualized to denote the presence of electronic transactions and communication in various forms between the supply chain partners (Greis and Kasarda, 1997; Carr and Pearson, 1999). In this case, we can speak an information system for SCM.

## 7. Information System for Supply Chain Management

Since the last years, the supply chain concept has become a concern due to global competition and increasing customer demand for value. So, it is an important issue that needs a detailed approach because economic environment have considerably changed due to increasing customer demands, development of the inter-organizational relationships and information technology. Thus, the information must be available in real time across the supply chain and this can not be achieved without an integrated software system for supply chain management. For this reason, it is necessary to used a strongly information system because the concurrency is very increasing. Also, the industrials productions hope to present any product in the exactly time to the customers.

The supply chain encompasses all organizations and activities associated with the flow and transformation of goods from raw materials to the end user and the information flows associated with it. Material and information flow up and down the supply chain. The value system is a connected series of organizations, resources and knowledge streams involved in the creation and delivery of value to the end customer.

The companies have to create higher value for clients, reduce cycle times for developing new products at lower prices. Costumers require new products based on the latest technologies and tailored to different market niches. The evolution of information technology is another factor that enabled the integration of supply chains into value systems. E-business technologies supported today's customer-centric environment where suppliers use the Internet to link their business information systems and to increase the efficiency of the decision-making process for their suppliers and customers. Intelligent supply chains information systems enable quality growth of products, and services, information services and e-business links, inventory reduction, customer service improvement.

Before implementing a complex information system for supply chain management, companies must redesign their supply chain; create an infrastructure to allow the usage of these modern technologies. In order to create an integrated value system, it is necessary to implement a series of activities:

- Rocess mapping;
- Internal integration of information systems between business functions ;
- Financial analysis to maximize value creation process;
- Collaboration and trust development with core suppliers/customers;
- Strategic cost management;

Providing customers with their requirements in terms of products, services and information is of paramount importance to businesses today. Research by Lancioni et al. (2000) has shown that the Internet can be used to improve communications with customers by receiving their complaints, emergency notifications and 24-h access to company information. The overall effect has led to reduced response times to customer service problems and increased customer loyalty. The improved quality of information due to the use of the Internet has also

benefited SCM. Pricing accuracy is very important in order processing and the Internet provides companies with the ability to check processes on-line before an order is placed. It also gives them access to latest prices. This is especially important for a company, since tracking deliveries provides the company with data on the reliability performance of the carriers. It also provides managers with the information they require to inform carriers of delays as they occur, and not have to wait for several days before the information becomes available for corrective measures to be taken. Successful supply chains have to connect different functions within the company

and the correspondent functions in partner organizations for a dynamic and real time information flow. Company strategy must be aligned with the information technology for attaining the optimization of supply chain management. Information systems enable the improvement of supply chain activities: increasing productivity for focusing on value-added activities, streamline materials flow across the supply chain, management of information and variables through simulation and decision-support systems, on-time communication among member companies, consolidation of purchase.

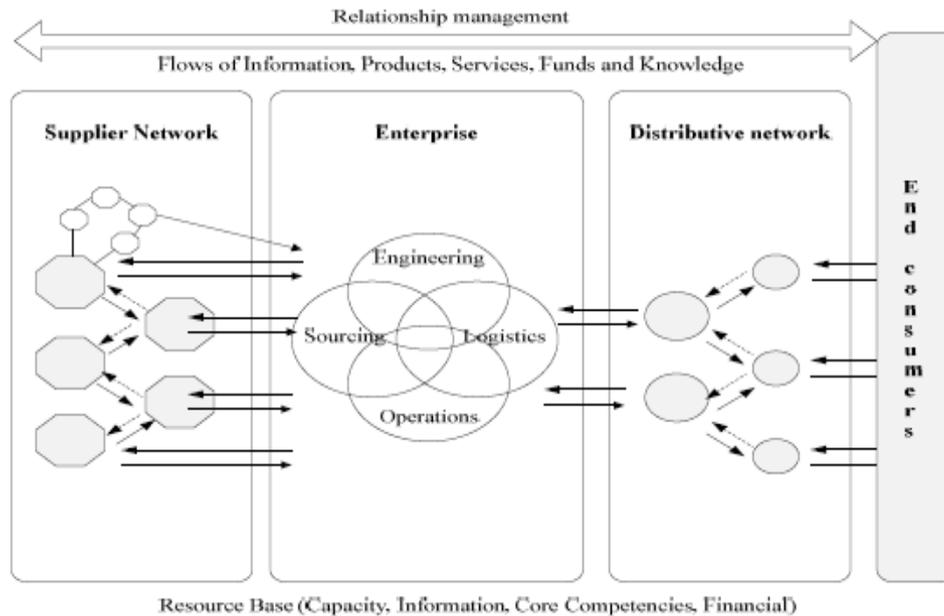


Figure 2. The Integrated Supply Chain (Handfield and Nichols, 2002)

## 8. Information Technology in Supply Chain Management

Recently the concepts of supply chain design and management have become a popular operations paradigm. This has intensified with the development of Information and Communication Technologies (ICT) that include Electronic Data Interchange (EDI), the Internet and World Wide Web (WWW) to overcome the ever-increasing complexity of the systems driving buyer-supplier relationships. The complexity of SCM has also forced companies to go for online communication systems. For example, the Internet increases the richness of communications through greater interactivity between the firm and the customer (Watson et al., 1998). Graham and Hardaker (2000) highlight the role of the Internet in building commercially viable supply chains in order to meet the challenges of virtual enterprises. Philip and Pedersen (1997) attempt to study the ways in which the business community harnesses EDI with the help of a literature survey based on the application. Armstrong and Hagel (1996) argue that there is beginning of an evolution in supply chain towards online business communities. The Automotive Network eXchange (ANX) will establish a standard method for parts suppliers to communicate with and obtain order information from the auto manufacturers (Graham and Hardaker, 2000). Supply chain management emphasizes the overall and long-term benefit of all parties

on the chain through co-operation and information sharing. This signifies the importance of communication and the application of IT in SCM. This is largely caused by variability of ordering (Yu et al., 2001).

Information sharing between members of a supply chain using EDI technology should be increased to reduce uncertainty and enhance shipment performance of suppliers and greatly improve the performance of the supply chain system (Srinivasan et al., 1994). Companies need to invest large amount of money for redesigning internal organizational and technical processes, changing traditional and fundamental product distribution channels and customer service procedure and training staff to achieve IT-enabled supply chain (Motwani et al., 2000). The following are some of the problems often cited in the literature both by the researchers and practitioners when developing an IT-integrated SCM: lack of integration between IT and business model, lack of proper strategic planning, poor IT infrastructure, insufficient application of IT in virtual enterprise, and inadequate implementation knowledge of IT in SCM. There is no comprehensive framework available on the application of IT for achieving an effective SCM.

With the emergence of the personal computer, optical fiber networks, the explosion of the Internet and the World Wide Web, the cost and availability of information resources allows easy linkages and eliminates information-related time delays in any supply chain

network [Handfield R, Nichols E.(2002), Hult G, Tomas M, Hurley RF, Giunipero LC and Nichols EL.(2000)]. This means that organizations are moving toward a concept known as e-commerce, where transactions are completed via a variety of electronic media, including the World Wide Web. These technologies are supply chain “enablers,” in that they can substantially reduce paperwork, improve communication, and reduce supply chain cycle times if properly implemented. A primary requirement is that buyers develop relationships with suppliers characterized by a willingness to share and receive information and work in a collaborative manner to improve efficiencies and reduce cycle time [Handfield R, Nichols E.(2002), Hult G, Tomas M, Nichols EL.(1996)].

## 9. An Empirical Study of Supply Chain Management Optimization an Performance

### 9.1. Case Study

Consider the SCM model in which is based in diagram of MPC scheme following for inventory control where is consisting of the process, the MPC law and the forecasting policy of customers demand. This model participates in measurement of performance, thus the society hope to optimize their supply chain in the future costumers demand. In particular, we will speak in our paper about the model predictive control.

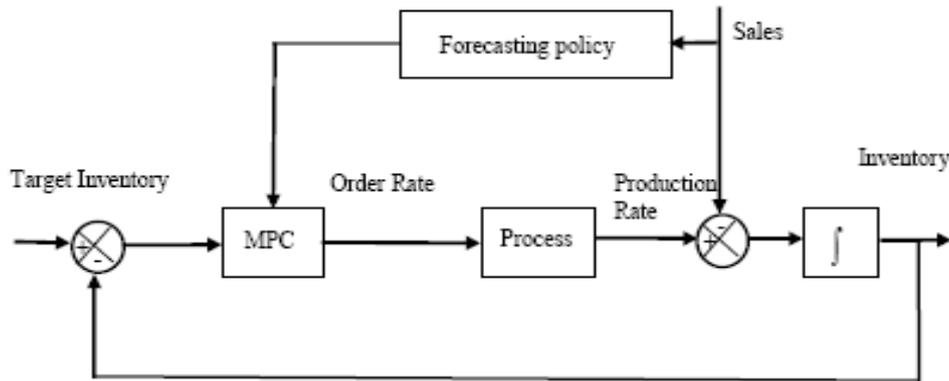


Figure 3. Block diagram of MPC (Philip Doganis et al, 2006)

Model predictive control (MPC) is nowadays recognized as a standard methodology for the control of industrial and process systems [Morari M. et Lee JH., (1999)]. This is because of its capability to incorporate constraints for the manipulated and/or the controlled variables, to handle the nonlinearities often present in dynamical systems and to overcome modeling mismatch. The idea of model predictive control is simple: A process model is used to predict the effect of a finite number of future moves on the controlled variables. This model is incorporated in an on-line open loop optimization problem,

which determines the optimal control sequence for a given performance criterion. The simplest MPC objective function is the weighted sum of the two basic control targets, namely the sum of squared differences between the predicted outputs and their set points over the future prediction horizon and the sum of squares of the control moves over the control horizon. After the solution of the minimization problem is found, only the first of the future control actions is implemented to the system. The same procedure is performed repetitively at each time step.

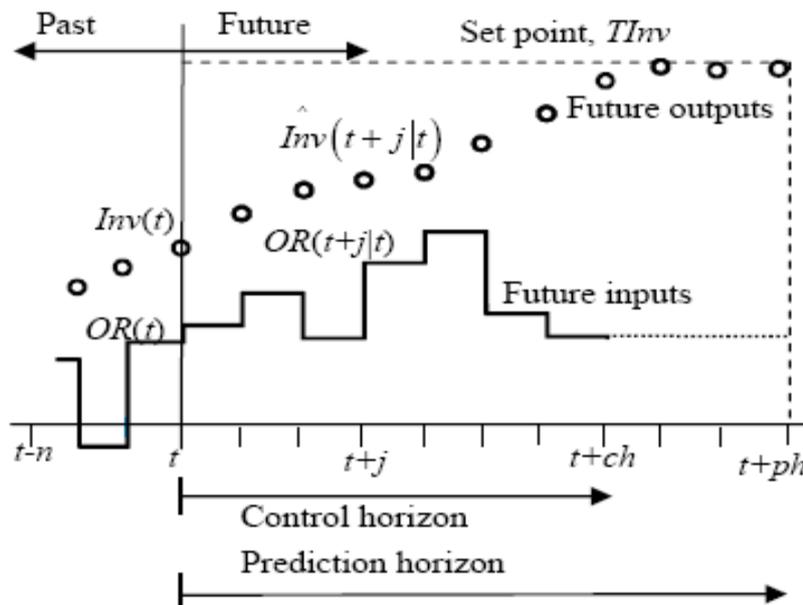


Figure 4. MPC basic concept (M. Morari, JH. Lee, 1999)

MPC was first applied to inventory management by Kapsiotis and Tzafestas, (1992), who studied a single manufacturing site problem and included a penalty term in the objective function for deviations from a reference path for inventory in order to compensate for production lead times. Perea-Lopez et al, (2003) employed MPC to the management of a multi-level supply chain with multiple products where demand was deterministic, so the need for an inventory control mechanism was reduced. Finally, Lin et al, (2005) presented a Minimum Variance Control system with a set point not only for the actual inventory level, but also for the WIP (Work-In-Process) level, while customer demand was expressed by an ARIMA model. In our case we are speaking about the forecasting operation:

### Forecasting

Forecasting plays a central role in the efficient operation of a supply chain, as it provides valuable information on the expected future direction of important factors, thus enabling planners to act preemptively and more effectively. Linear models are the most popular, partly due to their simplicity and ease of use. The forecast in these two methodologies is produced after differencing the time series at an appropriate order (if necessary) using weighted past values of the time series and past forecast errors. A general form of the ARIMA ( $p,d,q$ ) model is the following:

$$\left(1 - \sum_{i=1}^p \phi_i L^i\right) (1-L)^d X_t = \left(1 + \sum_{i=1}^q \theta_i L^i\right) \varepsilon_t \quad (1)$$

Where  $L$  is the lag operator,  $\phi_i$  are the parameters of the autoregressive part of the model,  $\theta_i$  are the parameters of the moving average part,  $p$  is the order of autoregression,  $d$  is the order of differencing,  $q$  is the order of the moving average process and  $\varepsilon_t$  are error terms. Depending on the values of the parameters in the general form depicted in Eq. (1), there are many types of ARIMA models, like the Autoregressive (AR) model, which is an ARIMA( $p,0,0$ ) model where only past values of the function are used to produce a forecast.

Another method widely used is the Holt-Winters, which is an exponential smoothing methodology. As such, it uses weighted values of past time series occurrences, where the coefficients decay exponentially with each period, thus giving more weight to recent values and less to more distant ones. Its structure can capture trends and seasonality in data, making it suitable for various types of time series data. The additive form of the Holt-Winters method is:

$$Y_{t+h} = \mu_t + b_t t + S_{t-p+h} + e_t \quad (2)$$

where  $Y_{t+h}$  is the predicted value of the  $h$ -th period ahead in time;  $\mu_t$  is a mean value of the series, which is updated as in Eq. (3), where  $p$  the periodicity of the seasonality;  $b_t$  is a trend parameter of the series, updated as in Eq. (4) and  $S_t$  is the seasonal component of the series, updated as in Eq. (5).

$$\mu_t = \alpha (Y_t - S_{t-p}) + (1-\alpha)(\mu_{t-1} + b_{t-1}) \quad (3)$$

$$b_t = \gamma (Y_t - \mu_{t-1}) + (1-\gamma)b_{t-1} \quad (4)$$

$$S_t = \delta (Y_t - \mu_t) + (1-\delta)S_{t-p} \quad (5)$$

Its inherent sophisticated structure allows it to capture the complexity in the behavior of series with nonlinearity, while at the same time model parameters can be determined with algorithms that require no trial-and error procedure. The RBF neural network consists of three layers. The input layer is used to feed the input variables ( $x_1, x_2, \dots, x_N$ ) into the model. The hidden layer contains a number of nodes ( $1, 2, 3, \dots, L$ ), which apply a nonlinear transformation to the input variables, using a radial basis function. The output layer serves ( $w_1, w_2, w_3, w_4, \dots, w_L$ ) as a linear summation unit ( $\hat{y}$ ).

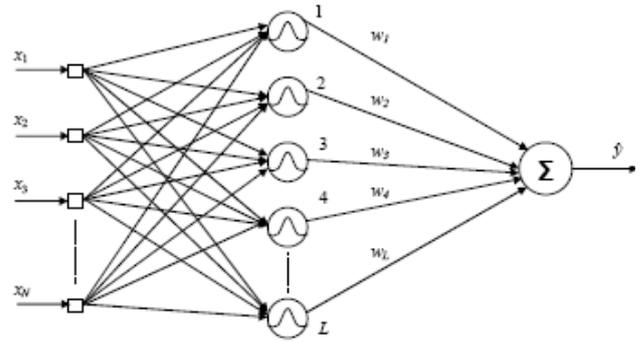


Figure 5. An example of the RBF neural networks architecture

## 9.2. Methodology

In many production-inventory systems, the production process is modeled by a pure delay unit, with a discrete transfer function equal to  $z^{-T}$ , where  $T$  is the lead time. However, such an assumption is not always realistic since the production rate may depend on orders given in different times in the past. In this work, we assume that the process dynamic behavior is described by a Finite Impulse Response (FIR) model. In this case, the system output (production rate  $R(t)$ ) will be given by the following Eq.:

$$R(t) = \sum_{i=1}^n g_i \cdot \text{Order}(t-i) \quad (6)$$

where  $\text{Order}(t-i)$ ,  $i=1, \dots, n$  is the order rate at time  $t-i$ ,  $n$  is the system order and  $g_i$ ,  $i=1, \dots, n$  are the system parameters. Eq. (6) can easily lead to the transfer function between production rate and order rate  $z$ -transformed signals:

$$\frac{R(z)}{\text{Order}(z)} = g_1 \cdot z^{-1} + \dots + g_n z^{-n} \quad (7)$$

Which obviously is a generalization of pure delay. From the block diagram of the principal model Figure 3, inventory  $Inv(z)$  is given by the following equation:

$$Inv(z) = \frac{1}{1-z^{-1}} (R(z) - Sales(z)) \quad (8)$$

Where  $Sales(z)$  is the  $z$ -transform of customers demand  $Sales(t)$  and  $\frac{1}{1-z^{-1}}$  is the transfer function of the integrator. Combining Eqs. (6) and (8) we arrive at Eq. (9), which shows that inventory at time  $t$  is related to order rate with an autoregressive with exogenous input model (ARX) that also considers customer demand as an external measured disturbance.

$$Inv(t) = Inv(t-1) + \sum_{i=1}^n g_i \cdot Order(t-i) - Sales(t) \quad (9)$$

In this section we will speak about the Robust Model Predictive Control Scheme, so, in case of inventory control (Fig. 1), manipulated variables of the proposed control scheme are the future order rates  $Order(t+j/t)$ ,  $j=0, \dots, ch-1$  and controlled variable is the predicted inventory  $\hat{Inv}(t+j/t)$ ,  $j=1, \dots, ph$ . A predictor for inventory is formulated based on the material balance represented of Eq. (9). In order to test the robustness of the proposed control scheme, we assume that the predictor is based on an approximation of the process parameters  $\hat{g}_i$ ,  $i=1, \dots, n$  and not their actual values (Eq. (6)). The inventory predictor also uses an estimation of unknown future sales  $ForSales(t+j/t)$ ,  $j=1, \dots, ph$ . This estimation can be the simple projection of current sales over the prediction horizon, or can be calculated from a forecasting policy, as is the case here. So, the optimization problem solved on line is described by the set of Eqs. (10)-(17).

$$\min_{\substack{OR(t+i) \\ i=0, \dots, ch-1}} \sum_{j=1}^{ph} \left( w \left( \hat{Inv}(t+j|t) - TInv \right) \right)^2 + \sum_{j=0}^{ch-1} \left( r \cdot \delta Order(t+j|t) \right)^2 \quad (10)$$

$$\hat{Inv}(t+j-1|t) + \sum_{j=1}^n \hat{g}_i \cdot \delta Order(t+j-i) - ForSales(t+j|t) + e(t+j|t) \quad (11)$$

$$e(t+j|t) = \begin{cases} e(t|t), & \text{if } j=1 \\ 0, & \text{else} \end{cases} \quad (12)$$

$$e(t|t) = Inv(t) - Inv(t-1) - \sum_{j=1}^n \hat{g}_i \cdot Order(t-i) + Sales(t) \quad (13)$$

$$\delta Order(t+j|t) = Order(t+j|t) - Order(t+j-1|t), \quad j=0, \dots, ch-1 \quad (14)$$

$$u_{min} \leq Order(t+j|t) \leq u_{max}, \quad j=0, \dots, ch-1 \quad (15)$$

$$\delta u_{min} \leq \delta Order(t+j|t) \leq \delta u_{max}, \quad j=0, \dots, ch-1 \quad (16)$$

$$\delta Order(t+j|t) = 0, \quad j=ch, \dots, ph \quad (17)$$

Where  $\hat{Inv}(t+j/t)$ ,  $j=1, \dots, ph$  is the  $j$ -step ahead prediction of inventory,  $ph$  and  $ch$  are the prediction and the control horizon respectively,  $TInv$  is the target inventory value,  $\delta Order(t+j/t)$ ,  $j=0, \dots, ch-1$  are the future control moves (Eq. (14)),  $w$ ,  $r$  are weight matrices and  $e(t+j|t)$ ,  $j=1, \dots, ph$  is the predictor error (Eq. (12)-(13)). Eq. (11) shows that the current value of the predictor is equal to the actual. Eq. (12) denotes that the predictor error should correct only the first prediction since Eq.(10) is an autoregressive

model. Eq. (13) gives the predictor error from current sales and inventory value. Eqs. (15)-(16) are hard constraints that bound the manipulated variables and the control moves respectively.  $u_{min}$ ,  $u_{max}$ , are the lower and upper bounds for order rates and  $\delta u_{min}$ ,  $\delta u_{max}$ , are the lower and upper bounds for control moves. Eq. (17) ensures that no control moves are made after the control horizon.

## 10. Conclusion

The supply chain concept has become a concern due to global competition and increasing customer demand for value. Thus, the information must be available in real time across the supply chain and this can not be achieved without an integrated software system for supply chain management. The development of an information system for supply chain management assumes the redesign of the existing supply chain for creating a solid network of suppliers and customers. Various linear and nonlinear forecasting methodologies were evaluated in order to investigate the existence of possible nonlinearity in the sales time series. The nonlinear method used, namely RBF neural networks, exhibited superior forecasting performance, showing that the series had mostly nonlinear character. The simulation results demonstrated that forecast accuracy leads to improved control performance, thus leading to more efficient management of the supply chain.

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