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MARMARA UNIVERSITY

INSTITUTE FOR GRADUATE STUDIES IN

PURE AND APPLIED SCIENCES

SUPPLY CHAIN PERFORMANCE MEASUREMENT AND A CASE STUDY IN MANUFACTURING INDUSTRY

İlhan DERMAN

(Industrial Engineer)

THESIS

FOR THE DEGREE OF MASTER OF SCIENCE

IN

ENGINEERING MANAGEMENT PROGRAMME

SUPERVISOR
Asst.Prof.Dr. Özalp VAYVAY

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This project would not have been possible without the support of many people. Many thanks to my adviser, Asst.Prof.Dr.Özalp VAYVAY, who read my numerous revisions and helped make some sense of the confusion. Also thanks to Levent HATİPOĞLU, Seda SOYATA, Nuri BULGULU and Selçuk ERGÜL who offered guidance and support during the literature survey phase and the case study phase in the manufacturing industry.

And finally many thanks to my parent, Nihal DERMAN and Kayhan DERMAN, and my brother, Korhan DERMAN, who endured this long process with me, always offering support and love.

July, 2006 **İlhan DERMAN**

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ÖZET

Tedarik Zinciri Yönetimi (TZY) zorlu rekabetin özelleştirilmiş ürünlere ve birebir hizmetlere odaklanmaktan daha çok önem kazandırdığı global iş dünyasında stratejik olarak kritik bir kavram olarak konumlanan değer zincirinin optimizasyonunu kapsamaktadır.

Tedarik zinciri yönetimi entegre lojistik süreçlerinin optimizasyonu ve süreçler arasındaki yetkinlikler üzerine odaklanmıştır.

Üretim alanında, TZY tedarikçilerle yakın işbirliği sağlamaktadır. Üretim sürecinin en iyi kalite, fiyat ve temin zamanını sağlayan tedarikçi ile yürütülmesini kolaylaştırır.

Müşteri hizmetleri alanında, şirketlere doğru fiyatı elde etme ve müşterilerine lojistik süreçlerini teklif etmeye izin vermektedir.

Satış ve pazarlama alanında ise en iyi ürünü sağlayarak ve satınalma süreçlerini kontrol ederek müşterilerine en iyi hizmeti sunmasına olanak tanımaktadır.
TZY şirketlerin müşterilerine yönelik stratejilerini yerine getirirken kendilerini en iyi pozisyona yerleştiren tedarikçilerini seçmelerini mümkün kılar.

Şirketler gerçek zamanlı planlama, karar verme, hızlı ve doğru müşteriye cevap vermek için sistemler üzerine odaklanmıştır. Anahtar faktörlere göre sistemi ölçümlemek ve teadrik zincirini kontrol altına almak en kritik nokta olmuştur.

Organizasyonlar sektörlerinin büyüdüğü iş süreçlerine adapte olabilmek ve çevrimin maliyetini azaltmak için TZY performans ölçüm sistemi kurmak zorunda kalmaktadırlar. Temel olan değer zincirlerini perofrmans yönetim ve bilgi sistemleri araçlarını kullanarak metodolojik bir yöntemle modellemek ve kontrol etmektedir.

Tedarik zinciri performans ölçümü kapsamında fırsatlar irdelenmeli, yürütülen süreçler ölçümlenmeli ve çıkan sonuçlar standart değerlerle kıyaslanmalıdır. Bu da süreç parametrelerinin limit değerler içinde kalmasını sağlayacaktır.

Bu çalışmada TZY kavramı iş, müşteri, iş süreçleri, öğrenme ve yaratma perspektifinden ele alınmış, bu başlıklar altında operasyonel ve stratejik kazançlar irdelenmiş ve imalat sektörüne özgü tüm zincirin yönetimini kontrol etmek için kurumsal kaynak planlama uyarlamasıyla birlikte değişimleri öneren bir ölçüm modellemesini kapsamaktadır

Bu ölçüm modeli şirketlerin tedarik zincirlerini çoklu boyutlar (müşteri, maliyet, yatırım, karlılık ve hız) arasındaki performansı optimize etme yetkinliğini sağlayan bir araç olarak tasarlanmıştır.

Yöneticilere sürekli değişen markete çabuk cevap verebilmelerini güçlendirmek ve dünya çapında esnek bir sistemi standartlaştırmak için kıyaslama ve rekabet bilgilerini geliştirmelerini sağlayan bir karne olarak referans alınabileceği öngörülmüştür.

Temmuz, 2006 **İlhan DERMAN**

ABSTRACT

Supply Chain management (SCM) encompasses the optimization of the value chain, which constitutes a strategically critical concept in the global business envirionment where though competition makes it more important than ever to focus on individually customized products and one-to-one service. SCM focuses on dealing with optimizing logistics by integrating processes and competencies across the entire supply chain.

In the production area, SCM ensures close cooperation with suppliers. This makes it much easier for a company to place production of product parts with the supplier who can carry out the job with the best quality, price and timing.

In the customer service area, SCM allows a company to offer customers a direct overview of logistics process and to obtain optimal prices.

In sales and marketing, companies can offer customers total service by providing the best product and handling of all purchasing tasks.

SCM makes it possible to choose precisely each of the suppliers who can put a company in the position to optimally fulfill its strategy towards its customers.

Companies are focused on strong systems for real time planning, decision making, faster and accurate customer response. The most critical point is to take under control their supply chain flow and measure the system based on the key factors.

Organizations are supposed to establish a SCM performance measurement system in order to adapt the business processes as their markets grow. It is essential to systematize and to control the value chain in a methodological way via using the information systems tools and performance measurement tools.

In the context of supply chain performance measurement concept it is supposed to examine the opportunities, measure the output of the processes enabled by the

supply chain and compare the results with a set of standards. Therefore the process parameter values need to be kept within the set limit remain relatively constant.

This study is described the concept of supply chain management in terms of financial perpective, customer perspective, internal business process perspective and learning and innovation perspective and there both strategic and operational rewards will be examined and included an applicable measurement model which offers challanges and advanteges to control the supply chain mechanism in manufacturing industry.

The measurement model is designed as a tool which enables the companies to be capable of optimizing the performance of the supply chain across multiple dimension (customer service, costs, investments, profits and speed). It is anticipated as a scorecard which enables the managers to develop benchmarks and competitive information in order to strengthen their ability to react quickly to a constantly changing market and to standize with one flexible system worldwide.

July, 2006 **İlhan DERMAN**

CLAIM FOR ORIGINALITY

Supply Chain Performance Measurement and A Case Study in Manufacturing Industry

The bottleneck to overcome in manufacturing industry is to clarify the critical performance indicator and to establish the performance measurement point in order to get the meaningful results throughout the supply chain process flow. As practices point of view, performance measurement systems are supposed to be integrated with the strategic goals of the company.

At this point, companies are required robust system to help them create adaptive supply chain network. This requirement brought a new concept to the managerial perspective: enterprise resources planning systems. With Enterprise resources planning system, Companies have the complete set of tools they need to network, plan, execute and coordinate supply chain operations – all in one comprehensive solution.

Although the trigger point is to measure the performance of the supply chain flow, the initial point is to map the value added process, to eliminate the non value added activities and to support the process with the ERP solutions. The solution also gives the companies in manufacturing industry the information they need to support strategic supply chain decision-making processes. It can help them address key issues, such as where to open or close plants or distribution centers, where to produce a given product, or where they can take advantage of strategic sourcing opportunities.

In the context of this study, the difficulties to measure the supply chain performance are examined and the steps supposed to be considered to design the effective supply chain infrastructure. The results are handled in terms of the delivery performance by applying the enterprise system solution. The benefits of the applied ERP solution is listed below,

- Continually assess possibilities and options for the supply chain infrastructure to make sure that the supply chain stays optimized over time.
- An end-to-end solution for planning highly configured products, with characteristics-based forecasting, planning, scheduling, and available-to-promise tools.
- A plug-and-optimize capability that makes it easy to integrate the company's own customized optimization tools and techniques
- Satisfy customer demand with flexible scheduling options
- Control the utilization of the manufacturing resources for optimum performance
- Track production progress and easily make changes to increase production efficiency and reduce costs
- Handle the reliable data in order to track the supply chain performance throughout the flow and integrate the performance indicator with strategic goals.
- Out-of-the-box optimization for manufacturing industry, including multilevel supply and demand matching functions feature-based optimization.

July, 2006 **Asst.Prof.Dr. Özalp VAYVAY** **İlhan DERMAN**

ABBREVIATIONS

SCM : Supply Chain Management
ERP : Enterprise Resources Planning
OEM : Original Equipment Manufacturer
JIT : Just in time
MRP : Material Requirement Planning
MRPII : Manufacturing Resources Planning
MTO : Make to Order
MTS : Make to Stock
EDI : Electronic Data Interchange
CRM : Customer Relationship Management
APS : Advanced Planning Schedule
DRP : Distribution Resources Planning
PMS : Performance Measurement System
BSC : Balanced Scorecard
VAS : Value Added Service

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PART I: INTRODUCTION AND OBJECTIVES

I.1. INTRODUCTION

In the new millennium, the trend is evolving to Supply Chain Management's use as a strategic business tool that can restructure an organization to optimize the value chain. The new angle is that companies to a much greater degree than ever before will open up their boundaries to include suppliers in a virtual business network as integral parts of their own organizations. The supply chain systems of today and tomorrow must be capable of optimizing the performance of the supply chain across multiple dimensions – customer service, costs, investments, profits, and speed. It is the integration of key processes from initial raw material extraction to the final or end customer, including intermediate processing, transportation, and storage activities and final sales to the end customer.

Competing successfully in any business environment today requires companies to become much more involved in how their suppliers and customers do business. Many firms are just now beginning to realize the advantages of supply chain integration. Supply chain management is an out-growth and expansion of logistics and purchasing activities and has grown in popularity and use since the 1980s.

I.2. OBJECTIVES

The popular and old adage 'You can't improve what you can't measure' is absolutely true for firms as well as their supply chains. One of the most difficult areas of performance measure selection is the development of performance measurement systems. This involves the methods by which an organization creates its measurement system. Important questions must be addressed here: What to measure?

How are multiple individual measures integrated into a measurement system? How often to measure? How and when are measures re-evaluated? Although all of the ideas important to examining measurement systems already in place apply, the problem is more difficult and the goal is to create the best possible measurement system for the supply chain or chains of interest.

Firms are also need to develop an entire system meaningful performance measures to become and then remain competitive, particularly when managing supply chains is one of the imperatives. When managing supply chains, adding several tiers of suppliers and customers further complicates an already-formidable performance measurement problem. With supply chains, the system has become much larger, characterized by a range of relationships and interactions. Performance at the end-product level depends on adequate performance among the primary trading companies along the supply chain. Thus, performance measures must be visible and communicated to all participating members of the supply chain while managers continue to collaborate to achieve results that allow all supply chain members to benefit.

This study tries to emphasize the main features of supply chain management, applicable models on it with proven methodologies and to draw an overview of performance measurement system with eligible indicators.

PART II. GENERAL BACKGROUND

GENERAL INFORMATION

II.1. SUPPLY CHAIN MANAGEMENT CONCEPTS

II.1.1. Overview of Supply Chain Management

Supply Chain Management (SCM) encompasses the optimization of the value chain, which constitutes a strategically critical concept in the global business environment where tough competition makes it more important than ever to focus on individually customized products and one-to-one service. Supply Chain Management focuses on dealing with sub suppliers as alternative production locations and knowledge centers to broaden competencies for a company.

SCM has been defined to explicitly recognize the strategic nature of coordination between trading partners and to explain the dual purpose of SCM: to improve the performance of an individual organization, and to improve the performance of the entire supply chain. The goal of SCM is to create sourcing, making and delivery processes and logistics functions seamlessly across the supply chain as an effective competitive weapon.

II.1.2. Literature Definitions of Supply Chain Management

The institute for Supply Management "supply chain management as the design and management of seamless, value added processes across organizational boundaries to meet the real needs of end customers. The development and integration of people and technological resources are critical to successful supply chain integration."

The Supply-Chain Council Managing "supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory

tracking, order entry and order management, distribution across all channels, and delivery to the customer."

The council of Logistics Management defines supply chain management concept as "the systematic, strategic coordination of the traditional business functions and the tactics across these functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."

Chan et.al. (2003) "Supply Chain Management" is a continuous process, from raw materials to finished goods, via each traditional distinct function such as forecasting, purchasing, manufacturing, distribution, and sales and marketing. Improvement of this business integration enables management to focus upon managing the core business and delegating the management of the support infrastructure to achieve the benefits of the economies of scale. The supply chain consists of different levels, e.g. supplier, manufacturing, distributing, and consumer.

Tan et al. (1998) "Supply chain management encompasses materials/supply management from the supply of basic raw" materials to "final product (and possible recycling and re-use). Supply chain management focuses on how "firms utilize their suppliers' processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency.

Kopczak et al. (1997) The set of entities, including suppliers, logistics services providers, manufacturers, distributors and resellers, through which materials, products and information flow.

Lee and Ng et al. (1997) A network of entities that start with the suppliers' supplier and ends with the customers' custom the production and delivery of goods and services.

Saunders et al. (1995) External Chain is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to ultimate end customers.

Berry et al. (1994) Supply chain management aims at building trust, exchanging information on market needs, developing new products, and reducing the

supplier base to a particular OEM so as to release management resources for developing meaningful, long term relationship.

Lee and Billington et al. (1993) Supply chain management networks of manufacturing and distribution sites that procure raw materials, transform them into intermediate and finished products, and distribute the finished products to customers.

Christopher et al. (1992) supply chain management is a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.

Ellram et al. (1991) Supply chain management a network of firms interacting to deliver product or service to the end customer, linking flows from raw material supply to final delivery.

Jones and Riley et al. (1985) Supply chain management an integrative approach to dealing with the planning and control of the materials flow from suppliers to end-users.

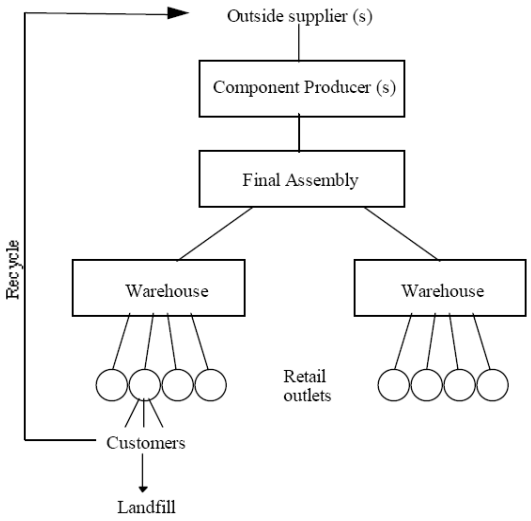


Figure II.1. A Schematic of a Supply Chain

II.1.3. Origins of Supply Chain Management

During the 1950s and 1960s, U.S. manufacturers were employing mass production techniques to reduce costs and improve productivity; while relatively little attention was typically paid to creating supplier partnerships, improving process

design and flexibility, or improving product quality. New product design and development was slow and relied exclusively on in-house resources, technologies and capacity. Processes on the factory floor were cushioned with inventory to keep machinery running and maintain balanced material flows, resulting in large investments in work-in-process inventory.

In the 1960s and 1970s, material requirement planning (MRP) systems and manufacturing resource planning (MRPII) systems were developed, and the importance of effective materials management was recognized as manufacturers became aware of the impact of high levels of inventories on manufacturing and storage costs.

The 1980s were the breakout years for supply chain management. Intense global competition beginning the 1980s provided and incentive for U.S. manufacturers to offer lower-cost, higher-quality products along with higher levels of customer service. Manufacturers utilized just-in-time (JIT) and total quality management (TQM) strategies to improve quality, manufacturing efficiency, and delivery times. In a JIT manufacturing environment with little inventory to cushion scheduling and/or production problems, firms began to realize the potential benefits and importance of strategic and cooperative supplier-buyer-customer relationships. The concept of these partnerships or alliances emerged as manufacturers experimented with JIT and TQM.

In the 1990s, accompanied by increasing logistics and inventory costs and the trend toward market globalization, the challenges associated with improving quality, manufacturing efficiency, customer service, and new product design and development also increased.

Business process reengineering and supply chain management rapidly increased in popularity as a source of competitive advantage for firms.

At the same time, companies also saw benefits in the creation of alliances or partnerships with their customers. Thus, supply chain management has evolved along two parallel paths: (1) the purchasing and supply management emphasis from industrial buyers and (2) the transportation and logistic as emphasis from wholesalers and retailers. The increasing popularity of these alliances with suppliers and customers in the later part of the 1990s and continuing today has also meant a greater reliance on the shipping, warehousing, and logistics services that provide

transportation, storage, documentation, and customs clearing services to many firms within a typical supply chain.

The need to assess the performance of these relationships periodically has also accompanied the growth of supply chain management.

Most recently, the rapid development of client/server supply chain management software that typically includes integrated supply chain management and electronic commerce components aided in the evaluation and adoption of supply chain management. Sharing information with supply chain partners through EDI and the internet has enabled firms to integrate stocking, logistics, materials acquisition, shipping, and other functions to create a more proactive and effective style of business management and customer responsiveness.

II.1.4. Business Process Chains

Referring to Davenport's definition of a process as a structured and measured set of activities designed to produce a specific output for a particular customer or market. A process can be viewed as a structure of activities designed for action with a focus on end customers and on the dynamic management of flows involving products, information, cash, knowledge, and/or ideas. Thousands of activities are performed and coordinated within a company, and every company is, by nature, in some way involved in supply chain relationships with other companies. When two companies build a relationship, certain activities will be linked and managed between the two companies. Since both companies have linked some internal activities with other members of their supply chain, a link between two companies is thus a link in what might be conceived as a supply chain network. For example, the internal activities of a manufacturer are linked with and can affect the internal activities of a distributor, which in turn are linked with and can have an affect on the internal activities of a retailer. Ultimately, the internal activities of the retailer are linked with and can affect the activities of the end customer.

The results of empirical research stressed that "the structure of activities within and between companies is a critical cornerstone of creating unique and superior supply chain performance". The executives believed that competitiveness and profitability could increase if internal key activities and business processes are linked and managed across multiple companies. Thus, "Successful supply chain

management requires a change from managing individual functions to integrating activities into key supply chain business processes". In some companies, management emphasizes a functional structure, others a process structure, and others a combined structure of processes and functions. Those companies with processes had different numbers of processes consisting of different activities and links between activities. Different names were used for similar processes, and similar names for different processes. The lack of inter-company consistency is a cause for significant friction and inefficiencies in supply chains. At least with functional silos, there is generally an understanding of what functions like marketing, manufacturing, and accounting/ finance represent. A simplified illustration of such a disconnected supply chain is shown in Figure II.2.

The primary focus thus far has been on determining processes internal to the company. The number of business processes that it is critical and/ or beneficial to integrate and manage between companies will likely vary. In some cases, it may be appropriate to link just one key process and in other cases, it may be appropriate to link multiple or all of the key business processes. However, in each specific case, it is important that executives thoroughly analyze and discuss which key business processes to integrate and manage.

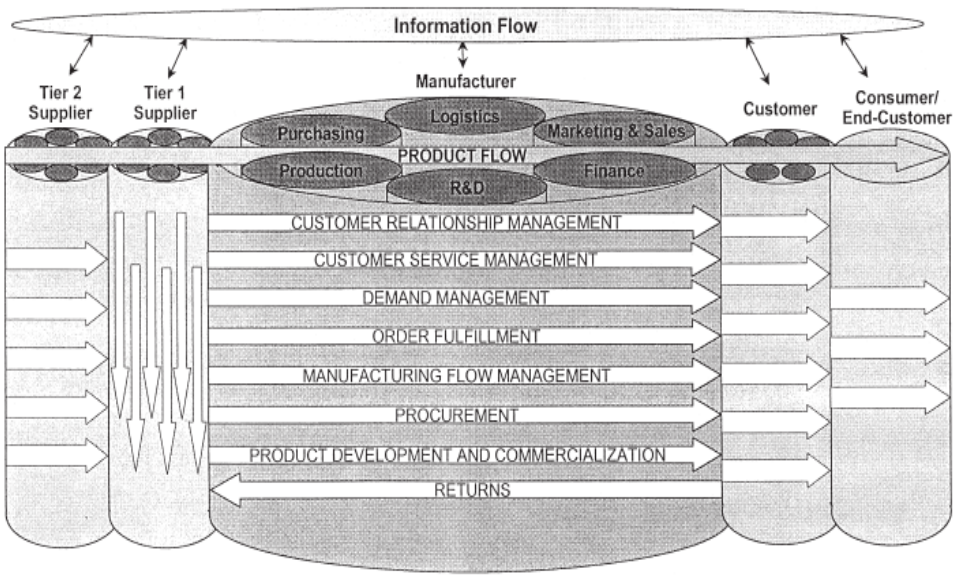


Figure II.2. Supply chain management: the disconnects (Lambert, Cooper, and Pagh, 1998)

II.1.5. Management Components of SCM

The SCM management components are the third element of the SCM framework (as pointed out Figure II.3). The level of integration and management of a business process link is a function of the number and level, ranging from low to high, of components added to the link. Consequently, adding more management components or increasing the level of each component can increase the level of integration of the business process link. The literature on business process reengineering, buyer—supplier relationships, and SCM suggests numerous possible components that must receive managerial attention when managing supply relationships.

It was identified the following nine management components for successful SCM: planning and control; work structure; organization structure; product flow facility structure; information flow facility structure; management methods; power and leadership structure; risk and reward structure; and culture and attitude. These are briefly described below.

Planning and control of operations are keys to moving an organization or supply chain in a desired direction. The extent of joint planning is expected to bear heavily on the success of the supply chain. Different components may be emphasized at different times during the life of the supply chain but planning transcends the phases. The control aspects can be operationalized as the best performance metrics for measuring supply chain success. The *work structure* indicates how the firm performs its tasks and activities. The level of integration of processes across the supply chain is a measure of organizational structure. All, but one, of the literature sources that were examined cited work structure as an important component.

Organizational structure can refer to the individual firm and the supply chain; the use of cross-functional teams would suggest more of a process approach. When these teams cross organizational boundaries, such as in plant supplier personnel, the supply chain should be more integrated.

Product flow facility structure refers to the network structure for sourcing, manufacturing, and distributing across the supply chain. Since inventory is necessary in the system, some supply chain members may keep a disproportionate amount of inventory. As it is less expensive to have unfinished or semi-finished goods in

inventory than finished goods, upstream members may bear more of this burden. Rationalizing the supply chain network has implications for all members.

Virtually every author indicates that the information flow facility structure is the key. The kind of information passed among channel members and the frequency of information updating has a strong influence on the efficiency of the supply chain. This may well be the first component integrated across part, or all, of the supply chain.

Management methods include the corporate philosophy and management techniques. It is very difficult to integrate a top-down organization structure with a bottom up structure. The level of management involvement in day-to-day operations can differ across supply chain members.

The power and leadership structure across the supply chain will affect its form. One strong channel leader will drive the direction of the chain. In most chains studied to date, there are one or two strong leaders among the firms.

The exercise of power, or lack thereof, can affect the level of commitment of other channel members. Forced participation will encourage exit behavior, given the opportunity.

The anticipation of sharing of risks and rewards across the chain affects long-term commitment of channel members.

Culture and attitude are very important considerations. Compatibility of corporate culture across channel members cannot be underestimated. Meshing cultures and individuals' attitudes is time consuming, but it is necessary at some level in order for the channel to perform as a chain. Aspects of culture include how employees are valued and how they are incorporated into the management of the firm. The management components can be divided into two groups. The first group is the physical and technical group, which includes the most visible, tangible, measurable, and easy-to-change components.

The research, and much literature on change management, showed that if this group of management components is the only focus of managerial attention, then the results will be disappointing at best. The second group is comprised of the managerial and behavioral components. These components are less tangible and visible and are often difficult to assess and alter. The managerial and behavioral components define the organizational behavior and influence how the physical and technical management components can be implemented. If the managerial and

behavioral components are not aligned to drive and reinforce an organizational behavior supportive to the supply chain objectives and operations, then the supply chain will likely be less competitive and profitable. If one or more components in the physical and technical group are changed, then management components in the managerial and behavioral group likewise may have to be readjusted. The groundwork for successful SCM is established by understanding each of these SCM components and their interdependence.

It was found all of the nine management components in the business process links that were studied. However, the number of components and combinations varied. The physical and technical components were well understood and managed the farthest up and down the supply chain. For example, in one case, the focal company had integrated its demand management process across four links by applying the following components: planning and control methods; work flow/activity structure; communication and information flow facility structure; and product flow facility structure. The managerial and behavioral management components were in general less well-understood, and more difficulties were encountered in their implementation. It was only found one example of managerial and behavioral management components that were coordinated across more than one link of the supply chain.

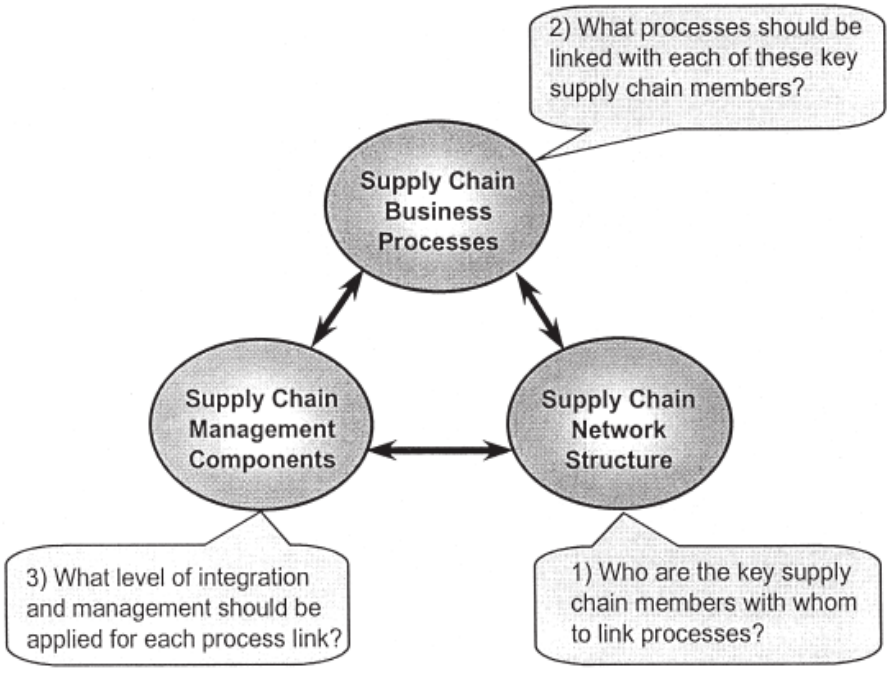


Figure II.3. Supply chain management framework: elements and key decisions (Cooper, Lambert and Pagh, 1997)

II.1.6. Constructs and Framework of SCM

SCM practices are defined as the set of activities undertaken by an organization to promote effective management of its supply chain. SCM practice is proposed to be a multi-dimensional concept than the narrower view (the supplier side, the internal side or the customer side).

Six distinctive dimensions of SCM practices emerge, including strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices and postponement. The six constructs cover upstream (strategic supplier partnership) and downstream (customer relationship) sides of a supply chain, information flow across a supply chain (information sharing and information quality), and internal supply chain processes (internal lean practices and postponement).

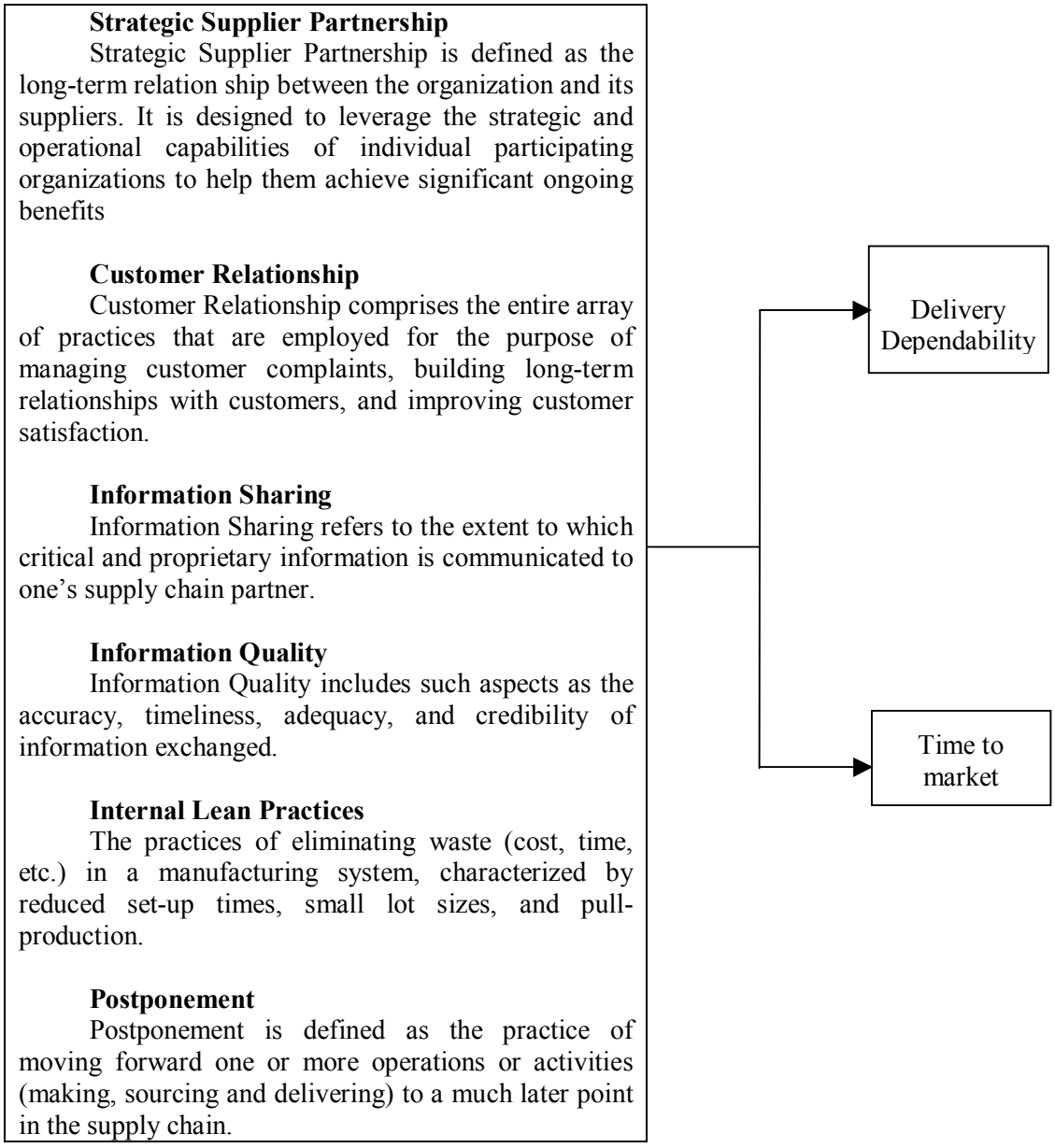


Figure II.4. Theoretical framework linking SCM practices constructs and performance (domain definitions) (Li., Rao, Nathan T. and Nathan B.R., 2005)

Strategic supplier partnership is defined as the long-term relationship between the organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organizations to help them achieve significant ongoing benefits. A strategic partnership emphasizes direct, long-term association and encourages mutual planning and problem solving efforts. Such strategic partnerships are entered into to promote shared benefits among the parties and ongoing participation in one or more key strategic areas such as technology, products, markets, etc. Strategic partnerships with suppliers enable organizations to work more effectively with a few important suppliers who are willing to share responsibility for the success of the products. Suppliers participating early in the

product-design process can offer more cost-effective design choices, help select the best components and technologies, and help in design assessment. Strategically aligned organizations can work closely together and eliminate wasteful time and effort. An effective supplier partnership can be a critical component of a leading edge supply chain.

Customer relationship comprises the entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction and consider customer relationship management as an important component of SCM practices. The growth of mass customization and personalized service is leading to an era in which relationship management with customers is becoming crucial for corporate survival. Close customer relationship allows an organization to differentiate its product from competitors, sustain customer loyalty, and dramatically extend the value it provides to its customers.

Information sharing refers to the extent to which critical and proprietary information is communicated to one's supply chain partner. Shared information can vary from strategic to tactical in nature and from information about logistics activities to general market and customer information. Many researchers have suggested that the key to the seamless supply chain is making available undistorted and up-to-date marketing data at every node within the supply chain. By taking the data available and sharing it with other parties within the supply chain, information can be used as a source of competitive advantage. Many researchers have emphasized the importance of information sharing in SCM practices. Supply chain partners who exchange information regularly are able to work as a single entity. Together, they can understand the needs of the end customer better and hence can respond to market change quicker. The negative impact of the bullwhip effect on a supply chain can be reduced or eliminated by sharing information with trading partners. Consider the effective use of relevant and timely information by all functional elements within the supply chain as a key competitive and distinguishing factor. As an example, sharing of information with suppliers has given Dell Company the benefits of faster cycle times, reduced inventory, and improved forecasts. Customers, for their part, have benefited by getting a higher-quality product at a lower price

Information quality includes such aspects as the accuracy, timeliness, adequacy, and credibility of information exchanged. While information sharing is important, the significance of its impact on SCM depends on what information is shared, when and how it is shared, and with whom. Sharing information within the entire supply chain can create flexibility, but this requires accurate and timely information. In the literature there are many examples of the dysfunctional effects of inaccurate/delayed information, as information moves along the supply chain. It has been suggested that organizations will deliberately distort information that can potentially reach not only their competitors, but also their own suppliers and customers. It appears that there is a built-in reluctance within organizations to give away more than minimal information since information disclosure is perceived as a loss of power. Given these predispositions, ensuring the quality of the shared information becomes a critical aspect of effective SCM. Organizations need to view their information as a strategic asset and ensure that it flows with minimum delay and distortion. Information shared must be as accurate as possible in order to obtain the best SCM solution.

Internal lean practices are the practices of eliminating waste (cost, time, etc.) in a manufacturing system, characterized by reduced set-up times, small lot sizes, and pull-production. The term ‘‘lean’’ is used to refer to a system that uses less input to produce at a mass production speed, while offering more variety to the end customers. Elimination of waste is a fundamental idea within the lean system. In ‘‘Lean Thinking’’ written by Womack and Jones (1996), five principles are identified as fundamental to the elimination of waste. (1) Specify what does and does not create value from the customer’s perspective; (2) identify all the steps necessary to design, order and produce the product across the whole value stream to highlight non-value-adding waste; (3) make those actions that create value flow without interruption, detours, backflows, waiting or scrap; (4) only make what is pulled by the customers just-in-time; (5) strive for perfection by continually removing successive layers of waste as they are uncovered. Following these principles, internal lean practices may include set-up reduction, pull production, short lead times from suppliers, streamlining ordering, receiving and other paperwork and continuous quality improvement. Lean thinking and lean practices have become very important aspects of effective SCM. Organizations that have not made the effort to drive out unnecessary cost, time and other wastes from their internal supply chain (so that they

can deliver high quality, best value products in a timely manner) will run the risk of losing customers. Lean operating practices are the dominant drivers of a highly integrated and down-sized supply chain, promising both cost savings and productive working partner relationships.

Postponement is defined as the practice of moving forward one or more operations or activities (making, sourcing and delivering) to a much later point in the supply chain. In general, there are three types of postponement: form, time, and place postponement. ‘‘Form postponement entails delaying activities that determine the form and function of products in the chain until customer orders have been received. Time postponement means delaying the forward movement of goods until customer orders have been received. Place postponement refers to the positioning of inventories upstream in centralized manufacturing or distribution operations, to postpone the forward or downward movement of goods’’. Two primary considerations in developing a postponement strategy are: (1) determining how many steps to postpone and (2) determining which steps to postpone. Postponement allows an organization to be flexible in developing different versions of the product in order to meet changing customer needs, and to differentiate a product or to modify a demand function. Keeping materials undifferentiated for as long as possible will increase an organization’s flexibility in responding to changes in customer demand. In addition, an organization can reduce supply chain cost by keeping undifferentiated inventories. Postponement needs to match the type of products, market demands of a company, and structure or constraints within the manufacturing and logistics system. In general, the adoption of postponement may be appropriate in the following conditions: innovative products; products with high monetary density, high specialization and wide range; markets characterized by long delivery time, low delivery frequency and high demand uncertainty, manufacturing or logistics systems with small economies of scales and no need for special knowledge.

Performance outcomes: The constructs of delivery dependability and time to market have been included primarily to evaluate the predictive validity of the six SCM practices constructs. Delivery dependability is the ability of an organization to provide products on time and of the type and in the volume as required by the customers. Time to market is the capability of an organization to introduce new products faster than the competitors. Delivery dependability and time to market are impacted by the SCM practices like strategic supplier partnership, information

sharing, postponement, etc. For example, strategic supplier partnership can reduce time to market and increase level of customer responsiveness and satisfaction. Information sharing will enable organizations to make dependable delivery and introduce products to the market quickly. Postponement not only increased the flexibility in the supply chain, but also balances global efficiency and customer responsiveness

II.2. MANAGING THE SUPPLY CHAIN

The aim of supply chain management is to gain an advantage in terms of customer service and cost over competitors.

The transition to the 21st century seems to have been accompanied by ever higher levels of turbulance in the business environment. Companies that were market leaders a decade ago have in many cases encountered severe reversals of fortune. Mergers and takeovers have changed the shape of many markets and the advent of Europen and changed the shape of many markets and the advent European and global competition have changed for all time the rules of the game. This has been a growing demand from the marketplace for ever-higher levels of service and quality. These pressures have combined to produce a new imperative for the organization: the need to be responsive.

The responsive organization not only seeks to put the customer at the centre of the business, but it designs all its systems and procedures with the prime objective of improving the speed of response and the reliability of that response. Traditional organizations have grown heavy with layer upon layer of management and bureaucracy. Such companies have little chance of remaining competitive in the new marketplace.

II.2.1. Creating the Logistics Vision

Making service happen is the ultimate challange. Recently, most companies are familiar with the idea of mission statements as an articulation of the vision of the business. The mission statement seeks to define the purpose of the business, its boundaries and its aspirations. It is now by no means uncommon for organizations to have such statements for the business as a whole and for key constituent components.

What some companies have found is that there can be significant benefits to defining the logistics vision of the firm.

The purpose of the logistics vision statement is to give a clear indication of the basis whereby the business intends to build a position of advantage through closer customer relationships. Such statements are never easy to construct.

Ideally the logistics vision should be built around the simple issue of "how to use logistics and supply chain management to create value for the customers". To operationalize this idea will necessitate a detailed understanding of how customer value is created and delivered in the markets in which the business competes. Value chain analysis will be a fundemental element in this investigation as will the definition of the core competencies and capabilities of the organization.

II.2.2. Mapping Supply Chain Processes

Flowcharting supply chain processes is the first step towards understanding the opportunities than exist for improvements in productivity through reengineering those processes. A critical concept that underpins such reengineering opportunities is the idea of 'value adding' time versus 'non-value adding time'.

Value adding time is time spent doing something which creates a benefit for which the customer is prepared to pay. It could be classified manufacturing as a value added activity as well as the physical movement of the product and the means of creating the exchange.

Non value adding time is time spent on an activity whose elimination would lead to no reduction of benefit to the customer. Some non value adding activities are necessary because of the current design of the processes but they still represent a cost and should be minimized.

The difference between value adding time and non value adding time is crucial to an understanding of how supply chain management activities can be improved. Once processes have been flowcharted the first step is to bring together the managers involved in those processes to debate and agree exactly which elements of the process can truly be described as value adding. Agreement may not easily be achieved as noone likes to admit that the activity they are responsible for does not actuall add any value for customers.

The next step is to do a rough-cut graph highlighting visually how much time is consumed in both non-value adding and value adding activities.

Throughput efficiency in a supply chain can be measured as:

(Value-added time / End-to-end pipeline time)*100

To begin to make significant improvements in throughput efficiency first requires detailed understanding of the processes and activities that are involved as the materials or products move through the chain. A useful tool is supply chain mapping.

A supply chain map is essentially a time based representation of the processes and activities that are involved as the materials or products move through the chain. Simultaneously the map highlights the time that is consumed when those materials or products are simply standing still, i.e. as inventory.

In these maps, it is usual to distinguish between 'horizantal' time and 'vertical' time. Horizantal time is time spent in process. It could be intransit time, manufacturing or assembly time, time spent in production planning or processing and so on. It may not necessarily be time when customer value is being created but at least something is going on. The other type of time is vertical time or product is standing still as inventory. No value is being added during vertical time, only cost.

Pipeline maps can also provide a useful internal benchmark. Because each day of process time requires a day of inventory to cover that day, the only inventory would be that needed to cover the process lead time.

In multi product businesses each product will have a different end-to-end pipeline time. Furthermore where products comprise multiple components, packaging materials or subassemblies total pipeline time will be determined by the speed of the slowest moving item or element in that product.

Mapping pipelines in this way provides basis for logistics reengineering projects. Because it makes the total process and its associated inventory transparent, the opportunities for reducing non value adding time become apparent. In many cases much of the non value adding time in a supply chain is there because it is self-inflicted through the rules that are imposed or that have been inherited. Such rules include: economic batch quantities, economic order quantities, minimum order sizes, fixed inventory review periods, production planning cycles and forecasting review periods.

II.2.3. Problems with Conventional Organizations

Among the experienced observers and commentators of the logistics management process there is general agreement that the major barrier to the implementation of the logistics concept is organizational. A major impediment to change in the crucial managerial area is the entrenched and rigid organizational structure that most established companies are burdened with.

There is a great danger that those companies that do not recognize the need for organizational change, or that lack the will to make it happen, will never achieve the improvements in competitive advantage that integrated logistics management can bring. The argument advanced is that the demands of the marketplace for enhanced service provision combined with dramatically heightened competition call for a paradigm shift in the way to think about the organizations.

The concept of integrated logistics management, whereby flows of information and material between source and user are co-ordinated and managed as a system is now widely understood, if not widely implemented. The logic of linking each step of the process as materials and products move closer to the customer is based on upon the principles of optimization. The goal is to maximize customer service while simultaneously minimizing costs and reduced assets locked up in the logistics pipeline.

However, in the conventional organization this poses an immediate problem. Most companies are organized on a functional basis. Each of the vertical functions in the conventional organization is normally headed up by senior managers who come to regard their functional area as their “territory”. Further reinforcing the functional or vertical orientation in the conventional organization is the budgeting system. Typically, each function will be driven by a budget that seeks to control the resources consumed by those functions. It is almost as if the company is working on the assumption that the prime purpose of any enterprise is to control the consumption of resources. The leading edge companies have long since realized that the sole purpose of the business is to create profitable outputs, not inputs, should form the basis both fir the way to organize as well as for the way to plan and control.

Inventory builds up at functional boundaries

If individual functions are encouraged to optimize their own costs because of the budegting system – then this will often be at te expense of substantially increased

inventory across the system as a whole. If production seeks to minimize the unit costs of production by maintaining long production runs with large batch quantities, is the creation of more inventory than is normally required for immediate requirements. If purchasing management seeks low material costs through bulk purchases then again the inventory of raw materials ahead of production will exist right across the supply chain at boundaries within organizations and moreover at boundaries between organizations.

II.2.4. Functional Boundaries impede Process Management

The process of satisfying customer demand begins with inbound supply and continues through manufacturing or assembly operations and onwards by way of distribution to the customer. Logically, the ideal way to manage this process is as a complete system, not by fragmenting it into watertight sections. It actually leads to a loss of effectiveness in compentive terms.

Many of the causes of variation in the order-to-delivery cycle, stem from the variability that inevitably arises in the inefficient processes that have to be created to manage the interfaces between functions. The time taken to process orders is often extended purely because of the paperwork, checking and re-checking, that conventional systems generate. Because organizations grow organically they tend to add to existing processes in a patchwork manner rather than taking a “clean piece of paper” approach. Consequently, the systems in use to tend to owe more to history than to any concept of holistic management. This phenomenon is further compounded by the inability of managers to detach themselves from their familiar surroundings. Instead there is a natural tendency to focus on pieacemeal improvements within their own narrow fuctional area.

To achieve a smooth-flowing logistics pipeline requires an orientation that facilities end-to-end process management. The principle can be compared to the management of an industrial process, where to ensure the achievement of optimum efficiency the entire process is managed and controlled as a system.

II.2.4. Conventional Organizations Present Many Faces to The Customer

The traditional organization is that it does not a present a “single face” to the customer. The criticism goes beyond the obvious problems that arise when a customer , information on an order, is passed from one section of the company to another although that is a common enough occurance. The real problem is that no one person or department is empowered to manage a customer from inquiry through to order delivery.

There will be a sequence of activities beginning with order entry. The point of entry may be within the sales or commercial function but then it goes to credit control from where it may pass to production planning or, in a make to stock environment to the warehouse. The order has been manufactured or assembled it will become the responsiblity of distribution and transport planning. At the same time there is a separate process involving the generation of documents such as bill of lading, delivery notes and invoicing. The problem is that these activities are sequential, performed in series rather than in parallel. Each function performs its task and then passes the order on the next function.

II.2.5. Developing the Logistics Function

Some comentators have suggested that the solution to the problems outlined above lies in creating a higher level of authority in the form of a logistics function that links together the purchasing, production and distribution tasks. Appealing as this may appear at first sight, it will not solve the underlying conflicts that the traditional organization creates. It merely adds another layer of management. At a time when the trend is towards ‘flattening’ organizations, this solution is unlikely to gain ground.

Instead radical solutions must be sought which may require a restructuring of the conventional ‘vertical’ organization and lead to the creation of a ‘horizontal’ or market-facing business.

The horizantal organization has a number of distinguishing characteristics listed below;

- Organized around processes, not tasks

- Flat and de-layered
- Built upon multi-functional teams
- Guided by performance metrics that are market based

It is focus on processes rather than functions that is the key to the horizontal organization. The basic percept of process management is that it is through processes that customer value is created. The logic of seeking to manage processes on an integrated basis.

In most organizations there will only be a limited number of core processes and the following are likely to be central to most business:

- Brand development (including new product development)
- Consumer development (primarily focused on building loyalty with end users)
- Customer management (creating relationships with intermediaries)
- Supplier development (strengthening upstream and alliance relationships)
- Supply chain management (the cash to cash process)

Typically companies that focus upon process management have recognized that they are best managed by cross-functional teams. These teams will comprise specialist drawn from the functional areas and will be led by 'integrators' whose job it is to focus the process team around the achievement of market-based goals.In such organizations a different type of skills profile is clearly required for managers at all levels. Equally the reward systems need to change as the horizantal organization by definition is flatter and hence the traditional upward promotion opportunities are fewer.

Making the change from the 'vertical' to the 'horizantal' poses many challenges and yet it is critical to the implementation of a market driven logistics strategy.

The achievement of this transformation might begin with the recognition that logistics is essentially a planning orientation, the logistics management process entails the linking of production plans with materails requirement plans in one direction and distribution requirements plans in the other. The aim of any organization should be to ensure that production produces only what the market place requires while purchasing supplies production with what it needs to meet its immediate requirement.

The key lies in the recognition that the order and its associated information flows should be at the heart of the business. The only rationale for any commercial organization is to generate orders and to fulfill those orders.

All of this leads to the conclusion that the order fulfillment process should be designed as an integrated activity of the company with the conventional functions of the business supporitng that process. To assist this transition the development of a customer order management system is a vital prerequisite.

A customer order management system is a planning framework that links the information system with the physical flow of materials required to fulfill demand. To achieve this requires the central management of forecasts, requirement plans, material and production control and purchasing.

At the crucial point of the customer order management system is a requirement plan which is market driven. The inputs to this plan include data and information relating to inquiries and orders, price changes, promotional activity and product availability. This information provides the basis for the forecast which then drives the requirements plan. Alongside this is a process for the fulfillment of current orders. They are not separeted but closely integrated through the information system.

Two practical steps for improving customer order management processes are suggested below:

II.2.5.1. Eliminate the Non Value Added Activities

In reviewing the existing order processing system each element and each link in the chain should be critically examined to identify the value that it creates and the cost that it adds. ‘Value’ in this context refers to customer value, meaning a benefit that will contribute to the total utility of the product or offer in the fornt of the customer.

In many service processes it is the case that a large proportion of the time spent is non-value-added time. The target should be to eliminate or reduce all non value added activities.

The goal should be to look for opportunities to combine steps in the processes, to integrate separate groups of people performaing adjacent tasks and to simplfy processes by reducing paperwork and reports.

II.2.5.2. Order Fulfillment Groups

Several companies have experimented with the idea of cross functional, cross departmental team to take responsibility for the management of orders. This team may be termed the order fulfillment groups. The idea behind such a group is that rather than having an organizational structure for order management where every activity separated with responsibility for each activity fragmented around the organization, instead these activities should be grouped together both organizationally and physically.Instead of seeing each step in the process as a discrete activity, they can be clustered.Consequently, the order fulfilment group might comprise commercial or sales office people, credit control and accounts, production scheduler and transport scheduler.

It is likely that in a large business serving many different customers a number of these teams may be required. The effect that such groups can have is often dramatic.Because all the key people in the order fulfilment process are bought together and linked around a common entity – the order – this group is better able to sort out problems and eliminate bottlenecks.

In a manufacturing context the customer order management system must be closely linked to production planning and the materials requirement plan.Ideally all the planning and scheduling activities in the organization relating to the order and its satisfaction should be brought together organizationally.

As markets, technologies and competitive forces change at ever-increasing rates the imperative for organizational change becomes more pressing. The paradox is that because organizational structures are rigid, they don't have the ability to change at anything like the same rate as the environment in which they exist.

The trend towards globalization of industry, involving as it does the co-ordination of complex flows of materials and information from a multitude of offshore sourcing and manufacturing plants to a diversity of markets has sharply highlighted the inappropriateness of existing structures.

To compete and survive in these global markets requires a logistics-oriented organization. There has to be nothing less than a shift from a functional focus to a process focus. Such a radical change entails a re-grouping within the organization so that the key tasks become the management of cross functional work flows. Order fulfilment has been recognized as a core process and there is one order management

system architecture that links order entry, order management and factory order/shipment processing. This core process is supported by a common information system that provides 'end-to-end' visibility of the logistics pipeline from order through to delivery. The information that flows from the marketplace at one end of the pipeline to supply points at the other will increasingly shape the organization.

II.3. SUPPLY CHAIN PROCESS INTEGRATION

The ultimate goal in supply chain management is to create value for the end customers as well as the firms in the supply chain network. To accomplish this, firms in the supply chain, network must integrate process activities internally and with other firms in the network.

II.3.1. The need for integration

Supply chain integration is a major challange to operations management discipline and practice. Many improvements within supply networks are enabled by developments in the areas of communication and information technology. The rapid growth of the global economy has brought with it an increased number of suppliers for many products. The internet has further fueled this competition by making it easier to locate and compare their offerings (Bakos, 1998). As the competitive environment intensifies, a firm's supply chain becomes an important contributor to its market success. To achieve top performance, a supply chain must surmount two issues. First, supply chain must ''fit'' the market characteristics of the products it distributes. Fisher's (1997) supply chain classification scheme points out the potential negative consequences of a mismatch between a supply chain and its products. A chain designed for least cost operations may be too inflexible to handle products that require a rapid market response to satisfy variable market demands. Stockouts and lost sales will result from the inflexibility.Similarly, a supply chain that is designed for flexible and rapid response is unnecessary and probably too expensive for standardized products with stable demands.

Many initiatives within the field of supply chain management and operations management are directed the removel of barriers. The most widely accepted philosophies or paradigms that focus on elimination of barriers are Lean Thinking (and Just in time). Leanness calls for the elimination of waste is important but not a

prerequisite. The ability to rapidly reconfigure the manufacturing system is essential. In order to achieve the main goals as elimination of waste, lead time compression, and the ability to reconfigure quickly, manufacturing flexibility is needed. Without elimination of barriers like high setup costs, large batch sizes, leanness and agility are difficult to achieve.

In a study of Frohlich and Westbrook (2002), integration is operationalized based upon eight different kind of activities that manufacturers commonly employ to integrate their operations with suppliers and customers: access to planning systems, sharing production plans, joint EDI access/networks, knowledge of inventory mixe levels, packaging customization, delivery frequencies, common logistical equipment and common use of third party logistics. The aim of these integrative activities is to eliminate operational barriers in the material flow and in the information flow. The main stream within the supply chain management literature seems to focus on barriers directly linked to these flows.

Second, it must overcome the well-documented bullwhip effect (Senge 1990;Lee et al., 1997). The bullwhip effect is a behavioral phenomenon in which orders become distorted and magnified as the members of the chain, fearful limited supply or imminent demand increases, over-order to ensure they receive adequate supplies. Controls are needed to dampen the bullwhip effect as much as possible.

To create a better fit with its products and to ameliorate the bullwhip effect, a supply chain often adds a decoupling point, which is a storage location along the chain (Hoekstra and Romme,1992). Upstream of the decoupling point the chain is designed for least cost, and downstream of the decoupling point it is designed for customer responsiveness. The storage buffers the two components and allows the chain to achieve elements of both responsiveness and low cost. Given the importance of designing a supply chain with the proper characteristics, it is necessary to measure its performance.

Supply Chain integration implies process integration, both upstream and downstream. Process integration means collaborative working between suppliers and buyers, joint product development, common systems and shared information.

In many industries the concept of process integration is increasingly accepted. Over the last ten years, there has been a significant change in the way in which many car manufacturers in Western Europe have changed from fragmented, transaction-focused businesses to highly integrated and relationship-based supply chains.

Companies like Rover have now embraced the philosophy of the "extended enterprise". In the extended enterprise the aim is to create seamless, 'end-to-end' processes so that innovative products are created and delivered to market at higher levels of quality, in shorter time-frames but at a price which in real terms is significantly less than it has ever been in the past. This is achieved through a number of means including:

1. Supply Base Rationalization

In the 80's Rover dealt with well over 2000 suppliers of components, materials and services. In the 90's that number was down to under 500. With remaining suppliers Rover has established significantly closer relationships and is now looking to these suppliers increasingly to provide systems rather than components. For example, a single first-tier supplier will be responsible for supplying the complete dashboard for a particular model of car, complete with all the controls, displays and wiring ready for installation as a single unit- the whole unit being delivered on a just-in-time-basis.

2. Supplier Development Programmes

As with the majority of companies, Rover used to view the procurement activity as primarily a purchasing function tasked with buying at the lowest price.

Supplier development has replaced the traditional purchasing function. The idea behind this is that a cross-functional team of Rover specialists will work closely with suppliers to seek improvements in the suppliers' processes as well as in the interfaces with Rover's processes.

3. Early Supplier Involvement in Design

Much innovation in the car industry today is supplier originated. By bringing the suppliers more closely into the new product development process it has been found that not only can innovation be continually embodied in new products but often that simpler, more cost-effective designs can be created.

It is now recognized that a significant proportion of the total cost of making and maintaining a car is 'designed in'; the challange today is to find ways of 'designing-out' those costs.

4. Integrated Information Systems

The use of Electronic Data Interchange (EDI) coupled with the growing acceptance of the 'just-in-time' philosophy led to a realization that the benefits of a fully transparent information system could be considerable. Thus suppliers can

manage the flow of material into the plant on the basis of advance notification of Rover's production schedules. There are no orders, no delivery notes, no invoices – only a single source of information that provides the basis for a timely physical response which itself triggers a payment to the supplier.

5. Centralization of Inventory

The extended enterprise of Rover does not only include upstream suppliers but the downstream flow of finished product through its dealer network. Traditionally dealers carried a stock of cars which may or may not have matched the requirements of their customers.If a customer demanded a colour or an option that the dealer who did have that particular vehicle. The dealers have only demonstration models, but they also have on-line access to the Rover Supply system and can give the customer immediate confirmation of the availability of the car of their choice and when it can be delivered.For those vehicles that are not available from stock the dealer can enter the order directly into the Rover production schedule and the car is in effect made to order.

II.3.2. Managing The Supply Chain as a Network

Extending the relations from simple buyer–supplier cooperation to a whole supply network from raw material suppliers to final customers provides several advantages that include for the buyers a large pool of suppliers, reduced transaction costs, market transparency, purchase transparency, lower prices, dynamic pricing models, control of maverick, buying, and lower inventory costs. For the suppliers the benefits among others are large pools of buyers, real time information, time to market, aggregation of small orders, efficient fund transfer. On the other hand, supply chain cooperation has some potential disadvantages like for the buyers unqualified suppliers, miscommunication, failed promises, hidden switching costs, missed value-creating opportunities; for the suppliers the disclosure of confidential information, pressure for price reductions, easy supplier switching, loss of established relationships, high initial investment.

Improving productivity through the reduction of process lead times is a well established in manufacturing studies. The faster the value adding process the more efficient the manufacturing unit. These benefits stem from reduced capital bound to operations, uniformity in output, i.e. low variation and therefore outstanding quality,

together with improved capability to react on market fluctuations. At the same time increased specialization has directed companies to focus on their core operations and competencies with the evident aim to be cost efficient and innovative in an ever-narrowing technical know-how and product offering. Produciing value to end customer has become more and more a joint effort that takes place in company networks, where flexibility and fast response to demand changes crucial for survival. The more complex the products to be produced the more collaboration with suppliers and partners is required.

The benefits of lead time reduction have been well documented and grounded in mathematical principles forming the foundations of operations management. These principles explain the relationships between lotsizes, utilization and lead time. In addition, when variation in lead times is introduced to the system, the principles predict its negative impact on operational performance and output of the process. Various operations management approaches have also focused on lead time reduction. The best known is the 1980s Just-in-time movement with its emphasis on inventory and waste reduction in general; it still had a strong impact on lead time reduction and well-documented processes to reduce capital bound to operations. This was accompanied by optimized production technology, which spotted bottlenecks as the limiting resource for total amount of the system. In the 1990s the time based competition was winning ground, after which arrived agile and lean manufacturing. The underlying aim of the above mentioned approaches to improve productivity has focused in one way or another on the reduction of process lead times. The mathematical principles are clear and simple and most successful changes in manufacturing processes, be it cell production, preventive maintenance, product layout, focused factories, set up time reduction etc., can be traced down to their favorable impact on lead times (Hameri and Paatela, 2005).

More and more of the end product value is delivered through a tier-structured supplier network with multiple connections to other value networks. Reduction of lead times has direct implication on the overall performance of the supply chain. Since Forrester's (1961) nonlinear simulations on information and delivery delays in supply chain, which helped to understand information distortion and order batching leading to ever longer lead times and inventory build up, the importance of supply chain management has been continuously increasing. Partnering with suppliers, which was already emphasized by the JIT approach, instead of keeping them at arms-

length has become more popular; the practices vary and should depend on the concerned industry and on the products made and delivered. At the same time companies are increasingly focused on their core competencies and aim toward scale and low costs in their operations. Along this development the emergence of even more structured supply networks have boosted the trend toward more modular product design. Supply networks have clustered around the certain technologies and services, which are consumed by one or several industries. Boundaries between companies are becoming transparent and focus is on the management of strictly defined interfaces, while leaving the modules and their internal workings to be managed autonomously by the supplier. Supply networks show emergent behaviour with all characteristics of a complex adaptive system, and therefore their management is difficult, especially if information delays exist and lead times are long and variable (Hameri and Paatela, 2005).

At the same time new networking technologies are easing this structural transformation of supplier networks (Frohlich and Westbrook, 2002).

Industries should pursue toward shorter lead times in their operations, while they intrinsically are aiming at cost efficiency through higher volumes. This has lead to the emergence of supplier networks where transactions between various up and downstream players produce higher value and more complex end products.

Industries are increasingly structured into supplier networks and products are delivered through network operations. Traditional integrated production units have broken into company networks, where individual operators specialize into certain value adding operations. Supplier companies serve often more than one value network.

Supplier networks are continuously evolving through contraction and expansion. The trend toward more and more focused value adding operations has lead to high level specialization and larger networks.

Supplier networks with highly specialized and cost effective units create business oppotunities for companies with superior operational concepts through the integration of distributed operations. These supplier networks evolve through contraction.

Numerous researchers have come to the conclusion that supply networks can enhance their performance through the consalidation of the supplier base, streamlining the chain by removing unnecessary steps, speeding information flows

by increasing information transparency in the supply network and by establishing long-term partnerships with major suppliers (Fisher 1997).

Supplier networks are emerging and continuously expanding and contracting in competitive industries, and this evolution creates possibilities for fast moving companies to deploy business models that deliver more value with outperforming operational efficiency.

Supplier networks with clear tier structure are less dependent on single value networks, as they are capable to serve other industries and their networks. There seems to be a limit which a network can expand through continuous focus on single operations and their cost efficiency through scale production. The limit comes when innovative and fast moving companies notice the opportunity to contract the network into one integrated operation that operationally and in perceived customer service level outperforms the other players focusing only on cost and scale. There seems to be a limit up to which a network can contract through the integration of various operations. Passing this limit means that the manufacturing becomes too complex and holds too many competencies, which are more efficiently managed by separate and dedicated suppliers. Managing separate value adding operations through the same management structure are better integrated than a sequence of operations performed by individual companies. The challange for supply chain management across company boundaries is a significant task.

The structured supply chains are better in tolerating business cycles in one industry through their increased independence of the concerned industry. At the same time there is a limit to which level the division of operational tasks can go while maintaining profitable business. This one sided focus on scale and cost establishes a limit, which the new entrants can exploit by integrating several otherwise dispersed value adding operations into one operational unit.

Customers are not willing to centralize their operations to optimize for the whole supply chain. They may also be reluctant to adopt other IT systems than the ones they are already used to. This means that despite the will to improve overall supply chain performance there may be several hindrances.Sharing of the scale benefits gained from the collaboration can cause problems for the suppliers.For reasons of competition, engagements are made usually for the short term in order to leave space for renegotiations. This usually leads to a situation where major operational changes and improvements outside of optimization of the supply chain

are not favored, as the contract will be terminated and renegotiated in short intervals.Customers are also reluctant to give the whole volume to one supplier, as they want to put different suppliers into price competition. Customers who engage themselves to networking without prior experience seem to value close proximity to vendors. This emphasizes how true networking is based on trust and long term relationships.

The stage of product life cycles has a direct impact on the network relationships between suppliers and customers. At the beginning of the life cycle it is important to secure the availability of the goods to the market.When the demand gets saturated, it is important to get costs down and fine tune the operations to meet the demand in a swift and flexible manner.If the product is strategically important to the customer often prefers to have the vendors closer proximity.Fluctuations in demand are generally difficult to manage through long supply chains from remote locations. As the product evolves in its product cycle, its supply chain structure also evolves, usually from closer proximity to longer supply chains where the sourcing units are often located in remote areas. This evolution also effects the service level in chain. There is constant interplay between service level and costs, and in cases where prices of the products have been strictly fixed, one must be able to manage long and inflexible supply chains in an optimized manner.

Supplier network optimization has emphasized forward logistics operations and to some extent ignored reverse network optimization. Depending on the business, these two types of operations may have strong interlinks through shared manufacturing operations, shared inventories and logistics operations. For total network optimum, the two flows should be considered simultaneously in case of apparent synergies.

The dynamics of supplier networks generate business opportunities for fast moving companies integrating some of the value adding operations in the network. Companies succeeding in doing this generate themselves an operationally outperforming position, where growth can be sought even in well established and saturated industries.

II.3.3. Organizational Factors

While the numerical modeling in the previous section shows the potential advantages of buyer– supplier policy coordination in the supply chain, there are a number of organizational factors that may influence whether firms will participate in this type of inter-organizational cooperation. Frameworks could provide conceptual bridges between an analytical operations research perspective and an organization/ management theory perspective, leading to new theories and important new insights.

II.3.3.1. Barriers and Bridges

Based on the literature it can be summarized the top 10 barriers to buyer–supplier coordination (Fawcett and Magnan, 2001):

- Inadequate information systems
- Poor/conflicting measurement
- Inconsistent operating goals
- Organizational culture and structure
- Resistance to change—lack of trust
- Poor alliance management practices
- Lack of supply chain vision/understanding
- Lack of managerial commitment
- Constrained resources
- No employee passion/empowerment

According to those references, the top10 bridges to coordination are (Fawcett and Magnan, 2001):

- Senior and functional managerial support
- Open and honest information sharing
- Accurate and comprehensive measures
- Trust-based, synergistic alliances
- Supply chain alignment and rationalization
- Cross-experienced managers
- Process documentation and ownership
- Supply chain education and training
- Use of supply chain advisory councils
- Effective use of pilot projects

II.3.3.2. Multi-level Framework of Cooperation

Five perspectives represented in the framework provides a valuable viewpoint from which to understand the factors that may influence participation in buyer–supplier policy coordination.

- Individual: At the level of the individual, for example, it can be drawn from theory in managerial and organizational psychology to develop an understanding of how managers gather information, identify opportunities and make decisions regarding policy coordination relationships (see, e.g., Walsh, 1988).
- Two or more individuals: The second theoretical perspective offered by the framework can be used to examine relationships between/among individuals in the buyer and supplier organizations. For example, a potential cause for the inability to form inter-organizational alliances is a clash of executive personalities (Moss-Kanter, 1994).
- Single organization: Using the single organization perspective, it can be investigated the factors that may influence a particular organization's (buyer or supplier) decision to engage in policy coordination arrangements.
- Buyer–supplier dyad: Pairs of buyer and supplier organization are the fourth perspective, enabling the examination of elements of the inter-organizational relationship such as power, conflict and motivations (Kelle and Akbulut, 2005). Organizational differences, such as incompatibility of organizational culture and values could also affect the formation of policy coordination arrangements (Moss-Kanter, 1994).
- Multiple organizations/Organizational Environment: The last perspective provides a level of analysis that can incorporate multiple buyers and sellers (e.g., industry groups) as well as other elements of the organizational environment. Organization theory offers several theories that can be applied at this level of analysis. Resource dependence theory incorporates the concepts of exchange relations, exchange networks, resource dependence, and power to describe and explain how external environments affect and constrain organizations and how organizations respond to those constraints. Institutional theory and population ecology can be used to examine how institutions (e.g., legal and regulatory systems, industry structures and norms, IT standards) affect and are affected by organizations. This level of analysis, for example, could be used to investigate participation in consortia

arrangements for buyer–supplier coordination. While each of these levels of analysis offers a distinct and valuable perspective, combining multiple levels of analysis (e.g., industry group and individual organization) may also yield valuable insights (Kelle and Akbulut, 2005).

II.3.4. The Supply Chain Integration Model

Figure II.5. presents a supply chain integration model, starting with the identification of key trading partners; the development of supply chain strategies; aligning the strategies with key process objectives; developing process performance measures; internally integrating these key processes; developing supply chain performance measures for each process; externally integrating key processes with supply chain trading partners; extending process integration to second tier supply chain participants; and then, finally, reevaluating the integration model periodically.

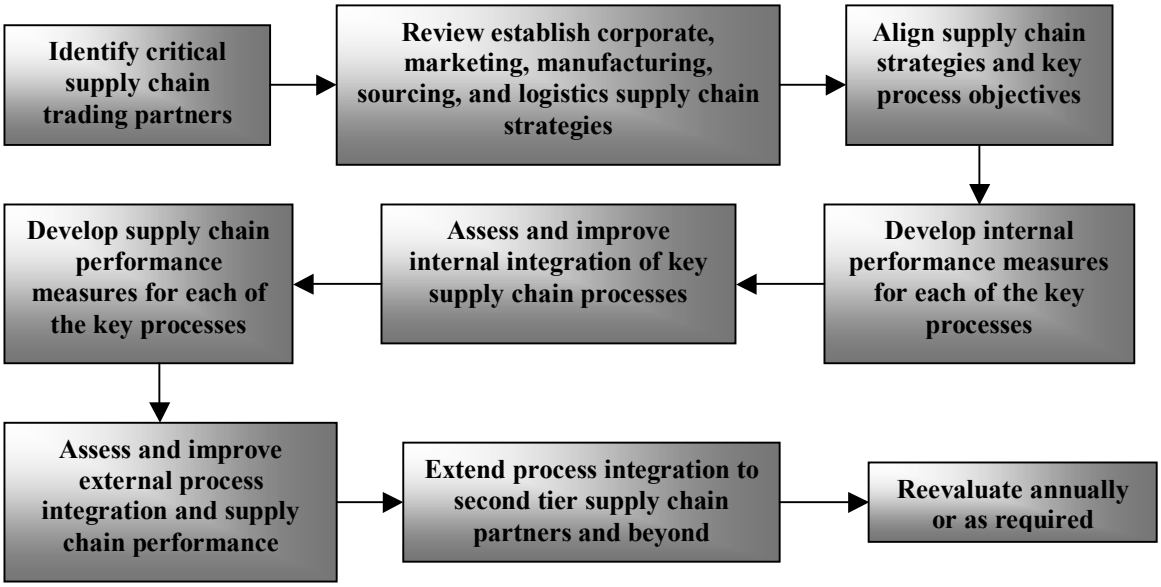


Figure II.5. The supply Chain Integration Model (Wisner, Leong and Tan, 2005)

II.3.4.1. Identify Critical Supply Chain Trading Partners

For each of the firm's products and services, it is important to identify the critical trading partners that will enable the successful sale and delivery of the end product to the final customer. At least, initially, including a large number of supply chain businesses will be extremely difficult and cumbersome, particularly as the firm moves out to second and third tier suppliers and customers. Identifying only the primary trading partners allows the firm to concentrate its time and resources on managing the important process links with these companies, enabling the supply

chain to perform. Including other non-essential or supporting businesses will prove counterproductive in terms of supply chain management.

Depending on where within a supply chain the firm is located, the structure of the network of primary trading partners will vary. Mapping the network of primary trading partners is something should be done to help the firm decide which business to include in its supply chain management efforts.

II.3.4.2 Review and Establish Supply Chain Strategies

On an annul basis, management must identify the basic supply chain strategies associated with each of its products or services. If an end product is competing based on quality, then supply chain members should also be using strategies consistent with delivering high quality products, along with competitive price and service levels. These strategies should then translate into internal functional policies regarding the types of parts purchased and suppliers used; the shop layout and manufacturing processes employed; the designs of the products manufactured; the mode of transportation used; the warranty and return services offered; the employee training methods used; the types of information technologies used; and, potentially, the amount of outsourcing employed. In each of these areas, policies should be geared toward supporting the overall quality-oriented strategy of supply chain.

II.3.4.3 Align Supply Chain Strategies with Key Supply Chain Process Objectives

Once the overriding strategy has been identified for each of the supply chain end products, managers need to identify the important processes linking each of the primary supply chain partners and establish process objectives to assure that resources and efforts are effectively deployed within each firm to support the overall end-product strategy.

Customer Relationship Management

The customer relationship management process provides the firm with the structure for developing and managing customer relationship. Relationship with these key customers are solidified through the sharing of information; the formation of cross company teams to improve products, deliveries, quality, and, cost; the development of shared goals; and, finally, improved performance and profitability for the trading partners along with agreements on how to share these benefits. The

firm should monitor the impact of customer relationship management efforts both in terms if the financial impact of these efforts and in terms of customer satisfaction.

Customer Service Management

The customer service management process is what provides information to customers while also providing ongoing management of any product and service agreements between the firm and its customers. Information can be provided through a number of communication channels including web sites, personnel interactions, information system linkages, and printed media. Objectives and policies are developed to assure proper distribution of products and services to customers; to adequately respond to product and delivery failures and complaints; and to utilize the most effective means of communication to coordinate successful product, service, and information deliveries.

Demand Management

The demand management process is what balances customer demand and the firm's output capabilities. The specific demand management activities include forecasting demand and then utilizing techniques to vary capacity and demand within purchasing, production and distribution function. Various forecasts can be used, based on the time frame, the knowledge of the forecaster, the ability to obtain point-of sale information, and the use of forecasting models contained in many ERP systems.

Order Fulfillment

The order –fulfillment process is the set of activities that allows the firm to fill customer orders while providing the required levels if customer service at the lowest possible delivered cost. Thus, the order fulfillment process must integrate the firm's marketing, production, and distribution plans to be effective. More specifically, the firm's distribution system must be designed to provide adequate customer service levels, and its production system must be designed to produce at the required output levels, while marketing plans and promotions must consider the firm's output and distribution capabilities.

Manufacturing Flow Management

The manufacturing flow management process is the set of activities responsible for making the actual product, establishing the manufacturing flexibility required to adequately serve the markets, and designing the production system to meet cycle time requirements.

Supplier Relationship Management

This process defines personnel routinely communicate with production personnel obtain feedback. Additionally suppliers are frequently contacted for new product development and performance feedback purposes.

Product Development and Commercialization

The product development and commercialization process is responsible for developing new products to meet changing customer requirements and then getting these products to market quickly and efficiently. In actively managed supply chains, many customers and suppliers are involved in the new product development process to assure that products conform to customers needs and purchased items meet manufacturing requirements.

Returns Management

Returns management process, while given little importance in some organizations, can be extremely beneficial for supply chain management in terms of maintaining acceptable levels of customer service and identifying product improvement opportunities.

II.3.4.4. Develop Internal Performance Measures for Key Process Effectiveness

As all used to in each of the preceding key processes, procedures and metrics must be in place to collect and report internal performance data for eight processes. Before companies can measure performance among supply chain partners, they must first build good internal performance measurement capabilities across function. Performance measures need to drive a consistent emphasis on the overall supply chain strategy and corresponding process objectives. In order to assure that processes are supporting the supply chain strategy, performance is continuously measured using a set of metrics designed for each processes.

II.3.4.5. Assess and Improve Internal Integration of Key Supply Chain Processes

Successful supply chain management requires process coordination and collaboration internally, between the firm's functional areas between the firm and its trading partners. Achieving process integration within the firm requires a transition from the typical functional activities to one of teamwork and cooperation across all business function. To achieve this, personnel must have management support,

resources, and empowerment to make meaningful organizational changes to foster the type of cooperation necessary to support the overall supply chain strategy. The formation of cross-functional teams to develop the key process objectives and accompanying performance measures is a good starting point in achieving internal process integration.

The primary enabler of integration is the firm's Enterprise Resources Planning (ERP) system. ERP systems link business processes and facilitate communication and information sharing between the firm's departments. Since the key business processes overlay each of the functional areas, the firm eventually becomes process oriented rather than functionally oriented once ERP systems are deployed. It is this visibility of information across the organization that allows processes to become integrated within the firm.

II.3.4.6. Develop Supply Chain Performance Measures for the Key Processes

Continuing with low-cost supply chain strategy, trading partners should decide on monitoring a number of cost-oriented measures that are averaged across the member firms for each of the key supply chain processes. The measures should align closely with the internal performance measures for each process but may vary based on purchasing, production, distribution, customer service, and other variations across participating firms.

II.3.4.7. Assess and Improve External Process Integration and Supply Chain Performance

Supply chain trading partners must concentrate on sharing sales and forecast information, along with information on new products, expansion plans, new processes, and new marketing campaigns in order to maximize profits for the entire supply chain membership. Focusing on process integration will enable firms to collaborate and share this information.

II.3.4.8. Extend Process Integration to Second-Tier Supply Chain Partners

As supply chain relationships become more trusting and mature, and as the supply chain software used to link supply chain partners' ERP applications and

legacy systems evolves and becomes widely used and relied upon, the tendency will be to integrate processes to second tier partners and beyond.

II.3.4.9. Reevaluate the Integration Model Annually

In the light of the dramatic and fast-paced changes occurring with the development of supply chain information systems and the frequent changes most likely occurring with new products, new suppliers, and new markets, trading partners should revisit the integration model annually to identify changes within supply chains and to assess the impact these changes have on integration efforts.

II.3.5. Obstacles to Process Integration Along the Supply Chain

A number of factors can impede external process integration along the supply chain, causing information distortion, long cycle times, stock-outs, and bullwhip effect, resulting in higher overall costs and reduced customer service capabilities.

Table II.1. Obstacles to Supply Chain Integration (Wisner, Leong and Tan, 2005)

Silo Mentality	Failing to see the big picture and acting only in regard to a single department within the firm a single firm within the supply chain.
Lack of Supply Chain Visibility	The inability to easily share or retrieve trading partner information in real time, as desired by the supply chain participants
Lack of trust	Unwillingness to work together or share information because of the fear that the other party will take advantage of them or use the information unethically
Lack of knowledge	Lack of process and information system skills and lack of knowledge regarding the benefits of SCM among management and other employees, within the firm and among partners
Activities causing the bullwhip effect	
Demand forecast updating	Using varying customer orders to create and update forecasts, production schedules, and purchase requirements.
Order batching	Making large orders for goods from suppliers on an infrequent basis to reduce order and transportation costs.
Price fluctuations	Offering price discounts to buyers, causing buying Patterns
Rationing and shortage gaming	Allocating short product supplies to buyers to increase future orders beyond what they really need

II.4. PERFORMANCE MEASUREMENT IN SUPPLY CHAIN

Performance measurement systems vary substantially from company to company. For example, may' firms performance measures concentrate solely on the firms' costs and profits. While certainly important, managers must realize that making decisions while relying on cost-based performance alone dooms organizations to continue repeating the mistakes of the past. Performance measurement consists of a set of analytical tools that take measurements, display recordable results, and the ability to initiate actions based on the measurement results. Performance measurement is essentially comprised of several criteria consisting of: effectiveness, efficiency, quality, productivity, quality of work life, innovation, and profitability.

When managing supply chains, adding several tiers of suppliers and customers further complicates an already-formidable performance measurement problem. With supply chains, the system has become larger, characterized by a range of relationships and interactions. Performance at the end product level depends on adequate performance among the primary trading companies along the supply chain. Thus, performance measures must be visible and communicated to all participating members of the supply chain while managers continue to collaborate to achieve results that allow all supply chain members to benefit.

Performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives. It reflects the need for improvement in areas with unsatisfactory performance. Thus, efficiency and quality can be enhanced.

The eventual and ultimate goal of supply chain is to successfully deliver products and services to end customers. Traditionally, to meet customer service requirements, firms along the supply chain would simply load their retail shelves, warehouses, and factories with finished goods. Today, this strategy would ultimately lead to inventory carrying costs and product prices so high that firms would no longer be competitive. For firms and their supply chains to be effective, customers along the supply chain and the ultimate users must be satisfied. Thus, firms must invest time and effort understanding end customers and supply chain partners and

then adjust or acquire supply chain competencies to satisfy the needs of these companies and end customers. To obtain the resources to accomplish these tasks, top managers become involved and support the firm's improvement efforts. Ultimately, well-designed performance measurement systems within each supply chain partner and integrated throughout the supply chain must be implemented to control and enhance the capabilities of these firms and, thus, the supply chain. Management that stresses the importance of supply chain management while continuing to evaluate the firm and its employees using performance measurement systems that either have no effect or adversely affect the supply chain will ultimately fail in its supply chain management efforts.

Supply chain management is a flow oriented concept with the objective of integrating resources across a pipeline which extends from suppliers to final customers, it is desirable to have a means whereby costs and performance of that pipeline flow can be assessed.

One of the main reasons that the adoption of an integrated approach to logistics and distribution management has proved so difficult for many companies is the lack of appropriate cost information. The need to manage the total distribution activity as a complete system, having regard for the effects of decisions taken in one cost area upon other cost areas has implications for the cost accounting systems of the organization. Typically, conventional accounting systems group costs into broad, aggregated categories which do not then allow the more detailed analysis necessary to identify the true costs of servicing customers with particular product mixes. Without this facility to analyze aggregated cost data, it becomes impossible to reveal the potential for cost trade-offs that may exist within the logistics system.

Supply chain models have predominately utilized two different performance measures: (1) cost and (2) a combination of cost and customer responsiveness. Costs may include inventory costs and operating costs. Customer responsiveness measures include lead time, stock out probability, and fill rate. Models which are cost, cost and activity time, Cost and Customer Responsiveness, Customer Responsiveness and flexibility use the listed performance measures as objectives that are either minimized or maximized, subject to various operational constraints.

Other performance measures have been identified as appropriate for supply chain analysis, but have not yet been used in supply chain modeling research. Although these measures may be important characteristics of a supply chain, their

use in supply chain models is challenging, since the qualitative nature of such measures make them difficult to incorporate into quantitative models.

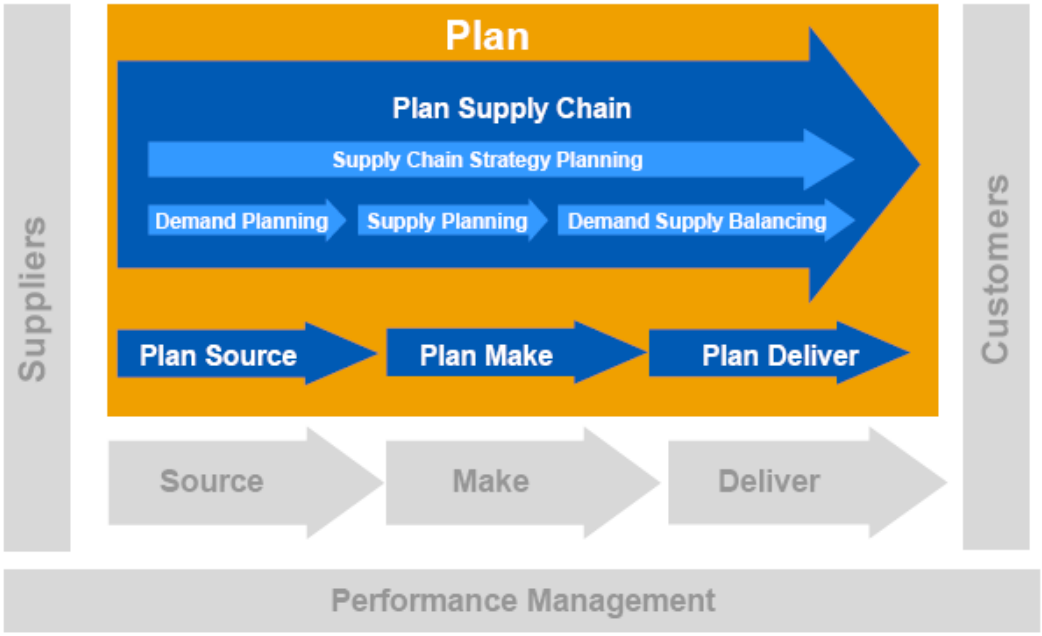


Figure II.6 The focus of the Supply Chain Performance Measurement (PRTM / SAP Benchmarking Study 2002-2003)

II.4.1. Evaluation of Supply Chain Performance Measures

Cost, activity time, customer responsiveness, and flexibility have all been used as supply chain performance measures either singly or jointly.

II.4.1.1. Single Supply Chain Performance Measures

The use of a single performance measure is attractive because of its simplicity. However, one must ensure that if a single performance measure is utilized, this measure adequately describes the system performance. Beamon (1996) identified and evaluated various individual supply chain performance measures. Significant weaknesses were present in each of the performance measures evaluated, based on such criteria as inclusiveness, universality, measurability, and consistency. The most consistent weakness for these performance measures was inclusiveness. In order for a measure to be inclusive, it must measure all pertinent aspects of the supply chain. Consider an example in which a company decides to use cost as the measure of supply chain performance. Although the supply chain may be operating under

minimum cost, it may simultaneously demonstrate poor customer response time performance, or lack flexibility to meet random fluctuations in demand.

II.4.1.2. Cost as a Single Supply Chain Performance Measure

Although cost as a resource measure is important, there are downfalls to relying on cost as the sole performance measure. Maskell (1991) identifies many shortcomings of traditional management accounting. The problems include a lack of relevance of the cost categories, cost distortions (especially overhead), and inflexibility, such as reports that are too late to be valuable. Lee and Billington (1993) identify many pitfalls in supply chain management and one identified pitfall is the incorrect assessment of inventory costs. It was identified two commonly omitted inventory costs: (1) obsolescence and (2) rework due to engineering changes. This problem is magnified by current cost accounting methods, such as overhead calculations, and omitted inventory costs. Existing supply chain models have typically restricted themselves to traditional cost measures, and have not yet utilized the advantages of strategic cost management of the supply chain.

II.4.1.3. Strategic Goals and Supply Chain Performance Measures

Maskell (1991) suggests that the type of performance measures required for a manufacturing organizations are directly related to the manufacturing strategy chosen by the company. The two reasons cited for establishing and maintaining this relationship are: (1) the company may determine if its performance is meeting its strategic goals, and (2) people in the organization will concentrate on what is measured, thus the performance measure will steer company direction.

Individual performance measures used in supply chain analysis have been shown to be non inclusive. Consequently, important supply chain characteristics and their associated interactions have been ignored. Measuring the use of resources, especially cost, has also been identified important part of the supply chain. Many strategic goals of organizations recognize not only importance of minimizing resources, but also the overall importance of the output of the system.

Additionally, ignoring the effects of uncertainty on the supply chain results a system that unable to adapt to future changes.

Current supply chain performance measurement systems are inadequate because they rely heavily on the use of cost as a primary measure, they are not

inclusive, they are often inconsistent with the strategic goals of the organization, and do not consider the effects of uncertainty. That is, although use of multiple supply chain performance measures may be commonplace in real-world settings, it is not commonplace in supply chain modeling. A performance measurement system for supply chain analysis must be developed that addresses these issues. The next step is to develop a framework for measuring supply chain performance.

Customer satisfaction level is an indication of the required standard of service level of a particular company, which is closely related to the whole performance of its supply chain. For different industries, customers look at different measures, such as delivery service, where time is no doubt their major concern; whereas for parts manufacturing, the accuracy of the specification may be the most important consideration. Thus, the weighting of each performance measurement can be different for each industry (Chan, 2003).

Traditionally, performance measurement is defined as the process of quantifying the effectiveness and efficiency of action. In modern business management, performance measurement goes well beyond merely quantification and accounting. It is supposed to contribute much more to business management and performance improvement in the industries.

From the management perspective, performance measurement provides the necessary information for management feedback for decision makers and process managers. It plays a critical role in monitoring performance, enhancing motivation and communication, and diagnosing problems. Furthermore, performance measurement provides an approach to identifying the success and potential of management strategies, and facilitating the understanding of the situation. It assists in directing management attention, revising company goals, and re-engineering business processes. Henceforth, accurate performance measurement is helpful in the improvement of SCM. Gunasekaran et al. develops a framework for measuring the strategic, tactical, and operational level of performance in a supply chain, which deals mainly with supplier, delivery, customer service, and inventory and logistics costs. Although workers attempt to build new measures and metrics for SCM, most of the current PMSs for the supply chain have too many defects to meet the SCM requirements. Besides the criticism about the non-connection with strategy and a biased focus on financial metrics, there are some in-depth problems of PMSs in the supply chain context:

1. The lack of a balanced approach to integrating financial and non-financial measures.
2. The lack of system thinking, in which a supply chain must be viewed as a whole entity and the measurement system should span the entire supply chain.
3. The loss of the supply chain context.

As a result these kinds of PMS encourage local optimisation

II.4.2. Framework for Performance Measurement

II.4.2.1 Quantitative Measures

1.a. Cost

The profit of an enterprise is directly affected by the cost of its operations. Henceforth, many people understand its importance and influence to the whole performance. It is the most significant direct kind of measurement.

Total cost is a sum of all its complex attributes. For different industries, the contribution of each attribute may be different. For a delivery service company, it should deliver its goods within the shortest time. Cost should be mostly a function of distribution and inventory cost, but a heavy contribution from inventory cost may infact indicate a poor performance as the goods are always kept for a long time. A manager should investigate carefully each subcost contribution to the performance.

Apart from the domestic supply chain, there is an international supply chain that may entail great geographical distance and time differences. The complication in a global supply chain may consist of multiple national markets which increase the costs, especially the incentive costs and subsidies or the sensitivity to long-term costs.

Distribution Cost. This includes the transportation and handling costs, safety stock cost, and duty.

Manufacturing Cost. This includes labour, maintenance and re-work costs. Also, there are purchased materials, equipment charges and the supplier's margin.

Inventory Cost. This includes the work-in-process and finished goods inventories.

Warehouse cost. This is sometimes mistakenly taken to be the same as the inventory cost, but there is a difference as warehouse cost is associated with the

allocation from one tier to another and usually involves the finished goods or products.

Incentive Cost and Subsidy. These are taxes and subsidies.

Intangible Cost. This includes quality costs, product adaptation or performance costs and coordination.

Overhead Cost. This is the total current landed costs.

Sensitivity to Long-term Cost. Long-term costs include productivity and wage changes, currency exchange rate changes, product design, and core competence. This cost is especially important for a global and worldwide supply chain.

1.b. Resource Utilization

The performance of a supply chain cannot be focused only on its output. A manufacturing process includes the input, the process, and the output. Thus, the input to the supply chain demands a further investigation. The inputs to a manufacturer include raw materials, the equipment or machines, human resources, energy resources, warehouse space, etc. The best performance is obtained by using all these resources in a well-organised and optimum way. It is easily understood that lack of raw materials for a manufacturing process is not allowed. It may lead to a long delay in finishing time, and most severely, loss of the contract or customer, and even to the loss of the company's reputation in the long term owing to the poor service performance. Many people think that the best use of raw materials is to have no surplus at the end of the manufacturing process.

However, this is not completely true. Safety stock is necessary, as there may be a sudden increase in orders or other interruptions can occur (which should be kept as low as possible) during the manufacture. Both lack of and excess of resources is a waste of time and money. It is important for the manager to determine the optimum resources necessary for every order. Most companies are now recruiting professionals in the relevant areas to ensure optimum use of the resources.

Labour, machine, capacity, energy resource utilisation. To measure the resource utilisation, a company can directly investigate the percentage of surplus or deficit of that particular resource within a period. Resource utilisation also shows the efficiency of that company. Optimum use of resources can save time and money, and in return, minimise the size of the company, and improve its performance.

II.4.2.2. Qualitative Measures

2.a. Quality

Quality is the standard of a product which is related to the customer satisfaction level. Any late deliveries can be regarded as bad for the customers. Thus, quality is related not only to a product but also to the services provided. Therefore, those outcomes resulting in customer satisfaction are all important.

High customer satisfaction is very important, as it is a key indicator of success. Only when the source of customers is unlimited, can a company gain profit and expand its market share and become a leading company within the industry. To provide customers with the type and quality of products and services that they require, time and cost are usually lowered.

Customer Dissatisfaction. A direct measurement of the quality is the customer satisfaction level. It can be measured by the number of customer complaints registered. However, the complaints or a questionnaire delivered to customer would only reflect part of the problem. Problems are not usually grouped into categories, and are usually left unsolved or are solved in an unsystematic way. Also, not all the unsatisfied customers would use his or her valuable time to launch a complaint. They would just turn away and place the order with another supplier without giving notice of the poor service delivered. Therefore, it may not totally reflect the real situation of quality perception of a customer. Time is a very important element anywhere in the world. “Time is money” is a correct and important edict in manufacture. If a product can be produced much faster than by other competitors, customers would certainly retain their relationship with the supplying company.

Customer Response Time. It is the amount of time between an order and its corresponding delivery; however, this term is sometimes misunderstood. It is also termed the order cycle time which includes the reaction time, manufacturing time, and transportation time. Sometimes, this customer response time is very short, if the product is available from the warehouse. This will be discussed in more detail later in this paper. However, this time element is typical for all types of industry. It is an overall calculation of the time involved, and gives the most direct impression to a customer about how a company performs. In fact, customer response time depends very much on the distribution network design of the company.

Lead Time: It is the time required once the product begins its manufacture until the time it is completely processed. Lead time is made up of queuing time,

processing time, batching time, handling time, and transportation time. It is affected by many external and environmental factors, such as capacity loading and scheduling, and it has a big impact on control, and hence on the costs of manufacturing systems.

On-Time Delivery: This measures the product delivery performance. It can be represented by the percentage of orders delivered on or before the due date. For better performance, a company must reduce all the measurable times for faster placement of orders to reach the end consumers.

Fill Rate: As mentioned above, whether the customer response time can be reduced or not will depend on the product availability. It is instead the fill rate, which can be expressed as the proportion of orders that can be filled immediately. When the customer (provided that the products ordered have already been in manufacture) places an order, some available stock can be used to fill the placed order immediately. It can reduce the customer response time, and hence the customer will be satisfied by this fast response.

Stockout Probability: However, it may not always be such a normal situation as described above. New orders may be based on the original but with a different specification. Then, its production time would depend on the availability of existing raw materials or equipment. The stockout probability of the supplier or backorders needs to be further investigated. Stockout probability is the instantaneous probability that a requested item is out of stock while the number of backorders is the number of item backordered because of stockout.

Accuracy: The accuracy of the products delivered is also a measure of quality. There may be inaccurate delivery or more importantly, incorrect specification of products made. It can be measured by the percentage of accurate goods delivered to clients.

Inaccurate delivery greatly reduces the confidence of customers towards the company. It is a serious mistake that must be avoided. Therefore, cross-checks must be included in every production and service to minimise the risk of any mistakes.

2.b. Flexibility

There are many definitions on flexibility. Generally, it is about the ability or the adaptability of the company to respond to diversity or change. A flexible system is important for responding to special service requirements and for achieving a

variety of operating attributes. A flexible system is required to support the new introduction of a product and is focused on this change of innovative services to target customers. The development of a flexible logistics systems is the main method for handling variability. Variability cannot be ignored, owing to the ever-changing environment. It does not only apply to product design changes in dimensions or the volume of an order, but to sudden phenomenon, such as breakdown of machines, late arrivals of raw materials, or even new competitors which have a large effect on the market.

Sometimes flexibility is divided into two categories: range and response flexibilities. Range flexibility refers to the extent of the operations to be changed whereas response flexibility is the time or cost or both of the operations which can be changed. However, it is not complete, and cannot cover all types of flexibility. Mix flexibility cannot fit into either of the types as it is measuring the variety of products, which can be produced without incurring high transition penalties or large changes in performance outcomes. In some cases, some measurements overlap both types. Modification flexibility, can be measured by the time required for a new modification to take place (which is the response flexibility) and also the new range that can be reached by a particular change in design, i.e. range flexibility. Instead, flexibility can be categorised simply by input, processes, output, and its improvement within the chain. It is easier to look at each category more carefully and measure its performance in a more comprehensive way.

Input: Labour Flexibility. Labour flexibility is relatively less important now, especially as division of labour is emphasized in training labour. It is believed that by specialisation of the skills of workers, efficiency can be raised. Therefore, each individual has their own role. A worker skilful in designing will not be asked to make the product himself or herself.

Much routine work is already replaced by industrial automation, only work particularly requiring human intelligence will be done by humans and this kind of work cannot be easily replaced.

However, it is supposed to be considered the number of different tasks a worker can perform. To improve labour flexibility, cross-training and appropriate reward structures can reduce transition penalties and lead to the motivation of employees who will be more consistent in working methods.

Input: Machine Flexibility. This is especially important in the shop scheduling and dual resources constraint situation. For a machine which can produce a number or variety of parts, it is more efficient as it reduces set-up time when switching machines or operations. Cost can also be reduced in set-up or the scrap produced due to the changeover. Therefore, the number and variety of operations that a machine can perform without incurring high penalties or large changes in performance outcomes is important. It can be measured by the efficiency of replacing the traditional switching- over machine by a more flexible machine (e.g. flexible manufacturing system). Both time and cost saved can be used to express its efficiency.

Process: Material Handling Flexibility. Materials should be allocated to different processing centres quickly, accurately, and in the correct amount. Large factories have a large number of working centres, and different volumes of the same materials may be used in different places. Therefore, a flexible material handling system should be installed.

The number of existing paths between processing centers, and the variety of materials, which can be transported along those paths without incurring high transition penalties or large changes in performance outcomes can be considered.

Process: Routing Flexibility. If the routing of the process is fixed, sudden breakdown or overloading of machines may affect the efficiency of production. In this connection, it is necessary to have alternative routes to handle uncertainties. More routing alternatives makes the system more complex; consequently, time and costs will be increased and more controls are required to ensure uniformity and quality. The general measurement is the number of products which have alternative routes and the extent of variation among the routes used without incurring other high costs in performance outcome.

Process: Operation Flexibility. Operation flexibility is the actual changing of operating sequences. This flexibility is different from routeing flexibility, which changes the sequence of machines performing the processes. It is important for reducing the bottleneck of a particular machine, but attention must be paid as it may change the physical configuration of the part and create addition complexity. Like routeing flexibility, time and cost may be increased owing to the effort spent on monitoring and control the quality and uniformity. Measurement is similar to routing

flexibility. It measures the number of products which have alternative sequencing plans without incurring high costs or large changes in performance outcome.

Output: Volume Flexibility. Volume of demand may change and organisations have to respond quickly and efficiently to either increases or decreases in aggregate demand levels. Volume flexibility can be measured in terms of production costs, quality levels or system profitability. An organisation, which can change production volume for its entire product line, is certainly more flexible than one that can change only the volume of production of a simple part. Then the extent of change and the degree of fluctuation in aggregate output level which the system can accommodate without incurring high costs or large changes in performance outcome can be measured as the volume flexibility.

Output: Mix Flexibility. In an organisation, the level of mix flexibility must be assessed within the current production system configuration without considering major set-ups or facility modifications. It facilitates a broad product line that improves a firm's competitive position. It is sometimes used interchangeably with process and job flexibility. It measures the number and variety of products, which can be produced without incurring high costs or large changes in performance outcomes. Sometimes, it is measured in terms of the time required to produce a new product mix.

Output: Delivery Flexibility. On-time delivery is important. Early delivery can certainly improve the satisfaction level of customers. The ability to move planned delivery dates forward to accommodate rush orders or special orders is described as delivery flexibility. It is expressed as the percentage of slack time by which the delivery time that is reduced.

Improvement: Modification Flexibility. A customer may request some modifications to the existing products such as a new specification without changing original functions of the product. Modifications must be made for the improved product design. It is important to satisfy the customer request for high service level and thus modification flexibility is important. It is defined as the number and variety of product modifications which can be accomplished without incurring high transition penalties or large changes in performance outcomes.

Improvement: New Product Flexibility. The introduction of a new product provides an insight to an organisation on product development. Indeed, the variety of new products is the innovation level of the company. New product flexibility is

defined as the ease with which new products can be introduced to the system. Time or costs are involved in creating a new product and quality must be controlled for new product. It is measured either by time or cost required when adding new products to the existing production operation. Alternatively, the number and heterogeneity of products which can be produced without involving high transition penalties or large changes in performance outcomes.

Improvement: Expansion Flexibility. Other flexibilities can be limited on currently available resources in a production system whereas additional machines or labour can be recruited for expansion flexibility. It is important to expand the firm with the state-of-the-art technology to sustain its competitive advantage. It considers the number and variety of expansions which can be accommodated without high cost involved or large changes in performance outcomes.

2.c. Visibility

A supply chain consists of suppliers, manufacturers, distributors, and customers, which may consist of more than one tier at each level. Therefore, once a customer wants to change some specifications or the design of the product, it takes a long time to transmit the message to the end of the supply chain. This not only wastes time, but the accuracy of the message can be distorted. Thus, it is important to improve the quality of information transfer by having a more visible information sharing system. It is now common to have an electronic data interchange (EDI) system within a supply chain. Thus, direct transfer of any amendment from one end to another is feasible. This shows that new information technology is very important in the development of supply chains.

Visibility for a supply chain is important for accurate and fast delivery of information. It is clear that measurement of visibility is the time and accuracy of information transfer.

Time, It is the direct measurement of time required for transferring the new information throughout the supply chain.

It is not merely the time required for the information to be transferred, but the time required from the moment the designer changes the design to the time the product starts being processed in the new way. It is important to include the overall time, as though the time required for information transfer on a computer is fast, yet from the top management level to the actual workers the process takes a considerable

amount of time. The manager in the factory may have notice of the change of specification of the design so the original manufacture is abandoned. However, the complicated hierarchy-working pyramid may result in an unexpectedly long time to transmit this information to the lowest level. This shows the efficiency is low and shows the need for improvement.

Accuracy. The measurement is by directly matching the new design or specification with new products made. To quantify this measurement, it can be simply interpreted by the percentage waste of incorrect products made after the new design had been launched.

2.d. Trust

Trust is the reliability and consistency between different levels of the supply chain and enhances the long-term relationship between them. Nevertheless, it is not common to investigate the supply chain for trust. As already mentioned, a supply chain is a vertical transmission of information and product making, which links up a number of companies for the successful manufacture of a product. It is important to keep a good relationship between each level or tier as they are dependent on each other. The supplier has to give qualified raw materials to the manufacturer, who in turn processes them to become standardised goods and passes them through distributors to the end users. They have to provide consistent and reliable services for the entire process. When an action is consistent and predictable over an extended period, it is considered to be reliable. The relationship between two parties should be based on this integrity or honesty. Trust is a conceptual idea. In order to enhance the reliability of two parties and their long-term relationship, an important approach is sharing. This includes risk sharing and information sharing, i.e. through compromise they will inform each other of any urgent issues or problems, so that they can solve the problem as quickly as possible and minimise any risk. Team building and industrial alliances are commonly adopted strategies nowadays by the practitioners concerned.

Consistency: Consistent supply from one tier to another is a requirement within many companies. A manufacturer relies on the suppliers' raw material for making and sending a product to the end users, and the end users rely on accurate and on-time delivery of products from the distributors, so it affects the whole chain once a part is delayed. The effect is severe. Therefore, there are usually commitments or

contract between the parties to ensure consistent supply. From another point of view, variability must be decreased. Variability is mainly caused by information distortion. This problem is easy to solve, by making data more direct and available to all streams in the company. The measure of consistency is the percentage of late or wrong delivery to the next tier which led to an inconsistent supply. For late delivery, it is the percentage of time delayed whereas for wrong delivery, it is the percentage of returned goods. Consistency is a combined measurement of time and accuracy of a product. Inconsistent supply is a delay of products or services which may or may not have a great effect on the final output, but it decreases the image and effectiveness of the whole supply chain.

Trust can be said to be very dependent on information sharing within the supply chain. In this connection, for a company to increase its own trust, agreement must be obtained from all tiers in the supply chain, to enhance their relationship and trust by fast and accurate data transfer. It is not only good for the present situation, but it also enhances the accuracy of forecasting future, which is no doubt important in any industry.

2.e. Innovativeness

In the ever-changing environment, innovativeness is important, thus attempts to add this element in a supply chain is a problem. The competition within industries is strong and it is important to have a particular competitive advantage which can be recognised easily by the customers. Both for a stagnant market, which does not have any growth in market, or a hightechnology market, such as the computer or automobile industry, innovativeness is the only way for a company to specialise. Even in a supply chain, with many levels of manufacturers or distributors within, once an innovative product or service is created, it can help the whole chain to be more specific and even explore a new area.

New Launch of Products: New products are continuously launched into market to stimulate the sales of a particular company or even of the whole market. For a company with innovative products launched periodically, whether or not the product receives a good response from the market, there is a high degree of promotion for the company. It helps the company to be more publicly noticed and advertised. In this connection, innovativeness is probably important. Thus, comparison can be made the number of products launched by a particular company within a period, conveniently,

it can be compared annually. This can be used to compare two known supply chains or companies.

Alternatively, for a particular supply chain, the acceptance of the innovative product in the market, that is the percentage of sales of the new product to the whole sales within a period of time for a company can be measured.

New Use of Technology: Apart from new products being designed, improving the efficiency can enhance the competitive edge of a company. It includes the use of new technology and even a new method in management. It may not be easy to relate efficiency to innovativeness. It is instead just one step further. Innovativeness is not applied to physical products only, but also to new management methods or strategies, which in turn help to improve efficiency. However, new technology is difficult to measure directly. Thus, the percentage increase in efficiency can be measured directly, that is the percentage decrease in time necessary for producing the same product.

II.4.3. Traditional Performance Measures

Most performance measures used by firms today continue to be the traditional cost-based and financial statistics reported and to shareholders in the form of annual report, balance sheet, and income statement data. This information is relied upon by potential investors and shareholders to make stock transaction decisions and forms the basis for many firms' performance bonuses. Decisions that are made solely to maximize current stock prices do not necessarily reflect than the firm is performing well or will continue to perform into the future. Success depends on the firm's ability to turn internal competencies into products and services that customer want, while providing desired availability, quality, and customer service levels at a reasonable price.

Traditional performance measures also tend to be short-term-oriented. To maximize profits next quarter, firms may spend considerable time delaying capital investments, selling assets, denying new project proposals, contracting out work, and leasing instead of purchasing equipment. These actions can significantly reduce a firm's ability to develop new products and remain competitive.

II.4.4. World-Class Performance Measurement Systems

A good performance measurement system should include measures of what is important to customers. These measures will vary by company and through time as strategic changes occur to the firm, its products, and its supply chains.

Developing World-Class Performance Measures

Creating an effective performance measurement system involves the following steps

Identify the firm's strategic objectives

Develop an understanding of each functional area's role and the required capabilities for achieving the strategic objectives.

Identify internal and external trends likely to affect the firm and its performance overtime.

For each functional area, develop performance measures that describe each area's capabilities

Document current performance measures and identify changes that must be implemented

Assure the compatibility and strategic focus of the performance measures to be used.

Implement the new performance system.

Periodically reevaluate the firm's performance measurement system as competitive strategies change.

Table II.2. World-Class Performance Measures (Wisner, Leong and Tan, 2005)

Capability Areas	Performance Measures
Quality	1. No. of defects per unit produced and per unit purchased 2. No. of product returns per unit sold 3. No. of warranty claims per units sold 4. No. of suppliers used. 5. Lead time from defect detection to correction 6. No. of work centers using the statistical process control 7. No. of suppliers who are quality certified 8. No. of quality awards applied for; no. awards won
Cost	1. Scrap or spoilage losses per work center 2. Average inventory turnover 3. Average setup time 4. Employee turnover 5. Avg. safety stock levels 6. No. of rush orders required for meeting delivery dates 7. Downtime due to machine breakdowns
Flexibility	1. Average number of labor skills 2. Average production size 3. No. of customized services available 4. No. of days to process special or rush orders
Dependability	1. Average service response time or product lead time 2. Percentage of delivery promises kept 3. Avg. no. of Days late per shipment 4. No. of stock-outs per product 5. No. of days to process a warranty claim 6. Avg. number of hours spent with customers by engineers
Innovation	1. Annual investment in R&D 2. Percentage of automated processes 3. No. of new product or service introductions 4. No. of process steps required per product

II.4.5. Supply Chain Performance Measurement Systems

Performance measurement systems for supply chains must effectively link the supply chain trading partners to achieve breakthrough performance in satisfying the end users. Measures must also overlay the entire supply chain to assure that firms are all contributing to supply chain strategy and the satisfaction of end customers. In a successful supply chain, members jointly agree on a supply chain performance measurement system.

The focus of the system should be on value creation for end customers, since customer satisfaction drives sales for all of the supply chain's members. Leading supply chains are achieving superior customer service levels at competitive prices, and their performance is improving continuously each year.

II.4.5.1. Specific Supply Chain Performance Measures

To achieve the type of performance, specific measures must be adopted for the supply chain itself, allowing trading partners to adjust their specific performance to further align with supply chain objectives. A number of there listed here,

1. Total supply chain management costs: The cost to process orders; purchase materials; manage inventories; and manage supply chain finance, planning, and information systems. Leading supply companies are spending from 4 to 5 percent of sales on supply chain management costs, while the average company spends about 5 to 6 percent.
2. Supply chain cash to cash cycle time: The average number of days between paying for raw materials and getting paid for product for the supply chain trading partners (calculated by inventory days of supply plus days of sales outstanding minus average payment period for material). This measure shows the impact of lower inventories on the speed of cash moving through firms and the supply chain. Top supply chain companies have a cash to cash cycle time of about thirty days, which is far less than the average company. These trading partners no longer view 'slow paying' as a viable strategy.
3. Supply chain production flexibility: The average time required for supply chain members to provide an unplanned, sustainable 20 percent increase in production. The ability for the supply chain to quickly react to unexpected demand spikes while still operating within financial targets provides tremendous competitive advantage. One common supply chain practice is to maintain stocks of component parts locally for supply chain customers to quickly respond to unexpected demand increases. Average production flexibility for best in class supply chains is from one to two weeks.
4. Supply chain delivery performance: The average percentage of orders for the supply chain members that are filled on or before the requested delivery date. In top-performing supply chains, delivery dates are being met from 94 to 100 percent of the time. For average firms, delivery performance is approximately 70 to 80 percent. Updating customers on the expected delivery dates of orders is becoming a common e-service for many supply chains.
5. Supply chain perfect order fulfillment performance: The average percentage of orders for supply chain members that arrive on time, complete, and damage free. This is quickly becoming the standard for delivery performance and represents a

significant source of competitive advantage for top-performing supply chains and their member companies.

6. Supply chain e-business performance: The average percentage of electronic orders received for all supply chain members. Today, supply chain companies are investing heavily in e-based order-receipt systems, marketing strategies, and other forms of communication and research using the Internet.

Table II.3.Supply chain performance metrics framework (Gunasekaran, 2004)

Supply chain activity/ process	Strategic	Tactical	Operational
Plan	Level of customer perceived value of product, Variances against budget, Order lead time, Information processing cost, Net profit Vs productivity ratio, Total cycle time, Total cash flow time, Product development cycle time	Customer query time, Product development cycle time, Accuracy of forecasting techniques, Planning process cycle time, Order entry methods, Human resource productivity	Order entry methods, Human resource productivity
Source	Supplier Delivery Performance	Supplier lead time against industry norm, supplier pricing against market, Efficiency of purchase order cycle time, Efficiency of cash flow method, Supplier booking in procedures	Efficiency of purchase order cycle time, Supplier pricing against market
Make/ Assemble	Range of products and services	Percentage of defects, Cost per operation hour, Capacity utilization, Utilization of economic order quantity	Percentage of Defects, Cost per operation hour, Human resource productivity index
Deliver	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule, Effectiveness of delivery invoice methods, Percentage of finished goods in transit, Delivery reliability performance	Quality of delivered goods, On time delivery of goods, Effectiveness of delivery invoice methods, Number of faultless delivery notes invoiced, Percentage of urgent deliveries, Information richness in carrying out delivery, Delivery reliability performance

II.4.5.2. Establish the right Metrics to measure the supply chain.

The first step in building a metric framework is to understand the key characteristics of a metric. Applied of these are:

- Reliability: This refers to the consistency of the metric to measure a given process. As long as the circumstances governing the process do not change drastically, the metric should return a fairly consistent value.

- Validity: A valid metric is one that actually measures the concept that thought as if it is measuring.

The relevance of metric thus depends on the context. If historically, work orders had been expedited in the company supply chain as a result of frequent machine breakdowns or delayed raw material shipments from suppliers, then the metric is not a valid indicator of improved planning process efficiency. However, with a status quo on machine breakdown and supplier delivery times, 'expedited work orders' was a valid indicator of an attempt to revise supply schedules to meet dynamic demand changes.

- Practicality: In addition to reliability and validity, good metrics must be practical such that the required data can be retrieved with reasonable effort and cost.
- Salience: They also need to be salient such that the concerned functions/people will relate to the information provided by the metrics and can take meaningful action based on such information.

In addition to the above defined characteristics of a good metric, some additional considerations about metrics highlighted below would help building an effected metrics framework:

- Metrics are most useful when they are embedded in a model that represents a business process
- The process performance insight that the metrics provide determines the overall criticality of the metric & hence its classification into strategic, tactical or operational metric
- Constantly monitor and modify the metrics to suit the current business context
- Assign metrics to various roles that have process execution, monitoring and tracking responsibility. This also helps design information delivery systems based on data and information flow requirement across the organization.
- Identify interdependencies of metrics and a metrics hierarchy which defines how a metric is impacted by other lower level metrics and how this metrics influences other higher level metrics

Linking metrics to the overall strategic objectives involves multiple steps :

- Determine the strategic objectives under which it is required to evaluate the supply chain – typically these strategic objectives could represent the effectiveness of the supply chain to meet customer requirements or it could also

be indicative of the intrinsic strength of the supply chain processes to achieve desired cost objectives. These strategic objectives are an outcome of the overall strategic intent of the enterprise.

- Under the each of these strategic objectives, build related supply chain metrics hierarchy starting with high level metrics suggestive of the overall health of the supply chain to mid level and lower level metrics that are more tactical or operational in nature in terms of impact and review.
- Creating the detailed metrics framework. This is a multi-step process through which an exhaustive set of related metrics is created. This process involves
- Associating a set of metrics with each supply chain process.
- Mapping the metric to the role that is directly accountable and responsible for the measurement and performance of the metric. Certain roles may need to be identified for the metric from a performance review standpoint.
- Identifying the importance of the metric based on the information and process health insight it conveys (Strategic, Tactical or Operational)
- Build high level interdependencies of metrics based on common knowledge and understanding of basic processes
- Identify the various hierarchies for which data will need to be obtained to enable a comprehensive view of the metric
- Determine how the metrics will need to be computed

- Determine also the frequency at which the metrics will be measured – this will also be governed by the granularity of available data and the cost-benefits associated with a certain measurement frequency.

II.4.6. The Balanced Scorecard and Supply Chain Management

The balanced scorecard approach to performance measurement was developed by Kaplan and Norton in 1992, as a way to align an organization's performance measures with its strategic plan and goals, thus improving managerial decision making. It has been a widely used model and, by 1998, 60 percent of the Fortune 1000 companies had experimented with BSC.

The need for such a tool has emerged from a growing recognition that financial measures alone are insufficient for managing modern organizations. Financial reporting has traditionally been performed using a retrospective accounting model that was developed centuries ago. Unfortunately, this model does not incorporate valuation of a company's intangible and intellectual assets, such as skilled employees, internal processes, and satisfied and loyal customers. One could argue that these intangible assets are more critical to the long-term future of the company than traditional physical and tangible assets. The Balanced Scorecard, in fact, complements financial measures of past performance by measuring the drivers of future performance.

Many companies have mission statements and visions, which are translated into business strategies. However, often these strategies never "leave the boardroom", and are therefore never fully implemented in the organization. The Balanced Scorecard is a tool that can help translate visions and strategies into an integrated set of performance and action measures that cascade down through the organization from divisions to departments, through operational units down to the individual employee.

The BSC is designed to provide managers with a formal framework for achieving a balance between non financial and financial results across both short-term and long-term planning horizons. The BSC framework consists of four perspectives.

1. Financial perspective: Measures that address revenue growth, product mix, cost reduction, productivity, asset utilization, and investment strategy.
2. Internal business process perspective: Focuses on performance of the most critical internal business processes of the organization including quality, flexibility, innovative elements of processes, and time-based measures
3. Customer perspective: Measures that focus on customer requirements and satisfaction including customer satisfaction ratings, customer retention, new customer acquisition, customer valued attributes, customer profitability, and market share.
4. Learning and growth perspective: Measures concentrating on the organization's people, systems, and procedures including intellectual assets, re-training employees, enhancing information technology and systems, and employee satisfaction.

These perspectives are all linked together through performance measures within each of the four areas. Measurements are developed for each goal in the organization's strategic plan and include both outcome measures and the performance drivers of those outcomes. In doing this, senior managers can channel the specific set of capabilities within the organization toward achieving the firm's goals. A properly constructed scorecard should support the firm's strategy and consist of a linked series of measures that are consistent and reinforcing.

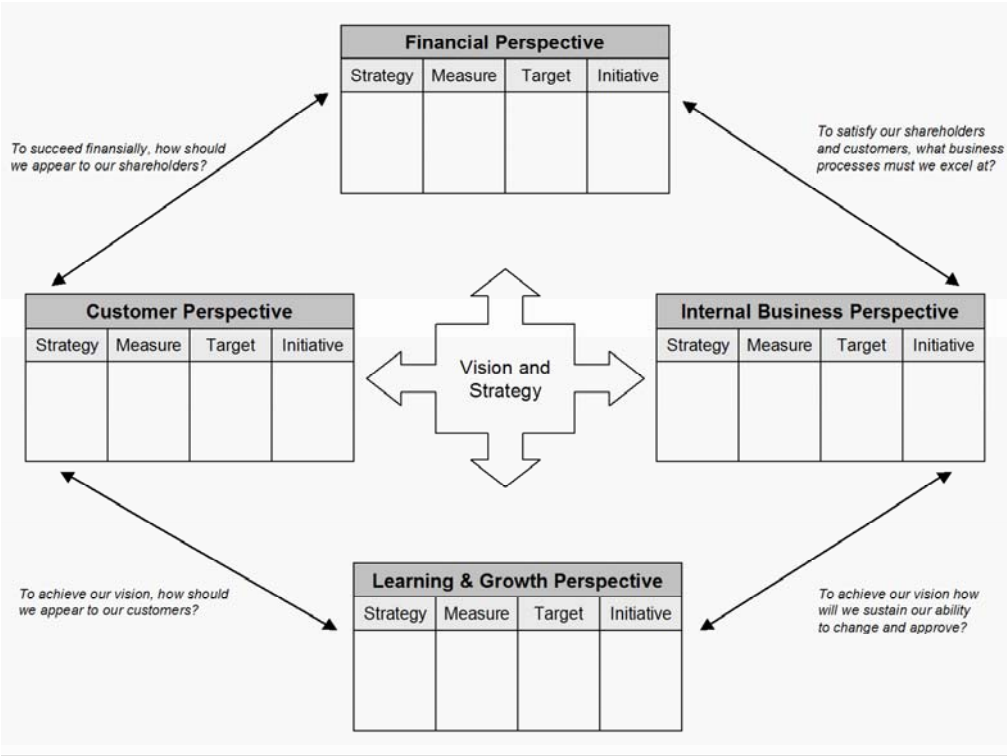


Figure II.7. By summarizing Kaplan and Norton's four perspectives of management (Kaplan and Norton, 1996)

The process of developing a balanced scorecard begins with defining the firm's strategy. Once the firm's strategy is understood and agreed upon by senior managers, the next step is to translate the strategy's goals into a system of performance measures. Each of the four perspective in the BSC require four to seven performance measures, resulting in a scorecard with about two dozen measures relating to one single strategy. The potential for failure, though, does exist when using the BSC if firms are not clear about what they are hoping to achieve and are not determined to ensure that the best scorecard with the right performance measures linked to firm strategy is used.

Table II.4. Balanced Scorecard Measurement Indicators ((Wisner, Leong and Tan, 2005), (Gunasekaran, 2004) and (Kaplan and Norton, 1996))

<table>
<tr>
<td>Financial Perspective

Revenue Growth
* Sales and market share
* Number of new products
* Number of new customers and market
* Number of customized service available

Cost Management
* Unit cost reduction
* % use of low cost business processes
* Information processing cost
*Scrap or spoilage losses per work center
* Average inventory turnover
* Average setup time
* Avg. safety stock levels
* No. of rush orders required for meeting delivery dates
* Downtime due to machine breakdowns
* Supplier Pricing against market

Asset utilization
* Return on capital
* Cash-to-cash cycle
* Inventory Reduction
* Efficiency of cash flow method

Budget
* Variances against budget
* Net profit versus productivity ratio
* Accuracy of forecasting techniques</td>
<td>Internal Business Perspective

Deliver
* % on time delivery
* Stock-outs
* Percent defects
* Flexibility of service system to meet customer needs
* Effectiveness of enterprise distribution planning schedule
* Effectiveness of delivery invoice methods
* Percentage of finished goods in transit
* Delivery reliability performance
* Avg. number of days late per shipment
Design
* Time to market
* Break – even time
* Annual investment in R&D
* Percentage of automated processes
* No. of process steps required per product
* Product development cycle time
Build
* Number of defects
* Process time
* Capacity utilization
* Planning process cycle time
* Average service response time or product lead time
* Utilization of economic order quantity
Source
* Supplier lead time against industry norm
* Efficiency of purchase order cycle time
* Supplier booking in procedures
Quality
* No. of defects per unit produced and per unit purchased
* No. of product returns per unit sold
* No. of warranty claims per units sold
* No. of suppliers used.
* Lead time from defect detection to correction
* No. of work centers using the statistical process control
* No. of suppliers who are quality certified
* No. of quality awards applied for; no. awards won</td>
</tr>
<tr>
<td>Customer
Market Share
* % of market segment captured by our organization
* % of each customer’s total requirement served by our company
Customer Satisfaction
* Number of complaints
* % of customers satisfied with our products
* % of customers satisfied with our quality

Customer Profitability
* Total profit per customer
* Total cost per customer or transaction</td>
<td>Learning and Growth Perspective
Employee capabilities
* Employee satisfaction
* Employee turnover
* Number of employees qualified for key jobs relative anticipated requirement
* Human resource productivity index
* Average number of labor skills
Motivation and alignment
* Employee suggestions revived
* Employee suggestions implemented
* Rewards provided
* % of employees with objectives aligned with key BSC measures</td>
</tr>
</table>

The BSC can also be utilized by firms in a collaborative supply chain setting by expanding the internal perspective of the scorecard to include inter functional and partnership perspectives that characterize the supply chain. In this way, the firm's employees are motivated to view their firm's performance versus the success of entire supply chain. The cash-to-cash cycle time is one example of an integrated measure embracing several functions across several organizations.

Table II.5. Balanced Scorecard Measures for Supply Chains (Kaplan and Norton, 1996)

Customer Perspective	1. Number of customer contact points in the supply chain 2. Customer order response time 3. Customer perception of supply chain value
Internal Business Processes Perspective	1. Value-added time/total time in supply chain 2. Number of choices/order cycle time
Financial Perspective	1. Supply chain costs of purchasing, carrying inventory, poor quality, and delivery failure 2. Percentage of supply chain targets costs achieved 3. Percentage of supply chain profits earned 4. Cash-to-cash cycle time 5. Return on supply chain assets
Learning and Growth Perspective	1. Time between product finalization and customer delivery 2. Number of shared data sets/total data sets 3. Number of substitute technologies demanded by customers

A Balanced Scorecard will become the focus of organization change. People's goals, investments, and activities should all be linked to the objectives and measures of the scorecard. It is essential, then, that this scorecard is designed in a way that accurately reflects the organization's strategy. The design of a good Balanced Scorecard is based on three principles that link the measures to strategy:

1. *Cause-and-Effect Relationships***.** A strategy is a set of hypotheses about cause and effect. A properly constructed scorecard should tell the story of the business unit's strategy through a sequence of cause and- effect relationships. The measurement system should make the relationships (hypotheses) among objectives explicit so that they can be managed and validated. *Every objective selected for a Balanced Scorecard should be part of a chain of cause-and-effect relationships that communicates the meaning of the business unit's strategy to the organization.*
2. *Outcomes and Performance Drivers*. All Balanced Scorecards use certain generic measures. These generic measures (such as profitability, market share, and customer satisfaction) tend to be "outcome" measures, which reflect goals common across many strategies and industries. The performance drivers, the lead

indicators, are the ones that tend to be unique for a particular strategy. *A good Balanced Scorecard should have an appropriate mix of outcomes (lagging indicators) and performance drivers (leading indicators) that have been customized to the business unit's strategy.*

3. *Linkage to Financials*. With the proliferation of change programs under way in most organizations today, it is easy to become preoccupied with goals (quality, customer satisfaction, innovation, and the like) for their own sake. While these goals can lead to improved business-unit performance, they may not achieve their purpose if they are taken as ends in themselves. A Balanced Scorecard must retain a strong emphasis on outcomes, especially financial ones. Ultimately, causal paths from all the measures on a scorecard should be linked to financial objectives.

II.4.6. The Supply Chain Operations Reference Model

One of the more recognized methods for integrating supply chains and measuring their members' performance is the supply chain operations reference (SCOR) model developed in 1996 by the Supply-Chain Council, a nonprofit global organization or more than 800 firms interested in supply chain management. The Supply – Chain Council's members continuously review and update the model for use by its members and others, who can purchase the SCOR model software. The SCOR model integrates the operations of supply chain members by linking the delivery operations of the seller to the sourcing operations of the buyer.

The SCOR model is used as a supply chain management diagnostic, benchmarking, and process improvement tool by manufacturing and service firms in a variety of industries around the globe. The Model itself contains several sections and is organized around the five primary management processes of PLAN, SOURCE, MAKE, DELIVER, and RETURN. By describing supply chains using these process building blocks, the Model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain. The Model has been able to successfully describe and provide a basis for supply chain improvement for global projects as well as site-specific projects. Some of the more notable firms to have success using the SCOR model include Intel, IBM, 3M, Cisco, Siemens, and Bayer. Striving for the best telecommunications,

supply chain. Alcatel used SCOR metrics following the economic downturn of 2001 to measure and benchmark its performance. Major improvements were realized in delivery performance, sourcing cycle time, supply chain management cost, and inventory days of supply.

The SCOR model separates supply chain operations into five process categories which are plan, source, make, deliver, and return.

Plan: Demand and supply planning including balancing resources with requirements, establishing/communicating plans for the supply chain; management of business rules, supply chain performance, data collection, inventory, capital assets, transportation, and regulatory requirements.

Source: Sourcing stocked, make-to-order, and engineer-to-order products including scheduling deliveries; receiving, verifying, and transferring product; authorizing supplier payments; identifying and selecting suppliers; assessing supplier performance; and managing incoming inventory and supplier agreements.

Make: Make-to-stock, make-to-order, and engineer-to-order production executions including scheduling production activities; producing, testing, packaging, staging, and releasing product for delivery; finalizing engineering for engineer-to-order products; and managing work-in-process, equipment, facilities, and the production network. Deliver: Order, warehouse, transportation, and installation management for stocked, make-to-order, and engineer-to-order product including all order management steps from order inquiries and quotes to routing shipments and selecting carriers, warehouse management from receiving and picking to loading and shipping products, invoicing customer, and managing finished product inventories and import/export requirements.

Return: Returns of purchased materials to suppliers and receipt of finished good returns from customers including authorizing and scheduling returns; receiving, verifying, and disposition of defective or excess products; return replacement or credit, and managing return inventories.

There are three standardized levels of process detail in SCOR model. At level 1, users select appropriate process categories from the SCOR configuration toolkit to represent their supply chain and select from thirteen performance attributes as shown in Table II.6. In level 2, the SCOR processes are further described by process type. Within each process type are process categories that users specify. The process types and categories are shown in Table II.7.

In level 3, process flow diagrams are defined with process element for specific tasks for each of the process categories established in Level 2, showing inputs, process elements, and outputs. Additionally, specific performance measures are identified for each of the process elements within the flow diagrams. Some example measures are shown in Table II.8. Best practices can also be identified at this level. Finally, implementation of supply chain management practices within the company occurs at Level 4 and beyond.

Table II.6. SCOR Level 1 Performance categories and attributes (Wisner, Leong and Tan, 2005)

Performance Category	Performance Attribute
Reliability	1.Delivery performance 2.Fill rates 3.Perfect order fulfillment
Responsiveness	1.Order fulfillment lead times
Flexibility	1.Supply chain response times 2.Production flexibility
Cost	1.Supply chain management cost 2.Cost of goods sold 3.Value-added productivity 4.Warranty cost or returns processing cost
Assets	1.Cash to cash cycle time 2.Inventory days of supply 3.Asset turns

Table II.7. SCOR Level 2 Process Types and Categories (Wisner, Leong and Tan, 2005)

SCOR Process Type	Characteristics	Process Category	
Planning	Processes that align expected resources to meet expected demand requirements	P1:Plan supply chain P2:Plan source P3:Plan make P4:Plan deliver P5:Plan return	
Execution	Processes triggered by planned or actual demand that changes the state of material goods. These are source (S1-3), make (M1-3), deliver (D1-3), and return (R1-3) processes.	S1:Source stocked product S2:Source MTO product S3:Source ETO product M1:Make to stock M2:Make to order M3:Engineer to order	D1:Deliver stocked product D2:Deliver MTO product D3:Deliver ETO product R1:Return defective product R2:Return MTO product R3:Return excess product
Enable	Processes that prepare, maintain, or manage information o relationships on which planning and execution processes rely	EX1:Establish and manage rules EX2:Assess performance EX3:Manage data EX4:Manage inventory EX5:Manage capitol assets EX6:Manage transportation EX7:Manage supply chain configuration EX8:Manage regulatory compliance EX9:Process specific elements	

Table II.8. SCOR Level 3 Performance Categories and Measures (Wisner, Leong and Tan, 2005)

Performance Attribute Categories	Measures
Reliability	Percentage of schedules generated within supplier's lead time Percentage of schedules changed within supplier's lead time
Responsiveness	Average release cycle of changes
Flexibility	Average days per schedule change Average days per engineering change
Cost	Product management and planning costs as a percentage of product acquisitions costs
Assets	None identified

As can be seen in the tables, implementing the SCOR model is no simple task and requires a significant investment of time and communication within the firm and among supply chain partners.

Thus, as can be seen by the information presented here, the SCOR model is used to describe, measure, and evaluate supply chain configurations. The model is designed to enable effective communication, performance measurement, and integration of processes between supply chain members. A standardized reference model helps management focus on management issues, serve internal and external customers. Using the SCOR software, virtually and supply chain can be configured, evaluated, and benchmarked against best practices, leading to continuous improvements and sustainable competitive advantage for the supply chain's participating members.

II.5. THE EVALUATION FROM MIS AND LOGISTICS TO ERP AND BEYOND

The evaluation of information technology in the 1960s and 1970s will recall that at that time there was an effort to integrate discrete applications islands into one processing platform, whose primary goal was to serve management requirements.In the 1960s, this was attempted through database management systems (DBMS), in the 1970s, it was the management information system (MIS) effort that attracted attention, including the following logistics operations, analytical accounting, order handling, and inventory control.

At the origin of the word logistics (noun, singular) is a Greek term meaning something logical but also a calculator and accountant. Webster's dictionary defines logistics as the branch of military science having to do with moving, supplying, and quartering troops. This definiton, and its predecessors, are too narrow and need to be extended in two ways;

1. Conceptually, to encompass not only military science and calculation, but also the support of basic entrepreneurial activities addressing all sectors of the economy.
2. In depth, to include prognostication, computation planning, scheduling, controlling, and other vital support acitvities that increasingly require online, interactive database mining.

Many logistics problems are medium range. Although short-range approaches are often targeted, these cannot be sustained in an effective manner without extending them to the medium term, which requires a host of other supporting services.

This need has evidently reflected itself in the way commodity enterprise software evolved during the 1980s. A study off-the-shelf offerings during that period has revealed that tier-1 organizations required this type of support because they were in the early stages of a process to make themselves more efficient. They needed processes able to reinvigorate their business activities, and these largely relatedto customer information, market analysis, and human resources management.

During the 1980s, the concepts underpinning MIS were extended beyond integrating discrete islands and providing some form of seamless access to database. One of the significant developments was expert systems. Another was the attention paid to facilitating one's ability to reach better and faster decisions, as a way to improve management's productivity.

Enterprise resources planning has been the direct aftermath of this drive. To better appreciate the transformation that took place as wall as the information requirements posed by this transformation, one should recall that in the 1980s, mass production, a concept of the early 20th century, was giving way to lean production. This process persisted to nearly 20 years, and its aftermath changed the modern industrial world.

Enterprise resources planning (ERP) is an information system that manages, through integration, all aspects of a business including production planning, purchasing, manufacturing, sales, distribution, accounting, and customer service. It

streamlines data flows throughout the entire organization and allows managers direct access to real time operations. Through data integration, ERP eliminates counter-productive processes and cross functional coordination problems that hinder the integration of the organization. ERP arrived at a time when process improvement and accuracy of information became critical strategic issues. The emphasis on supply chain management and the advancement of information technology created a need for enterprise-wide integration.

There are different ways of defining ERP: a business perspective, a technical perspective or a functional perspective. One way of looking at ERP is as a combination of business processes and information technology. For instance, J.D. Edwards, an American ERP system vendor, defines ERP as an umbrella term for integrated business software systems that power a corporate information structure, controlling a broad range of activities, from the procurement of supplies to shop floor control and financial accounting. It provides the glue that binds management functions across geographic sites and complex heterogeneous networks. From a more strategic perspective, JBA, a British consulting firm, views ERP as a business approach that starts in the boardroom and permeates the entire organization. From a technical perspective, ERP can be seen as the logical extension of MRP systems of 1970s and of MRP II systems of 1980s. ERP's impact, however, has been much more significant. Following the American Production and Inventory Control Society's (APICS) ''MRP Crusade,'' sales of MRP software and implementation support exceeded one billion dollars in the United States by 1989. Worldwide sales of ERP packages together with implementation support, on the other hand, have exceeded fifteen billion dollars at the turn of the century with annual growth rates of over 30%. Functionally, an ERP system primarily supports the management and administration of the deployment of resources within a single (though possibly multi-site) organization. These resources can be materials, production capacity, human labor, or capital. Current ERP systems contribute to this aim by providing three different types of functionality:

- A transaction processing engine, allowing for the integrated management of data throughout the enterprise;
- Work flow management functions controlling the numerous process flows that exist in the enterprise, such as the order-to-cash process or the purchasing processes;

- Decision support functions, assisting in the creation of plans (e.g., by doing an MRP run), or in deciding on the acceptance of a specific customer order (e.g., by performing an available-to-promise (ATP) check).

As a result, ERP provides the following business functionality:

- ERP systems have replaced a myriad of old, undocumented, non-integrated legacy systems by state-of-the-art, integrated and maintainable software. It is hard to overestimate the crucial importance of this obvious point. As an illustration, during the preparation of the workshop, one interviewee described a real-life situation where a relatively simple change in the logistic process (direct, and therefore cross-border, delivery form factory to customer) was found to be very sensible. However, implementation of this process had to be canceled because it would involve the modification of six separate IT systems. Just the effort needed to convince their owners to agree to the change was already expected to be higher then the potential savings. The number of local IT systems to be replaced by an integrated ERP system usually runs into the dozens up to a hundred or more in multinational companies.
- ERP systems provide an enterprise transaction backbone that constitutes the glue between all kinds of best-of-breed solutions for specific processes or business areas. It allows these bestof- breed solutions to leverage the investments made in the ERP systems, and partly explains the impressive ROI's achieved by these solutions.
- ERP systems can be instrumental in transforming functionally oriented organizations into process oriented ones. The very nature of the ERP system forces one to think process-wise, rather than department-wise. Indeed, some of the unexpected benefits of ERP implementations may well stem from improved communication between different departments across business processes (McAfee, 1998).

Then a new agent of transformation came along in the 1990s. By the mid-to late 1990s, the Internet spawned a wave of innovation that required industry leaders to reinvent both internal and external business partnerships or be overtaken by competitors. By 2001 this had hit all sectors of the economy; automobiles, aerospace, materials systems, telecommunications, environmental services and technology.

In a way, it is only normal to experience a major evaluation in management information requirements, which has been the drivng force behind the change from MIS to Internet-oriented ERP solutions. Nearly a quarter century down the kine, after the advent of MIS, it should be expected that;

- New integrative software systems are necessary.
- New systems are much more sophisticated than those they replace.
- The software industry will come forward with valid solutions.

Internet-oriented ERP software is increasingly richer in agents, has direct online access to live database (rather than extracts from operational databases that were typically used by MIS), and can be severely handicapped by delays in data streams, information element updates, as well as errors and mistakes. That are, as well, other differences:

- MIS approaches were typically developed in-house, with the vendor providing the extract routine and some advice.
- ERP software comes off-the-shelf, seamlessly integrates with live databases, and is immediately available for testing and implementation.

In contrast, Internet-oriented ERP software must offer more than that, but also it demands a great deal of preperation for its implementation to be successful. Among crucial queries demanding factual and documented answers are: What tools do managers need to assess their distant partners? Given the increasingly global business-to-business (B2B) Internet partnerships, how can one's company match – without any delay and in a cost-effective manner – one's business partners' best practices? The answer to some of the queries requires considerable study and experimentation. For example,

- What costs and what benefits may result if all industries adapt the so called "Dell direct" model of customized ordering?
- How will information available on the Internet shape the tactics of small- and medium-size companies?

Answers to these and other critical questions provide a context for the analysis and evaluation of business practices that will characterize the first decade of the 21st century.It is increasingly necessary to exchange ideas on ways to apply multidisciplinary expertise to emerging issues facing industrial sectors worldwide. It is just as important to develop scenarios on how government regulation will, or

might, support greater transparency. This will facilitate customer access to vital information.It will also help verify quality of service in Internet commerce.

II.5.1. The Supply Chain IT Framework

It is important to develop a framework that helps a manager understand how this information is utilized by the various segment of IT within the supply chain. IT is valuable to note that the driver of IT in the supply chain has increasingly been the enterprise software developed to enable processes both within and across companies. Enterprise software collects transaction data, analyzes this data to make decisions and executes on these decisons both within an enterprise and across its supply chain. Other parts of IT beyond enterprise software such as hardware, implementation services, and support are all crucial to making IT effective. Within a supply chain, the different capabilities provided by IT have as their most basic building block the capabilities of the supply chain's enterprise software. In many ways, software shapes the entire industry of IT as the other components follow the software lead.It is for this reason that enterprise software and its evoluation as the primary guide in analyzing IT and its impact on the supply chain methods have been used. The evolution of enterprise software provides insights not only into this evolution and its impact on companies' supply chain processes.

The enterprise software landscape became increasingly overpopulated during the late 1990s. The unprecedented flow of venture capital into new software companies led not just to an increase in the number of software companies, but also to the profileration of entire categories of software. The growth of the number of software product lines combined to create an enterprise software landscape that was not only much more crowded than in the past, but also much more dynamics. It was an environment ripe for significant evolutionary change to take place.

The downturn in technology spending since the second half of 2000 has brought about this evolutionary pressure, thereby causing many software companies to cease operations or merge with existing software firms. Some entire software categories are well on their way to extinction, with many of the recently created categories landing on this endangered species list.

There are a wide variety of factors affecting the natural selection of software companies. Three of the main drivers of the evolution taking place in enterprise

software are the three major groups of supply chain processes, called as supply chain macro processes. The successful categories of software will be those focused on the macro processes.

II.5.2. The Supply Chain Macro Processes

The emergence of supply chain management has broadened the scope across which companies make decisions. This scope has expanded from trying to optimize performance across the division, to the enterprise, and now to the entire supply chain. This broadening of scope emphasizes the importance of including processes all along the supply chain when making decision. From an enterprise's perspective, all processes witihn its supply chain can be categorized into three main areas; processes focused downstream, processes focused internally, and processes focused upstream. The three macro supply chain processes:

- Customer Relationship Management (CRM): Processes that focus on downstream interactions between the enterprise and its customers.
- Internal Supply Chain Management(ISCM): Processes that focus on internal operations within the enterprise. Supply chain management includes all three macro processes CRM, ISCM and SRM.
- Supplier Relationship Management (SRM): Processes that focus on upstream interactions between the enterprise and its supplers.

As the performance of an enterprise becomes more closely linked to the performance if its supply chain, it is crucial that firms focus on the macro processes. A firm must expand the scope beyond internal processes and look at the entire supply chain to achieve breakthrough performance. The goal should be to increase the total profitability of the supply chain.

II.5.2.1. Customer Reationship Management

The CRM macro process consists of processes that take place between an enterprise and its customers downstream in the supply chain. The goal of the CRM macro process is to generate customer demand and facilitate transmission and tracking of orders. The key processes under CRM as follows;

- Marketing: Marketing processes involve decisions regarding which customers to target, how to target customers, what products to offer, how to price products and how to manage the actual campaigns targeting customers.CRM provide analytics that improve the marketing decisions on pricing, product profitability

- Sell:The sell process focuses on making an actual sale to a customer (compared to marketing where processes are more focused on planning who to sell what to sell). The sell process includes providing the sales force the information they need to make a sale and then executing the actual sale. Executing the sale may required the sales person (or the customer) to build and configure orders by choosing among a variety of options and features. The sell process also requires such functionality as the ability to quote due dates and access information related to a customer order. At this point CRM provides targeted sales force automation, configuration and personalization to improve the sell process.
- Order Management: The process of managing customer orders as they flow through an enterprise is important for the customer to track their order and for the enterprise to plan and execute order fulfillment. This process ties together demand from the customer with supply from trhe enterprise. Order management software has traditionally been handled by legacy systems or been a part of an ERP system. New order management systems have emerged with additional functionality that enables visibility of orders across the often numerous order management systems that exist within a company.
- Call/Service Center: A call/service center is often the primary point of contact between a company and its customers. A call/service center helps customers place orders, suggests products, solves problems, and provides information on order status.

The CRM processes are crucial to the supply chain as they cover a vast amount of interaction between an enterprise and its customers. The customer must be starting point when trying to increase the supply chain surplus because all demand, and therefore revenue, ultimately arises from them. Thus, the CRM macro process is the staring point when improving supply chain performance. It is also important to note that CRM processes must be integrated with internal operations to optimize performance. The need for integration between CRM and internal operations emphasizes the importance of CRM to an effective supply chain.

II.5.2.2. Internal Supply Chain Management

ISCM is focused on operations internal to the enterprise, ISCM includes all processes involved in planning for and fulfilling a customer order. The various processes included in ISCM are as follows:

- Strategic Planning: The goal of this process is to plan resource availability in the supply chain network. The decisons made include where to locate plants and warehouses, what type of facilities to build, and what markets to serve from each facility.
- Demand Planning: This set of processes involves forecasting future customer demand.In addtion to forecasts, demand planning also includes decisions to manage demand, such as promotions planning.
- Supply Planning: The supply planning process takes as an input the demand forecasts produced by demand planning and the resources made available by strategic planning, and then produces an optimal plan to meet this demand. Factory planning and inventory planning capabilities are typically provided by supply planninfg software.
- Fulfillment: Once a plan is in place to supply the demand, it must be executed. The fulfillment process links each order to a specific supply source and means of transportation. The software applications that typically fall into fulfillment segment are transportation and warehousing applications.
- Field service: Finally, after the product has been delivered to the customer, it eventually must be serviced. Service processes focus on setting inventory levels for spare parts as well as scheduling service calls.

Given that the ISCM macro process aims to fulfill demand that is generated by CRM processes, there needs to be strong integration between the ISCM and CRM macro processes. When forecasting demand, interaction with CRM is essential as the CRM applications are touching the customer and have the most data and insight on customer behavior. Similarly, the ISCM processes should have strong integration with SRM macro process. Supply planning, fulfillment, and field service are all dependent on suppliers and therefore the SRM processes.

II.5.2.3. Supplier Relationship Management

SRM includes those processes focused on the interaction between the enterprise and suppliers that are upstream in the supply chain. The major SRM processes are as follows:

- Design Collaboration: The goal of this process is to improve the design of products through such ideas as the joint selection (with suppliers) of components that have positive supply chain characteristics such as ease of manufacturability or

commonality across several end products. Other design collaboration activities include the sharing of engineering change orders between a manufacturer and its suppliers. This eliminates the costly delays that occur when several suppliers are concurrently designing components for the manufacturer's product. Good collaboration at this stage can create huge value because about 80 percent of product cost is determined at the design stage.

- Source: The source process qualifies suppliers and helps in supplier selection, contract management, and supplier evaluation. A key goal is to analyze the amount that an enterprise spends with each supplier, often revealing valueable trends or areas for improvement. Suppliers are evaluated along several key criteria including lead time, reliability, quality, and price. This evaluation helps improve supplier performance and aids in supplier selection. Contract management is also an important part of sourcing, as many supplier contracts have complex details that must be tracked (such as price reductions for reaching certain volume targets). Successful software in this area helps analyze supplier performance and manage contracts.
- Negotiate: Negotiations with suppliers involve many steps starting with a request for quote (RFQ). The negotiation process may also include the design and execution of auctions. The goal of this process is to negotiate an effective contract that specifies price and delivery parameters for a supplier in a way that best matches the enterprises needs. Successful software automates the RFQ process and the execution of auctions.
- Buy: The buy process executes the actual procurement of material from suppliers. This includes the creation, management and approval of purchase orders. Successful software in this area automates the procurement process and helps decrease processing cost and time.
- Supply Collaboration: Once an agreement for supply is established between the enterprise and a supplier, supply chain performance can be improved by collaborating on forecasts, production plans, and inventory levels. The goal of collaboration is to ensure a common plan across the supply chain.

Significant improvement in supply chain performance can be achieved if SRM processes are well integrated with appropriate CRM and ISCM processes. Sourcing, negotiating, buying, and collaborating primarily tie into ISCM as the supplier inputs

are needed to produce and execute an optimal plan. But even these segments have the need to interface with CRM processes such as order management. The theme of integrating the three macro processes is crucial for improved supply chain performance.

II.5.3. How to Ascertain that Integrated Solutions Work Well in Daily Practice?

People and companies participating in the research pressed the point that effective solutions to Internet oriented ERP challanges- from manufacturing to logistics- recast business and industry in a new pattern. They also warned that factual and documented optimization studies need far better information technology than has been classically provided through legacy data processing and mainframes or by means of client/server solutions.

Crucial along this line of reference is the timeliness, accuracy, and quality of analtical information provided to senior management. Typically, in the vast majority of companies, the so-called electronic data processing (EDP) operations paid only lip service to management information – despite MIS.

Modeling and experimentation are needed for many managerial reasons, including the more efficient movement of products inside and outside the firm, as well as the reduction of delays, closing gaps in quality assurance, and optimizing storage and transport expenditures. Decisions regarding efficiency in production and distribution have common elements with asset allocation. A proactive approach to asset allocation leads to the strategy of getting the best out of the customer relationship, using an integrated logistics management system, and organizing to provide on-time, high quality customer.

All of these are very relevant to Internet oriented ERP systems because thay impact not only the supply chain of other manufacturers but also wholesale and retail outlets. A new age of retail is indivisible from retail business models enhanced by everything online, from POS to databases of business partners.

Making gain in an online supply chain is no different making gain in a traditional supply chain.

ERP experts and logistics planners are faced with the task of solving problems that become increasingly complex in a delivery sense. They are charged with the job of quickly developing an optimal course of action for moving supplies in an

environment where it is inherently impossible to outguess future consumption patterns and therefore get an exact amount of supplies anywhere at any time. Optimization is not doable without the use of sophisticated technology.

As an alternative, big manufacturers concerns develop smaller, limited scope captive companies specializing in reverse auctions. Visteon is an $18 billion captive supplier of Ford Motor company. Its auctions and reverse auctions on the Internet have achieved a rumored 15 percent cost savings on the $500 million amount of new business it puts up for bid in several auctions. The company's goal is to use electronic bidding to determine market prices, open up the supply base, and gain significant cost savings. One of the results of this intensive activity in B2B auctions has been that Vistean located new business partners.

Specialization through captive companies is one way to beat the rapidly developing overpopulation of processes, products, transactions, and their permutations. This growing complexity is one of the reasons why management must increasingly use analtical models to identify customer patterns, map supplychain relationships and analyze distribution networks.Internet commerce adds to these requirements, leading to more explicit needs for high performance ERP solutions necessary in:

- Anticipating process boundaries at any given time.
- Shrinking to a bare minimum the lead-time required to transit from production to distribution.
- Elaborating and analyzing a seemingly endless list of interdependent variables.

Until new technology served as an enabling agent in logistics planning, the then-prevailing conditions were dramatically over-constrained. Not only were the mainframes of EDP a poor way of handling the concepts and models that mathematicians, logicians, and production management experts were developing. Optimization is a management philosophy that can be successfully applied to all business processes or, alternatively, to none of them.

In conclusion, top management must be co-involved in Internet-oriented ERP solutions.It is known that supplying all business units with everything required at every instant is impossible if one is unable to reach great detail at high speed, then the job is to:

- Assess the risk associated with not meeting each and every one of the ongoing requirements.
- Decide how to achieve the best possible allocation of resources, everything considered.

A crucial criterion of success is to respond instantly to changing market constions and customer demands. Most employess, customers, suppliers, and other business partners are willing and able to collaborate in ways that allow them to be more productive, adapt to change, and make effective decisions.

II.5.4. The Synergy in Managing Information Technology and Procurement

Some companies have introduced into their organizations a new job; the Chief Web Officer (CWO).Others, such as General Electric (GE), have given the CIO the responsibility of looking after the synergy of IT and procurement. Either way, job requirements must be met, and these include overseeing information systems and Internet strategies, creating and running the interwoven network of extrastructure, and forging flexible Internet commerce links with business partners.

At GE, the CIO works closely with suppliers to get them seamlessly inline and manages all links connected to GE's massive procurement program. This synergy will increase in the coming years technology moves so fast.

The perspectives of synergies continue to expand. As computers and communications become increasingly pervasive in the work, in the daily lives, and in the transportation environment, many instances of convergence are developing in the functionality of products and processes and the accompanying communications infrastructure.

IT and internet solutions are merging. personal computers function as web access points, phones and home automation controllers all at the same time. Software is being designed to allow multi-purpose products, while hardware is becoming more and more flexible.Personel devices and communications infrastructure converge to provide new functionality and handle all data, including voice, video, and the Internet.

Implementation of ERP also generates a rich knowledge stream that should be preserved for further usage. The appreciation of this fact has led to the institution of knowledge management procedures by leading organizations.

Knowledge management projects include a corporate memory facility into which are registered all decisions as well as their reasons and aftermath: expert systems and agents that improve productivity and replace old approaches to computer programming, and a growing array of tools for knowledge management.

The primary benefit of SCM systems is better operational and business planning. The MRP II and ERP systems of the nineties usually included only rough-cut capacity planning logic, with basic finitecapacity planning functionality limited to key work centers. SCM systems use finitecapacity planning algorithms that do not require iterative adjustments to the master schedule, and real-time planning capabilities allow firms to react quickly to supply and demand changes. Coordinated planning and flow of materials and information among supply chain partners can mitigate the ‘‘bullwhip effect’’. Increased revenue, increased productivity, operational cost savings, lower inventory, and reduced order-to-fulfillment cycle time are some of the benefits from SCM system implementations (Hendricks, Singhal and Stratman, 2006).

II.5.5. ERP Supply Chain Management Features

Supply Chain Execution for Enterprise Resources Planning system helps industrial manufacturing companies manage and optimize performance at every step of the fulfillment process, increasing efficiency and reducing costs. Integrated extended warehouse management and transportation execution functionality can synchronize real-time product movement and improve productivity within the company’s distribution operations—helping the business to increase its competitive advantage.

Supply Chain Execution for ERP integrates information from business and the entire supply chain to help synchronize real-time product movement and improve productivity within distribution operations. This comprehensive, fully integrated business solution helps companies to balance the demands of extended supply chains and move product more efficiently to increase sales, improve fill rates, and decrease costs.

Building on the multilanguage, multicurrency functionality provided by ERP systems, Supply Chain Execution for ERP offers a powerful competitive advantage for companies distributing across a global marketplace. The supply chain solution

can be most beneficial to organizations that seek to improve current distribution operations or to manage new initiatives for the following:

- Distribution capacity
- Transportation optimization
- Delivery service improvement
- Retail compliance
- International expansion
- Implementation of barcode and RF data collection
- Global supply chain visibility
- Trading partner collaboration

With the ability to handle single-byte and double-byte languages, international currency exchange, various warehouses, and multiple companies, Supply Chain Execution for ERP can manage entire supply networks. As organizational needs change, the ERP three-tiered, scalable system architecture make it easy to tailor the solution both for today's requirements and for the future growth of the business.

Key Solution Benefits are listed below.

- Improve order fulfillment and accuracy
- Eliminate inefficient processes and excess inventory
- Enhance workload balancing and planning
- Enable compliance with industry standards
- Reduce transportation costs

Supply Chain Execution for ERP delivers a flexible, modular approach, which offers cost-effective options for taking advantage of the functionality that can best enhance the operations. Extended Warehouse Management options streamline receiving, slotting, picking, and order fulfillment. RFID-enabled technology helps ensure Electronic Product Code (EPC) compliance with customer requirements and increases product visibility to facilitate tracking and inventory management while improving cross docking and expedition of back orders. Strategies and tools for selecting optimal product placement enable to increase efficiency, shorten order fulfillment cycles, and eliminate user error. By balancing workloads, setting performance targets, and deploying resources, companies can achieve maximum

work force productivity. Tracking all warehouse activities, sharing key performance indicators, and measuring against baseline standards help ensure a company's operations are performing at full potential.

With integrated Transportation Execution options, companies can simplify and speed transportation management tasks. Efficient load building, automated carrier assignments, and quick generation of compliant documentation boost efficiency, eliminate errors, and reduce costs. Shipments can be confirmed and tracked as needed to maintain visibility throughout distribution and help ensure timely delivery and customer satisfaction.

Extended Warehouse Management and Transportation Execution together can provide these specific benefits:

- Increased warehouse productivity
- Reduced labor, transportation, and administrative costs
- Improved space utilization
- More accurate inventory
- Higher fill and throughput rates
- Enhanced utilization of assets (such as forklifts or pallet jacks)
- Optimal transportation service levels
- Stronger distribution capacity
- Enhanced customer service through improvements to:
    - Order fill rates
    - Order accuracy
    - On-time delivery rates
    - Value-added services
    - Customer compliance
- Support for international expansion
- Smooth implementation of barcode and RF data collection, such as through RFID
- Global supply chain visibility
- Facilitation for trading partner collaboration

5.a. ERP tools: Opportunities and obstacles for supply chain integration

The implementation of ERP enables the companies to move towards an extended enterprise business model that enhances value across the total supply chain. In order to gain supply chain efficiencies, companies need to exchange large amount of planning and operational data, ranging from information for annual contracts and periodic progress reporting to real-time delivery and invoicing data. The advantages and obstacles of ERP tools have been discussed in several research papers. 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 (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). ERP provides several tools; the two most important for supply chain integration are the real-time transaction tracking and the internal process integration. It was outlined the four main opportunities offered and the obstacles of using them. The traditional vertically integrated business model requires re-evaluation. The ERP software vendors saw the above problems and started providing advanced decision support tools that are the new ERP software extensions. Among them the most important directions are: the Advanced Planning and Scheduling (APS), Demand Planning and Revenue Management, Customer Relationship Management (CRM), Sales Force Automation, and Supply Chain Management (SCM).

With the quantitative analysis for inventory management aspects of supply chain coordination are presented results in information systems area by

- providing guidelines for transaction tracking,
- promoting visibility of information for the supply chain, and by
- supporting coordination among business partners.
- improve the quality of ordering and transportation decisions (for SCM and DPRM),

- provide quantitative tools to find the joint optimal policy and help in contract negotiations (for SCM, APS, and CRM),
- estimate the fair amount of compensation necessary (for CRM),
- promote cooperation between the buyer and the supplier (for CRM).

Different theories are available to support supply chain cooperation. Management theory states that efficient supply chain requires cooperation. Quantitative modeling proves that the total system cost can be reduced by coordinated policy. At the same time, practice and theory shows several barriers in organizational factors (organizational theory) and subjective factors (behavioral theory). Few results integrate the results and combine the quantitative and organizational effects. The goal is to

- provide quantitative modeling, numerical and sensitivity analysis to measure the potential monetary value of cooperation,
- combine it with organizational and management factors, and
- integrate in a multi-level framework of policy coordination.

PART III. CASE STUDY

In order to justify the change, a benefits and value analysis methodology can be used. Capital expenditure in manufacturing must meet one, or more, five objectives:

1. To meet capacity demands
2. To meet customer driven functionality
3. To meet product assembly or process technology
4. To meet regulatory and compliance requirements
5. To reduce the cost of manufacturing

Establishing the gains and return on investment a supply chain management solution can deliver in a specific manufacturing environment. This solution can be mapped against each of the existing capabilities. Consequently, it reveals sufficient performance data exists to complete the benchmarking exercise. In the case of the unavailability, manufacturing process from the analysis, performance targets can be set, along with the monitoring and control mechanisms required to achieve them.

III.1. OVERVIEW OF THE MANUFACTURING INDUSTRY

Industrial manufacturers produce some of the most complex products in the world. The manufacturing industry includes businesses engaged in the mechanical or chemical transformation of materials or substances into new products. These businesses are usually described as plants, factories, or mills and characteristically use power driven machines and material handling equipment. Businesses engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials, such as lubricating oils, plastics, resins, or liquors.

They also face intense business pressures, including price erosion, growing environmental requirements, and global competition. Increased speed, reduced costs, more accurate fulfillment, and value-added services (VAS) are everyday requirements. In the context of the economical conditions in Turkey, responsiveness speed to the customer, adapting constantly changing volumes and delivery schedules are the indicators to be able to lead in the manufacturing industry. It is supposed to be considered both cost and lead time constraints by tracing the online data gathered from the distributed department while responding to the customer quotation

Demand can come from several areas. Some of the areas that might create this demands are, quotations, which are taken into account when generating the master plan depending on the success percentage that is assigned to the quote. Sales order have not been satisfied, there may be a Sales Forecast for some items, and some production orders for which are short some of the components.

There are many different possibilities which are tried to cover as many of these throughout the demand fulfillment process. There are two critical points for the companies in manufacturing industry which goes toward seamlessly. Two different manufacturing policies when fulfilling the customer demands are adapted These policies are called as “Make to stock (MTS)” and “Make to Order (MTO)”.

The firm’s primary production comes from efficient capacity and its resulting MTS production. But since MTS has the disadvantage of not exactly matching demand in the period, the firm restricts its efficient capacity (MTS output) to avoid

building excess stock of the standard product. Concurrently, it holds some separate flexible capacity that it uses in MTO fashion only if it realizes demand exceeding MTS capacity. The result is that efficient capacity is fully utilized, while flexible capacity is used only if there is sufficient demand.

The critical point to establish the streamline workflow for supply chain management is to generate master data like items, bill of material, manufacturing operations, work center capacity accurately. It is overwhelmingly crucial to manage master data in order to perform the processes which satisfy the each chain of supply sources.

III.2. EFFECTIVE SCM IN MANUFACTURING INDUSTRY

Inventory is the material and supplies that a business carries either for sale or to provide input in the manufacturing process. All businesses and institutions require inventory. Inventory consists of a number of different items held by the company. These items can be:

- Raw materials and supplies
- Goods in production
- Sub assemblies
- Finished goods ready for sale.

Inventory Management is responsible for planning and controlling inventory from the raw material stage to the customer. Inventory must be considered at every planning level. Inventory is managed at both the aggregate level and the item level.

Effective inventory management includes effective management of the following areas:

- Maximum customer service
- Low-cost plant operation
- Minimum inventory investment

Maximum customer service

Inventory needs to be available to the organization and customers when required. A customer can be a purchaser, a distributor, another plant in the organization, or the work center where the next operation is to be performed.

Inventory helps maximize customer service by protecting against uncertainty. An organization may need to carry extra inventory to achieve this. This is called a safety stock.

Low-cost plant operation

Inventory between work-centers (operation buffer inventory) allows the longer production runs (more items per series), helps a manufacturing operation be more productive, therefore resulting in lower setup and ordering costs per unit.

Minimum inventory investment

Actual figures vary from industry to industry and company to company. Capital costs may vary depending upon interest rates, the credit rating of the firm, and investment opportunities. Storage costs (space, workers, equipment) vary depending on location and the type of storage needed. Risk costs (obsolescence, damage, theft) can be very low or can be close to 100% of the value of the item. The carrying cost is usually defined as a percentage of the value of inventory per unit of time.

To gain maximum profit, a company must have at least four main objectives:

- Provide the best customer service
- Produce the lowest production costs
- Produce the lowest inventory investment
- Produce the lowest distribution costs

These objectives create conflicts within the sales and marketing, production, and finance departments, because each department has its own responsibilities in these areas:

Sales and marketing must maintain and increase revenue; therefore it must provide the best customer service possible, by maintaining high inventories, so goods are always available for customers.

Finance must keep investment and costs low by reducing inventory, so inventory investment is at a minimum and possibly also decrease the number of warehouses.

Production must keep its operating costs as low as possible - make long production runs of relatively few products and maintain optimal inventory of raw materials and operations.

One important way to resolve these conflicting objectives is to provide close coordination of the supply, production, and distribution functions. A balance between the conflicting objectives needs to be established in order to minimize the total of all the costs involved and maximize customer service consistent with the goals of the organization. Logistics is the creation and maintenance of this balance.

Value proposition of the Effective Supply Chain Management systems are in proposed ERP solutions are listed below.

Reduce Inventory Purchasing Requirements

- Improve inventory accuracy
- Improve supply chain visibility
- Improve planning lead times
- Respond intelligently to supply chain events

Increase Productivity of Distribution Labor

- Provide system direction of distribution tasks
- Perform labor optimization
- Enable labor-performance tracking

Improve Customer Service and Loyalty

- Increase order accuracy
- Improve order turn times
- Increase on-time delivery
- Ensure customer compliance

More Revenue from Existing Orders

- Increase order fill rates
- Improve inventory accuracy
- Improve inventory sourcing

Enable New Sources of Revenue

- New channels
- New products
- New geographic markets

Increase Inventory Accuracy

- Scan verification of all inventory moves
- Perform systematic cycle counting

Reduce Inventory Purchasing Requirements

- Improve supply chain visibility
- Improve planning lead times
- Respond intelligently to supply chain events

Microsoft Business Solution Axapta implemented as an ERP system does not intend to answer an individual or organization's logistics questions or make company decisions, rules or politics but rather manages the cost and quantities of the items bought and sold. Whether a retail business with merchandise inventory or a manufacturing company with finished goods, materials, and work in process, the system provides inventory in terms of physical and financial

Microsoft Business Solution Axapta tracks inventory movement in an organization and also enables the organization to calculate the cost of goods sold. Different units of measurement can be used for purchasing, selling, stocking, and pricing items. Inventory movements are tracked with quantities and costs.

As a result, an organization is always in control of every aspect of its inventory.

III.3. BUILDING BASIC METRICS IN MANUFACTURING INDUSTRY

In the contest of this study, it is focused on a balanced improvement of delivery performance, an improvement of delivery performance to commit and request, delivery performance to requested delivery data and the fill rate, the reduction of order fulfillment lead times (for Make to Order policies).

In order to achieve the established the performance metrics through the company, Initially ERP implementation phased which enables them to gather data adequately into unique database was completed. ERP offers best practices applied for all various type of sector and the method which met the company business flow is supposed to be adopted by the management team of the company. They need to face the challenges of increasing customer requirements, globalization, multiple distribution channels and compliance with trading partner initiatives while continuing to grow their business.

At this stage one of the pioneer ERP systems was implemented and the defined metrics were embedded to the system. The initial step is to take over was streamline the business flow according to the business logic behind the system.

The particular issues has to be overtaken by the supply chain execution system within the companies are;

- Expediting work orders is established as a positive fall-out of the need to make the supply chain more responsive, the Production Engineering function needs to proactively implement practices and tools that allow production line-changeovers at minimal time and cost as soon as they find an increasing trend of expediting of work orders.
- When a sales order comes in, they need to run master planning calculates what is needed to fill the order. It is supposed to check the physical inventory, and, if the items are not available, automatically produce the necessary purchase orders or production.
- In terms of response to customer quotations, it is supposed to provide more accurate expected delivery date and price with the right cost. This process takes to much time to respond since to gather data from the planning, procurement, engineering and accounting department. They need an integrated system which includes the data gathered systematically.
- Assembly process is executed in manufacturing and to assign the jobs to the feasible work centers and schedule the job plan based on the requirement plan generated by automatic material requirement planning.
- Inaccurate view of own stocks. They need better visibility all the time, automatically, and the ability to retrieve specialized information. This is very important for management not to use standard reports, but to be able to get specialized reports, and to be able to get this information from the system. This enables the management cut the administration time and costs in half.
- Customers want personalized service. Adapt easily to the partners' different systems. Large customers want to be served as if they were the only customer. They expect tailor-made service. Therefore, having an adaptable business management solution allows the company to be prepared for the next way customers want to interact.

In the context of the study the application method is defined below:

- Implement a non rigid application
  - Allow for little to no setup to run application
  - Reduce duplicate data across applications
- Supply preconfigured setup information
  - Industry specific
  - Best business practices
  - Master data immigration (bill of materials, production routes, item master, vendor master, price and cost list, customer master)

III.4. ERP IMPLEMENTATION FOR SUPPLY CHAIN MANAGEMENT IN MANUFACTURING INDUSTRY

III.4.1. Creation bills of material

The Graphical BOM Designer is a graphical suite used to create and manage BOMs based on Microsoft drag-and-drop technology. The familiar and user-friendly environment makes it faster and easier to construct BOMs using a graphical tree-structure. The BOM designer displays all levels and components of the BOM.

The BOM designer also displays the route for the current BOM, allowing dragging and dropping items from the BOM into the operations on the route where they are to be consumed. This helps to achieve more accurate lead time calculations when scheduling production in Microsoft Axapta Master Planning.

III.4.2. Flexible management of bills of material

Microsoft Axapta gives an efficient and flexible means of managing bills of material (BOM) to ensure to get the most accurate costing and materials requirements information.

An infinite number of BOM levels can be managed effectively and accurate consumption of raw materials can be calculated using formulas specific to each component. Price calculations, using cost price, can be done for each level of the BOM, giving accurate and detailed pricing information which is updated throughout the solution. Multiple BOM versions can be created to provide maximum flexibility

and the version date can be used to control the validity of particular BOM versions. Previous BOM versions can be accessed and reused at any time.

The bill of materials (BOM) is critical in translating product demand into raw material inventory requirements. Everything from forecasting, planning and scheduling item purchases and production, to determining pick lists and identifying cost and pricing information is tied up in the accuracy of the BOM. Microsoft Axapta provides with an effective means of handling the BOM for complex products through the use of specifications such as virtual inventory items, versions and product configurations. In cooperation with Inventory Management and Master Planning, the BOM feature facilitates just-in-time deliveries and optimal reordering levels.

The price calculation based on the finished BOM item can be done for one or more BOMs in multiple levels, giving access to the most accurate price information. In turn, the information on the BOM is updated throughout Axapta so that the accuracy is registered throughout the business. Cost price or purchase price can be used when calculating the price.

III.4.3. Inventory Management → Items

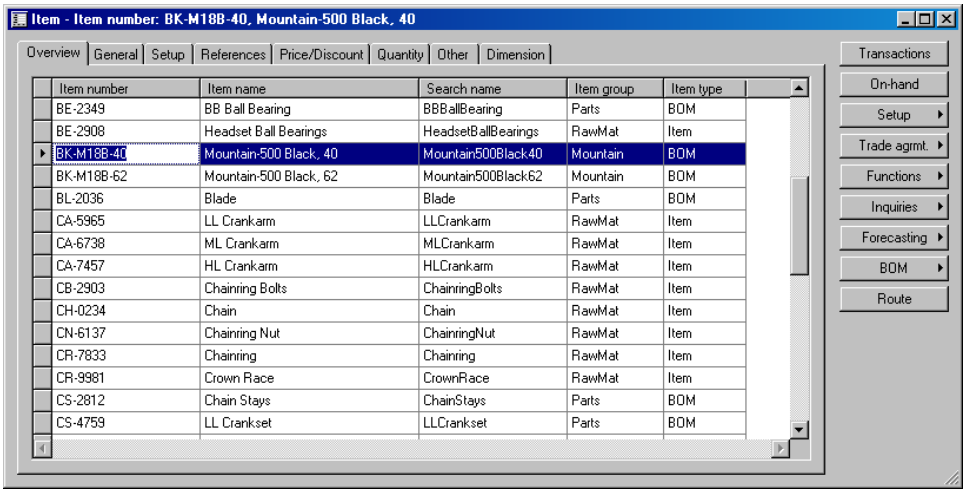


Figure III.1. Item Definition Form in Axapta ERP solution

Bills of material (BOM) Management

- Multi level BOMs
- Version and Date control of multiple BOMs
- Approval routing
- Formulas for calculation of variable or constant consumption
- Supports phantom BOMs
- Variance configurator

- Allowances for scrap can be made in the consumption calculation
- Where used feature

BOM explosion for materials planning and pricing calculation on all BOM levels

III.4.4. Graphical BOM designer

- Graphical suite for designing BOMs and gaining insight into existing BOMs
- All levels and sub levels of the BOM are visible in a graphical tree structure
- Circulation check to control which functions can be performed on certain BOMs
- System alerts notify when a BOM is active and should not be modified

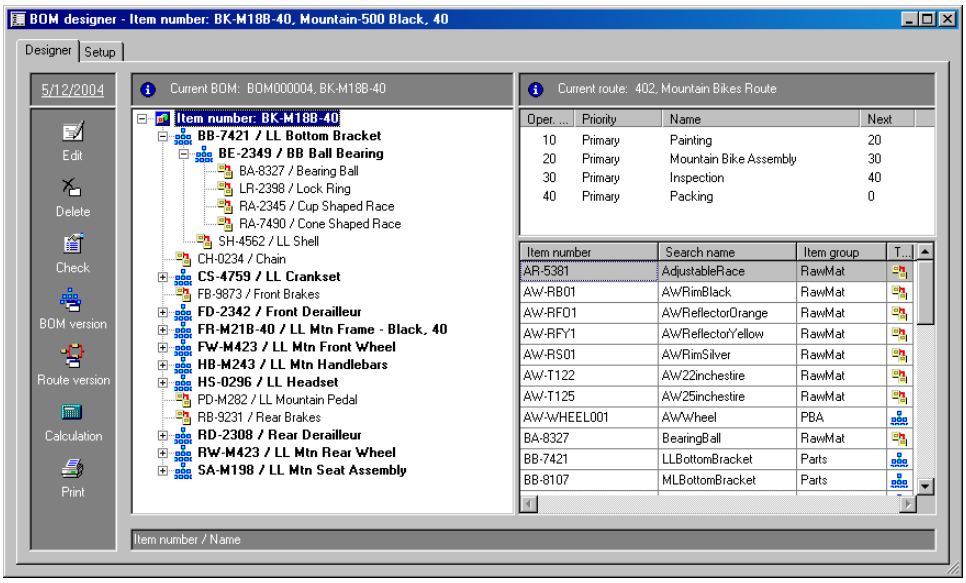


Figure III.2. Bill of Material Definition Form in Axapta ERP solution

Based on the definition, essential information to manage and measure the performance of the process is defined to the system in terms of capacity, quantity, scrap values, consumption quantities, planning time zones, forecast information in monthly basis, production routes, subcontracting processes, warehouses, inventory tracibility rules, inventory allocation rules,

III.4.5. Accounts Receivable → Sales Order

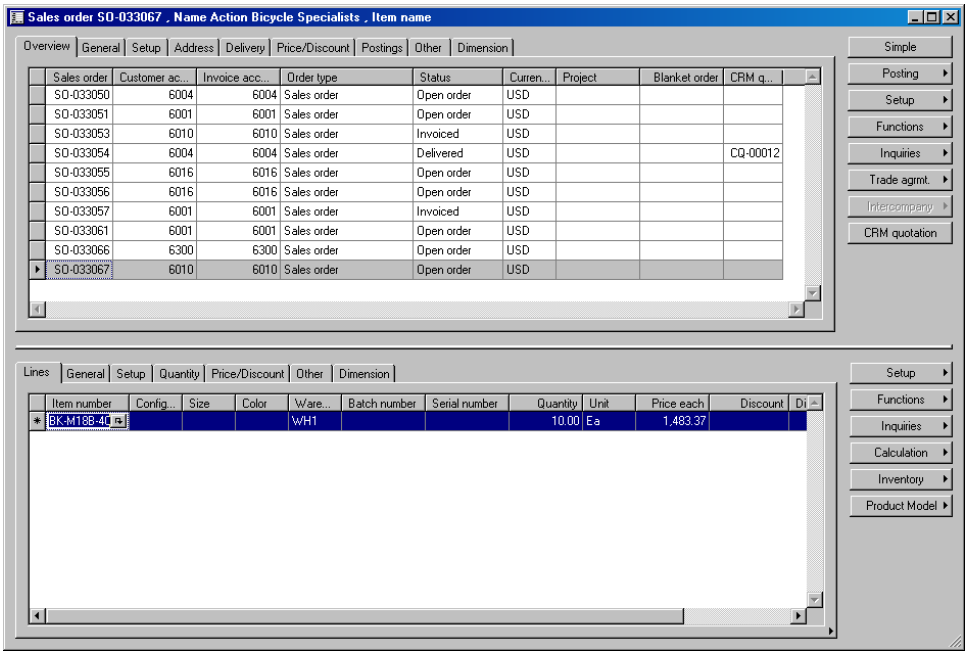


Figure III.3. Sales Order Entry Form in Axapta ERP solution

Click on the Setup tab.

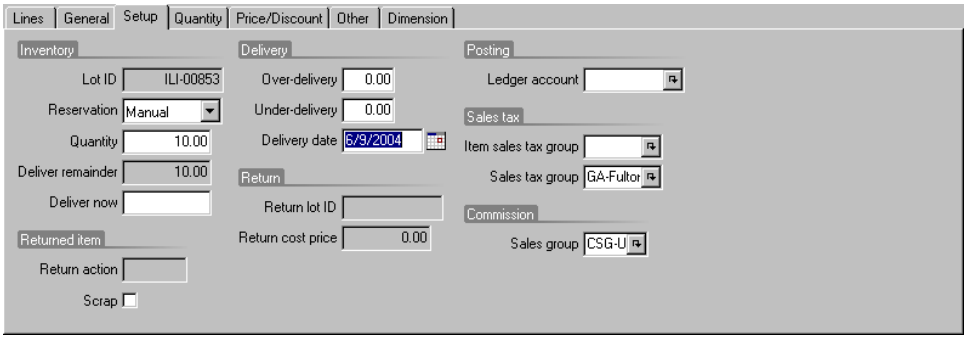


Figure III.4. Order Delivery Date Entry Form in Axapta ERP solution

a *Delivery Date* of 4 weeks in the future, as that is approximately the lead time to receive/manufacture all of the components.

Since this item is a make to order item, the next step is to run the master schedule to be able to deliver the good.

Sales order explosion gives the ability to break down a BOM item, and calculate an earliest possible delivery date based on route and incoming items using Available-to-promise (ATP), which calculates delivery date based on available

inventory and current production orders, and Capable-to-promise (CTP), which calculates delivery date based on available materials and production capacity.

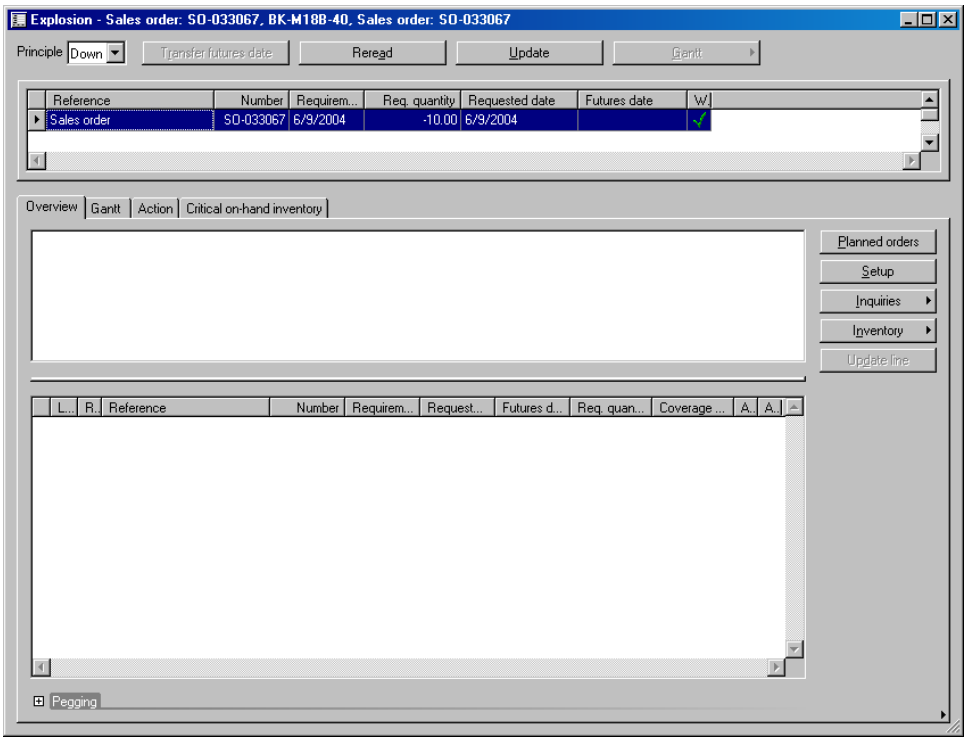


Figure III.5. Planned Delivery Date Calculation Form in Axapta ERP solution

It can be seen the Requested date, but to find out if the requested date is actually satisfied, it is supposed to run the master plan.

When press the Update button, which will run the Master Planning engine for this item/sales order. The following screen will comes up.

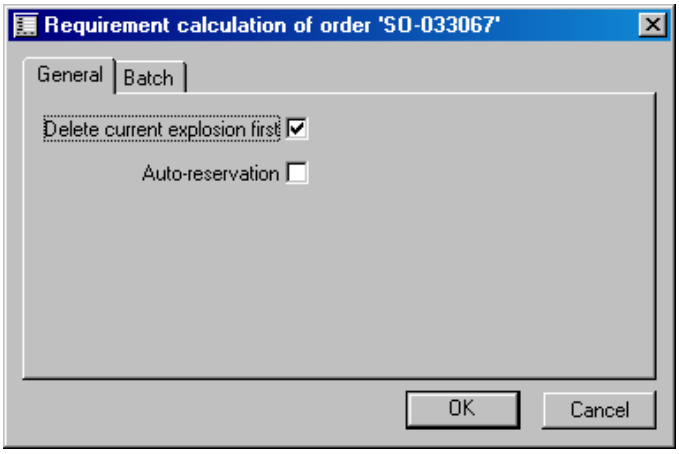


Figure III.6. Planned Delivery Date Calculation Form in Axapta ERP solution

The update is complete the following information is displayed. This screen shows all of the planned orders linked to the planned production order.

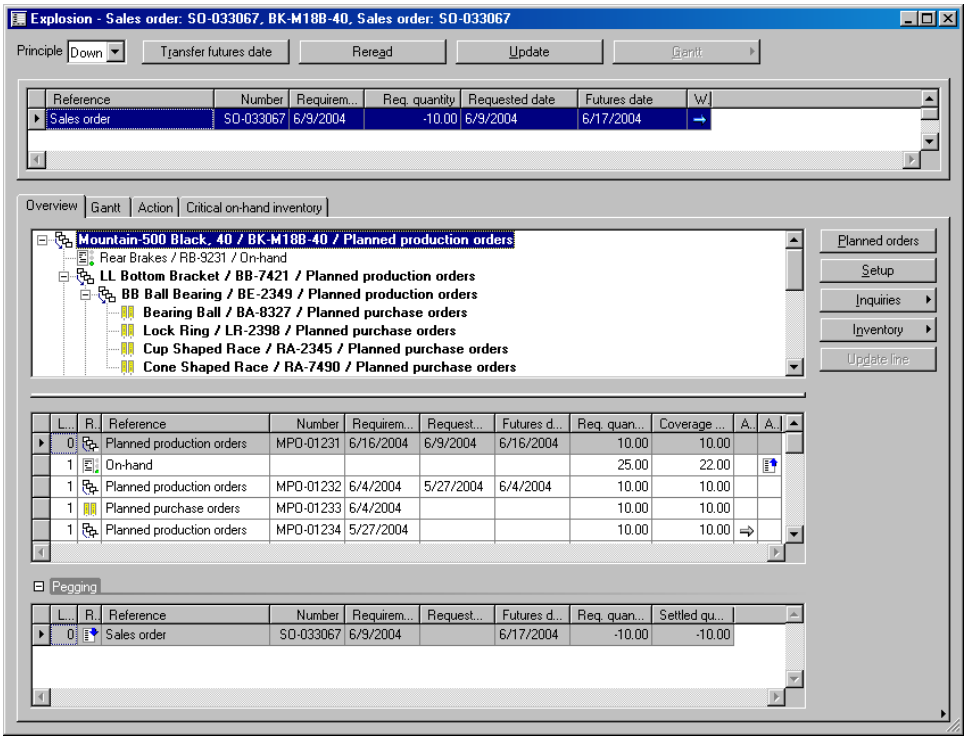


Figure III.7. Explosion results for sales orders

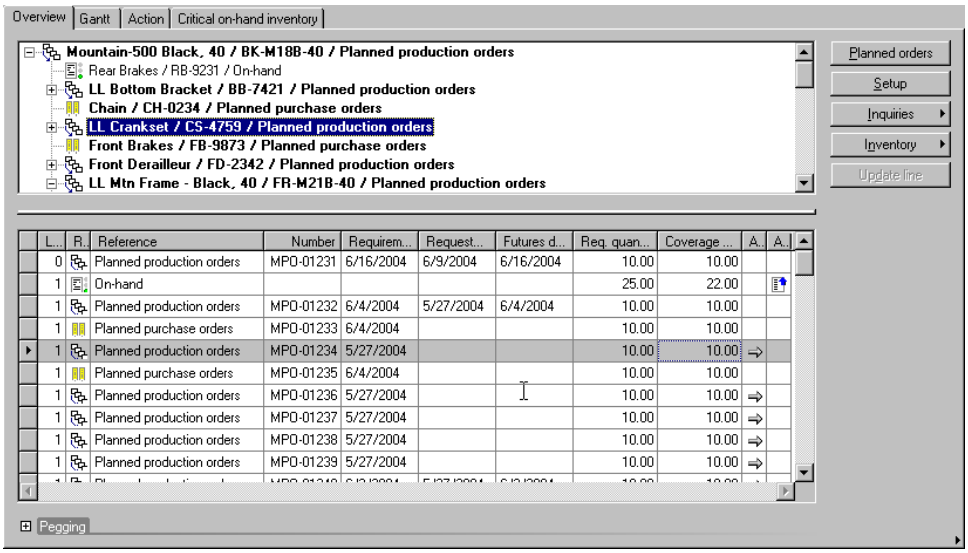
The system is also showing that in reality it will only be able to satisfy this customer at a later date; that date is showed in the Futures date field.

All items the have a green light, such as the Rear Brakes / RB-9231 / On-hand, indicate that there is sufficient inventory on hand to satisfy the requirement.

At this point it can be asked the customer if they would like to change the quantity, or accept the new, realistic delivery date.

This allows the company to keep the delivery promises with order promising functionality that uses information from sales, warehouse, purchasing and production to give an accurate overview of stock availability, delivery time and price. Avoid making delivery promises it can't be kept by running available-to-promise (ATP) calculations based on available inventory and current production orders, as well as capable-to-promise (CTP) calculations based on raw material lead-times and production capacity.

It is also possible to review all of the planned orders, and see which individual item created what type of demand. In the following case, in order to complete the production order, it supposed to manufacture item *CS-4759*



L...	R..	Reference	Number	Requirem...	Request...	Futures d...	Req. quan...	Coverage ...	A..	A..
0		Planned production orders	MPO-01231	6/16/2004	6/9/2004	6/16/2004	10.00	10.00		
1		On-hand					25.00	22.00		
1		Planned production orders	MPO-01232	6/4/2004	5/27/2004	6/4/2004	10.00	10.00		
1		Planned purchase orders	MPO-01233	6/4/2004			10.00	10.00		
1		Planned production orders	MPO-01234	5/27/2004			10.00	10.00	⇨	
1		Planned purchase orders	MPO-01235	6/4/2004			10.00	10.00		
1		Planned production orders	MPO-01236	5/27/2004			10.00	10.00	⇨	
1		Planned production orders	MPO-01237	5/27/2004			10.00	10.00	⇨	
1		Planned production orders	MPO-01238	5/27/2004			10.00	10.00	⇨	
1		Planned production orders	MPO-01239	5/27/2004			10.00	10.00	⇨	

Figure III.8. Planned Production Order

On the Action tab, system proposes to change the production order start date since all of the necessary components to manufacture are not available on inventory.

Item number	Reference	Number	Action	Days	To date	With quan...	To quantity
BK-M18B-40	Planned production orders	MPO-01231					
RB-9231	On-hand		Increase			8.00	33.00
BB-7421	Planned production orders	MPO-01232					
CH-0234	Planned purchase orders	MPO-01233					
CS-4759	Planned production orders	MPO-01234	Postpone	8	6/4/2004		
FB-9873	Planned purchase orders	MPO-01235					
FD-2342	Planned production orders	MPO-01236	Postpone	8	6/4/2004		
FR-M21B-40	Planned production orders	MPO-01237	Postpone	8	6/4/2004		
FW-M423	Planned production orders	MPO-01238	Postpone	8	6/4/2004		
HB-M243	Planned production orders	MPO-01239	Postpone	8	6/4/2004		
HS-0296	Planned production orders	MPO-01240	Postpone	1	6/3/2004		
PD-M282	Planned purchase orders	MPO-01241					
RD-2308	Planned production orders	MPO-01242	Postpone	8	6/4/2004		
RW-M423	Planned production orders	MPO-01243	Postpone	8	6/4/2004		
SA-M198	Planned production orders	MPO-01244	Postpone	3	6/3/2004		
TT-M928	On-hand						
RF-9198	Inventory journal transfer	IJ-000007	Postpone+Decrease	27	6/3/2004	-8.00	82.00
AR-5381	Planned purchase orders	MPO-01245					
BE-2349	Planned production orders	MPO-01246					
BE-2908	Planned purchase orders	MPO-01247					

Figure III.9. Future messages based on the MRP results

Explosion to show the requirements for the item *CS-4759*.

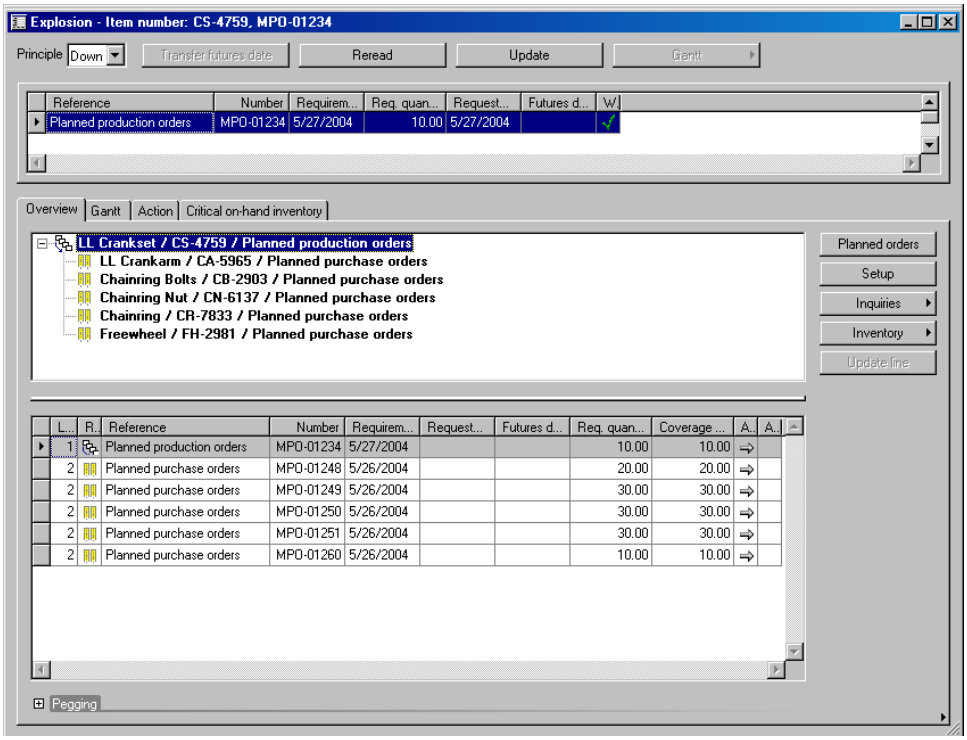


Figure III.10. Planned Purchase Order Form

There were five planned purchase orders created to satisfy the planned production order.

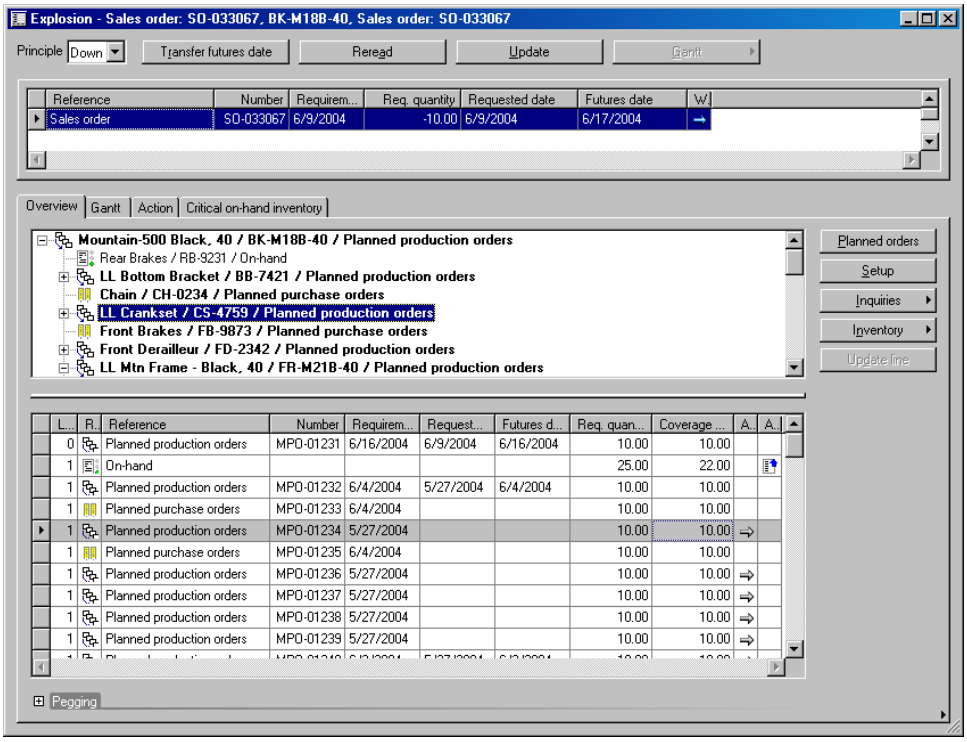


Figure III.11. Explosion of planned purchase order

The Gantt chart gives a graphical view of all transactions, and it enables rescheduling by dragging and dropping.

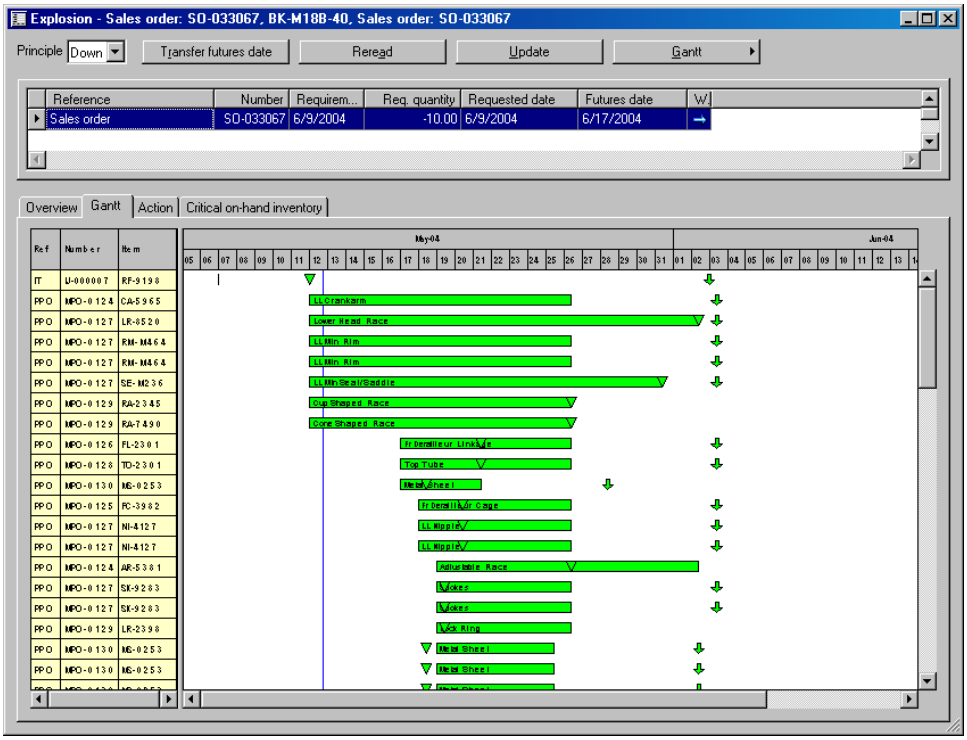


Figure III.12. Gantt chart form

Since it can be seen very clearly that it would be had to place some orders in the past to satisfy this order, change the sales order line delivery date to reflect the value in the Futures date, in this case, 6/17/2004.

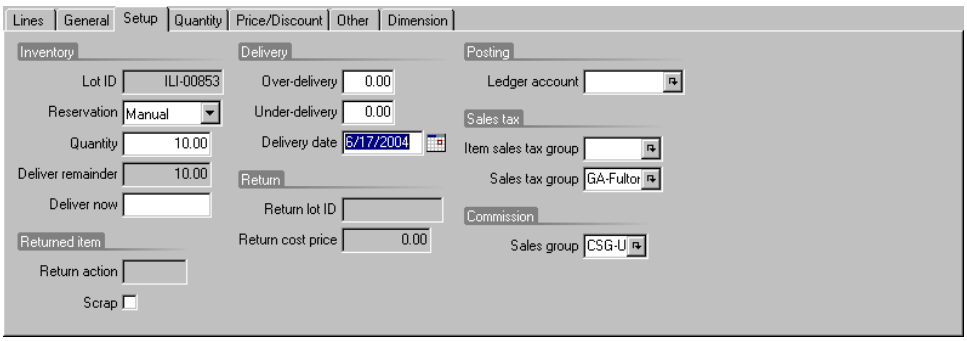


Figure III.13. Delivery date entry form

When the delivery date is changed, it is supposed to update the plan. Click on the Inquiries button and select the option Explosion.

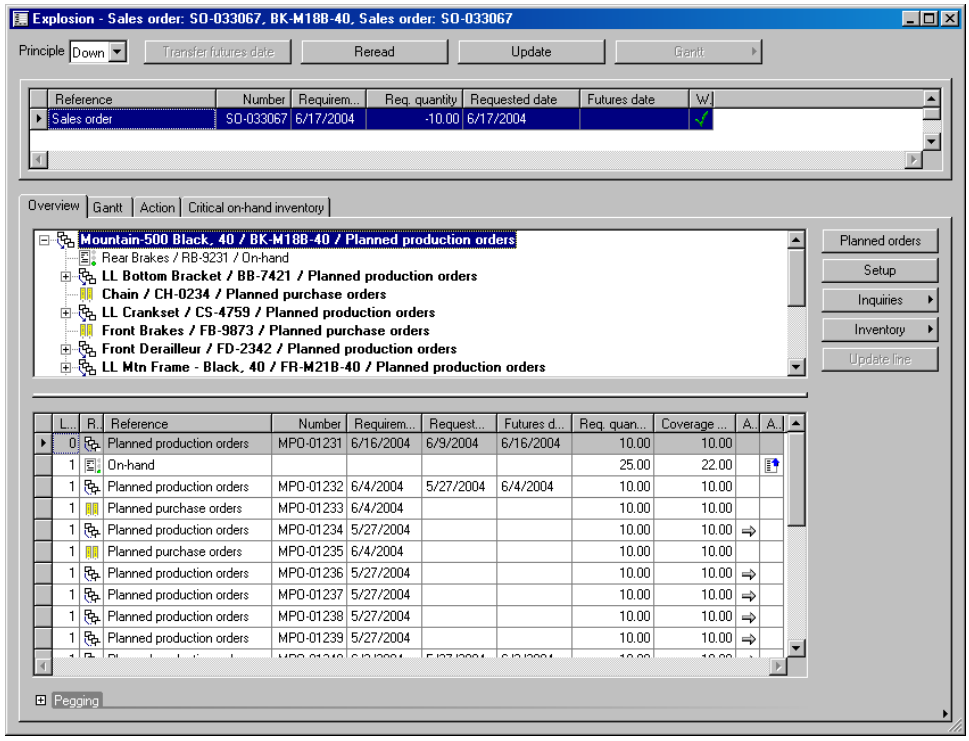


Figure III.14. Update MRP results

When pressing the Update button, which will run the Master Planning engine for this item/sales order. The following screen will comes up.

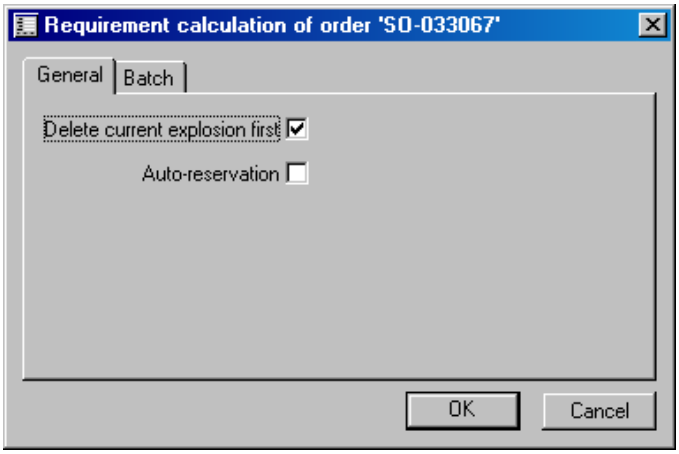


Figure III.15. Run principles of MRP

It is accepted the default information and clicked OK

Once the update is complete the following information is displayed. This screen shows the updated information.

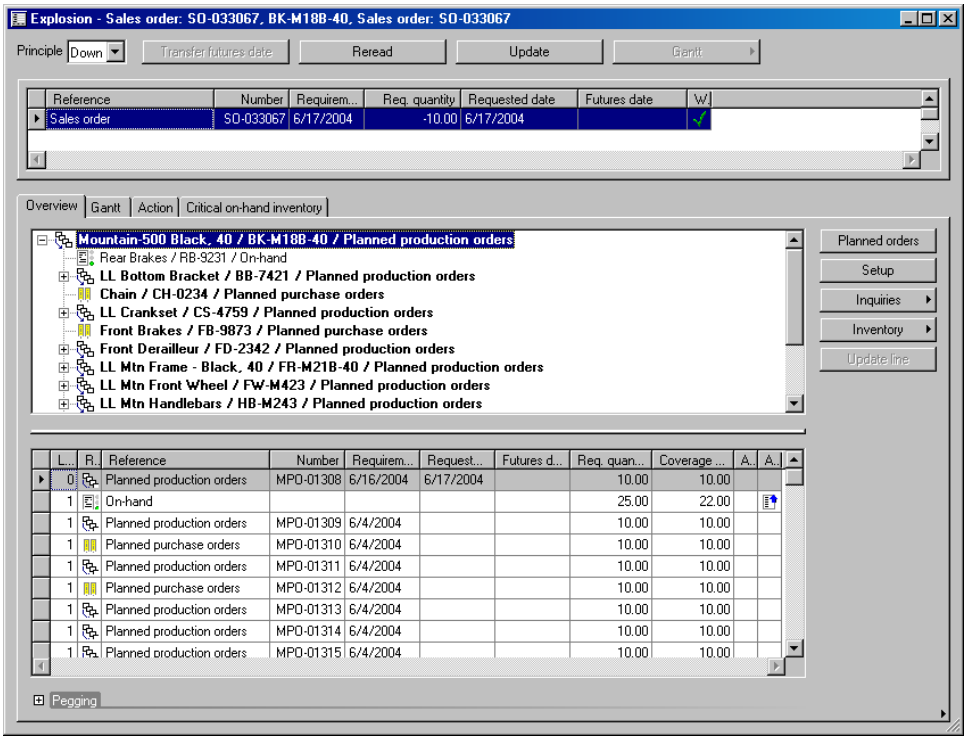


Figure III.16. Re-run results of MRP

The Futures date field is blank, which means that this order can be satisfied by the Requested date.

The next step is to confirm the planned orders, and the easiest way to confirm only the orders related to this demand is to click on the Planned orders button.

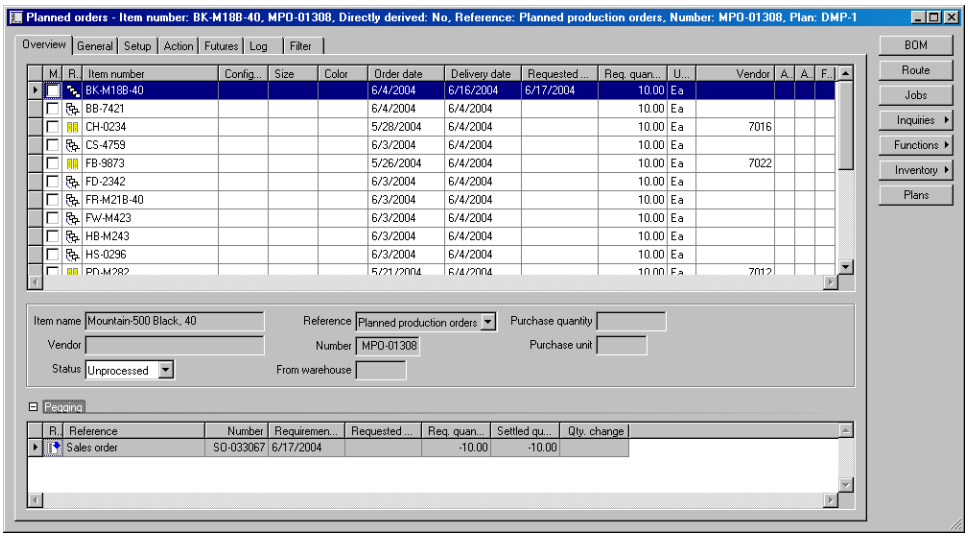


Figure III.17. Planned order inquiry screen

All of the planned purchase orders already have a vendor selected. This is extremely important as it is wanted to be made sure that the system allows to search and to find the right vendor for each situation.

This will allow companies to reduce costs and lead times by finding the vendor that offers either the lowest price or the shortest lead time for a particular item. It can be manually searched for vendors depending on priorities or Microsoft Axapta Master Planning can automatically select the best vendor based on predefined requirements.

It could also be outsourced production to sub-contractors as the need arises in order to help free up capacity and keep the delivery promises to customers. Sub contractor model capacity levels can be set in the system and quickly implemented make or buy strategies at all times in the planning process.

When marked all of the records, to firm all orders. This will firm all of the planned production and planned purchase orders, and create actual production orders and purchase orders.

III.4.6. Production Orders

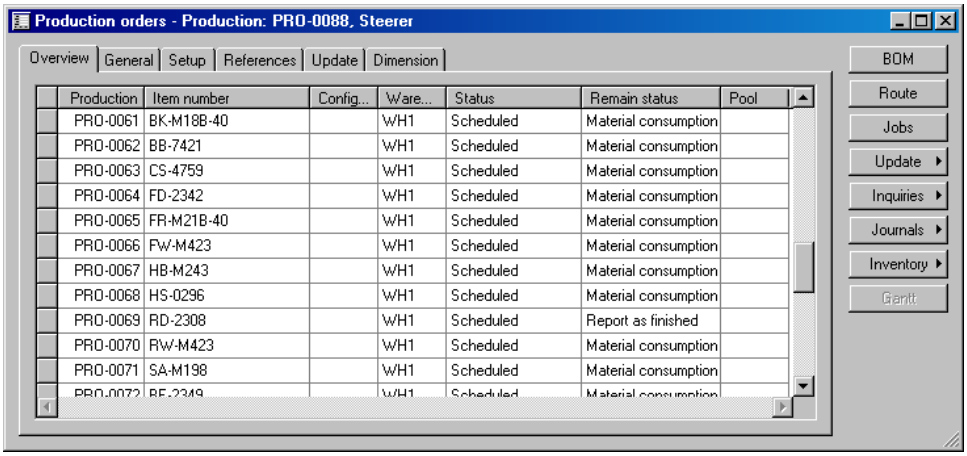


Figure III.18. Production Order form

The flexibility that the system offers is to achieve maximum profitability from the manufacturing resources. Production orders can be created independent of or on the basis of proposals from master scheduling, and Microsoft Axapta Production enables efficient management of bills of material (BOM). Get a quick and reliable overview of the manufacturing resources required to meet customer demand by performing rough capacity scheduling taking both finite or infinite capacity and materials scheduling into consideration. The flexibility to schedule production

processes are backwards or forwards from any date. System creates also purchase orders based on planning.

III.4.7. Accounts Payable → Purchase Orders

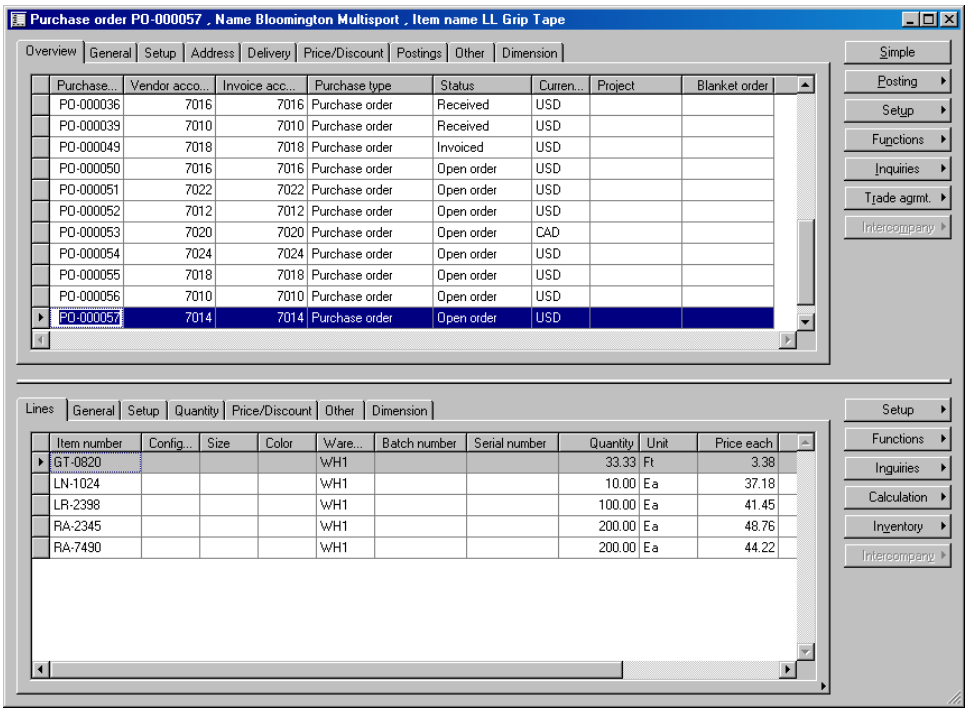


Figure III.19. Purchase Order form

When it is firmed up the planned purchase orders, the system combined different planned orders for the same supplier on one purchase order.

The next step is to receive the purchase orders.

III.4.8. Production → Production Orders

With Microsoft Axapta production, The visibility into all the information needed to efficiently manage the production processes, which include planned production orders, production start times, capacity loadings, delivery dates, and materials availability. Detailed job monitoring gives a clear overview of individual work centers' activities during the course of the day, so that it can be assessed production performance to schedule.

Select all orders by clicking on Edit and on the Select All CTRL+A option, or by simply clicking CTRL+A.

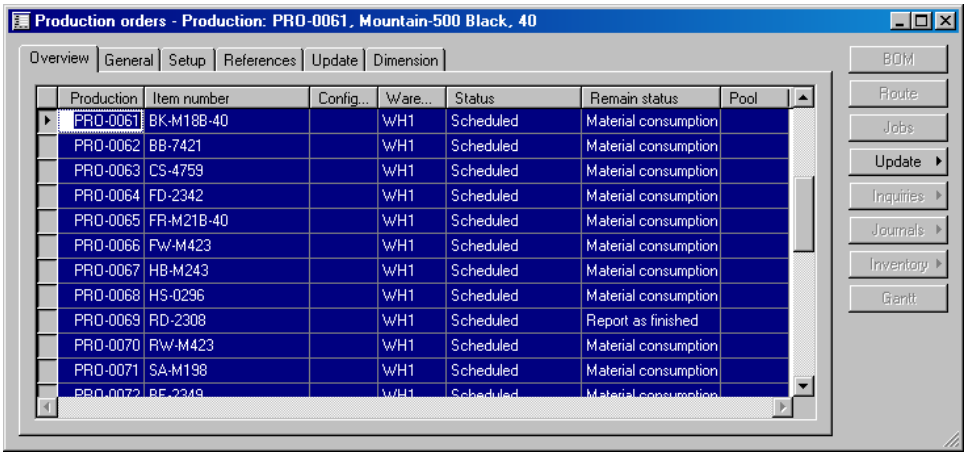


Figure III.20. Production Order fulfillment form

Next click on the Update button and select the option Report as finished.

The following screen comes up.

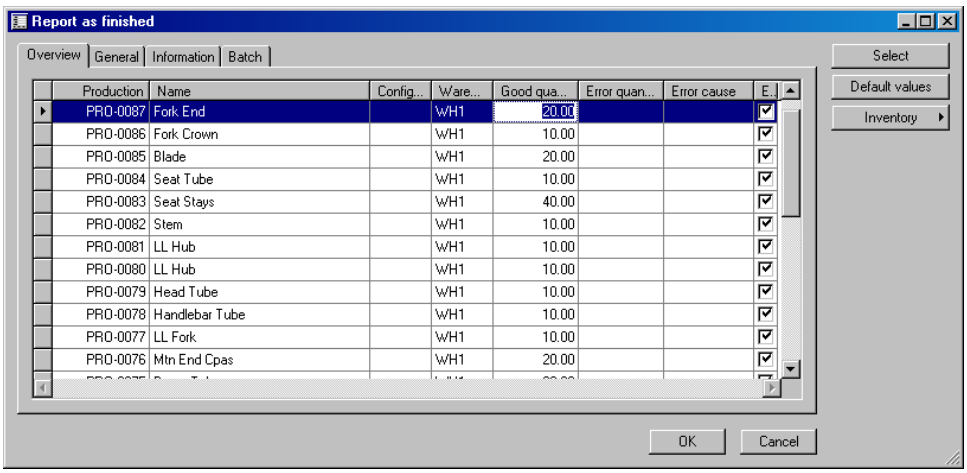


Figure III.21. Delivering production quantities to inventory

Then click the OK button to report as finished all selected production orders. The following info log comes up.

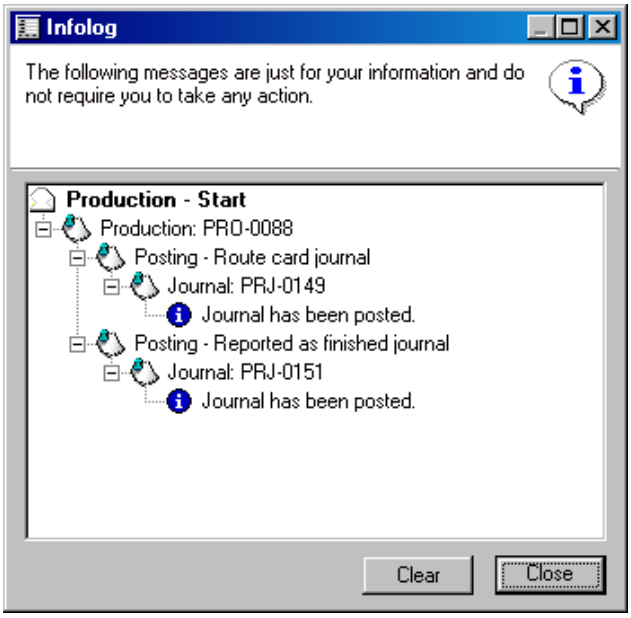


Figure III.22. Infolog screen

If there are no errors, all production orders were reported completed successfully.

Click on the  button.

The next step is to ship the finished goods to the customer, but before it is supposed to go and verify the inventory for the item.

III.4.9. Accounts Receivable → Sales Order

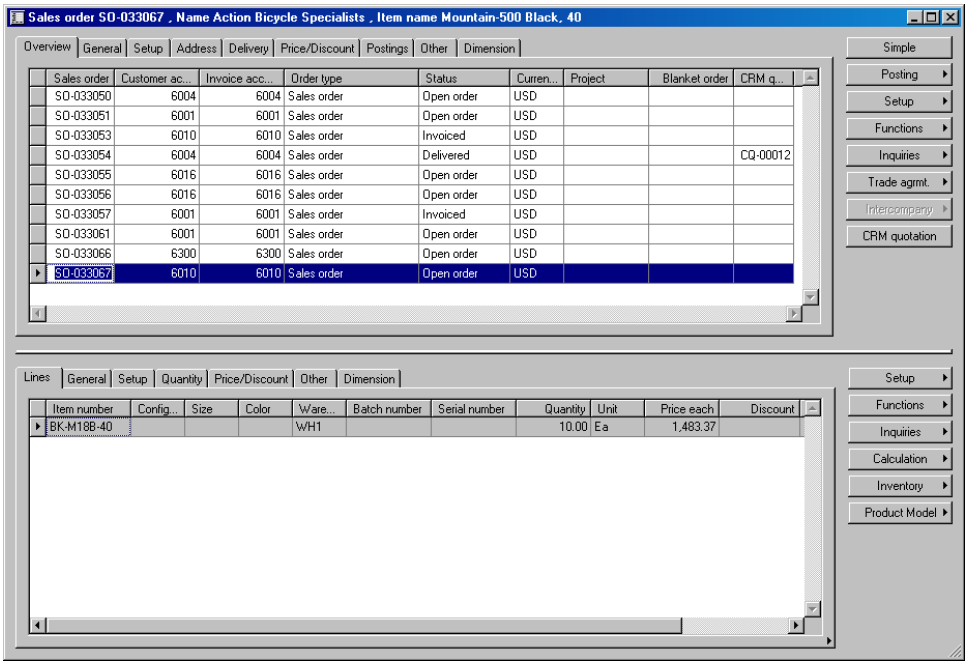


Figure III.23. Sales Order Form

It is supposed to check the on-hand inventory. Press Inventory and select On-hand.

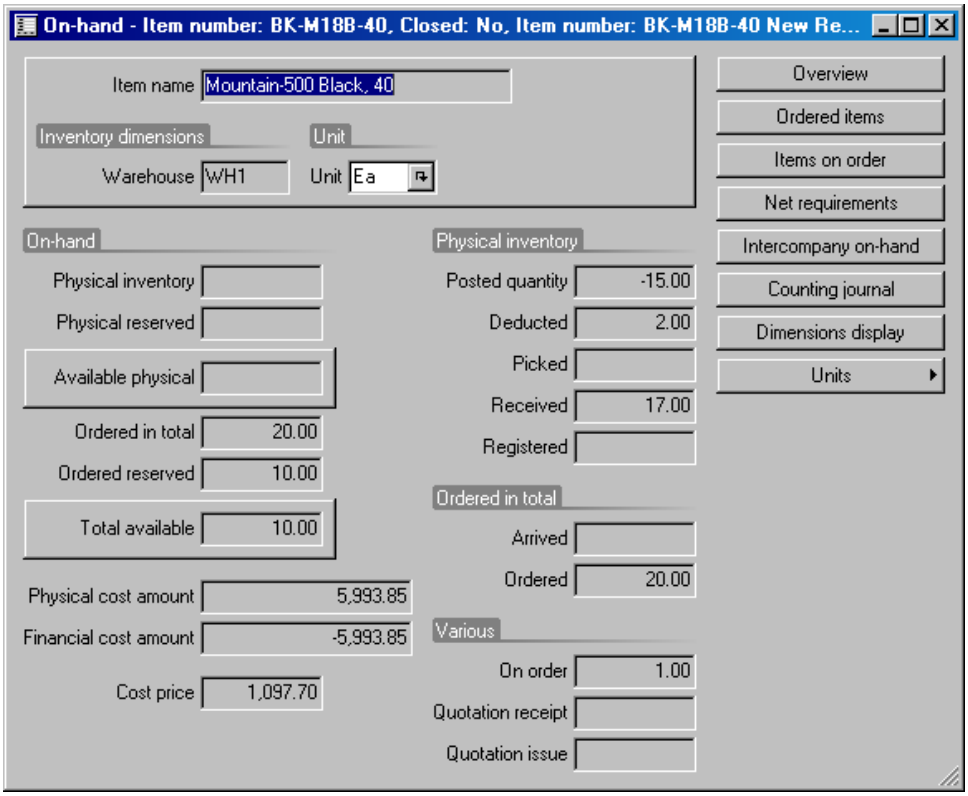


Figure III.24. Item availability screen

It can be seen that Total available 10.00, which is exactly what required to produce.

The next step is to deliver the sales order to the customer.

Microsoft Axapta Master Planning uses information from across the company and supply chain to help to optimize production and materials planning, and scheduling. Finite materials and capacity scheduling can be performed at the same time so that available capacity, inventory levels and purchase lead times are taken into consideration in production planning. The result is more reliable planning of purchase, production and transfer orders, which optimizes the production flow and helps ensure on-time delivery to customers.

III.4.10. Make to Stock Process Flows - Sales Forecast

With Microsoft Axapta it is applicable to use different master planning versions to run online simulations and what-if calculations, henceforth it is possible to foresee the impact of different sales forecasts and planning strategies. Master scheduling can be run in a fast, net change mode where only the latest changes are included in the calculations. This allows to run materials and production planning as often the time interval of company need to in order to have an up-to-date picture of net requirements.

Forecasting Key Features

- Create sales and purchase forecasts based on the historical data
- Use item and period allocation keys to allocate forecasts to individual items and time periods
- Consolidate sales and purchase forecasts into one inventory forecast

III.4.11. Inventory Management → Item

The forecast screen looks then as follows.

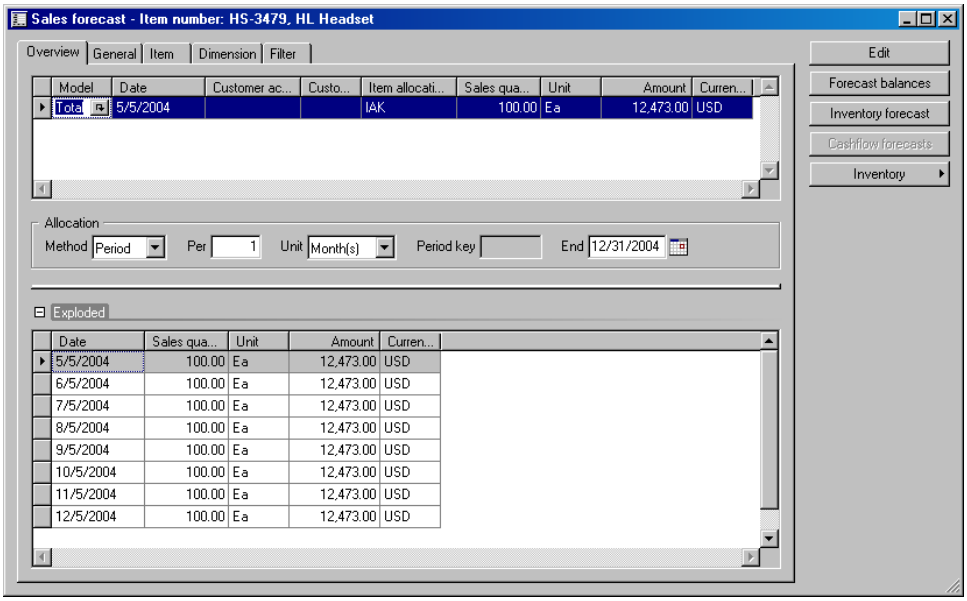


Figure III.25. Sales Forecast screen

Microsoft Axapta Logistics offers strong forecasting functionality that supports long-term planning and helps to optimize inventory levels. Sales and purchase forecasts can be created based on items and time periods and it is possible to use an unlimited number of forecast models to simulate various future scenarios. To quickly

project cash flow, item forecasts can be transferred to the general ledger forecast. Next step is to run the Master Planning for Master Plan MP-1:

III.4.12. Master Planning → Periodic → Master Scheduling

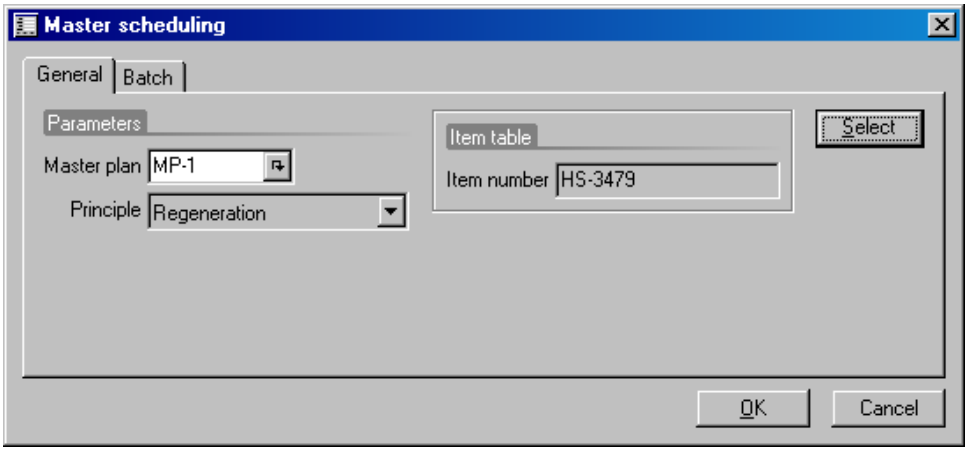


Figure III.26. MRP run-on screen

MRP is run for the HS-3479 item. Once the process is done, the following screen will be appeared.

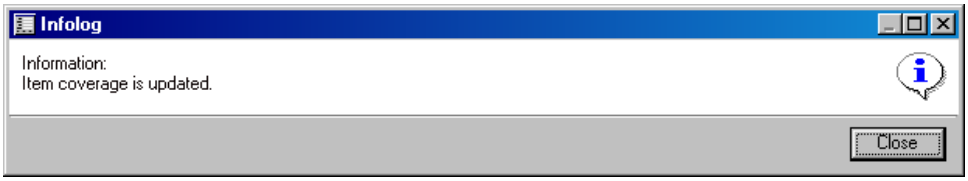


Figure III.27. MRP infolog

The planned orders are generated. The planned orders for item HS-3479, that they were generated because of the sales forecast that was entered earlier.

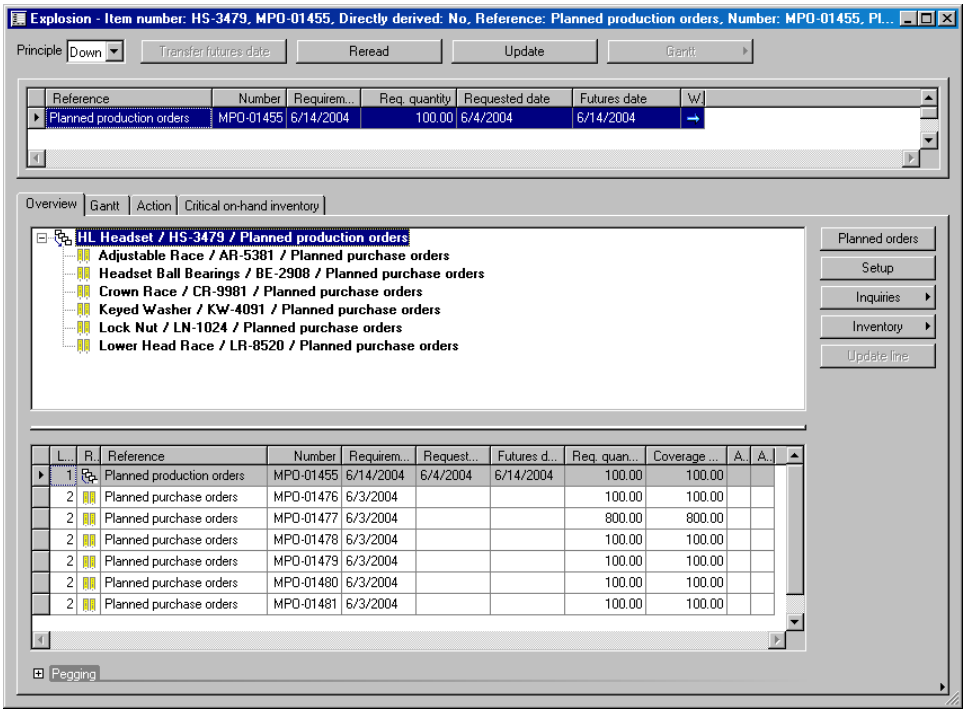


Figure III.28. MRP results

III.5. INTEGRATING PROCESS FLOWS IN ERP WITH REPORTING SYSTEM FOR PERFORMANCE MEASUREMENT

The aim is to establish a performance measurement system in order to justify the efficiency of the ERP system to the company. In the context of this requirement, several reports are developed in the system. These reports and their benefits to the defined measurement metrics are,

Purchase Receipts Inquiry Report

The Purchase Receipts Inquiry Report lists the receipts for an item at a particular site and date. This report also shows the vendor ID, receipt type, date received, quantity received, unit cost, extended cost, and quantity sold for each receipt.

PURCHASE RECEIPTS INQUIRY REPORT
Inventory Control

Item Number: 333PROC 333 Processor
Site ID: WAREHOUSE
Ranges: From: To:
Date First Last
Sorted By: Quantity Type/Date

Receipt Number	Vendor ID	Receipt Type	Receipt Date	Quantity Received	Unit Cost	Extended Cost
Purchase Order No.	Qty Type			Quantity Sold		Value Remaining
00000000000000029	INV ADJ	Adjustment	6/15/2006	10	238.50	2,385.00
INV ADJ	On Hand			0		2,385.00
Totals:				10		2,385.00
				0		2,385.00

Quantities: On Hand 10 Current Cost: 238.50
Available 10 Standard Cost: 0.00
Total Receipts: 1

Figure III.29. Purchase receipt inquiry report

Stock Status Report

The Stock Status Report can be printed at any time for an at-a-glance report of the current status of the inventory. This report includes the quantity on hand, quantity allocated, quantity back-ordered, quantity on order, current cost, and extended cost for each item.

1:36:31 PM **STOCK STATUS REPORT** Page: 1

Inventory Control

Ranges: From: To:
Item Number: 100XLG 64 SDRAM
Item Description: First
Item Generic: First
Bin: First
Account Number: From: - -
To: - -

Manufacturer: From: First To:
Style: First
Feature: First

Sorted By: Item Number

Include Items With Zero Quantities: No
Include Serial/Lot Numbers: No

Item Number	Item Description	Qty Back Ordered	Qty On Order	Qty Requisitioned	Qty On Hand	Qty Allocated	Current Cost	Inventory Value
128 SDRAM	128 meg SDRAM	0	0	0	10	0	152.10	1,521.00
24X IDE	24x CD-ROM	0	0	0	10	0	45.00	450.00
256 SDRAM	256 meg SDRAM	2	0	0	10	0	247.50	2,475.00
32 SDRAM	32 meg SDRAM	0	0	0	10	0	40.50	405.00
32X IDE	32x CD-ROM	0	0	0	10	0	49.50	495.00

Figure III.30. Stock status report

Purchase Advice Report.

The Purchase Advice Report allows the purchasing department to see at a glance which items have fallen below the suggested quantity levels. It displays all items with a quantity equal to or less than the reorder level or the maximum inventory level specified for the items.

PURCHASE ADVICE REPORT
Inventory Control

Ranges:	From:			From:	To:
Item Number	ACCS-CRD-25BK		Style	First	
Item Description	First		Feature	First	
Item Generic	First				
Vendor ID	First				
Manufacturer	First				

Sorted By: Item Number
Include Items With Zero Order Point Qty: Yes
Include Quantities Requisitioned: Yes
Calculate Suggested Quantities Using: Order-Up-To Level

Item Number	Item Description	On Hand	Allocated	Available	Backordered	On Order
* - Primary Vendor	Order Point Qty	Reorder Variance	Order-Up-To Level	QTY To Order	U Of M	QTY in U Of M
Vendor ID	Vendor Name	EOQ	Minimum QTY	Avg Lead	Last Cost	
ACCS-CRD-25BK	Phone Cord - 25' Black	55	2	53	0	22
	0	0	0	0 Each		1
COMVEXIN0001	ComVex, Inc.	0	1	3.00	5.98	
* ELECTRON0001	Electronic Services	0	1	3.00	0.00	
ACCS-HDS-1EAR	Headset-Single Ear	29	7	22	0	15
	0	0	0	0 Each		1
ALLENSON0001	Allenson Properties	0	1	3.00	0.00	
COMVEXIN0001	ComVex, Inc.	0	1	3.00	38.59	
* ELECTRON0001	Electronic Services	0	0	0.00	0.00	
ACCS-HDS-2EAR	Headset - Dual Ear	111	10	101	10	0
	0	0	0	0 Each		1
ATTRACTI00001	Attractive Telephone Co.	0	1	3.00	41.98	
* ELECTRON0001	Electronic Services	0	1	3.00	0.00	
ACCS-RST-DXBK	Shoulder Rest-Deluxe Black	1	9	(8)	0	0
	0	0	0	8 Each		1
* ELECTRON0001	Electronic Services	0	1	5.00	0.00	

Figure III.31. Purchase Advice report

Gross Requirements Report

The Gross Requirements Report displays a detailed list of information about a specific item or a group of items. The report includes item numbers, site IDs, buyers, dates, total requirements, and order and quote sales orders.

GROSS REQUIREMENTS
Bill of Materials

Ranges:	From:	To:
Component Item	400PROC	
Site ID	First	Last
Document Date	First	Last

Sorted By: Component Item/Site ID Print: All
^ Default Site

Component Item	Description				Site ID	
Document Number	Document Date	Start Date	U of M	Quantity Required	Quantity Available	Shortage
ACCS-CRD-12WH	Phone Cord - 12' White				WAREHOUSE	
ASM00000000000006	7/24/2005	7/24/2005	Each	5	26	0
ASM00000000000009	8/27/2005	8/27/2005	Each	7	21	0
					Site Shortage:	0
					Item Shortage:	0
ACCS-HDS-1EAR	Headset-Single Ear				WAREHOUSE	
ASM00000000000006	7/24/2005	7/24/2005	Each	5	22	0
ASM00000000000009	8/27/2005	8/27/2005	Each	7	17	0
					Site Shortage:	0
					Item Shortage:	0
ANSW-ATT-1000	Attractive Answering System 1000				WAREHOUSE	
ASM00000000000004	7/20/2005	7/20/2005	Each	1	3	0
					Site Shortage:	0
					Item Shortage:	0

Total Items: 3

Figure III.32. Gross Requirement report

Turnover Report

The Turnover Report shows how quickly inventory items are selling, and indicates when to modify the reorder levels entered for selected items.

TURNOVER REPORT
Inventory Control

Ranges: From:
Item Number 100XLG
Item Description First
Item Generic First
Manufacturer First
Style First
Sorted By: Item Number
Item Number Item Description

Item Number	Number of Receipts	Quantity Received YTD	Average Inventory	Quantity Sold YTD	Number of Turns YTD	Annual Turns
100XLG	Green Phone					
	0	0	0	0	0.00	0.00
128 SDRAM	128 meg SDRAM					
	0	0	1	0	0.00	0.00
24X IDE	24x CD-ROM					
	0	0	1	0	0.00	0.00
256 SDRAM	256 meg SDRAM					
	0	0	1	0	0.00	0.00
32 SDRAM	32 meg SDRAM					
	0	0	1	0	0.00	0.00
32X IDE	32x CD-ROM					
	0	0	1	0	0.00	0.00
333PROC	333 Processor					
	0	0	1	0	0.00	0.00
4.5HD	4.5 gig Hard Drive					
	0	0	1	0	0.00	0.00
400PROC	400 Processor					
	0	0	1	0	0.00	0.00
40X IDE	40x CD-ROM					
	0	0	1	0	0.00	0.00
450PROC	450 Processor					
	0	0	1	0	0.00	0.00

Figure III.33. Turnover report

Item Period History Report

The Item Period History Report displays detailed information about a specific item or range of items. The report includes item IDs, item descriptions, total sales quantities, total sales costs, total sales amounts, dependent usage quantities, dependent usage costs, and projected usage quantities.

Item Period History Report
Inventory Control

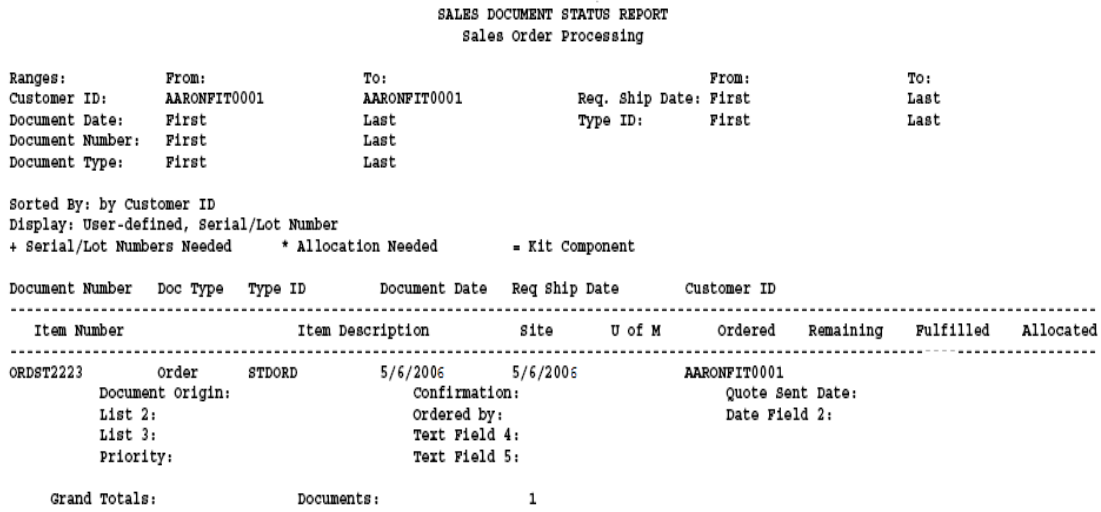
Ranges: From: To:
Item Number 100XLG ANSW-PAN-1450
Item Description First Last
Date First Last
Site First Last
Sorted By: Item Number
Print: Calendar
Item Number Item Description Site

Prd/Mth	Period Name	Year	Total Sales Quantity	Total Sales Costs	Total Sales Amount	Dependent Usage Quantity	Dependent Usage Costs	Projected Usage Quantity
100XLG								
1	January	2006	33	1,831.50	1,978.35	0	0.00	0
2	February	2006	22	1,221.00	1,318.90	0	0.00	0
3	March	2006	9	499.50	539.55	0	0.00	0

Figure III.34. Item period history report

Sales Document Status Report

The Sales Document Status Report displays the items remaining on a document that require further processing.



SALES DOCUMENT STATUS REPORT
Sales Order Processing

Ranges:	From:	To:		From:	To:
Customer ID:	AARONFIT0001	AARONFIT0001	Req. Ship Date:	First	Last
Document Date:	First	Last	Type ID:	First	Last
Document Number:	First	Last			
Document Type:	First	Last			

Sorted By: by Customer ID
Display: User-defined, Serial/Lot Number
+ Serial/Lot Numbers Needed * Allocation Needed = Kit Component

Document Number	Doc Type	Type ID	Document Date	Req Ship Date	Customer ID
ORDST2223	Order	STDORD	5/6/2006	5/6/2006	AARONFIT0001

Item Number	Item Description	Site	U of M	Ordered	Remaining	Fulfilled	Allocated

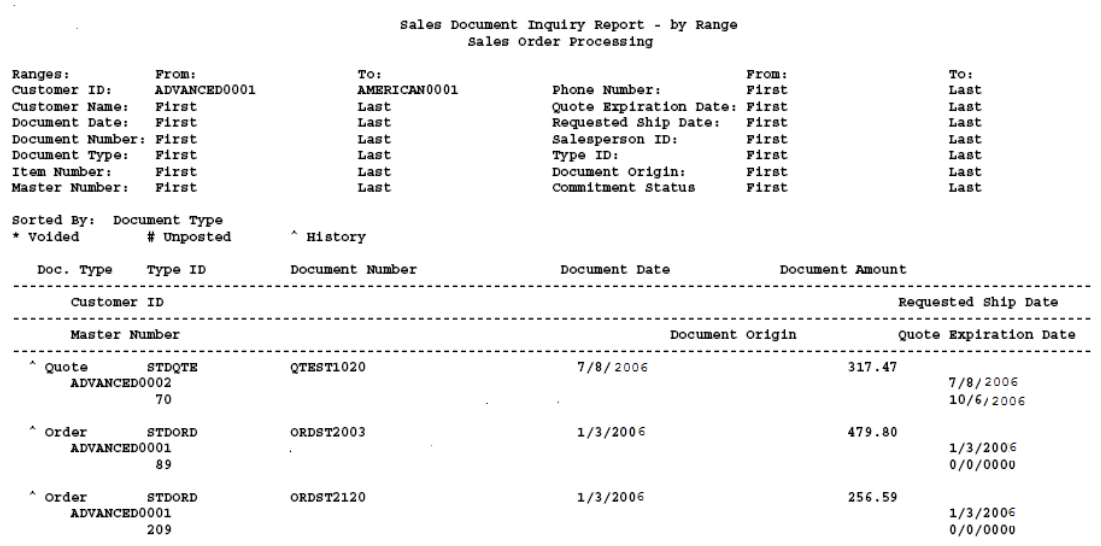
Document Origin:	Confirmation:	Quote Sent Date:	
List 2:	Ordered by:	Date Field 2:	
List 3:	Text Field 4:		
Priority:	Text Field 5:		

Grand Totals: Documents: 1

Figure III.35. Sales Document Status report

Sales Document Inquiry Report

The Sales Document Inquiry Report contains the document type, document number, document date, salesperson, customer name, ID, phone number, and document amount for a range of documents. The report also displays which documents are not posted and which have been moved to history. The Sales Document Inquiry Report can be used to list all orders entered for a date range or all orders entered for a customer.



Sales Document Inquiry Report - by Range
Sales Order Processing

Ranges:	From:	To:		From:	To:
Customer ID:	ADVANCED0001	AMERICAN0001	Phone Number:	First	Last
Customer Name:	First	Last	Quote Expiration Date:	First	Last
Document Date:	First	Last	Requested Ship Date:	First	Last
Document Number:	First	Last	Salesperson ID:	First	Last
Document Type:	First	Last	Type ID:	First	Last
Item Number:	First	Last	Document Origin:	First	Last
Master Number:	First	Last	Commitment Status	First	Last

Sorted By: Document Type
* Voided # Unposted ^ History

Doc. Type	Type ID	Document Number	Document Date	Document Amount	Requested Ship Date
Customer ID					
Master Number			Document Origin		Quote Expiration Date
^ Quote	STDQTE	QTEST1020	7/8/2006	317.47	
ADVANCED0002					7/8/2006
70					10/6/2006
^ Order	STDORD	ORDST2003	1/3/2006	479.80	
ADVANCED0001					1/3/2006
89					0/0/0000
^ Order	STDORD	ORDST2120	1/3/2006	256.59	
ADVANCED0001					1/3/2006
209					0/0/0000

Figure III.36. Sales Document Inquiry report

Receiving Transaction History Report

The Receiving Transaction History Report lists the shipment, shipment/invoice, and invoice receipts that currently exist in history. This report lists the receipt

number, vendor document number, vendor name, and vendor ID. For each receipt, the report lists the items included on the receipt, quantity shipped, quantity invoiced, quantity rejected, and cost. The totals and subtotals also are given for each receipt.

RECEIVINGS TRX HISTORY REPOR
Purchase Order Processing

Ranges: From: To:
Receipt Number RCT1001 RCT1003

Sorted By: Receipt Number Print Option: Detailed Display: Serial/Lot Numbers

Non-Inventoried Item * Voided Transactions ^ Invoice Landed Cost

Receipt Number / Item	Vendor Doc. No. / Description	Document Date / U of M	Vendor ID / Qty Shipped	Name / Qty Invoiced	Vendor Item / Qty Rejected	Audit Trail Code / Unit Cost	PO Number / Extended Cost
RCT1001	528	4/18/2006	FABRIKAM0001	Fabrikam, Inc.		RECVG00000045	
PHON-GTE-5043	Cordless-Grand S5043				GTES5043		PO1002
WAREHOUSE		Each	8	0	0	81.25	650.00
PHON-GTE-3458	Memory-Grand M3458				GTEM3458		PO1002
WAREHOUSE		Each	6	0	0	75.00	450.00
						Subtotal	1,100.00
						Trade Discount	0.00
						Freight	0.00
						Miscellaneous	0.00
						Tax	0.00
		-				Total	1,100.00
RCT1002	45993	4/29/2006	CRUGEREN0001	Cruger Engineering Compan		RECVG00000001	
HDWR-TPS-0001	Tape Unit/Mass Storage				TAPEMASS		PO1003
NORTH		Each	1	1	0	1,224.64	1,224.64
						Subtotal	1,224.64
						Trade Discount	0.00
						Freight	48.00
						Miscellaneous	0.00
						Tax	73.48
						Total	1,346.12

Figure III.37. Receiving transaction history report

Supply Chain Execution for Microsoft Axapta helps empower distribution operations with speed, efficiency, and comprehensive control. The solution integrates smoothly with the enterprise management applications to help the company orchestrate product movement and optimize complex processes in real time.

Companies in manufacturing industry have the tool via Supply Chain Execution for Microsoft Business Solution Axapta, which enables them to face the challenges of increasing customer requirements, globalization, and multiple distribution channels and to comply with trading partner initiatives while continuing to grow their business.

PART 4: RESULTS

Companies in manufacturing industry targets are focused on strong and robust tools and models for real time planning, decision making, faster and accurate customer response. The bottleneck that they are face to face is to take under control their supply chain flow and measure the system based on the key factors.

In the context of Supply Chain performance measurement in this study in order to compare the results the metrics are classified as before ERP period and ERP period.

When this case study was written, the design of the Supply Chain Performance Measurement by using ERP system had just been completed. Therefore, the following list of benefits is preliminary and should be evaluated as such:

- Trust amongst the supply chain partners was increased through information exchange.
- The success of the supply chain co-operation could be continuously monitored.
- The result of actions initiated by the partnership could be evaluated.
- The ERP system provided a focus on critical performance measures.
- By using inter-enterprise performance measures potentials for improvement in the supply chain could be identified and implemented within the ERP system.
- Planning security could be enhanced through better information exchange.
- The ERP system provided an effective framework to discuss joint improvement efforts in a structured way.

The developed reports which retrieve the statistical data in order to trace the performance of process flow in supply chain management are run on the system on daily basis. The strategic goal aimed is "**consistently deliver the product, which is manufactured according to the make to stock policy, to the customer on time**". In the scope of this study, implied performance measurements are,

- On time delivery performance to requested date (%)
- Fill Rate % by Order
- Order Fulfillment Lead Time in Days

For each of the two period (before ERP and ERP), it is taken the 200 sales order in order to evaluate the delivery performance metrics.

According to the statistical history the critical performance indicators are measured.

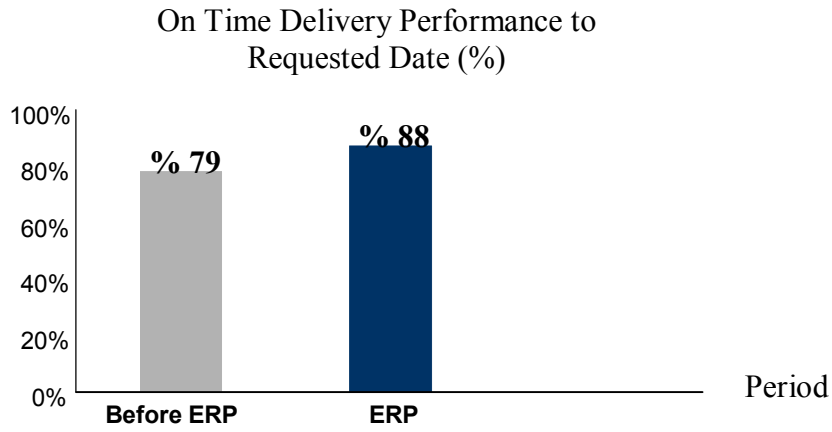


Figure IV.1. On time delivery performance

11% reduction with ERP practice is handled in terms of on time delivery performance to requested date.

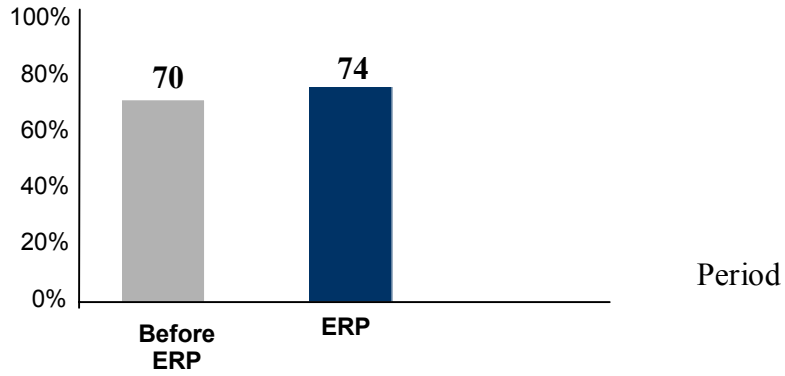


Figure IV.2. Fill Rate % by Order (MTS only)

6% reduction with ERP practice is handled in terms of fill rate % by order (for MTS only)

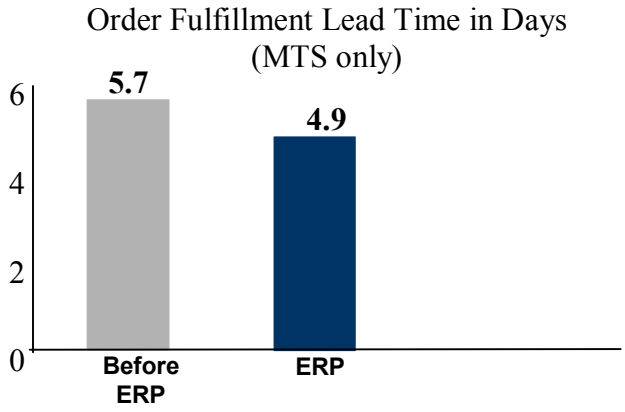


Figure IV.3. Order Fulfillment Lead Time in Days (MTS only)

14% reduction with ERP practice is handled in terms of order fulfillment lead time in days (for MTS only)

Performance measurement provides an approach to identifying the success and potential of management strategies, and facilitating the understanding of the situation. It assists in directing management attention, revising company goals, and re-engineering business processes. Henceforth, accurate performance measurement is helpful in the improvement of supply chain management.

PART 5: DISCUSSIONS AND EVALUATIONS

Organizations are supposed to establish a measurement system in order to adapt the business processes as their companies grow and reduce the cost of the cycle. It is essential to systematize and to control the value chain in a methodological way. Many firms have adopted performance measurement systems that measure the wrong things and are thus finding it difficult to achieve strategic goals and align their goals with those of the other supply chain members and the supply chain as a whole. Good performance measures drive performance and can turn a supply chain into a world-class supply chain that benefits all of its members.

Each enterprise is expected to have a metrics model that is unique in terms of number and types of causes, hierarchy of causes and criticality of causes to the end effect.

Although workers attempt to build new measures and metrics for SCM, most of the current PMSs for the supply chain have too many defects to meet the SCM requirements. Besides the criticism about the non-connection with strategy and a biased focus on financial metrics, there are some in-depth problems of PMSs in the supply chain context:

1. The lack of a balanced approach to integrating financial and non-financial measures.
2. The lack of system thinking, in which a supply chain must be viewed as a whole entity and the measurement system should span the entire supply chain.
3. The loss of the supply chain context.

Financial performance, while important to shareholders, is argued to provide too little information regarding the long-term effectiveness of the firm in satisfying customers. Thus, use of measures that indicate something about the firm's product

quality, productivity, and customer service capabilities have begun to be used successfully in many organizations.

World-class organizations realize how important it is to align strategies with the performance of their people and processes, and performance measurement systems give these firms a means for directing efforts and firm capabilities toward what the firm is trying to do over the long haul – meet strategic objectives and satisfy customers.

Performance measurement systems should be a mix of financial, non financial, quantitative, qualitative, cost-oriented, process-oriented, and customer-oriented measures that effectively link the actions of the firm to the strategies defined by the firm's executive managers. Firms are trying to manage their supply chains have an added layer of performance measure requirements. Measures must be added that link the operations of member firms as well as linking the actions of the firms to the competitive strategies of supply chain.

Performance measurement selection is a critical step in the design and evaluation of any system. Generally, the larger and more complex the system, the more challenging it becomes to measure effectively. While there is an ever-increasing number of supply chain models presented in the literature, there is very little available in supply chain performance measure selection. As such, many of the existing models use inappropriate or ineffective performance measures that are limited in scope (non-inclusive).

The use of simple performance measures is tempting, since simple measures are more easily implemented into numerical models; however, by limiting the scope of the performance measurement, these models ignore important performance tradeoffs. The effects of these performance trade-offs are magnified when the supply chain is reconfigured on the basis of a non-inclusive measurement system. In order to improve the effectiveness of supply chain models, performance measures must be selected that will allow for a more complete and accurate analysis.

This research discusses the importance of a supply chain system to simultaneously achieve a high level of efficiency, a high level of customer service, and the ability to respond effectively to a changing environment. The categorization of supply chain performance measures resulted in the identification of three types of performance measures that are necessary components in any supply chain performance measurement system: resource, output, and flexibility. Although many

individual supply chain performance measures exist for resources and output, the number of flexibility measures actually applied to supply chains is few.

Some of the key points to be considered while defining the metrics model can be summarized as follows:

- No metrics model is likely to identify all relevant variables – however, enterprises need to make a conscious effort to build a metrics model that is comprehensive while providing an in-depth cause and effect analysis. This can be best achieved by deploying a cross-functional team that has a strong understanding of underlying processes. More process-oriented companies also support such teams with advanced statistical and quality tools to help them determine highest impact causes. Most importantly, such a team should have a stake in terms of accountability and responsibility for the metrics being measured and the resultant actions emanating from these metrics.
- Despite use of advanced statistics, some element of judgment and approximation on behalf of the team developing the metrics model is unavoidable. Given this imperfection, the attempt therefore should be to identify the most relevant & highest impact causes keeping in mind that each additional metric in the model requires investment of time, effort and money to collect the right data and to ensure its quality over time.
- Like metrics, models tend to be highly contextual in nature. They are very much dependent on the team of people developing them – their knowledge of underlying processes and causes, goals for measurement and their vision of how a supply chain performance measurement system should integrate with the overall enterprise performance management objectives. Besides people, another important factor which constrains the ultimate design of the metrics model is data in terms of availability, accuracy and cost of obtaining this data. In the above example, getting accurate and real-time data on product availability is itself likely to pose a major challenge. This in turn, would decide how the metrics model would ultimately shape up.
- Metric models cannot be static. Depending on the nature of business changes, changes in process maturity as well as changes in the vision of the enterprise, metrics models will need to be refined to align with the latest enterprise objectives and needs. As the IT landscape of the enterprise changes, some metrics which

might have been consciously ignored because of data availability reasons may now need to be accommodated in the model to make the model more robust and relevant.

2. Data Analysis across various dimensions

While a metrics model provides the various metrics or attributes for analysis, another dimension of analysis is the hierarchy of data. Typically, data hierarchy allows one to move up or down on a particular attribute.

3. Quantify financial impact of supply chain metrics using Scorecards. This is the process be which typical supply chain metrics are linked to financial KPIs. For example, Cash-to-cash cycle time metrics model can be linked to Return on Assets. Similarly, Total Supply Chain Cost metrics model can be linked to Net Margin through Cost of Goods Sold. Establishing the link with financial measures helps quantify the performance of Supply Chain as well understand its full impact on the enterprise's top line and bottom line.

4. Review the Supply Chain Scorecard in the Sales & Operations Planning process.

While metrics reflect the overall health of the supply chain and its various functions, they need to be supported with a process mechanism which enables a joint review and formalization of corrective plans from a cross functional perspective. Some key best practices for implementing effective S&OP processes include :

- Establish a prescheduled meeting with a well-defined agenda involving vendor, subcontractor, and any other critical players in the supply network along with their cross functional teams
- Articulate and quantify the performance for the supply network as a whole which in turn leads to performance measures for individual players of the supply network and also helps speedy determination of causes of failures
- Need to have representation by key decision makers including Executive involvement that can take deterministic action and unite multi-functional objectives
- Adequate groundwork on performance review and failure analysis needs to be undertaken at a functional level to the supply network performance review in the S&OP meeting so that the S&OP meeting is more of a "confirmation" only with "no surprises

- Benchmark supply network performance with the best in the industry and across industries – use these benchmarks to continually "raise the bar" on performance

On the other hand, one of the key challenges to enable an effective S&OP is to have an efficient IT capability to aggregate and structure enormous amounts of supply chain information & data originating from disparate IT systems such that it enables an overall view of the supply network.

Delivering the Metrics framework

This is the domain of Supply Chain analytics. Supply Chain analytics is the process of extracting, transforming and presenting supply chain information on a common information platform in various presentation formats like dashboards, reports, email alerts to fulfilling the diverse information needs of operational managers, senior executives as well as remote users or business partners.

Supply chain models that utilize this framework can more completely characterize the supply chain system and the resulting reconfiguration effects, thus enabling the development of models that are more complete, accurate, and therefore, more effective. The IT integration with supply chain management system is the key tool for the company. ERP systems include supply chain management solution enable the process management methodology be applied to different types of business flow.

The system works more robust with integrated solution within the supply chain routine. Each component in the chain is supposed to behave as a live mechanism in order to justify and evaluate the produced outputs by the system. In order to get the accurate measurement inputs, initial step is to handle the accurate data on time from the associated data generation resources within integrated system. The most difficult point is to establish the measurement indicator and design the ERP system to be able to get the inputs for measurement.

ERP implementation requires business process refinement or reengineering methodology at design phase of the system. Effective system will also bring the elimination of the redundant activities performed within the business flow. In terms of performance, it is focused on value added activities. The measurement points are supposed to be addressed into the system.

REFERENCES:

Akkermans H.A.; Bogerd P.; Yucesan, E.; Wassenhove L.N., "The impact of ERP on supply chain management : Exploratory findings from a European Delphi study", *European Journal of Operational Research*, 146, **(2003)** 284–301.

Beamon B.M., "Performance Measures in Supply Chain Management", *Proceedings of the 1996 Conference on Agile and Intelligent Manufacturing Systems*, Rensselaer Polytechnic Institute, Troy, New York, **(1996).**

Bolstroff P.; Rosenbaum R., "Supply Chain Excellence: a handbook for dramatic improvement using the SCOR model", AMOCOM, USA, **(2003)**.

Chan F. T. S., "Performance Measurement in a Supply Chain", *International Journal of Advanced Manufacturing Technologies*, 21:534–548, **(2003)**.

Chopra S.; Meindl P., "Supply Chain Management", Prentice Hall, USA, **(2003)**.

Chorafas D.N., "Integrating ERP, CRM, Supply Chain Management and Smart Materials", Auerbach, USA, **(2003)**.

Christopher M., "Logistics and Supply Chain Management : Strategies for Reducing Cost and Improving Service", Financial Times Prentice Hall, USA, **(1998)**.

Cooper, M. C.; Lambert, D. M.; Pagh, J. D., "Supply Chain Management: More Than a New Name for Logistics", *The International Journal of Logistics Management*, 8, **(1997)**, 1-13.

Croom S.; Romano P.; Giannakis M., "Supply chain management: an analytical framework for critical literature review", *European Journal of Purchasing & Supply Management*, 6, **(2000)**, 67-83.

Edwards, P.; Peters, M.; Sarman, G., "The effectiveness of information systems in supporting the extended supply chain", *Journal of Business Logistics*, **(2001)**, 1–28.

Fawcett, S. E.; Magnan, G. M., Achieving world-class supply chain alignment: Benefits, barriers, and bridges available http://www.capsresearch.org/completed.htm, (2001).

Fisher M.L., "What Is the Right Supply Chain for Your Product?", Harvard Business Review, 75, **(1997)**, 105-116.

Frolich, M. T.; Westbrook R., "Demand chain management in manufacturing and services: Web based integration, drivers and performance", *Journal of Operations Management*, 20, **(2002)**,729-746.

Gunasekaran A.; Patel C.; McGaughey R.E., "A framework for supply chain performance measurement", *Int. J. Production Economics*, 87, **(2004)**, 333–347.

Hameri A., Paatela A.," Supply Network Dynamics as a Source of New Business", *Int. J. Production Economics*, 98, **(2005)**, 41-55

Harrold, D., "How manufacturing benefits by understanding ERP and IT", *Control Engineering*, 48, **(2001)**, 26–36.

Hendricks K.B., Singhal V.R., Stratman J.K., "The impact of enterprise systems on corporate performance:A study of ERP, SCM, and CRM system implementations", *Journal of Operations Management*, **(2006)**.

Hoekstra S.; Romme J., "Integral Logistics Structures Developing Customer – oriented Goods Flow", McGrow-Hill Book Company, London, **(1992)**.

Holmberg S., "A systems perspective on supply chain measurements", *International Journal of Physical Distribution & Logistics Management*, Vol. 30 No. 10, **(2000)** 847-868.

Hong, K.K., Kim, Y.G., "The critical factors of ERP implementation: An organizational fit perspective", *Information and Management*, 40, **(2002)**, 25–40.

Kaplan R.S., Norton D.P., "The Balanced Scorecard: Translating Strategy into Action", Harvard Business School Press, Boston, USA, **(1996)**.

Lambert D.M., Cooper M.C., "Issues in Supply Chain Management", *Industrial Marketing Management*, 29, **(2000)**, 65–83.

Lambert, D. M., Cooper, M. C., and Pagh, J. D.: "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management*, 9(2), **(1998)**, 1–19.

Landeghem, H.V., Vanmaele, H., "Robust planning: A new paradigm for demand chain planning", *Journal of Operations Management*, 319, **(2002)**, 1–15.

Lee, H.L. and Billington, C., "Material Management in Decentralized Supply Chains", *Operations Research*, Vol. 41 No. 5, **(1993)**, 835-847.

Li S, Rao S. S., Ragu-Nathan T.S., Ragu-Nathan B., "Development and validation of a measurement instrument for studying supply chain management practices", *Journal of Operations Management*, 23, **(2005)**, 618–641.

Maskell, Brian H., "Performance Measurement for World Class Manufacturing", Productivity Press, Portland, Oregon, **(1991)**.

Moss-Kanter, R., “Collaborative advantage: The art of alliances”, *Harvard Business Review*, 72 (4), **(1994)**, 96–108.

Scott, J.E., Kaindl, L., “Enhancing functionality in an enterprise software package”, *Information and Management*, 37, **(2000)**, 111–122.

Senge P., “The Fifth Discipline: The Art and Practice of the Learning Organization”, Doubleday, Newyork, **(1990)**.

Shank, J.K. and Govindarajan, V., “Strategic Cost Management and the Value Chain”, *Journal of Cost Management for the Manufacturing Industry*, Vol. 5 No. 4, **(1992)**, 5-21.

Stenger T., “PRTM / SAP “Benchmarking Study 2002-2003: Supply Chain Planning”, *SAP Forum*, **(2006)**.

Themistocleous M., Irani Z., Love P., “Evaluating the integration of supply chain information systems: A case study”, *European Journal of Operational Research*, 159, **(2004)**, 393–405.

Walsh, J.P., “Selectivity and selective perception: An investigation of managers’ belief structures and information processing”, *Academy of Management Journal*, 31, **(1988)**, 873–896.

Wisner J.D., Leong G.K., Tan K.C., “Principles of Supply Chain Management: A Balanced Approach”, South-Westers, USA, **(2005)**.

VITA

Date of Birth	30.03.1978	
Date of Place	İstanbul	
High School	1991 - 1994	Şişli Terakki High School
Graduate	1994 – 1998	Istanbul Technical University
		Department of Industrial Engineering
Certificates	1998 – 1999	Marmara University
		Management Information System
	2005	MBS Axapta Production Consultant
	2004	MBS Axapta Finance Consultant
	2004	MBS Axapta Logistics Consultant
Work Experience	2003 -	Anadolu Bilişim Hizmetleri A.Ş.
		Axapta ERP Consultant
	2002 – 2003	Intergen – ENKA
		ERP Supervisor
	2000 – 2002	Globalsoft
		ERP Consultant
	1998 – 1999	Marshall Boya ve Vernik Sanayi A.Ş.
		Industrial Engineer / IT department

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Established committee listed below, on 12.07.2006 and 2006/18-34 by the *INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES*' Executive Committee, have accepted Miss İlhan DERMAN's Master of Science thesis, titled as "Supply Chain Performance Measurement and A Case Study in Manufacturing Industry" in Engineering Management.

COMMITTEE

Advisor : Asst.Prof.Dr. Özalp VAYVAY, Marmara University

Member : Assoc.Prof.Dr. Yasemin Claire ERENSAL, Dogus University

Member : Asst.Prof.Dr. Serol BULKAN, Marmara University

Date of thesis' / dissertation's defense before the committee : 31.07.2006

APPROVAL

~~Mr.~~ / ~~Mrs.~~ / Miss. İlhan DERMAN has satisfactorily completed the requirements for the degree of ~~Doctor of Philosophy~~ / Master of Science in Engineering Management at Marmara University.

~~Mr.~~ / ~~Mrs.~~ / Miss. İlhan DERMAN is eligible to have the degree awarded at our convocation on 03.08.06 and 2006/20-5 Diploma and transcripts so noted will be available after that date.

Istanbul

DIRECTOR

Prof. Dr. Adnan AYDIN

MÜDÜR