

INFORMATION TECHNOLOGIES AND MATERIAL REQUIREMENT PLANNING (MRP) IN SUPPLY CHAIN MANAGEMENT (SCM) AS A BASIS FOR A NEW MODEL

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Abstract. In this study, information technologies, one of the biggest enablers of the modern supply chain management (SCM), are discussed. Types and ways of information technologies related to supply chain management are analyzed. Material Requirement Planning (MRP), Enterprise Resource Planning (ERP), and electronic trade are discussed to provide an example.

Keywords: supply chain management, information technologies, material requirement planning, enterprise resource planning

Introduction

Information and communication technologies (ICT) are one of the most important enablers of effective supply chain management. A great deal of interest in supply chain management stems from the availability of information and the methods to analyze this information to reach meaningful results. New opportunities exist as electronic business gain importance, and es-

pecially the widespread use of internet is increasing the interest for the information technologies (Simchi-Levi et al., 2000).

Supply chain management consists of many functional areas in companies and it is affected by the communications of these groups. Thus, this paper aims to discuss the information technology structures of companies, supply chain applications and intra-company communications.

Information technologies are a source of competitive power for many companies. Especially for service industries such as big retailers, transportation companies, and airway companies where they have been started to widely used, information technologies have earned a vital role.

The time and opportunities to reach information is very important for supply chain management which aims to increase service level and decrease the costs and lead times. Along with this, many companies are offering information technologies based services to their customers in order to gain competitive edge and sustain long term relationships with them. Such a service offered by a single company in an industry makes it an obligation for the rest of the companies competing in the same industry. According to the research conducted by Subramani (2004), relationship-specific intangible investments play a mediating role linking SCM systems use to benefits. Evidence that patterns of information technology use are significant determinants of relationship-specific investments in business processes and domain expertise provides a finer-grained explanation of the logic of IT-enabled electronic integration.

The technologies used in different departments in the company differentiate from each other by the time. For successful supply chains it is vital to integrate and standardize these technologies.

Electronic trade

Electronic trade transformed the traditional, physical trade into electronic environment where there are new ways of communication between suppliers and customers. Operating an integrated supply chain requires a continuous information flow between the parties involved in the chain (Lambert & Cooper, 2004). Depending on the extent of communication network, several concepts such as *intranet*, *extranet*, and *internet* can be defined. An *intranet* is a private computer network that uses internet protocol technologies to securely share any part of an organization's information or network operating system within that organization. The term is used in contrast to *internet*, a network between organizations, and instead refers to a network within an organization. An *extranet* is a private network that uses internet protocols, network connectivity. An extranet can be viewed as part of a company's intranet that is extended to users outside the company, usually via the internet. Electronic trade is often used between the customers and companies, as well as among the companies. Shopping over the internet and checking emails are some of the examples.

After the spread of internet and acceptance of certain internet standards such as EDI (Electronic Data Interchange), electronic trade has gained importance and made the sales over the internet possible, as well as making it possible for customers to log in the database of companies and track the products. EDI is the structured transmission of data between organizations by electronic means. It is used to transfer electronic documents from one computer system to another (from one trading partner to the other). It also refers specifically to a family of standards. However, EDI also exhibits its pre-Internet roots, and the standards tend to focus on ASCII (American Standard Code for Information Interchange)-formatted single messages rather than the whole sequence of conditions and exchanges that make up an inter-organization business process.

Here are some of the advantages of the electronic trade (Simchi-Levi et al., 2000): (i) The companies and publishers gain a global existence, the choices for customers increase, and they can reach information easily; (ii) the companies increase their competitive power and service quality by making it possible for the customers to reach the services offered from anywhere and anytime. The companies can also track the customer preferences and demands on electronic environment; (iii) the companies can analyze the interest in different products; (iv) the supply chain lead time decreases. Especially for books and software products that can be provided over the internet, this is a major issue; (v) since some of the companies playing role in the distribution of the products to the customers, even the sales points in some cases are not needed anymore, there is a serious cost reduction; (vi) the small companies with the lack of resources for big investments in structure and marketing gain a chance for competition; (vii) electronic trade has resulted in an increase of electronic companies selling and distributing only over the internet. These companies can provide the customers with the products for much cheaper prices since they do not have to maintain warehouses or sales points.

On the other hand, certain barriers also exist in front of the electronic trade, namely: privacy issue; internet fraud; bad website design and service; undependable distribution and returns; competitions and conflicts among the buyers and the sellers; protection of intellectual knowledge.

Material requirement planning (MRP)

The raw material, parts and other components of the products are named as dependent demand. In order to manage this kind of demand, there is a need for a different method rather than the classical inventory management techniques.

The difference in the management of inventories stems from the difference in the structure of demand for those products. The demand for prod-

ucts such as raw materials and parts that are used in the production of final product is called dependent demand. For instance, since the demand for parts and materials required for the production of automobile depends on the amount of demand for automobile, it is classified as dependent demand. On the other hand, demand for automobile is an independent demand as it is not a component of another product.

Dependent demand exhibits a discontinuous nature as opposed to the continuous nature of independent demand. That is because certain components are used in large lots in certain periods of the production line and not used at all in other periods.

For instance, the same company might be producing different products in different periods of the year. Some parts of these products might be common in every product. Thus, the company always has to keep such components in the inventory. However, some parts are only required for certain products. So they will be needed in periods where these products will be produced, resulting in discontinuous demand for these types of parts (Sagbansua, 2006).

As a result of that characteristic, the products with independent demand should be stocked continuously, while the products with dependent demand should only be stocked just before the time they will be used in the production process. The fact that the dependent demand products are known in advance, the need for safety stock is eliminated or reduced to a minimum.

MRP is a computer-based system designed to organize the timing and ordering of the dependent demand products. The demand for the raw material and components of the final product are calculated by using the demand for the final product and it is determined how much and in what quantity to order from these components and raw material, considering the production and lead times and counting back from the delivery time of the product. Thus, the demand for the final product is used to calculate the demand for the components

in lower levels. This process is divided into planning periods and the production and assembly functions are organized, resulting in lower inventory levels along with ensuring the timely deliveries of the final product.

From this perspective, MRP is a philosophy as much as it is a technique and a time management as much as it is an inventory control method.

Ordering and timing processes were facing two difficulties in the past. The first one was the difficulty of production scheduling, dealing with the changes in the orders, and tracing many parts and components supplied by many suppliers. Due to this complexity, several policies have been proposed in the literature. Minner (2003) provides an overview of multiple-supplier models. The second difficulty was the lack of distinction between the dependent and independent demand. The techniques designed for the independent demand was being used for the dependent demand as well, resulting in high levels of inventories. Consequently, inventory planning and production scheduling were major problems for the manufacturers.

The manufacturers in 1970s have started to realize the need for a distinction between these two types of demands and different approaches to utilize for each of them. Many companies have left the record keeping and component requirements to the computers using MRP system.

MRP starts with a schedule for the final product, and this schedule is transformed into another schedule ensuring the timely delivery of the components and raw material required in the production of the final product. Thus, MRP is designed to answer three questions: What is needed? When is it needed? How much is it needed?

The inputs for the MRP system is a bill of material, a main schedule showing when and how much of the final product is needed, and an inventory records file showing how much inventory is at hand or how much is ordered. The planner determines the requirements for each planning period, using these inputs.

The outputs of the process are the planned order schedules, order confirmations, changes, performance control reports, planning reports, and exception reports.

In a discrete parts manufacturing environment, material requirement planning (MRP) is carried out without considering the manufacturing resource capacity. As a result, during implementation, adjustments in planned orders may become necessary. Pandey et al. (2000) present a finite capacity material requirements planning algorithm (FCMRP) to obtain capacity-based production plans.

Theoretically, there is no need for safety stock in the inventory systems based on the dependent demand, which is one of the main benefits of the MRP approach. After the main schedule is prepared, it is assumed that there is no need for safety stock when the managers can see the amount of usage. However, exceptions may occur in practice. For instance, variable waste ratios can cause disruptions in the operations. Moreover, the higher production times than what is expected and late deliveries of the components can also cause problems in the production process. Although the stakeholders of a supply chain make part of the same system, they take decisions which often ignore the interdependencies which in return disrupts the operations (Thomas & Griffin, 1996). It can be argued that using safety stock would eliminate the disruptions in the operations but it becomes more complex in multi-level production systems, as insufficient amount of any component will disrupt the final product production. Also, using safety stock would eliminate one of the biggest advantages of the MRP; operating without safety stock.

MRP systems deal with such problems using different methods. The goal of the managers is to find out the operations with variability and determine the extent of this variability. In situations with variable lead times, concept of safety lead time is used rather than safety stock. This concept requires to order the components to receive before the time they will be needed; thus,

eliminating the possibility of waiting for these components, or at least minimizing it. If there is variability in the amounts of components, a certain amount of safety stock can be held but the managers must carefully calculate and analyze the cost of such a safety stock. Usually, the managers choose to hold safety stock for the situations where the demand for the final product varies, and the safety lead time is not possible.

Wacker (1985) has presented a theoretical MRP model which includes both demand and supply uncertainties from quantity and timing variations. The model suggests empirical methodologies to estimate the variances of final outputs and components for estimates of safety stock requirements to reduce uncertainty. Wacker suggests a methodology for safety stock estimates to alleviate demand uncertainty for trade-to-stock organizations and made-to-order organizations. He also suggests methodologies to estimate safety stock for the production systems to alleviate supply uncertainty.

The managers must be sure of the lead times especially when the components are expected to reach the production point just before they will be used. The early component entries would be increasing the current inventory levels, while the late entries would delay the other operations, resulting in important losses and extra costs. Considering this fact, the managers choose to show the lead times longer than they are, accepting certain amounts of early entries.

Choosing a lot size for orders or production is an important issue both for the dependent and independent demand products. Usually, the economic order quantities and economic production quantities are used to the independent demand products, whereas many different methods are used for the dependent demand systems, stemming from the fact that no method exhibits an obvious advantage over the others (Taha, 2006).

The priority of the inventory management for both of the demand types is minimizing total of the ordering and holding costs. The independent

demand exhibits an even distribution during the planning horizon while the dependent demand has a more intermittent structure and a shorter planning period. Thus, it is more difficult to calculate economic lot quantities.

Anderson et al. (1981) report on a simulation study of hierarchical planning methods, which can be utilized in connection with material requirements planning. The company considered produces one final product having a complex structure. The factory is functionally organized. Two different cases have been studied. In the first case there were both seasonal and independent stochastic variations in demand and in the second case only stochastic variations.

A simulation experiment that compares alternative procedures for determining purchase quantities in MRP systems when quantity discounts are available, is reported by Benton (Benton & Whybark, 1982).

MRP has many benefits both for production and assembly operations. Some of these benefits are listed here: low levels of in-process stocks, a possibility to track the component needs, a possibility to evaluate the capacity requirements suggested by the main schedule, a possibility of distributing the production time. The conditions required to successfully and efficiently utilize and use the MRP system are: computers and software should maintain the records and execute the calculations; computers should be accurate and updated together with integrity of the information (main schedules, bill of material, inventory records).

Enterprise resource planning (ERP)

ERP is a system originated from the need for the integration of the standardized record-keeping to enable the information sharing between different units of the companies. It responds to the needs of all these units by linking all units and functions in the company to a computer system.

A wide range of software to serve the employees in every unit is required. In fact, every unit possesses its own computer system and these systems are designed to enable these units to execute their duties at a maximum level. ERP enables the information sharing of all units and communication with each other by bringing all of these systems in an integral software program supported by a common database.

Conclusions

The traditional purchasing and logistics functions have evolved into a broader strategic approach to materials and distribution management known as supply chain management. Information technologies as one of the biggest enablers of the supply chain management, is discussed in this research. Types and ways of information technologies related to supply chain management such as electronic trade, MRP and ERP are among the examples provided.

Many employees are using the information provided by MRP in manufacturing companies with this system. Production planners, production managers, customer service representatives, purchasing managers, and inventory managers are some of them. The benefits of the MRP system depends heavily on the availability of the usage of computers which will maintain updated data about the component needs.

Accuracy has a vital role in a successful MRP system. The mistakes in inventory records or bill of material would result in missing parts, over-ordering of some products and under-ordering of others, deviations from the production schedule, all of which cause bad results such as low level of customer service, inefficient use of resources, and untimely deliveries to the customers. Moreover, MRP system can be difficult to utilize and expensive. Thus, the companies planning to use this system must carefully evaluate the benefits and the necessities of MRP.

Electronic trade has eliminated the barriers to do business internationally. Even the small companies have started to compete in international markets. The developments in communication and transportation industries are the main enablers of this trend. The companies can market their products to the customers anywhere in the world over the internet. The customers also benefit from the developments by gaining access for more information and product alternatives.

Future research will be conducted to introduce an MRP model for multi-echelon inventory systems and include the experimental results of the model utilization.

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