

An MRP Model for Supply Chains

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Abstract

The information technologies pose as one of the biggest enablers of the modern supply chain management (SCM). This study focuses on one of the vital use of information technologies in SCM context, namely Materials Requirement Planning (MRP). Types and ways of information technologies related to supply chain management is analyzed. MRP is discussed along with a model to provide an example. Information about the developed software for the model is also provided. MRP and its value in inventory management systems are stated as a basis for the future research which will improve the current MRP model introduced along with the experimental results as a basis for comparison.

Keywords: Supply Chain Management, Information Technologies, MRP

1. 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 especially 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, 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 (Subramani, 2004).

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.

2. 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 products 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.

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, tracing many parts and components, and dealing with the changes in the orders. 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., presents a finite capacity material requirements planning algorithm (FCMRP) to obtain capacity-based production plans (Pandey et al., 2000).

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. 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) presents 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 (Wacker, 1985).

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.

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.

Andersson reports 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 (Andersson et al., 1981).

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

3. An MRP Model

The model introduced in this section is designed to manage a manufacturing facility chosen as a model, producing a large set of SKUs (Stock-Keeping Unit), along with hundreds of components going into the production process, and a long list of suppliers list. Before building the model, below conditions that are required to successfully and efficiently utilize and use the MRP system are ensured to exist:

- Computers and software to maintain the records and execute the calculations
- Accurate and updated
 - Main schedules
 - Bill of material
 - Inventory records
- Integrity of the information

The steps of the MRP model are as follows:

The company receives the order from the customers. Following the meeting at the end of each week, job orders are given to the manufacturing department. Inventory manager checks the inventory levels recorded using Figure 1.

The MRP software determines the material requirements moving back from the bill of materials recorded. An example of a bill of materials is shown in Figure 2.

Comparing the inventory levels with the resources required for the production, the inventory department determines the needs. The information of requirements is given to the purchasing department, using a material requirement slip in the Figure 3.

The purchasing department requests proposals from 6 different suppliers which are listed in the suppliers list. The rule of '6 suppliers' provides the purchasing department with a strong basis for comparison in its decision making process. The supplier information is recorded using the Figure 4.

The performance of these suppliers are continuously recorded and tracked, based on two dimensions: Lead times and the quality. The quality performance is calculated in terms of the defective parts received before, and number of returned products in the past.

The performance in terms of the lead times is calculated based on the comparison of the number of delayed deliveries of the past and the number of on-time deliveries. These scores are constantly updated. Figure 5 shows the track of performance for a given supplier both in quality and lead times.

Upon receipt of the proposals from the suppliers, the software evaluates the proposals on an individual product base and determines the best choice of supplier for each product as shown in Figure 6.

The purchasing department chooses the best selection of suppliers to satisfy the order and passes this information to the executive director. If confirmed, the purchasing department orders the products using the form in Figure 7.

The inventory manager distributes the received products to the appropriate point in the manufacturing as the employee initiating the ordering process is recorded using the Figure 8.

The entrance of the parts to the inventory is recorded as shown in the Figure 9, as well as the outflow of the parts either to the internal customers or to the external customers.

The software tracks which materials are used in which products as well as from which suppliers they are provided from, thus, satisfying the traceability requirement of ISO standards. Figure 10 presents the form used for this purpose in which the specific materials can be tracked throughout its movement in the supply chain.

4. Conclusion and Future Research

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. MRP as one of the most vital functions of information technologies related to supply chain management is 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. A software developed for an MRP model is introduced as a part of this research.

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.

The software tracks the supply process of materials which starts with the materials requirement slip, followed by the proposal, confirmation, order, and inventory.

MRP model introduced in this research and utilized has proven to improve both the production and assembly operations in the model manufacturing facility. Some of these benefits are listed below:

- Low levels of in-process stocks
- The possibility to track the component needs
- The possibility to evaluate the capacity requirements suggested by the main schedule
- The possibility of distributing the production time

Future research will be conducted to enhance the capabilities of the MRP model introduced in this research and include the experimental results of the developed model as a basis for comparison with the current model. The developed model is intended to include the lead time estimations for each individual raw material in order to

improve the accuracy of estimates of order time. This additional feature is tended to reduce the lead times as a result of better planning capabilities with the extra information obtained.

References

- Andersson, H., Axsater, S., Jonsson, H. (1981). Hierarchical Material Requirements Planning, *International Journal of Production Research*, vol.19-1.
- Benton, W., Clay, D. (1982). Material Requirements Planning (MRP) and Purchase Discounts, *Journal of Operations Management*, vol.2-2.
- Heizer, J., Render, B. (2004). Operations Management, *Prentice Hall*, USA.
- Lambert, D., Cooper, M. (2000). Issues in Supply Chain Management, *Industrial Marketing Management*, vol.29-1.
- Min, H., Zhou, G. (2002). Supply Chain Modeling: Past, Present and Future, *Computers & Industrial Engineering*, vol.43-1-2.
- Minner, S. (2002). Multiple-Supplier Inventory Models in Supply Chain Management: A Review, *International Journal of Production Economics*, vol.81-82.
- Pandey, P., Yenradee, P., Archariyapruet, S. (2000). A Finite Capacity Material Requirements Planning System, *Production Planning & Control*, vol.11-2.
- Stevenson, W. (2002). Operations Management, *McGraw-Hill*, USA.
- Subramani, M. (2004). How Do Suppliers Benefit from Information Technology Use in Supply Chain Relationships? *MIS Quarterly*, vol.28-1.
- Şağbaşıua, L. (2006). Tedarik Zinciri Yönetimi, *AB Girişimcilik Kursu Destek Yayın Dizisi*.
- Simchi-Levi D., Kaminsky, P., Simchi-Levi, E., (2000). Designing and Managing the Supply Chain, *McGraw-Hill*, USA.
- Taha, H., (2006). Operations Research, *Prentice Hall*, USA.
- Tan, K. C. (2001). A Framework of Supply Chain Management Literature, *European Journal of Purchasing & Supply Management*, vol.7-1.
- Thomas, D., Griffin, P. (1996). Coordinated Supply Chain Management. *European Journal of Operational Research*, vol.94-1.
- Wacker, J. (1985). A Theory of Material Requirements Planning (MRP): An Empirical Methodology to Reduce Uncertainty in MRP Systems, *International Journal of Production Research*, vol.23-4.
- Zipken, P., (2000). Foundations of Inventory Management, *McGraw-Hill*, Boston.

Appendix

The screenshot shows a software window titled "Stok Bilgi Formu". It contains several input fields and buttons. The fields are organized into a grid-like structure. The top row has "Stok No" (129) and "Tipli". The second row has "Kodu" (124VİS090) and "Kullanıcı Adı". The third row has "İşlet" (KAPAK VİBRO (SPERO GÖVDE KAPAKI)). Below these are fields for "Birim" (ADET), "Emanet", "İmen Stok", "İşlet", "Makale", "Bazın Stok", "Safname No" (MEŞ-15), "Özel Kod", "İşlet Miktar", "Çalış Miktar", "Geçen Yıl Kullanılan Miktar", "Son Fiyat" (0.00 TL), "Son Giriş Tarihi" (26.01.2004), "Son Giriş Miktar", "Ağırlık Ortalama Fiyat", and "Elimine Et". On the right side, there are buttons for "İzlen", "İptal", and "Liste".

Figure 1. Inventory Information Form

The screenshot shows a software window titled "Ürün Açıklama Toplu Ürünler Formu". It contains a list of materials with columns for material name, quantity, and unit. The materials listed include various types of cables, wires, and components, such as "C ÇEKME BORDU ÇAP 1000/20", "ALUMINYUM ETİHAL 3-5-7", "EMAYE BOBİN TELİ ÇAP 0.05", "NİKLON F CLASS Ø2.5 mm", "NİKLON F CLASS Ø4 mm", "NİYAT KABLO Ø 75 mm 150 C SİYAH (SİYAH)", "NİKLON F CLASS Ø3 mm", "TRET BANT (REVİREX DİNGUL) En. 3 mm", "TTR YANARAK KABLO (PVC) Ø11 5 mm", "YEPİRİK TRANSPLAÇ 200/70 SU BAĞLI H (SİYAH)", "KAPAK AYRILI YERİNE (SİYAH)", "A BAĞLI ÇUKATA İNDİREK KALİTE", "YATLI RÖNDELA HİS", "NİKLON FİNGİNG Pİ 135", "SAC ÇAP 20/1000-0000", "SAC BAĞLI 5/5/1000 RÜLÜ SAC", "ÇELİK TRANSİYON ÇAP 50MM", "KATON KERESTE 1 SİYAH 200/100 AÇI ÇUKULUĞU", "MOLAR 5/100mm", "SAPLAMA İNDİREK A BAĞLI", "ÇELİK İNDİREK HİS", "TİTİRUL RÖNDELA HİS", "ÇELİK SAC 1500 ÇAP 35MM", "PULMAN KÖK 22 C3".

Figure 2. Bill of Materials

The screenshot shows a software window titled "Malzeme İhtiyaç Fiyatı". It contains a table with columns for material name, quantity, and unit. The materials listed include "EKSENEL YATKAR ÇUKATA İNDİREK 300/100", "EKSENEL YATKAR ÇUKATA İNDİREK 300/100", "EKSENEL YATKAR ÇUKATA İNDİREK 300/100", "EKSENEL YATKAR ÇUKATA İNDİREK 300/100".

Figure 3. Material Requirement Slip

The screenshot shows a software window titled "Firma Bilgileri Formu". It contains a form for entering company information. The fields are: Firma No: 478, Ürünü: KIVANÇ DÖKÜM, Yetkili: BAYRAM KIVANÇ, adres-1: DÖKÜMCÜLER SAN. SİT. 9 SK. NO: 98, adres-2: ANKARA, İlçe: SINCAN, Telefonu: 2670375, Faks: 2671449, Cep Telefonu: , Özel Kod: , Köşe Puanı: , Zaman Puanı: 100.

Figure 4. Supplier Information Form

Debit Entry / Credit Entry

Debit Pay No. 100

Debit No. 100

Date 20.05.2002

Amount 2,350,000.00 TL

Date	Description	Debit Amount	Credit Amount	Balance
20.05.2002	PRINCIPAL REPAY 20.05	2,350,000.00 TL		2,350,000.00 TL
20.05.2002	PRINCIPAL REPAY 20.05		2,350,000.00 TL	

Buttons: Print, Save, Cancel, Exit

Figure 9. Inventory In/Out/Return Form

The screenshot displays the SAP Financial Accounting (FI) system interface. The main window shows the 'Bank Statement' (Kontostatistik) for the 'Bank of America' (Kontenrahmen). The interface is divided into two main sections: 'Bank Statement' and 'Bank Statement'.

Bank Statement (Left Table):

Datum	Umsatz	Saldo	Umsatz	Saldo	Umsatz	Saldo	Umsatz	Saldo
01.01.2004		100,00		100,00		100,00		100,00
02.01.2004	100,00	200,00	100,00	200,00	100,00	200,00	100,00	200,00
03.01.2004	100,00	300,00	100,00	300,00	100,00	300,00	100,00	300,00
04.01.2004	100,00	400,00	100,00	400,00	100,00	400,00	100,00	400,00
05.01.2004	100,00	500,00	100,00	500,00	100,00	500,00	100,00	500,00
06.01.2004	100,00	600,00	100,00	600,00	100,00	600,00	100,00	600,00
07.01.2004	100,00	700,00	100,00	700,00	100,00	700,00	100,00	700,00
08.01.2004	100,00	800,00	100,00	800,00	100,00	800,00	100,00	800,00
09.01.2004	100,00	900,00	100,00	900,00	100,00	900,00	100,00	900,00
10.01.2004	100,00	1000,00	100,00	1000,00	100,00	1000,00	100,00	1000,00
11.01.2004	100,00	1100,00	100,00	1100,00	100,00	1100,00	100,00	1100,00
12.01.2004	100,00	1200,00	100,00	1200,00	100,00	1200,00	100,00	1200,00
13.01.2004	100,00	1300,00	100,00	1300,00	100,00	1300,00	100,00	1300,00
14.01.2004	100,00	1400,00	100,00	1400,00	100,00	1400,00	100,00	1400,00
15.01.2004	100,00	1500,00	100,00	1500,00	100,00	1500,00	100,00	1500,00
16.01.2004	100,00	1600,00	100,00	1600,00	100,00	1600,00	100,00	1600,00
17.01.2004	100,00	1700,00	100,00	1700,00	100,00	1700,00	100,00	1700,00
18.01.2004	100,00	1800,00	100,00	1800,00	100,00	1800,00	100,00	1800,00
19.01.2004	100,00	1900,00	100,00	1900,00	100,00	1900,00	100,00	1900,00
20.01.2004	100,00	2000,00	100,00	2000,00	100,00	2000,00	100,00	2000,00
21.01.2004	100,00	2100,00	100,00	2100,00	100,00	2100,00	100,00	2100,00
22.01.2004	100,00	2200,00	100,00	2200,00	100,00	2200,00	100,00	2200,00
23.01.2004	100,00	2300,00	100,00	2300,00	100,00	2300,00	100,00	2300,00
24.01.2004	100,00	2400,00	100,00	2400,00	100,00	2400,00	100,00	2400,00
25.01.2004	100,00	2500,00	100,00	2500,00	100,00	2500,00	100,00	2500,00
26.01.2004	100,00	2600,00	100,00	2600,00	100,00	2600,00	100,00	2600,00
27.01.2004	100,00	2700,00	100,00	2700,00	100,00	2700,00	100,00	2700,00
28.01.2004	100,00	2800,00	100,00	2800,00	100,00	2800,00	100,00	2800,00
29.01.2004	100,00	2900,00	100,00	2900,00	100,00	2900,00	100,00	2900,00
30.01.2004	100,00	3000,00	100,00	3000,00	100,00	3000,00	100,00	3000,00
31.01.2004	100,00	3100,00	100,00	3100,00	100,00	3100,00	100,00	3100,00

Bank Statement (Right Table):

Datum

Figure 10. Inventory Information Form