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The choice of replenishment policies in an MRP environment

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Abstract

This paper studies the choice of replenishment policies in an MRP environment. It discusses the classification of items and the criteria to use in the classification especially in a general assemble-to-order company. The paper presents a stepwise procedure to classify items into five general groups. The stepwise classification saves work by excluding items from further analysis in each step. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

Materials requirement planning (MRP) and simpler methods, such as re-order-point (ROP) or visual review systems such as two-bin system are usually considered as mutually exclusive. However, in the market there is pressure towards shorter delivery lead time as well as towards more customer-oriented products. In this situation some manufacturing companies, especially assemble-to-order (ATO) companies, have found it necessary to use re-order-point (ROP) or visual review systems such as two-bin, in addition to their MRP systems [1].

The problem is that in the literature MRP and ROP are usually seen as mutually exclusive methods. Thus, there is not much literature dealing with the parallel use of MRP and ROP or dealing with the classification of items into groups that should be managed by MRP or by other methods.

One approach used in the literature is to compare replenishment policies by simulating different demand distribution patterns and forecast accuracies. In production environment there have been studies also on mixed use of different policies, for example, kanban and MRP [2,3]. In these studies the different policies are used in serial processes where one policy is used in the first stages of the process and another policy in the following stages. These studies made in serial processes are, however, not directly applicable in raw-material inventory. The studies made on raw material inventories have

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usually compared replenishment policies by their service levels and total inventory capital. The administrative costs of different policies are usually ignored. Axsäter and Rosling [4] did not compare different policies, but presented how different ROP policies (Installation stock (Q, r^i), Kanban, order-up-to-S, Echelon stock (Q, r^e)), can be imitated with MRP. This means that MRP can perform in all situations at least as well as any of these studied policies. However, they also say that in some practical situations a simple reorder point may be advantageous compared to MRP, e.g. because of lower administrative costs.

Another approach in the literature is to classify items either by mathematical methods or by traditional ABC (Pareto) analysis and its extensions.

With mathematical methods items are grouped usually by several criteria. Partovi and Burton [5] used analytic hierarchy process (AHP) to calculate criticality indices for items and applied ABC-analysis to these indices. Cohen and Ernst [6] used cluster analysis to group similar items.

Pareto-literature has articles where ABC-analysis is used on several criteria and articles on traditional, value-usage-based ABC. Multiple criteria ABC-analysis-studies group items and selects appropriate replenishment policies for each group. Studies use criteria like unit value, criticality on production and on maintenance to improve traditional ABC-analysis. The replenishment system is formed as a combination of these policies. In most articles there are two criteria used in a matrix form [7–9]. These two criteria can be calculated as a combination of several other factors as discussed by Duchessi et al. [9]. In some literature the ABC-analysis is modified manually by moving items from one group to another according to specific criteria such as problems in procurement [10–12].

Traditional ABC-analysis has been applied in an MRP-environment by Nicol [13] and Willis and Shields [14]. They classified items into A- and C-classes. An item was classified as an A-item if it was characterised by high cost, uniqueness and limited availability. The A-class items they decided to manage with MRP and the C-class with two-bin or re-order-point policies.

Common to most literature dealing with the selection of replenishment policies is to select replenishment policies for individual items or item groups. The final total system is formed from the selected policies. This approach produces a system that makes it possible to steer all items with a policy that gives the best results. On the other hand, the system might also become scattered, the maintenance can be difficult, updating all the parameters needed is very complex, etc. These problems with updating the system can easily lead into an obsolete system where steering parameters are out-of-date.

The ABC-analysis literature classifies items based on their criticality, but it does not offer any information about the inventory management characteristics of an item. Even if these characteristics have been used to define the criticality of an item, the information is not easily available when selecting inventory management policies. These analyses also require a lot of work because all items have to be evaluated by each criterion.

In this paper we suggest a simple, but systematic and practical procedure to classify items into five groups specially in the ATO-environment. The steps of the procedure are illustrated by using examples from a case-company.

This paper is organised as follows: In Section 2 we describe the case-company. Section 3 presents our procedure and illustrates it with examples from the case-company. Finally, in Section 4 we give a few concluding remarks.

2. Company

The case-company is an assembly plant. The products are investment goods and this makes the delivery lead time a less important marketing factor. Instead, the ability to customize the end-product to each customer from existing modules is the main competitive factor of the company. This kind of mass customisation requires a lot from the inventory management system as there seldom exist two identical end-products. On the other hand, the production is arranged into an assembly line. This makes the production quite inflexible against fluctuations in volume but makes the inventory management a little easier.

2.1. Products and product structures

The production rate is 100 end-products per week. The products are assembled from items which are either modules, components, parts or accessories. Modules form some functional unit of the product. There are eight module groups, and from each group the customer has to select one alternative. There exist altogether about 100 different variations of these modules. This makes the number of possible end-products without any accessories about half a million (all combinations of modules are not possible due to the size, strength, etc., factors).

Components include common items used in all end-products and items which are used to evaluate the functionality between customer chosen modules. These latter items are not directly chosen by the customer, but the combination of the modules chosen by the customer dictates what kind of items have to be used. For example a combination of power unit X and transmission Y, both chosen by the customer, requires clutch Z.

Parts are small items used to assemble modules, components and accessories together. These parts are mostly fasteners, brackets, bolts, screws, etc.

The accessories are all chosen by the customer to add some functionality or make the use of the product easier or more ergonomic. There exist altogether 200 accessories in 60 groups.

2.2. Inventory management

The inventory management system was designed when the company was still making to stock (MTS-production). In this MTS-environment all the inventory management was done with MRP based on the master production schedule. MRP worked fine, because the production schedule was fixed for a long-time horizon. There were also a limited number of end-products to be kept in stock. In today's assembly-to-order (ATO) environment the MRP system has problems. The final assembly schedule is known only for a few weeks. As this is used as input to the MRP, the material procurement and handling costs have increased as the lot sizing is done only for the known demand periods. Some items have been shifted from MRP system to ROP system because of long supply lead times. The relatively low-production volume, varying demand and zero-demand periods on item-level add their share to the problems too.

Because of the problems, the company started a development project to define a new inventory management system. The objects were to create an administratively lighter inventory management system by concentrating the use of MRP to only part of the items and to find suitable methods to manage the rest of the items. The aim to have a lighter system meant also that there should not be too many different replenishment policies in the system as otherwise their updating would take as much effort as was required for the MRP-system. The object of having a suitable method for all items, on the other hand, meant that there has to be more than one or two different replenishment methods.

3. Replenishment policy system formulation

In an industrial company there are a countless number of factors that influence the material management. These factors have been studied widely. In grouping of items, however usually only a limited number of factors are used. In the simplest ABC-analysis only one factor, the value of the uses needed whereas, on the other hand, Cohen and Ernst [6] have used up to 40 operational criteria to classify items into groups.

Generally, three main criteria to be used would be enough to keep the classification simple and easy to understand: Value of usage, supplier lead time compared with the final assembly schedule (FAS) and demand distribution pattern. We use these criteria one at a time to separate items to different classes. In the first step we separate items with low value of usage (C-items), in the second step items whose supply lead time is shorter than FAS, in the third step we finally group the rest of the items by their demand pattern. Our procedure results in five groups of items in a general case in an ATO-company. The process is illustrated in Fig. 1.

The inventory management of each of these five groups has different aims and characteristics. Inventory management methods differ by their

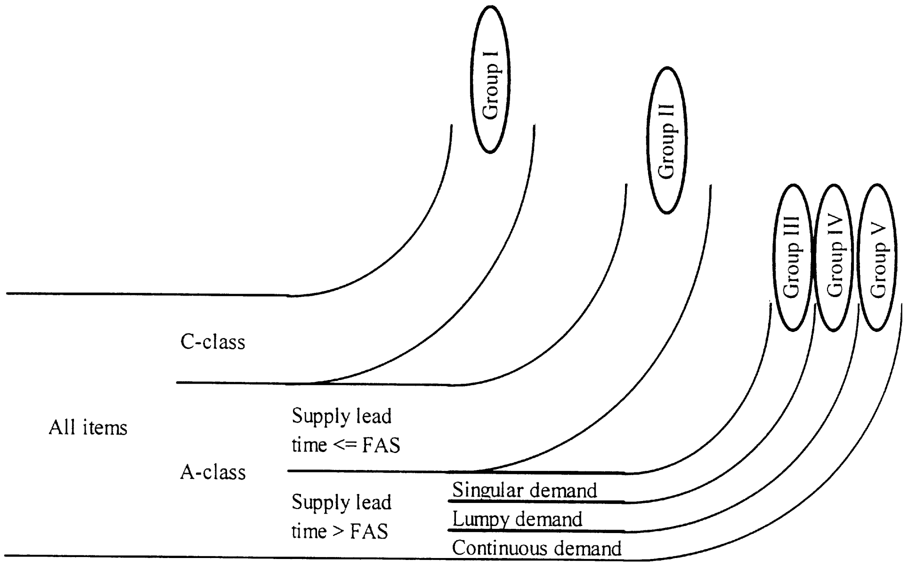

Fig. 1. The classification process.

accuracy and amount of administrative work needed to run the system. In this paper we discuss the three main methods: Material requirements planning (MRP), reorder-point (ROP), and visual systems.

MRP is the most sophisticated system in ATO-environment. MRP needs a lot of accurate input information about product structures, inventory status records, production and supply lead times and demand data.

Reorder-point system (ROP) is simpler than MRP-system. ROP systems are real-time systems (if inventory records are real time) triggering orders as the inventory levels reach order points. ROP gives also opportunity to plan purchasing lots mathematically.

Visual systems are the simplest methods based on some visual control mechanism. Visual systems are usually considered as a subgroup of reorder-point systems, but in our classification the use of computers in keeping inventory records makes the difference: In visual systems there are no inventory records, in reorder systems inventory records are today usually held in computers. For example, two-bin system is a typical visual system [15] (p. 233).

3.1. C-items (Group I)

The first step of the classification of items is ABC (Pareto) analysis. Normally, this analysis uses three classes, A, B and C but we found two classes are enough, A- and C-classes. Nicol [13] and Willis and Shields [14] came to the same conclusion. We found it necessary to isolate C-items from further analysis to avoid unnecessary work. All the C-items are "small items" with low-value.

In the case-company there were about 4500 items to be controlled. When the limit in yearly value of use was set to 50 000 FIM/y, AC-analysis put 20% of items into A-class and 80% into C-class. The usage value of A-class was 95% of total usage, C-class only 5%.

The main interest in the management of these low-value items is to avoid stock outs and to reduce procurement, material handling and order inspection costs. In general, the C-class items are often stored both in workcenters and in the central warehouse of a factory. C-class items, which are typically fasteners, brackets, bolts, etc., are also often used in several workcenters and it is more practical to store large purchase quantities centrally. The material management in workcenters should be simple and easy and thus visual methods like two-bin method should be preferred to computer-based ROP because of simplicity. The central warehouse can be managed with computer-based ROP methods.

The workstation's material management was organised with a two-bin system. The system has one standard bin. The number of the items per bin was set to correspond 2–6 weeks usage depending on the package size, physical volume or other practical criteria.

The case-company decided to use ROP in their central warehouse. The reserve stock was set to two months use and replenishment volume to three months if the value usage was 20.000–50.000 FIM and to six months if the usage was below 20.000 FIM.

3.2. Items with supply lead time shorter than FAS (Group II)

As the classification continues, we have the class A to process. All items in A-class are much more valuable than the items in C-class. This means that on A items the inventory management is aiming at a proper balance between high service level and a low inventory level. This means that other criteria than value of usage should be used in the further classification of this group. The next step is to isolate items whose supply lead time is shorter than FAS. This determines whether the inventory management of the item is based on firm customer orders or on forecast. In ATO-environment the FAS is not always that simple for all items. If we have a stocked accessory item that is not necessary to the product, it is enough to know the need of this accessory just before the product enters to the stage where the accessory should be installed. In case the accessory is purchased on order, the FAS on this item must be at least as long as the supply lead time not to cause extra problems.

In the case-company the FAS is six weeks. The items that have supply lead time of six weeks or shorter were classified in group II. If the supply lead time was longer, the item was not classified and it was further processed.

The material management in the group II is quite straightforward. The replenishment can and should be based on orders, and can be done with MRP. The only uncertainty is supply lead time variation.

The case-company decided to use MRP for the group II items. The MRP is calculated weekly after the previous week was removed from the system and a new week was added to the end of FAS.

3.3. Distribution pattern of demand

We can classify the demand distribution of items roughly into three classes: singular, lumpy and continuous demand. A singular demand means that the item has demand now and then, usually one unit per order. The demand is usually Poisson distributed. These items belong to group III. Lumpy demand items belong to group IV. The demand of these items occurs now and then like the demand of singular items. But these items are demanded in batches of variable, sometimes large sizes. The demand does not follow any known distribution or the distribution cannot be recognized because of lack of data. Lumpy demand can exist, for example, in small batch production. The rest of the items have a relatively continuous demand and they form group V.

In the case-company the demand distribution pattern was connected with the demand rate. The items with demand lower than five units/week were classified as singular demand items (Group III). All other items were positioned into group V. The sales of the company come from independent customer orders usually for one unit at a time. This prevents the company from having lumpy demand for any of its items.

In groups III–V there is uncertainty in demand and supply lead times. This makes their inventory management more difficult.

In group III volumes are too low or the item's demand may fluctuate during the item's supply lead time. This makes the use of MRP quite difficult. Jacobs and Whybark [15] found that if forecasts may have significant errors, the ROP may give even better results than MRP, and with far less effort. This makes ROP preferable in the management of items in group III.

The case-company decided to use ROP in their system for group III. The safety stocks were calculated applying Poisson-distribution and replenishment quantity planning was based on an EOQ-model.

The management of group IV is most difficult. The demand per order distribution is unknown and so is the distribution of the timing of orders. One solution for these items is to lengthen the company's own delivery lead time to be longer than the items supplier lead time. This would move the item into group II. But the decision cannot, of course, be based purely on the inventory management point of view.

In the case-company there are no Group IV items because there are almost no batch orders.

In group V the demand forecast for a specific item can be derived from the sales forecasts of end-products. This is advisable as the share of end-products containing a specific item is quite steady. The uncertainty in demand can be met by overplanning for items (see, for example, [16] (p. 388)).

In the case-company the items in group V are managed with MRP based on sales forecasts. The items are overplanned to ensure some safety stock against fluctuations in sales.

3.4. Additional criteria

Besides the three main criteria there are also some additional criteria. These criteria can be linked to individual items or group of items. For example the availability of an item might be problematic due to, e.g., a small number of suppliers or high demand of an item. Also, items with high risk of obsolescence (e.g., with high-technology items) could be considered as "problem" items, especially if the management of these items cannot be based on orders. It could be feasible to create a separate group for these "problem" items. The separation of "problematic" items should be done before the actual classification process.

The case-company had one item–group in which they had problems with delivery times and reliability because of high demand compared to manufacturing capacity in Europe. There are quite a few suppliers in Europe for this item. These items were separated before the actual classification. These items were managed manually and the safety stock was raised to several months. The case-company also started to look for suppliers outside Europe. So far, they had avoided global suppliers because of long lead times and high delivery costs.

3.5. Results of the classification process

Table 1 summarises the classification of items in the case-company. In the table there are also the replenishment policies for each class.

As one can see in Table 1, AC analysis was applied to all items. The following analysis based on supply lead time comparison, was applied to only 20% of items. However, these 20% made 95% of the value of usage. The analysis of the usage value, demand distribution pattern was applied only to 10% of items and 20% of the usage value.

By the time this paper was finished the classification process was already carried out and a pilot project was started in order to first implement new replenishment policies in respect to a limited set of items. The overall implementation is waiting for experiences from the pilot project and a new information system. The items in the pilot-project have so far achieved the same service levels as they did in the old MRP system. On the other hand, both the order- and forecast-based MRP-systems are easier to understand because of the lower number of items. The mixed use of MRP, ROP and two-bin methods has not caused problems except those resulting from the old, inflexible information system. The old system has required programming work to enable some new features, but still parts of the pilot project are run in PC environment. Because of the old information system and the simultaneous use of the PC-system it is too early to draw

Table 1
Classification of the items in the case-company

Criteria 1. Annual value of usage of an item				
$\leqslant$ 10.000 US$/a	> 10.000 US$/a			
	Criteria 2. Supply lead time			
	Shorter than FAS	Longer than FAS		
		Criteria 3. Demand distribution		
		Singular (max. 5 units/week)	Lumpy	Steady (over 5 unit/week)
Group I	Group II	Group III	Group IV	Group V
Central warehouse ROP, workcenters two bin	MRP based on orders	ROP		MRP based on forecasts, overplanning
8% of items, 5% of US$ usage	*10% of items, 75% of US$ usage*	*2% of items, 3% of US$ usage*	*No items*	*8% of items, 17% of US$ usage*

conclusions about the effects on the maintenance of the system.

4. Conclusions

This paper suggests a stepwise procedure to classify items into five groups in a typical ATO-environment. In the first step it separates C-items, in the second step it separates items which have a supply lead time which is shorter than the fixed assembly schedule, and in the third step it creates groups for steady, singular and lumpy demand items. The stepwise separation of classes saves work in the following steps. The criteria used in each step are relevant in selecting appropriate replenishment policy. This helps to assign an appropriate replenishment policy for each of the final groups. The stepwise procedure is simple, practical and systematic and the procedure makes it easy to assign new items into the right group. Repeating the procedure frequently is not difficult and helps to keep the system up to date. The need of updating the system and its parameter is further reduced by the capability of ROP and two-bin methods to adapt to small fluctuations on demand with their relatively high levels of safety stocks.

In the literature MRP and ROP are quite often seen as mutually exclusive methods. In the case-project we found that in an ATO-environment there are items that can be managed with ROP and get results as good as, or even better than with MRP. In the pilot project there have been no problems caused by running several different replenishment policies simultaneously. On the contrary, both order-based and forecast-based MRP-systems are now easier to use because of the lower number of items to be managed. The management of the C-items with two-bin system in workcenters and ROP in the central warehouse has played a major role in lowering the load on MRP-system. On the management of singular demand items the ROP-system has been found to be a lot easier to use than the previous MRP-system, and without any loss in performance. The risk of obsolescence is in control because the valuable A-items are steered with more sophisticated methods, and in C-class the value of obsolete inventory cannot rise very high because of low value.

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