MRP(Material Requirement Planning) Applications In Industry-A REVIEW

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Abstract

Material requirements planning (MRP) is a production planning and inventory management system used to manage logistics processes and designed to assist production managers in scheduling and placing orders for items of dependent demand. If it is implemented and used properly, it can be helpful for production managers to plan capacity needs and allocate production time. The article provides characteristics of the mentioned method; it describes the possible areas of application in manufacturing, purchasing and delivering activities. The paper considers the analysis of the production logistics in the chosen industrial company, focusing on information MRP system and the bottlenecks in the production. *The work is a part of subject review about MRP applications in industrial companies.*

Key Words: MRP applications-benefits of MRP-limitations-strecture-steps-shortcoming.

1. Introduction

Several different methods for the planning and control of the flow of material in manufacturing companies have been developed over the years and a number of these are used in manufacturing industry. These planning methods are based on different principles but all provide essentially the same type of support. Even though they are designed to provide the same type of support, they vary in applicability, with the extent to which they can be used in an efficient and effective way mainly dependent on environment. This has been emphasized by several researchers [1][2][3][4]. Re-order point methods, for example, are component-oriented and primarily designed for items with independent demand.

They are normally more appropriate the more standardized the product components are, the longer life cycles they have, and the more stable the demand [5][6][7][8]. Material requirements planning (MRP) is a generally applicable method. It works reasonably well in all manufacturing environments, not least because of its strength in planning items with dependent demand. However, its major strength is in situations with complex standardized products or product options, long manufacturing lead times, and items with time variations and uneven demand [9][10][11][12]. Kanban is a re-order point method that works best with a regular and steady demand, where the products have a simple and flat bill of material and short lead times together with small order quantities [13][14].As well as by matching methods to specific environments, planning performance also depends on how the methods are applied within the principles they are designed for. Extensive research has been conducted on the principles on which various material planning methods are built and even more on the technical and computational issues relating to them [15][16][17]. Less effort has been spent on finding out how to apply them in order to obtain as efficient and effective material flows as possible. All material planning could be conducted without support from enterprise resource planning (ERP) software or other supporting planning and control software. However, the functionality supported by software and the way it is used could affect the possibility of successfully applying a material planning method. ERP is here defined in accordance with [18][19] as an integrated software approach used to manage the transactions and track the status of a firm's day to day activities. The ERP system is thus the vehicle through which different activities are accomplished [19]. Most ERP systems include functional support for accomplishing material planning with different planning methods, [20] showed that, compared to low performing users, high performing MRP users-based lead-time determination on quantitative calculations in the ERP systems or monitored actual time to a greater extent. High performing users also reviewed lead times and safety mechanisms more frequently and used daily planning rather than the weekly planning of low performing users. High performing re-order point users calculated the re-order point as the demand during the lead time plus a safety stock; in contrast, low performing users-based re-order point determination on experience and judgment. High performers also reviewed the re-order points more frequently. Consequently, this study shows that the high performing material planning users work more analytically and with higher review frequency compared to the low performing users. This can partly be accomplished by more actively using the functionality of the ERP system.

Considering that the planning environment and the way a material planning method is applied have a major influence on how efficiently and effectively it can be used, it is interesting to examine further which material planning methods companies use and how they use them. Several studies [21][22][23][24]have suggested that practitioners have not done well in applying the models and functionality that are available to them. Thus, this knowledge is important. Most empirical studies covering the use of methods are relatively old [25][26][27]. Most studies focus on a few material planning methods and none is longitudinal and identifies trends. Therefore, a description of the state of the art and recent trends in material planning practice would be an important input in identifying training and education needs, developing more user friendly methods and software, and to serve as a guide for choosing and applying methods. The objective of the paper is to describe the (purpose,benefits,limitations,methods,stracture,evolution,steps,schedule,lot size).

2. The Purpose of MRP System:

Terms or MRP logic comprised by evolving MRPII/ERP systems serve the organization by providing the functions below:

In terms of Inventory [28]:

Determine the number of parts, components, and materials needed to produce each end item. Determine the right part, right quantity, & right time to order parts. Provide time schedules for ordering materials & parts. Maintain a bill of materials sequencing the assembly parts of the final product ("schematic, product structure tree").

Priorities: Order for the right due date, keep the due date valid.

Capacity: Plan to optimize the use of plant & equipment capacity, Plan an accurate

Objectives: MRP has the same objectives as any inventory management system

1. To improve customer service
2. Minimize inventory investment
3. Maximize production operating efficiency

According to fundamental philosophy of Material Requirements Planning: the materials should be expedited (hurried) when their lack would delay the overall production schedule and de-expedited (delayed) when the schedule falls behind and postpones their need [29].

When MRP systems are implemented properly they allow firms to realize the following benefits:
ability to price more competitively ,reduce sales price ,reduce inventory, better customer service ,better response to market demands, ability to change the master schedule ,reduce setup and tear-down costs, reduced idle time.
In addition to these benefits, MRP systems also:
Gives advance notice so managers can see the planned schedule before actual release orders.
Tell when to de-expedite as well as expedite. Delays or cancels orders.
Changes order quantities. Advances or delays order due dates.
Aids capacity planning .Despite of beforehand mentioned advantages we cannot forget about various shortages which arise from real world MRPII/ERP applications. We will define them precisely in the next section.

3. Benefits of MRP

MRP users reported many benefits among these:-

1. Reduction in inventory.
2. Improved customer service.
3. Quicker response to changes in demand and in the MPS.
4. Reduce set-up and product changeover costs.
5. Better machine utilization.
6. Increased sales and reduction in sales price.

Benefits of MRP II

Most of the companies that implement MRP II successfully have realized many significant benefits. In the narrow sense, the chief benefit of MRP II is its ability to generate valid schedules and keep them that way. A valid schedule has different benefits for the entire company, including the following.

1. It improves on-time completions. Industry calls this improving customer service, and on-time completion is one good way to measure it. MRPII companies typically achieve 95% or more on-time completion.
2. It cuts inventories. With MRP II, inventories can be reduced at the same time a customer service is improved. Stocks are cut because parts are not ordered if not needed to meet requirement for parent items. Typically gains are 20 to 35 %.
3. It provides data (future orders) for planning work center capacity requirements. This benefit is attainable because the basic MRP is enhanced by a capacity requirements planning.
4. It improves direct-labor productivity. There is less lost time and overtime because of shortages and less need to west time due to stopping one job to set-up for a *"shortage-list job"* or *"hot job"*. Reduction in lost time tends to be from 5 to 10% in fabrication and from 25 to 40% in assembly. Overtime cuts are grater, on the order of 50 to 90%.
5. It improves productivity of support staff. Purchasing can spend time saving money and selecting good suppliers. Materials management can maintain valid records and better plan inventory needs. Production control can keep priorities up-to-date. Supervisors can better plan capacity and assign jobs. In some cases, fewer support staff are needed.
6. It facilitates closing the loop with total business planning. That includes planning capacity and cash flow, which is the chief purpose and benefit of MRPII.

4. Limitations of MRP Assumptions:

Traditionally, MRP system implementation has been based on the assumption of a deterministic environment. Thus, demand and lead times have been assumed to be deterministic. In a typical manufacturing environment, nevertheless, this assumption is invariably violated. This conflict between the assumption and reality in the implementation of MRP is often advanced as the reason for the failure of MRP to fulfill its promise. MRP system which intends to determine the gross and exact needs of the enterprises in the inventory units seems to be efficient but has some defective sides. These defective sides are; determining the best application to obtain the MPS (Master Production Schedule), determining the lot sizes, determining the customer demands, capacity requirement planning, inventory levels and locations. These uncertainties cause the enterprises to be away from the appropriate conditions [30].

The APICS literature, cited the following four problems as the cause of most MRP system failures:

1. Lack of top management commitment.
2. Lack of education of those who use the system.
3. An unrealistic MPS.
4. Inaccurate data, including BOM and inventory records.

The inaccuracy of the bill of materials and inventory database is a common problem with MRP systems. Inaccurate bills of materials mean inaccurate material and capacity plans. Providing a management system that will facilitate data accuracy will likely require major adjustments in strategic management approaches Being able to cope with the uncertainty of the manufacturing environment is of course not a new concern, even if it is more and more relevant with regards to the present industrial context. Many uncertainties in Material Requirements Planning (MRP) systems are treated as "*controllable*" elements, with a variety of buffering, dampening and other approaches being used to cope with them [31]ergency measures to ensure delivery performance. MRPII/ERP systems use fixed lead-time to plan for material purchase and product manufacture. This ignores real life uncertainties of supply unavailability and variability of queue, set-up and run times on the hop floor.

Net requirement patterns generated do not consider the availability of resource simultaneously, but identify resources required as a separate, subsequent activity.

MRPII/ERP systems may be loaded with a predetermined scrap rate. Any increase in this rate will automatically render due date uncertain unless corrective

measures are taken. Such measures may well impact upon other products in the system, an effect that is not normally monitored [32].Existing traditional methods have also other weakness which considerable limit their practical applications. For

example they search for optimum considering all possible cases, therefore when planning horizon is becoming longer the number of alternative schedules increase dramatically. Moreover these methods establish lot sizes for individual items only on one level in the bill of material structure (BOM) hence have got false assumption of the demand for the item that is constant. Summing up our dissertations the most commonly shortages of MRP systems, from our point of view, are following:

1. Limitations on the length of the MRP planning horizon over which optimal order schedules can be found. Usefulness in practical situations is questionable since

large numbers of alternative schedules would need to be considered and, in addition, optimal short-term schedules would not necessarily result in optimization

of inventory over the long term.

2. Limited use in manufacturing industry owing to the complexity of the procedures required to generate optimal or near-optimal schedules. These have often been found to be difficult for operating personnel within manufacturing organizations to understand.

3. Existing methods treat the lot sizing problem as asingle-stage process, but MRP is a multistage process and, hence, any lot sizing techniques must consider all items whose demand is related, both horizontally and vertically, throughout the bill of material (BOM)structures [33].There are conducted various researches and in

particular the following issues are considered as analysis domains:

a. the impact of forecast processing frequency ,especially when combined with a variable frozen period in production planning ;

b. the impact of the MRP procedure running frequency;
c. the impact of lead time uncertainty. [347] Regardless of the types of MRP/ERP systems used within the MRP-planned manufacture, uncertainty that could occur during the manufacturing process is indifferent. For instance, scrap could be caused by the poor quality of raw material, machine variation or labour mistakes.
Therefore we must enable a complete consideration of all combinations of uncertainties under an MRP-planned manufacture for preventing discrete examination on uncertainty .An uncertainty categorization structure can be
developed using the systems theory to categorize uncertainty into input and process. This structure has also addressed the uncertainty that occurs in the supply and
demand chain of the manufacturing process.

5. Usage and modes of applying material planning methods:
Material planning can be seen as a tactical planning level. It concerns balancing supply and demand and in this respect deals with the initiation, control, and monitoring of manufacturing and purchasing orders in order to maintain an uninterrupted material flow and value-adding activity in manufacturing. The two basic questions to address in material planning are “When to order/deliver?” and “How much to order?” – i.e. one time-related and one quantity-related question.
Some of the best known and widely used material planning methods are re-order
point, fixed interval ordering, run-out time planning, MRP, and Kanban [35][36][37][38][39] methods. These methods are included in this study. They all answer the two basic material planning questions above, however, they can be applied in various ways.
The material planning methods use specific mechanisms to determine the time and
quantity-related questions and the uncertainty considerations related to balancing
supply and demand. The quantity mechanisms are more or less the same for all
methods, but the timing mechanisms are specific to each method.
Consequently, as well as choosing a method that is appropriate for its context, it
also needs to be properly applied, for example, determining and reviewing planning
parameters in “correct” ways. The main types of planning parameters may be related to lot sizing, safety mechanisms, and lead times. The planning frequency, re planning strategies, etc. may also differ.[40][41][42]
6. The Structure of MRP II
The technical differences between closed-loop MRP and MRP II are small compared to the real significant functional difference. *Figure (1)*Practically, MRP II requires several additions to the inputs of the system, the key one is bill of materials. MRP II requires extending the bill of materials to include all the details of the resources needed to produce one unit of product. Those included are mainly; labor, machinery, tools, space and materials. In fact it will be a *"Bill of Resources"* (BOR), which can be used by MRP II to project shortages at specific times, giving departments advance notice of required remedial action, like need to hire or train labor, need for support resources. MRP II can keep track of machine loads and whether there is a need for more machines or subcontractors, or not. Also MRP II treats cash flow almost like materials. The system calculates the cost of all planned order releases and creating a cash flow forecast. This includes payments to suppliers, wages, power and all other costs associated with production. The additional functions of MRP II, means it includes extra modules to those included in closed-loop MRP. The extra modules generate extra feedback loops.[43][44]

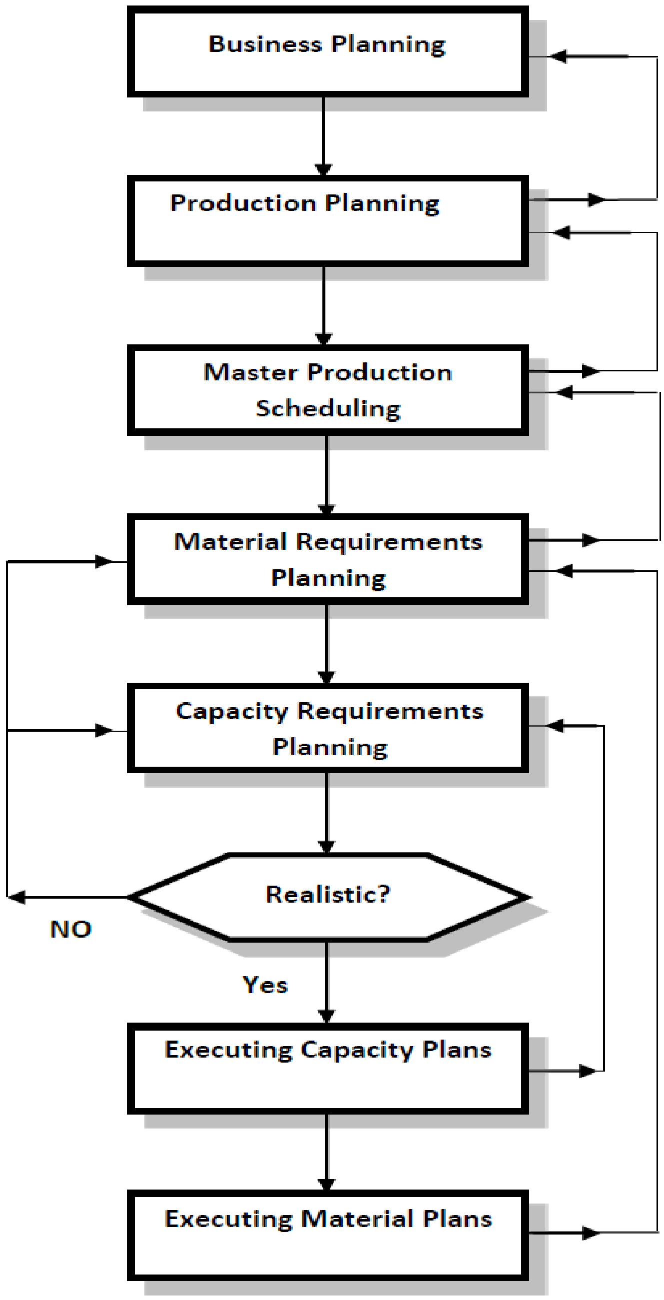

Figure (1) Schematic Diagram of MRP II

7. Evolution Stages of MRP-TYPE Systems:

Material Requirements Planning (MRP), combined with computer technology gave the most adequate successful computerized production requirement system.

No doubt, production requirements techniques always need a lot more due to the competition in businesses and the growing requirements of manufacturing systems. Thus, MRP systems are developed with the time to be capable to cover these growing requirements. As a result, this led to generate a series of MRP-type systems through the following five evolution stages:- [45]

1. Evolution stage I: Material Requirements Planning (MRP).
2. Evolution stage II: Closed- loop MRP.
3. Evolution stage III: Manufacturing Resource Planning (MRP II).
4. Evolution stage IV: Enterprise Resource Planning (ERP).

5. Evolution stage V: Enterprise Resource Planning Extended (ERP II).
Practically, MRP is still in use as the core (central module) in all of MRP-type systems and the other modules in all of these systems are built around this core.[46][47]
The stages of MRP-type systems evolution can be represented as shown in *Figure(2).*
In this chapter these systems and their developments are explained consequently according to their evolution stages.

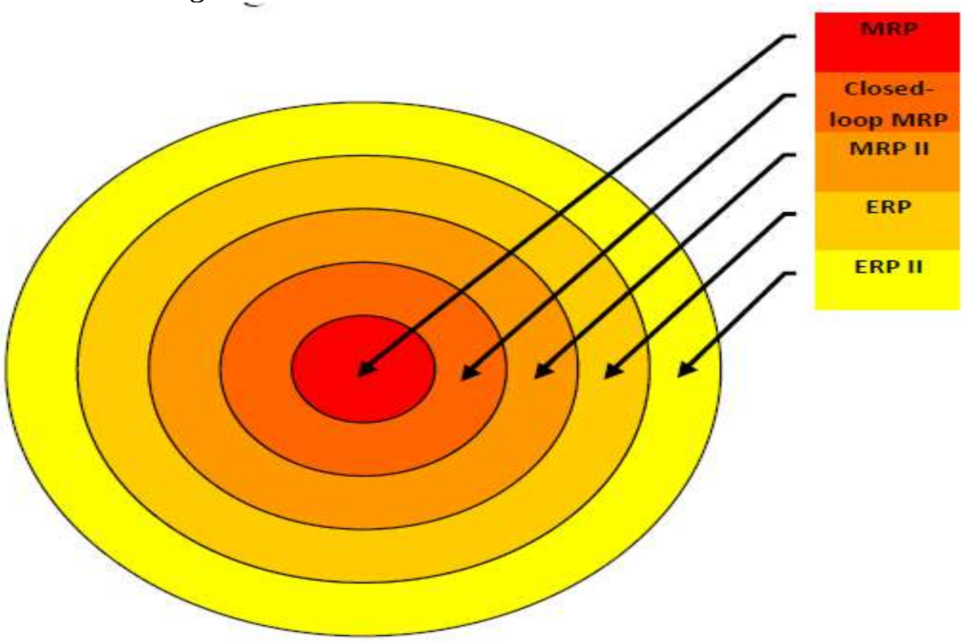

Figure (2) The Evolution Stages of MRP-type Systems[48]

8. Starting with end items the MRP process goes through the following steps:
1. Establish gross requirements.
2. Determine net requirements by subtracting scheduled receipts and on hand inventory from the
gross requirements
3. Time phase the net requirements.
4. Determined the planned order releases.

Week	1	2	3	4	5	6	7
Gross requirements							
Scheduled receipts							
Net requirements							
Time-phased net req							
Planned order releases							

Table 1: MRP Table

The planned order releases aggregated over all the end items will result in the gross requirements for level one items, the gross requirements for this items are then netted and time phased to determined their own order releases. The process is continued until all the items have been exploded.

Table 1 shows a typical MRP table.
Example 3 MRP computations are shown in Table 2 where the lead-time is two weeks. Here the planned releases were obtained by solving a Wagner-Whitin problem with time-varying demand. More often, however, MRP will plan releases in a lot-by-lot fashion.

Week	1	2	3	4	5	6	7
Gross requirements	10	15	25	30	45	20	30
Schedule receipts	10	25					
Net requirements			15	30	45	20	30
Time-phased net req	15	30	45	20	30		
Planned order releases	45	0	45	50			

Table 2: Standard MRP Table

9. Expediting and Deferring Scheduled Receipts:
The process of determining net requirements, as outlined above, is to subtract scheduled receipts and on hand inventory from the gross requirements. Occasionally, because of anticipated changes in the MPS, we will find that the scheduled receipts are not enough to cover the gross requirements within a lead time. Consider, for example, Table 3, and assume that the lead time is three weeks.
Notice that the schedule has a net requirement of 15 units in period 2. An order placed for 15units in period 1 will arrive in period 4, so it would need to be expedited to be ready by period 2.An easier alternative, is to issue an expedite notice to the schedule receipt of period 3, stating that we need 15 units by period 2. Suppose that it is only possible to have 10 units ready by period 2.Then we will have a shortfall of five units. When a shortage occurs, it is important to backtrack and
identify the source of demand. It may be that 10 of the 15 units required in period 2 are for actual orders, while the other five are in anticipation of future demand. In this case, we will allocate the 10 units to the actual order and avoid a stockout. On the other hand, there may be changes in the MPS that make scheduled receipts unnecessary. In that case the schedule receipts can be deferred to a later period.[47][48][49]

Week	1	2	3	4	5	6	7
Gross requirements	10	15	25	30	45	20	30
Schedule receipts	10		25				
Net requirements		15		30	45	20	30

Table 3: Expediting in MRP

10.Lot Sizing Rules:
The problem of lot sizing is one of satisfying the requirements while trying to minimize holding and setup costs. A variety of lot sizing rules have been proposed. The lot-for-lot (LFL) is the simplest approach, and it calls for producing in period t the net requirements for period t. The LFL approach minimizes the holding cost by producing just-in-time. This approach is optimal if setup costs and setup times have been reduced to negligible levels, but

it may be expensive if setup costs are significant. A variety of lot sizing algorithms have been developed to deal with the case where setup costs are significant. The Wagner-Whitin (WW) algorithm can be used to optimally select the lot sizes at one level. However, applying the Wagner-Whitin algorithm, or any other single level approach, to different levels does not guarantee that the overall policy is optimal. An alternative to the Wagner-Whitin policy is the Silver-Meal (SM) heuristic. Starting from the first period with positive requirements, the SM heuristic attempts to cover more and more periods with
one setup while the average cost of doing this is decreasing. Once it is determined that adding the requirements of the next period increases the average cost, a new setup is incurred and the method is repeated until all the requirements are covered. Another approach, which is popular in practice,is the part period balancing (PPB) heuristic which attempts to select the number of periods covered by a setup by making the holding cost over the covered horizon as close as possible to the setup
cost. The fixed order quantity (FOQ) heuristic is to order a predetermined quantity whenever an order is placed. Finally, the fixed order period (FOP) heuristics calls for covering the demand of afixed number of periods with one setup. Vollman et. al. [1] recommend the use of different lot-sizing rules for different levels in the BOM, with FOQ for end items, either FOQ or LFL for intermediate levels, and FOP for the lowest levels. The idea is to avoid the propagation of the bullwhip effect to
the lowest items.

11. Dealing with Uncertainty in MRP:
There are several sources of uncertainty that we have ignored so far. These include uncertainty in the quantity demanded (forecast errors) and the quantity supplied (yield losses), and uncertainty in the timing of demand and the timing of supply (random lead times). Many MRP systems cope with uncertainty by inflating lead times (inducing safety time), by expediting orders, and by shifting priorities of shop and vendor orders. Another way of protecting against uncertainty is to carry safety
stock for end items with random demand, and to carry safety stock of items produced at bottleneck operations.[49]

12. Shortcomings of MRP:
12.1 expects the lead time to be constant regardless of how much work has been released into the production system, so it is implicitly assuming infinite capacity. This can create problems when production levels are at or near capacity. One way to address this problem is to make sure that the MPS is capacity feasible. Rough-cut capacity planning (RCCP)(look[50]), attempts to do this by checking the capacity of a few critical resources. RCCP makes use of the bill of resources (BOR) for each item on the MPS. The BOR specifies the number of hours required at each critical resource to build a particular end item and its components, and then aggregates the number of hours required at each critical resource over the end items in the MPS. RCCP then checks whether the available resources are enough to cover the MPS on each time bucket. Notice that RCCP does not perform time offsets ,so the calculation of the number of hours required has to be done with time buckets that are large enough so that parts and their components can all be completed within a single time bucket. This usually makes RCCP an optimistic estimation of what can be done. Advanced MRP systems provide more detailed capacity analysis proposing alternative production schedules when the current plan is not feasible.
12.2 Long Lead Times
There are many pressures to increase planned lead times in an MRP system. MRP uses constant lead times when, in fact, actual lead times vary considerably. To compensate,

planners typically choose pessimistic estimates. Long lead times lead to large work-in-process (WIP) inventories.

12.3 Nervousness

MRP is typically applied in a rolling horizon basis. As customer orders firm up, and forecasts become better, a new MPS is fed to MRP which produces updated planned order releases that may be very different form the original. Even small changes in the MPS can result in large changes in planned order releases. [49], give an example where a small decrease in demand causes a
formerly feasible MRP plan to become infeasible.

13.Conclosions:

*Insight: distinction between independent and dependent demands.

* Advantages:

- General approach.

-Supports planning hierarchy (MRP II).

*Problems: Assumptions --- especially infinite capacity.

- Cultural factors --- e.g., data accuracy, training, etc.

- Focus --- authority delegated to computer.

14. Future research

Several companies have problems in successfully implementing ERP systems and applying material planning methods to their processes. Therefore, it is important to carry out research that improves our knowledge about successful and unsuccessful uses of planning systems and methods .Very few studies similar to the present one have been conducted in the area of material planning and manufacturing planning and control. Therefore, it is not possible to compare our findings. It would, nevertheless, be interesting to compare the results of this study with future studies in other countries and industries. The longitudinal analysis conducted in this paper contain some potential weaknesses due to the lack of perfectly homogeneous samples and since the analyses are not restricted to focused fields, like a specific industry, a specific company size, a specific manufacturing process, a specific planning environment, etc. Only few differences in method usage and modes of applying the methods were, however, identified between company sizes and different industries, which verify the appropriateness of the samples and analyses. Studies looking at method usage in more restricted fields than conducted here would be valuable in order to further validate the findings of this study and to gain deeper knowledge about the method usage in specific situations. The study did not, for example, analyze the appropriateness of the planning methods in various planning environments (e.g. manufacturing of complex customer products vs repetitive mass production), although the planning methods are more or less applicable to various planning environments. Further, the study did not differentiate between material planning of items in manufacturing companies and products and spare parts in distribution companies. A contingency approach could be applied to the material-planning problem. Such an approach could become an important managerial support when choosing and applying material planning methods.

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