Extending the Pareto Principle to MRP Controlled Parts and Regaining MRP Control

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The Pareto principle is commonly practised in inventory management. Many companies are controlling the 'A' class items by JIT and the 'C' class items by some form of two-bin (max-min) system. The vast majority of the remaining parts ('B' class) are controlled by MRP. This paper discusses the outcome of a research project which has developed a decision-aid based on the Pareto principle to enable MRP parameters to be set in a way which will allow a prediction of eventual MRP system performance.

Problems with MRP

Predicting, let alone controlling the MRP performance is impossible (when all the part numbers are considered together). This view is commonly expressed at MRP user group meetings {1,2}. Management is constantly fighting a losing battle with MRP to achieve the business plan (even assuming the plan is achievable in the first instance).

Some other limitations of MRP include frequent order reschedules due to fluctuating demands, unpredictable numbers of new orders and a wide variation in inventory levels. Consequently, the total order workload and inventory levels are often erratic and rarely, if ever, match the business plan.

If the MRP order workload is not controlled effectively, then the additional cost of managing excessive workload will outweigh the reduction in inventory. MRP order workloads and hence inventory are affected by ordering and rescheduling parameters.

Up until now, little had been understood about the impact of different parameters on order workload and inventory in a real MRP system. Setting and managing MRP parameters were thought of as a 'black art' and left well alone for fear of making the situation worse. Parameters tended to be set at only the initial implementation, causing subsequent problems.

Outcome of the IBM/ACME Research Project

A two year jointly sponsored research project was set up by IBM (Havant) and SERC's ACME (Application of Computers to Manufacturing Engineering) Directorate using researchers from Aston Business School to address these common industrial problems. The research has resulted in a method to set parameters more scientifically and extends the Pareto principle to MRP controlled parts. It reduces the complex technical problem to a clear graph, enabling management to dictate the MRP performance. The parameters can now be updated as frequently as necessary, to reflect the changing business requirements.

The method has already been used successfully in the IBM plant at Havant, where it has resulted in an inventory saving of £1.5 million together with an 8% reduction in total workload in the materials organisation during 1989.

The method is applicable to purchased (bought-out) parts within a repetitive batch manufacturing environment.

IBM Havant Background

Havant is essentially an assembly plant specialising in disk files and telecommunication controllers. The majority of the parts are bought-out, either from local vendors or sister plants.

Like many companies, Havant operate a CFM (JIT) system for the 'A' class items and a two-bin system to manage the 'C' class items. The remaining 'B' class items (roughly 4000) are on a MRP system which is run once a month.

Havant's Pareto distribution is about 90/10 ie. 10% of the parts represent 90% of the usage value.

Inventory and Workload Reduction Principle

Whilst the MRP controlled parts represent only 10% of the usage value, they are however responsible for the majority of the administration workload. Frequent top level changes cause inappropriate recommendations for order movement which absorb a lot of resources in manually amending the MRP recommendations.

The objective at IBM is to move more parts on to JIT control. Increasing the number of JIT controlled parts requires an increase in administrative resources. In order to achieve this, the MRP system must be made more intervention-free, so that the freed resource can be utilised to control additional JIT parts. (Intervention-free means that the MRP recommendations should be correct, so that manual amendments are not required).

10% of value still represents a significant investment in inventory at Havant. Therefore, there is further scope to reduce inventory through smaller but more frequent orders/deliveries (following the JIT principle).

More frequent orders will reduce inventory, but it will increase the number of orders, perpetuating the rescheduling problem. For business efficiency, a balance must be achieved between reducing inventory and minimising the cost of managing the additional order workload.

The conflicting objective of reducing inventory and reducing workload was achieved by :-

- Increasing the ordering frequency (increasing the number of orders).
- Compensating for the increase by applying calculated dampening to reduce the number of reschedules, resulting in a net workload reduction.

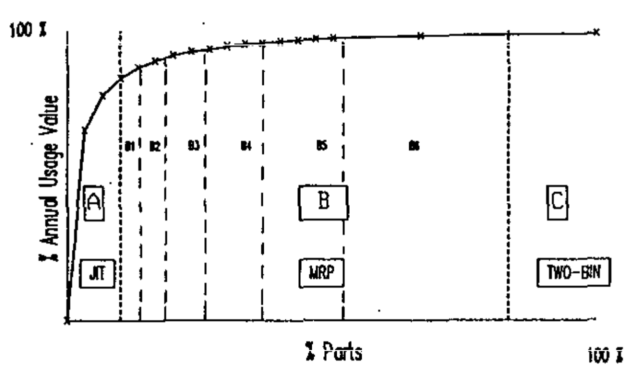
Both ordering frequency and dampening is set according to the annual usage value (unit cost x average annual demand) of the parts ; the higher the value, the more frequent the ordering and the lower the dampening.

Using this principle, the new order and reschedule increases in the high value parts will be compensated by a reduction in the number of orders and reschedules in the low value parts — the inventory reduction achieved in the high value end will be more than offset by the slight increase in the lower range.

Ordering Methodology

The method to achieve the balance between inventory and workload is to classify the MRP parts into B1, B2, B3 etc... (Fig.1) and each class or group of parts is ordered on a common ordering frequency according to its usage value.

Fig 1 - Pareto of Parts V Annual Usage Value



This type of rule is commonly used by many companies because of its simplicity and JIT type order/delivery pattern. Regular order patterns tend to ease scheduling and improve delivery performances {3}. Typically, the grouping (size of group) is based on the Pareto principle.

The research shows that not only the size of each group and its ordering frequency but also the number of groups affect the number of orders and hence inventory levels. For a typical range of Pareto distributions (70/30 — 90/10), there is no significant inventory saving in using more than 6 groups, but a noticeable reduction is achievable if more than the traditional 3 (ABC) groups are used.

It seems logical to try a practical order frequency progression of weekly, fortnightly, four weekly, eight weekly etc... (Table 1). Mathematically this is a geometric progression which incidentally represents the optimum approach. {3}.

Table 1 — Order progression by value

Group	Order Cycle (days)	Order Frequency (Orders/year) (240 days/year)
B1 (Highest Value parts)	5 (Weekly)	48
B2	10 (Fortnightly)	24
B3	20 (4-weekly)	12
B4 (Lowest Value Parts)	40 (8-weekly)	6

Assuming the number of groups and the order frequencies have been established, then it only remains to determine the optimum group sizes. This can be calculated mathematically by iterating for every permutation of group size. For a practical system containing several thousand part numbers and just two groups, the number of permutations is several million {4} which is not practical to try ; it would probably take longer to run than the actual MRP system.

More logical methods to determine the group size were tried eg. permutations of equal areas under the pareto distribution. The method that produced near optimum group sizes was the one based on a modified EOQ (Economic Order Quantity) for the average of the group.

The EOQ formula in terms of the economic ordering frequency and annual usage value is:-

$$\$D = (2xC/I) \times F^2$$

Where $D = Annual usage value (unit price x annual demand)

C = Ordering + Receipt Cost

I = Inventory carrying rate (as a decimal)

F = Ordering frequency (No. of orders per year)

(also = days per year/Order Cycle)

2C/I = Cost ratio

The EOQ has quite rightly been dismissed by many because of its reliance on ordering and inventory holding costs, which are obviously difficult to determine in practice. Fundamentally, the EOQ idea is sound, if only the absolute costs can be replaced by some other controlling parameter.

We have replaced the costs by a cost ratio, K (where K=2C/I and $\$D = K \times F^2$). By flexing K we can calculate different group sizes. Different K values will obviously give different groupings. The detailed process is described in {4}. Using K eliminates the need to determine absolute costs.

Example: for 6 groups

Group	Order Cycle (days)	Order Frequency (Order/year) (240 day year)	Group Boundary (K=K1)	Group Boundary (K=K2)
B1	5	48	210,000	110,000
B2	10	24	52,500	27,500
B3	20	12	13,125	6,875
B4	40	6	3,280	1,718
B5	80	3	820	429
B6	160	1.5	0	0

For K=K1, all parts with usage values between 210,000 and infinity are classified as class B1, between 210,000 and 13,125 = class B2, between 820 and 0 = class B6. A plot of these values on the Pareto distribution will look similar to Figure 1.

Once the group boundaries and order frequencies are established, the actual number of orders and average inventory expected can be calculated from the MRP data. To calculate the number of orders, count the number of parts falling within each group and multiply by the corresponding order frequency. Summing the result for each group will give the total number of orders expected in the plant.

To calculate the average inventory resulting from delivered quantities, sum the usage value of parts in each group and divide by the corresponding order frequency and then multiply the result by a half. Summing the results for each group will give the average plant inventory.

Example: Data from an imaginary MRP system

Group	Ordering Frequency	No of Parts in Class	Annual Spend of Classes	No of Orders	Inventory
1	48	20	80,000	960	833
2	24	30	15,000	720	312
3	12	50	5,000	600	208
Totals		100	100,000	2,280	1,353

Repeat the process for another K value, hence a different grouping. These results can then be plotted as in Figure 2. which represents the plant's 'Exchange Curve'. It shows the optimum balance between the conflicting requirements of low inventory and number of orders when all the purchased part numbers within the plant are considered together. It represents the near optimum trade-off. It is the near optimum because a group size of one part per group would give the true optimum.

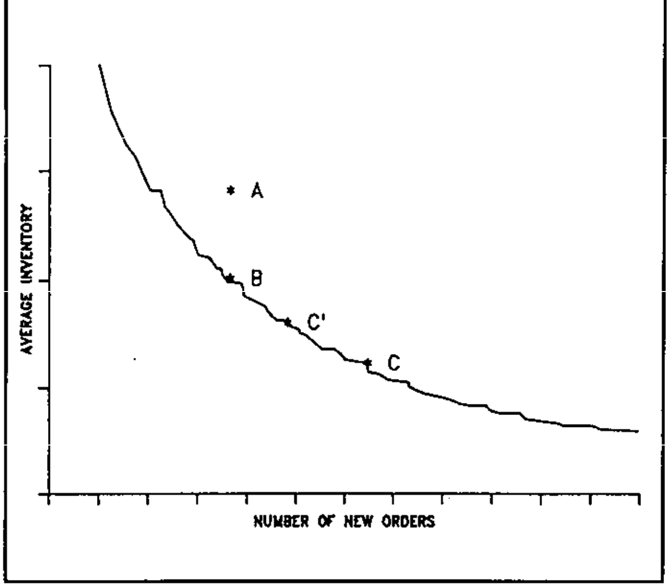
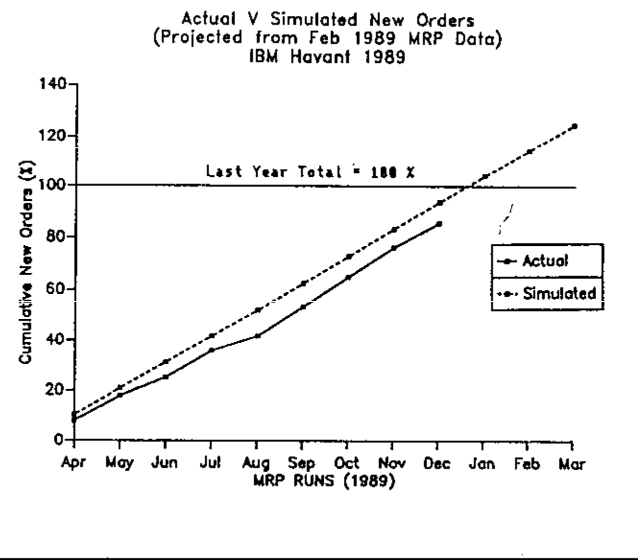
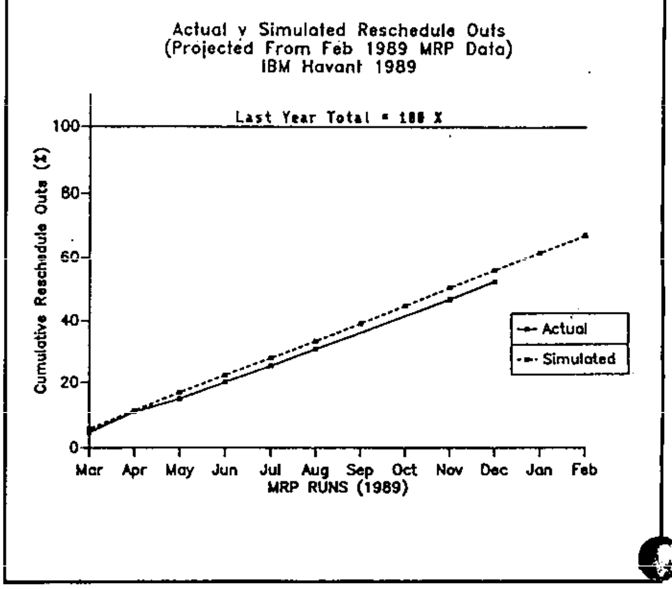


Fig 2 – Plant's Exchange Curve

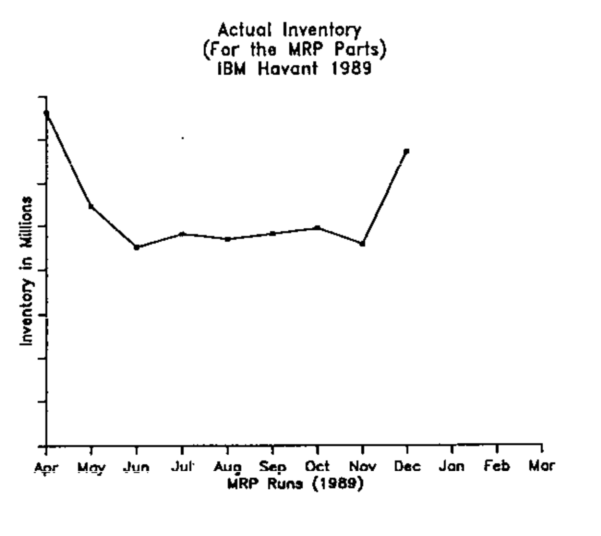
Result Diagram 1



Result Diagram 2



Result Diagram 3



Each point on the curve is derived from a set of ordering parameters. Point A might represent the performance under an existing arbitrary set of parameters. For many MRP systems point A can be as much as 20% above the minimum inventory possible for the given workload. For the same workload, point B represents the optimum performance.

Using the curve, management can now decide by how much the number of orders should be increased. If the number of people in the ordering process are known, then it is possible to estimate the productivity increase needed. To achieve maximum benefit, it is desirable to increase the number of orders by as much as possible as long as existing resources can manage. Beyond that, an additional cost will be incurred. Management should weigh the inventory benefit against any possible cost increases.

Having decided the required position on the curve, the user can then implement the parameters corresponding to that position.

Rescheduling Methodology

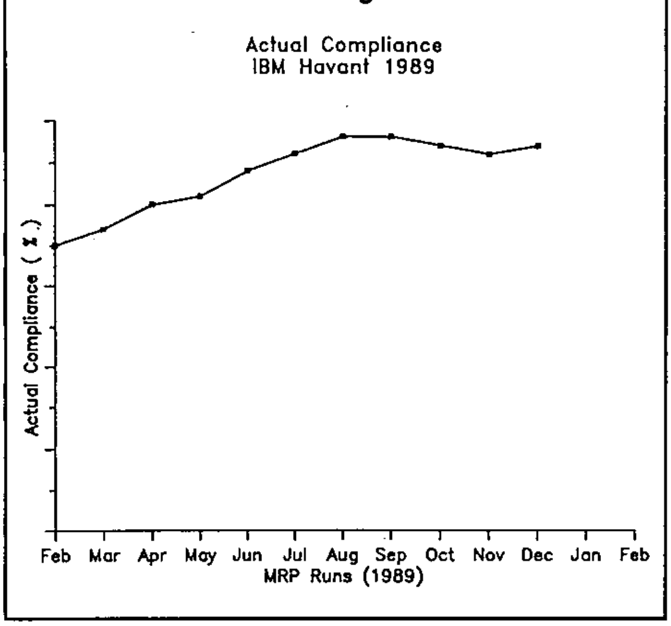
As a consequence of increasing the order base, the number of order reschedules will inevitably increase. This is one of the MRP paradoxes. However, the number of rescheduling notices can be reduced by applying suitable dampening.

The dampening logic mirrors the ordering logic ie. the higher the value of the order, the lower the dampening and vice-versa. Dampening is applied in days ie. any order movement less than 'x' days will be suppressed. eg.

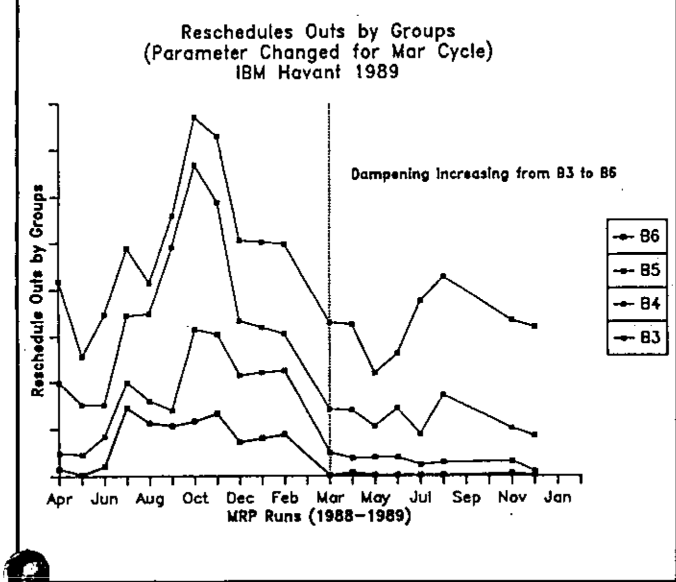
	Order Cycle (days)	Dampening (in days)
Class B1	5	0
Class B2	10	5
Class B3	20	10
Class B4	40	20

This logic is used only to suppress reschedule-out notices (ie. delaying the delivery); expediting of orders is not suppressed for fear of suffering shortages.

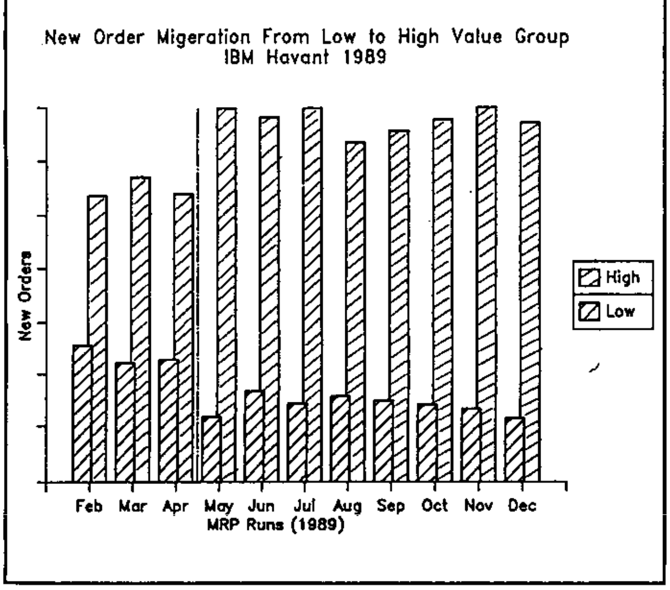
Result Diagram 4



Result Diagram 5



Result Diagram 6



Suppressing movement-out will create inventory because the delivery is not consumed in the originally planned period. With this dampening approach however, the overall value of the resulting inventory is small compared to the benefit of considerably reduced rescheduling workloads.

This logic is not restricted to any specific MRP system. If this facility is not available on a user's MRP system, then the same effect can be achieved by filtering the orders through a suitable database. Average inventory impact can also be deduced if a history of orders and their value is available.

With this rule it is now possible to reduce the total order workload whilst still increasing the new orders' base. Previously, increasing the new orders' base lead to an increase in reschedule notices.

Results

IBM Havant used the model to set their rescheduling parameters in March 1989 and ordering parameters in April 1989.

To validate the method on the live system, the number of new orders were not stretched to the maximum limit tolerable with existing resources (point C Fig. 2). An intermediate position (point C′) was chosen.

In gaining approval to reset parameters, the projected benefits were simulated using February 1989 MRP data. The following benefit statement was presented to management:

	Current	Proposed	Change	Inventory Benefit
No of New Orders	xx	aa	+20%	- £1.7 million
No. of Reschedule Outs	yy	bb	-30%	+£0.2 million
Total order base	zz	cc	- 8%	££,£££,£££
(includes new, amended and cancelled orders)				

Business Benefits (See Results Diagrams 1-6)

Inventory Reduction = £1.5 million
Total workload Reduction = 8% (of total order base)
= 1.5 Heads
Compliance Improvement = 8%

(Compliance is a measure of how many MRP recommendations are accepted without manual amendments i.e. intervention-free).

Simulation Model

To facilitate the task of testing the effect of different group sizes, number of groups, and different ordering frequencies on inventory and workload, the method has been computerised. It has been developed as a PC-based model which enables several values to be tested quickly.

By accessing data from the MRP system, a user is able to carry out 'what-if' exercises to investigate the effects of different ordering scenarios and planning parameters. Following analysis of the simulated performance, the desired parameters can then be selected for the formal MRP run.

The benefits of this approach are:

1. Define MRP planning parameters more scientifically.
2. Test and validate the inventory plan before committing.
3. Instil greater confidence in long-term inventory planning.
4. Maintain a much better control over the MRP system.
5. Optimise the inventory/workload situation.

The existing PC-based application can be readily integrated into any existing MRP batch environment, where the above benefits can be demonstrated within a short period of time.

Data Requirements

Mandatory — Annual Usage Value by part.
— Either existing parameters or existing inventory level and number of orders. (Required to compare difference between existing and proposed inventory and workload)

Optional — History of orders and their value.
— Headcount in Materials Planning areas.

If the MRP data is not available as a database file, then, for small systems, the data can easily be recreated manually and simulated using simple spreadsheets.

Summary

Inventory reductions achieved using JIT methodologies have been frequently reported. JIT relies on high delivery frequencies (often daily) usually leading to increased ordering and delivery workloads. JIT is invariably applied on the Pareto class 'A' parts.

The middle ground is often left to look after itself and can result in inefficient order management. Users of medium to large MRP systems will recognise the workload problems arising from unbridled MRP parameters. The features of this solution commended by the SERC/ACME research review were simplicity and effectiveness.

References

{1} — MRP User Group, Manchester Business School.

{2} — MRP Workshop, Aston Business School, Oct 1989.

{3} — Aggarwal, V., 'A Closed-Form Approach for Multi-Item Inventory Grouping', Naval Research Logistic Quarterly, Vol.30 p 471-485 (1983).

{4} — Shah,S., Burcher, P.G. & Relph G.,'The Setting of Ordering Parameters in a MRP/JIT Environment', Working Paper, Aston Business School, Oct 1989.

About the Authors

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