IMPROVED INVENTORY PERFORMANCE INTO THE 21ST CENTURY

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This article describes a joint research project undertaken by IBM and Sunderland University School of Engineering and Advanced Technology into the performance of a Periodic Order Cycle inventory management system.

The outcome of this research is a proven methodology for setting the optimum number of classes and class boundaries in any industry.

In 1960's, a 3 class ABC analysis using Pareto principles was all that most industries could manage. In the 1980's, with the increasing availability of computerised systems such as MRP, and the increasingly competitive environment that companies such as IBM had to survive in, there was a move to the greater degree of inventory management that a 6 class system provided.

The research by IBM and the University of Sunderland concludes that a move to 8 classes will become necessary to retain competitive inventory advantage in manufacturing for the next century.

The increased complexity of managing an 8 class system will require simple tools and techniques to set rational class boundaries, allocate parts within the classes, and manage the migration of parts between classes.

It is not sufficient to assume that the parameters set six months ago are relevant today. Shorter product life-cycles and market driven demand means that manufacturing is now as dynamic and fast moving as retailing.

The development of the K-Curve Methodology (KCM) provides a technique able to respond to such a dynamic environment.

BACKGROUND

In the May 1990 issue of BPICS Control a paper was published jointly by IBM and Aston Business School (Shah, Burcher & Relph) on the outcome of a research project to develop a Pareto based decision aid to enable MRP parameters to be set in a way that provided predictions of the overall inventory performance within the MRP system.

The decision aid was developed, and trialled at IBM Havant on raw materials, where an inventory saving of £1.4 million was achieved along with an 8% reduction in the total workload in the materials organisation.

Since 1990 IBM have been using this decision aid within their consultancy practice, as one of the of tools in their JIT philosophy, Continuous Flow Manufacturing (CFM).

The decision aid is called the K-Curve Methodology (KCM). KCM is basically a periodic order cycle inventory management approach.

Although KCM has been used successfully for three years, and commended for its simplicity by SERC, it requires a high level of skill and judgement on behalf of each practitioner to both use the methodology and interpret the results obtained.

The initial research was conducted using materials requirements from a sophisticated electronic manufacturing plant, and the applicability to other industries of the K-Curve parameters was not always readily accepted.

Further research was therefore required to determine how any of the following factors affected inventory performance:

- Industry type (eg. Electronics, Motor)
- Usage value
- Number of parts
- Average value per part
- Shape of the Pareto curve
- The number of inventory classes
- The class boundaries

The research was to determine what correlation's existed, if any, and to demonstrate the applicability of the methodology as a general approach.

OUTLINE OF RESEARCH

A seventeen week research project was set up by IBM Industrial Consultancy and the University of Sunderland School of Engineering and Advanced Technology to address these issues.

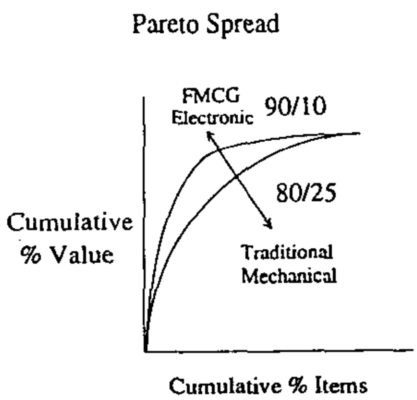
The research covered the following industry sectors:

- Electronics
- Fast Moving Consumer Goods
- Motor Manufacturing
- Motor Vehicle Suppliers
- Plastics Moulding
- Mechanical Engineering

The total cumulative annual usage value range of the businesses considered was between £1.6 million and £412 million, with the number of parts ranging between 364 and 4,094.

FIGURE 1.

PARETO VARIATIONS BY INDUSTRY TYPE



Part of the aim of the research was to see how inventory performance was affected by the shape of the Pareto. The shape of the Pareto is a reflection of the nature of the business. Mechanical engineering tending towards 80/20, with Electronics tending towards 90/10. (Figure 1.)

The spread of the Pareto curves analysed ranged from 80/25 to 90/10. This represents the variation in the value of components in the overall business.

It was initially felt that to optimise inventory performance the different Pareto shapes would require different numbers of classes and class boundaries.

The experimentation looked at different inventory management policies expressed as periodic order series and classes in an attempt to prove or disprove that the correlation's existed.

The seventeen sets of data used were:

FIGURE 2

TABLE OF PARETO PROFILES USED SHOWING VARIATIONS IN VALUE, PARTS & PROFILE

Data Set	Annual Value (millions)	# Parts	Pareto
1	£10.5	4,094	80/10
2	£1.8	712	80/20
3	£156.8	4,061	90/10
4	£9.3	364	80/20
5	£4.2	380	80/20
6	£1.7	566	80/15
7	£11.9	1,502	80/10
8	£23.3	949	85/10
9	£54.1	6,351	85/10
10	£72.2	2,125	80/15
11	£47.5	2,335	80/20
12	£33.0	1,251	80/10
13	£54.1	1,543	80/20
14	£13.9	1,114	80/20
15	£5.9	588	80/15
16	£28.2	875	80/25
17	£412.1	2,220	90/10

The twelve inventory management policies compared were from 3 to 9 classes, covering both traditional, linear, and geometric progressions, as follows:

FIGURE 3

PERIODIC ORDERING CYCLES USED FOR EXPERIMENTS, EXPRESSED IN DAYS.
(Series 6 was used as the Baseline/Default Series)

Series	# Classes	1	2	3	4	5	6	7	8	9
1	3	5	20	240						
2	3	5	20	160						
3	6	5	10	20	40	80	160			
4	6	1	2	5	10	20	40			
5	6	5	10	15	20	25	30			
6	8	1	2	5	10	20	40	80	160	
7	8	5	10	15	20	25	30	35	40	
8	9	1	2	4	8	16	32	64	128	256
9	8	1	2	4	8	16	32	64	128	
10	6	2	4	8	16	32	64	128	256	
11	5	1	3	9	27	81	243			
12	8	1	4	16	64	256				

The data was analysed using a PC based software tool developed jointly by Aston University and Epsim Ltd, called the inventory analyser.

The inventory analyser created K-Curve profiles for each period order cycle series and each data set. The K-Curve profiles were then analysed using an overall performance index.

The K-Curve profiles were generated based on the following mathematical process.

K-CURVE METHODOLOGY (MATHEMATICAL PROCESS)

The K-Curve methodology is a development of the theory used as the basis of the economic order quantity formula (Harris & Wilson) and the optimal policy curve (Starr & Miller).

The essential difference in the approach is that whilst the economic order quantity formula considers inventory performance at the individual item level, the K-Curve Methodology considers the total inventory performance of a group of items.

By using this approach, some of the well documented difficulties in establishing the stockholding and order raising costs for each individual item are avoided.

All that is required is a list of part numbers and an annual usage value for each part.

The standard EOQ formula is:

$$EOQ = \sqrt{\frac{2.A.Co}{i.Cm}}$$

where A Annual usage
Co Cost of ordering and delivery per occasion
i Annual stockholding interest rate
Cm Item cost

The EOQ can be firstly rearranged in terms of the economic ordering or delivery frequency (F):

$$F = \frac{A}{EOQ}$$

And then eventually rearranged again in terms of the annual usage value, as follows:

$$F^2 = \frac{i}{2.Co}\,(A.Cm)$$

$$A.Cm = \left(\frac{2.Co}{i}\right)F^2$$

$$AUV = K.F^2$$

where AUV Annual usage value ($A.Cm$)
F Ordering or delivery frequency
K Cost ratio K ($2.Co/i$)

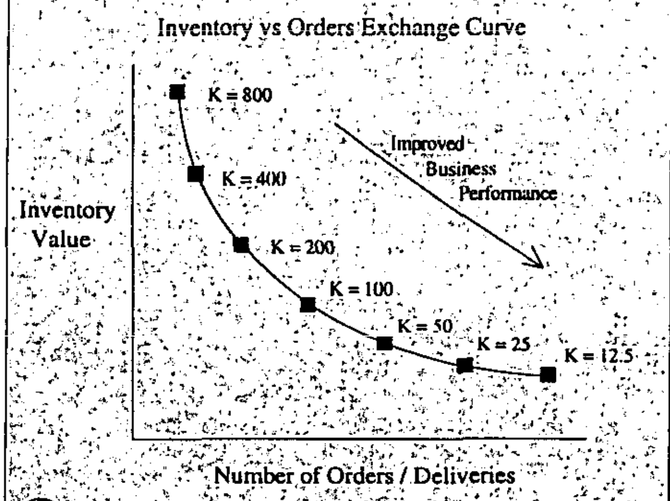
The annual usage value (annual usage * item cost) is therefore related to the square of the ordering or delivery frequency by the cost ratio (2Co/i).

When dealing with items at the macro level, the cost ratio can be considered a constant, and the letter K substituted in the equation for 2Co/i.

By substituting different values of K into the formula it is possible to predict the total inventory performance in terms of both the number of orders and the average inventory value that the policy would generate, as shown in Figure 4.

FIGURE 4

MODIFIED OPTIMUM POLICY CURVE - K-CURVE



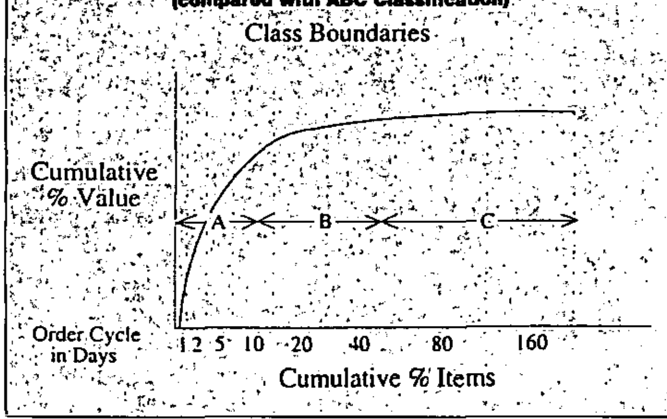
Each value of K would generate a different optimum solution in terms of the number of orders and average inventory value.

It is easy to see from Figure 4 that the value of K established for a business will tend to decrease with time, as continual process improvements are introduced, increasing the number of orders/deliveries processed, it is in effect a reflection of the speed of the business. The ability to operate using lower values of K is a reflection of improved business and manufacturing processes.

Thus, it is possible to partition the items into groups with identical ordering frequencies, as shown in Figure 5.

FIGURE 5

SEGMENTATION OF PARETO CURVE USING K-CURVE AND PERIOD ORDER CYCLES.
(compared with ABC Classification)

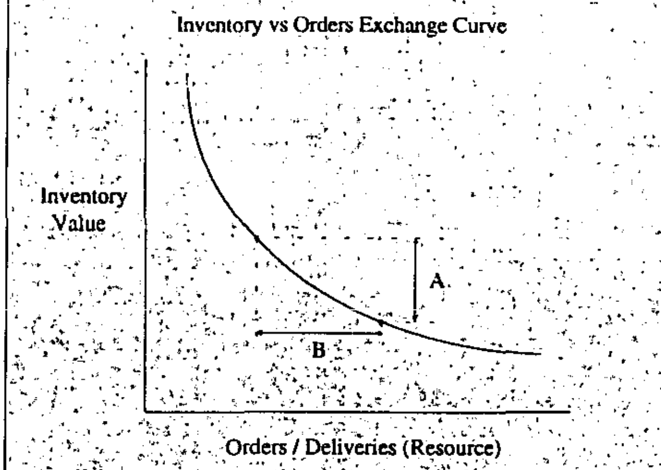


From this it is possible to model the effect of using a particular periodic order cycle (POC) policy in terms of average inventory and total number of orders/deliveries generated.

The key to the success of the methodology is the way in which the partition boundaries are fixed, and the value of K established for the particular business, this allows the inventory holding and resourcing decisions to be expressed in business case form.

FIGURE 6

BUSINESS CASE RELATIONSHIP WITHIN THE K-CURVE MODEL



A = Inventory benefit by reduction.
= Capital released + savings in holding charges.

B = Costs incurred to enable business and manufacturing processes and systems to manage higher volume of orders/deliveries.

RESULTS OF THE RESEARCH

The outcome of the research was:

- The standard Pareto series of ordering a week, a month and a year's supply for Class A, B and C items respectively performed badly relative to the default series.
- Geometric progressions performed better than linear progressions.
- The optimal number of classes was eight, the benefits of going above this figure being too small to be measurable in practice.
- The inventory performance of the optimum series was independent of the industry type, the inventory value, the number of parts, the average value per part, and the shape of the Pareto curve

Thus the relative inventory performance between the series was solely dependent on the number of inventory classes and the class boundaries.

This makes the approach relevant to anybody using periodic cycle ordering to control inventory, as well as users of MRP.

It is thus possible to extend this simplified and generic approach of modelling the effects of setting periodic ordering cycle parameters against inventory and resource targets, to a wide range of industry sectors.

In Figure 7 overleaf, the relative overall performance of each inventory series is compared to that of Series 6. A negative number indicates an inferior relative performance, and a positive number indicates a superior relative performance.

FIGURE 7

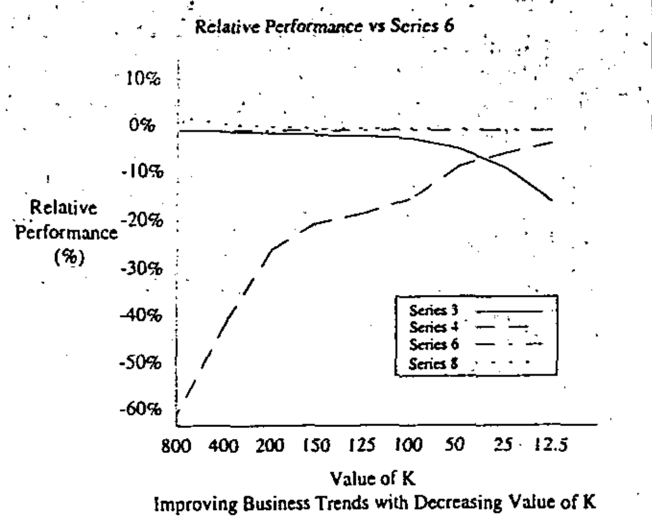
TABLE OF RESULTS

SERIES	K800	K400	K200	K150	K125	K100	K50	K25	K12.5
1	-16.7%	-17.55	-16.5%	-15.8%	-15.3%	-14.8%	-13.94%	-15.6%	-22.3%
2	-12.3%	-12.6%	-12.4%	-12.2%	-12.0%	-11.8%	-12.0%	-14.6%	-21.6%
3	-0.0%	-0.2%	-0.6%	-0.9%	-1.2%	-1.6%	-3.8%	-8.2%	-16.6%
4	-62.1%	-40.0%	24.5%	-19.7%	-17.1%	-14.3%	-8.2%	-4.5%	-2.6%
5	-96.3%	-63.1%	-39.9%	-32.6%	-28.7%	-24.7%	-16.9%	-15.3%	-20.4%
6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	-61.6%	-39.4%	-24.3%	-19.9%	-17.5%	-15.2%	-11.2%	-12.0%	-18.6%
8	3.3%	2.6%	1.5%	1.2%	1.0%	0.9%	0.6%	0.6%	0.4%
9	-4.7%	-2.1%	-1.3%	-5.4%	-0.8%	-0.6%	-0.2%	0.1%	0.2%
10	3.3%	2.6%	1.4%	1.2%	1.0%	0.8%	0.2%	-0.3%	-1.6%
11	0.4%	-0.3%	-1.5%	-1.8%	-2.0%	-2.1%	-2.7%	-2.5%	-2.5%
12	-1.7%	-2.7%	-4.2%	-5.0%	-4.8%	-5.0%	-5.1%	-5.2%	-5.3%

The series which performed best across all values of K for all seventeen sets of data was series 8, a 9 class true geometric progression.

FIGURE 8

PERFORMANCE OF SERIES 3, 4, AND RELATIVE TO SERIES 6



Series 6, an 8 class modified geometric progression performed so closely to series 8 that the modifications to make the ordering cycle fall onto weekly boundaries appeared to have little effect on overall inventory performance. As it is easier to use a system based on weekly boundaries, the small differences in overall performance would in reality be offset by the operational practicalities. The delta is further minimised as the value of K decreases with improved business operations.

What was interesting to note was that series 4 performed as well as series 6 for low values of K, and that series 3 performed as well as series 6 for high values of K. series 6 is in effect a combination of series 3 and 4.

As the class boundaries become lower for lower values of K, so the longer ordering cycles become depopulated with more items being pushed into shorter cycles.

Both the above observations reflect the changes that manufacturing will continue to experience in the next decade, with lower values of K being required to respond to improved business and manufacturing processes.

Series 6 automatically depopulated and populated the classes according to the value of K.

CONCLUSIONS

The research set out to examine the relationship of Pareto curves (which are in effect MRP's view of businesses) to periodic order cycle inventory management policies.

KCM has been promoted as a predictive inventory management tool, the research demonstrates the applicability of the techniques to the broad industry base that uses MRP and periodic order cycle techniques.

The key conclusions drawn from the research are:

- The variation in Pareto profile and thus industry does not affect the optimum periodic order cycle solution.
- The more advanced a business enterprise the greater the advantage in moving from traditional ABC to 6 or 8 class divisions.
- Using the KCM 8 class approach gives automatic progression from 8 to 6 classes.
- KCM use as a generic inventory management tool is now supported by quantitative research.

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