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MULTI-ITEM CLASSIFICATION AND GENERIC INVENTORY STOCK CONTROL POLICIES

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In many inventory systems, the number of stock-keeping units (SKU) is so large that it is not computationally feasible to set stock and service control guidelines for each individual item. As a result, items are often grouped together and "generic" control policies are set for each group. Under such policies, common inventory controls (such as service level/safety stock coverage) are applied to each item in a group. Grouping provides management with more effective means for specifying, monitoring, and controlling system performance, since strategy objectives and organization factors can often be represented more naturally in terms of item groups.

In practice, the ABC inventory classification scheme is the most frequently used method for item aggregation; it groups items based on annual dollar usage. The ABC approach is based on the fact that a small fraction of items account for a high percentage of total dollar use. Most inventory systems apply different control schemes for the small number of high volume items from the schemes used for the much larger number of small volume items.

While simple to implement, the ABC method and its associated control policies may provide unacceptable cost and service performance since they do not take into account other managerially significant variables (related to production, distribution, and sourcing). The grouping method introduced in this article is a blend of statistical clustering procedures and operational constraints which can make use of any collection of operationally relevant item attributes. This technique for generating operations-related groups (ORG) [3] can be used to define group-based operational control policies. For example, with ORG we can specify (Q, R) inventory control parameters (where R is the re-order point based on a group safety factor and Q is the quantity ordered).

Any grouping of SKUs will entail a penalty in terms of cost and service performance if control policies generic to the groups are used in lieu of policies generated for individual SKUs. We examine the relationship be-

tween this penalty and choice of the grouping method: ABC, ORG, or management-constrained ORG (use of ORG within major groups defined by management). Our results demonstrate that a significant trade-off exists among grouping methods between such penalties, computational costs, and measures of statistical discrimination.

Application of the ORG method to SKU grouping unconstrained by operational performance requirements provides significant improvement over the ABC method in terms of statistical criteria. The groups resulting from an unconstrained ORG approach, however, may not be easy to assimilate into a firm's organization and control structure. This is because clustering methods tend to group items which, from a management perspective, are essentially different. This difficulty can be significant, since managerial acceptance of the groups is required for the successful utilization of the control policies which are developed on the basis of the groups. Conversely, management-constrained groups may not be optimal with respect to statistical criteria (i.e., where the degree of association in terms of a set of attribute variables is high among members of the same group and low between members of different groups [1]). Management-constrained ORG methods can lead to groupings with a balance of operational and statistical performance.

Our results indicate that the ABC method is surpassed by unconstrained ORG in terms of both operational and statistical performance. Inclusion of operational performance constraints in the ORG procedure can take explicit account of managerial priorities such as inventory service, costs, and functional similarity, and provide statistical performance superior to ABC.

A CASE ANALYSIS

The ORG method was applied to a sample of SKUs managed by the inventory control system for the distribution of automotive spare parts of a major man-

ufacturing firm. Management had established a catalog which grouped parts into 17 major categories based on their end use; e.g., electrical, motor, transmission, trim, body, etc. We extracted 40 operational attributes for some 2502 part records, including:

- The price of the item to the dealer
- The cube (volume of the part)
- Supplier lead times (mean, standard deviation)
- The degree of commonality of usage over different car models
- An internal criticality index
- The year the part was introduced
- A variety of demand data parameters broken down by sales market and time.

Within-group variation of the attribute variables for each of the catalog groups was relatively high. We chose five sets of three groups from the original 17 catalog groups. For each set, we took two random samples of 100 parts. For each of the parts, we determined its minimum inventory control cost individually using a standard (Q, R) algorithm described in [4]. The summation of the individual item minimum costs within the group provides us with a reference (lower bound) upon which to compare the various grouping methods.

We computed the costs associated with the generic policy for each group by using group average parameter values (e.g., mean, variance of demand). These generic policies were defined by setting the safety stock multiplier (k factor) of demand standard deviation to be common for each group. We then defined the percentage increase of expected inventory costs (relative to the minimum costs resulting from individual treatment of the items). This percentage is a measure of

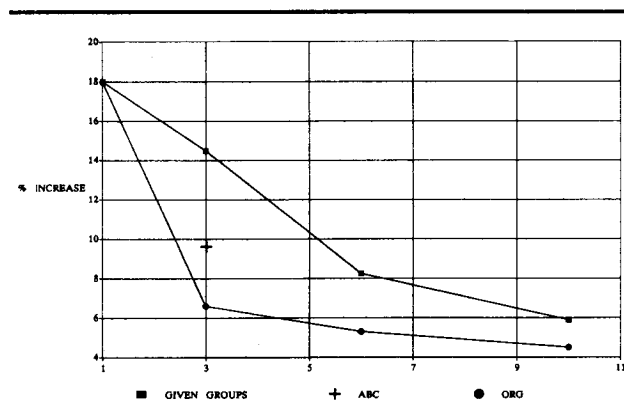


FIGURE 1: Percentage increase in total cost versus maximum number of groups (q^*).

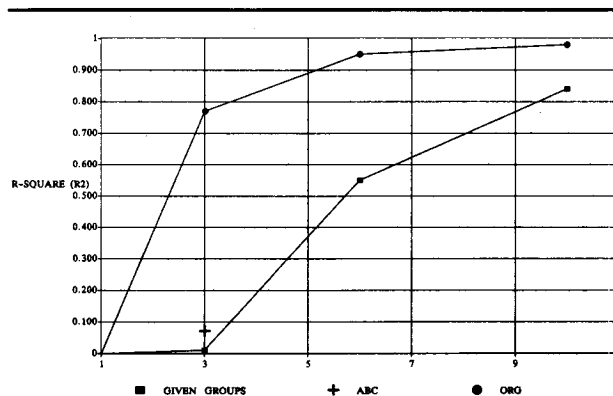


FIGURE 2: R^2 versus maximum number of groups.

the cost penalty associated with use of inventory control policies generic to the groups. The graph in Figure 1 illustrates the average value of this increase across all sample sets for each grouping method. Figure 2 illustrates the variation in the coefficient of determination (R^2) versus the maximum number of groups. The value of R^2 increases with the number of groups, since it demonstrates the explanatory power of the grouping with respect to all item attributes.

Both operational and statistical performance improves with the number of groups. Computational costs will, of course, also increase. The objective is to select the number of groups by trading off these opposing costs in an acceptable manner.

THE ORG METHOD

The analysis begins with the collection of a data set in which each observation includes physical and technical descriptors of the corresponding SKU, attributes of its market, production- and distribution-related parameters, and financial data. (In most firms, such data are readily available in machine-readable form.) The fact that each observation typically contains a wide variety of measurement units and variable types makes it difficult to define meaningful measures of association between observations for a given set of values.

The SKU-based control problem can be formulated as an optimization problem where the objective is to obtain the minimum number of groups which satisfy both operational performance and statistical constraints. The operations performance constraint can be expressed in terms of the penalty associated with the application of generic policies relative to individual-based policies. The statistical constraint can enforce

a minimal level of statistical discrimination. Complete development of the mathematical terms and expressions used in formulating the ORG problem is in [3]. It is also available, upon request, from the authors.

A solution procedure consists of the following:

1. Set the number of groups q^* equal to 1.
2. Compute optimal inventory control policies and associated performance for each item *without* grouping.
3. Check operational performance by solving the (Q, R) inventory problem for the current grouping to generate group-specific optimal policies. If the maximum penalty cost constraint is satisfied, then STOP; otherwise, go to Step 4.
4. Increase the maximal number of groups from q^* to $q^* + 1$ and re-solve the grouping subproblem (i.e., without operational constraints) by application of the clustering procedure described in Step 3. Then go to Step 3.

Application of this procedure to the entire set of SKUs requires estimation of membership functions and computation of stock control parameters based on a sample of items (see [3]).

CONCLUSIONS AND ACKNOWLEDGMENTS

The main departure of this analysis from earlier work is: (1) the approach can handle any combination of item attribute information that is important for managerial purposes (e.g., sales pattern, margin, physical volume, source of procurement, degree of

commonality); (2) management's preferences for groupings based on operational performance can be accommodated; (3) statistical discrimination criteria are considered; and (4) group definition reflects the application context, e.g., control policies based on group membership.

The advantage of using the ORG procedure for grouping and for developing generic, group-based policies can be substantial. The performance relative to the ABC method is especially significant, and its use to generate more than three groups may not improve performance significantly [2]. This follows, since ABC is based on only two item attributes, while our method can utilize the complete range of SKU descriptors.

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