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SIM: Selective inventory management

Jack K. Wirth

Nicholas Radell

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SIM

TRB&S HAS RECENTLY COMPLETED an extensive research and development project to explore the feasibility and desirability of using Operations Research techniques in the area of inventory management for a retail department store. Although this project was under the direction of the Management Sciences Division of the firm, much of the development work was done by members of the Audit and Management Services staffs of the Detroit and St. Louis Offices. Several man-years of effort were devoted to this project before a practical and economical inventory management system was designed. This system was given the name "Selective Inventory Management."

Operations Research

Before discussing some of the basic principles of Selective Inventory Management, we should consider the reasons why our research effort was directed to the retail industry. During the years following World War II considerable interest developed in the study of the feasibility of applying Operations Research (abbreviated OR) techniques to the solving of business problems. Most of the research efforts during these years were directed toward industrial situations. As our firm developed a staff of scientists qualified in OR techniques, we decided to explore the areas in retailing wherein OR techniques might have application.

Our preliminary research in retailing was motivated by the fact

SELECTIVE INVENTORY MANAGEMENT

by Jack K. Wirth and Nicholas J. Radell

that little had been accomplished in retailing in this area, and by our belief that the field of retailing presented an excellent opportunity for the application of OR techniques. We also felt that, because of our firm's dominant position in the field of retailing, we had an obligation as a firm to lead in the development of some new ideas and useful techniques which would represent a significant contribution to the management of retail enterprises.

The early research in the application of OR techniques in retailing suggested several problem areas which might benefit from a scientific approach. The determination of the size and location of warehouses or branch stores were problems suited to the use of mathematical techniques. Other questions of importance to management such as the effect on sales of night openings or promotional advertising were also suitable for the application of OR techniques. However, our preliminary research indicated that the area in which a significant impact could be made quickly was inventory management.

Inventory management is one of the most pressing problems facing retailers today. In the day-to-day operation of any store, a large number of inventory buying decisions must be made. With the growth in size of main stores and the addition of branch stores, the number of buying decisions have been multiplied to the point where buyers are finding it difficult to handle effectively the routine buying decisions and still devote the necessary time to other merchandising problems such as promotions and the selection of new items. As a result, many of these buying decisions are being made hurriedly based upon piecemeal information or are being relegated to untrained clerical personnel.

Upon considering this problem, it became apparent that the development of "decision rules" to assist a buyer in making inventory management decisions would represent a significant aid to the effective management of inventory. Operations Research and its associated mathematical inventory theory could furnish these decision rules.

This mathematical inventory theory is particularly applicable to staple, nonfashion merchandise which has a stable sales pattern and is frequently reordered. In typical department stores, it is estimated that the merchandise in from 25% to 50% of the departments would fall within this classification. These high reorder departments include such departments as housewares, hardware, drugs, notions, men's shirts, cosmetics, and others.

Taking all of these factors into consideration, the decision was made to direct our research on the application of OR techniques in retailing to the problem of inventory management.

Inventory Management System

Our objective was to design a system which could be utilized by a retail store in the management of departmental inventory without incurring significant additional cost for its installation or operation. The system had to be practical and one that could be operated by clerks with a minimum of supervision. The design of the system was, therefore, purposely made simple and unsophisticated.

The nature of retail merchandising imposed some other limitations on the system design. The system had to be compatible with existing monetary inventory controls and also be acceptable to the buyers and merchandise managers who would have to work within the requirements of the system.

With these factors in mind, we proceeded to design a scientific inventory management system which we called Selective Inventory Management, which in turn was referred to as SIM. Since its original conception, the basic principles of the system have received considerable publicity both within the firm and in retailing circles generally. The Management Sciences Division of the firm has issued a technical report on the system which should be referred to for a more comprehensive discussion of some of the basic concepts of the system.

The purpose of this article is to set forth in nontechnical terms some of the background and basic concepts of SIM. From this we hope that members of the audit staff particularly will better understand what SIM is and what it can accomplish in the area of inventory management. As will become apparent from this article, while SIM was designed to be used in the management of inventory in a retail department store, the principles of the system design are readily adaptable to industrial situations. For example, with some modification SIM could be used effectively for the management of inventory by an automotive parts supplier, a distributor of surgical instruments, or any enterprise where the inventory is characterized by a large number of items which must be frequently reordered.

Design Considerations

SIM uses two rudimentary scientific inventory formulas for determining "when" and "how much" of a given item to reorder. The mathematics used in SIM are neither complicated nor new to the theory of inventory management. The classical economic lot formula used in SIM has been known for years. However, the number of applications in retailing activities have been limited. There were two major reasons for this. First, when retailers attempted to apply mathematical inventory theory, they usually found that the installation and operating cost of the associated inventory system was prohibitive. Second, many retailers felt that it was too difficult to accurately forecast retail sales. Consequently, any formula which required the use of forecast sales would be inaccurate and could not yield better inventory decision information than a "rule of thumb" decision based upon a buyer's intuition or experience.

Preliminary investigation indicated that the first reason was a more fundamental objection than the second. Relatively simple forecasting rules have been used with acceptable accuracy in departments where the theory seemed most applicable. Therefore, the problem of developing a practical system using known mathematical inventory concepts appeared to be the principal obstruction in the application of the theory.

An inventory management system had to be designed which would provide the discipline of consistent decision rules applied on an item-by-item basis and yet which could be administered and operated by existing department store personnel with a negligible increase in operating costs. At the same time, the associated installation costs had to be small enough to assure their recovery in a relatively short period of time.

Selectivity

The major contribution of SIM to the theory of inventory management, and the underlying concept which makes SIM a practical system for the retail industry, is the reallocation of available management and control effort to each of the inventory items in proportion to their contribution to total sales of a department. By applying the concept of selectivity, effective management and control are obtained without prohibitive cost of operation.

In the departments studied, each item in the inventory tended to receive approximately the same amount of control effort under the existing systems. The departments studied carried from 2,400 to 6,000 items. Under SIM, control effort was redistributed so that those items which made the greatest sales contribution to the department were most carefully controlled.

To determine the items which made the greatest sales contribution to the department, the inventory was classified by annual dollar sales. This classificaion indicated that the items in the department's inventory would fall roughly into three groups, as follows:

CLASS	PER CENT OF ITEMS IN INVENTORY	ESTIMATED PER CENT OF TOTAL YEARLY SALES
A	10%	50%
B	40	40
C	50	10

This pattern of selectivity repeated itself in every department studied. Utilizing this information, we were able to classify the inventory into three groups which we identified as Classes A, B, and C. We then suggested a reallocation of available management and control effort so that the items in Class A would receive the largest amount of effort per item and Classes B and C items would receive correspondingly less effort. Some of the areas in which a reallocation of management and control effort was made, for example, were:

1. The forecasting of yearly sales and lead times
2. The review and updating of these forecasts
3. Stock counting
4. The setting of buffer or safety stocks

Mathematics

Having established the concept of selectivity and the associated reallocation of management and control effort, it became feasible to apply the mathematical formulas to compute optimum reorder quantities (how much to buy) and to determine the statistical reorder points (when to buy).

The formulas used for determining reorder quantities and reorder points are an essential element of SIM. The principal value of the formulas in the system is that they provide a basis for making consistent inventory management decisions for each item to which they are applied.

There is nothing complicated about the formulas used in SIM. They can be easily understood by anyone who is not bothered by the use of symbols rather than words to express a relationship of factors. For an understanding of SIM, it is not necessary to understand the mathematical derivation of the formulas or even to be able to perform the calculations necessary to solve the equations. Our technical staff has developed simple tables which can be used by the clients' clerical personnel for determining reorder quantities and reorder points.

Optimum Reorder Quantity

The optimum reorder quantity (Q) is the quantity of an item which is ordered each time the reorder point (P) is reached.

The formula used to determine the reorder quantity (Q) is:

$$Q = \sqrt{\frac{2 \cdot C_1 \cdot S}{C_2 \cdot i}}$$

Where

Q = economic reorder quantity (in units)
S = annual demand (in units)
C_1 = cost of placing an order (in dollars)
C_2 = unit cost of the item (in dollars)
i = cost of holding inventory (as a % of unit cost)

This is one of the simplest of the optimum (most economic) lot-size formulas. More comprehensive relationships have been developed which recognize additional factors such as the cost of being out-of-stock.

A considerable amount of research effort was devoted to the study of the cost of ordering and holding inventory (C_1 and i). While the elements of cost which made up these factors could be defined with some degree of exactness, it was not possible to measure many of these costs with more than a general approximation. However, the useful application of the reorder quantity equation is not dependent upon a more accurate measurement of these costs.

Many past attempts to use the economic lot-size formula in the management of inventory never got beyond the frustrating study of determining finite values for these cost factors. The cost factors must certainly, to some extent, be imputed rather than determined by analysis. A successful if not theoretically ideal application of the formula can be achieved by employing imputed cost factors.

Statistical Reorder Point

The other formula used in SIM to determine the statistical reorder point (P) is:

$$P = B + \overline{m}$$

Where

P = reorder point (in units)
B = buffer or safety stock (in units)
$\overline{m}$ = average demand during the replenishment period (in units)

This formula says that the reorder point (P) is equal to ($\overline{m}$) the estimated sales of the item over the period of time required to get delivery of the item from the supplier plus (B) a buffer or safety stock. When the number of items remaining in stock and on order is equal to or less than the reorder point (P), the reorder quantity (Q) should be ordered.

Since $\overline{m}$ is an estimate based upon average sales rates per day and average lead time in days, it is expected that the sales rate or lead time, or both, would fluctuate above the average at least half the time. This would cause an out condition to develop unless a buffer or safety stock is provided. By assuming that the average demand will fluctuate in accordance with a known statistical distribution such as the Poisson* distribution, we are able to determine the buffer stock necessary to protect against fluctuations. A probability of going out-of-stock can also be associated with the size of the buffer stock. Since the

The Poisson distribution is a mathematical distribution function which is commonly used for measuring the probability of events which have a small probability of occurrence.

buffer stock is determined based upon a statistical distribution and associated probability, the reorder point is referred to as a statistical reorder point.

To approach a 100% probability that an order will be delivered before the stock of an item is exhausted would require a prohibitively large buffer stock. However, the retailer is able to specify a 95% or even 98% probability requirement and accordingly determine a buffer stock which will produce the desired result.

Again we would like to point out that the formulas discussed above are the classic inventory management formulas. They demonstrate the basic principles of the system. More sophisticated formulas have been developed and are being used in SIM installations.

Evaluation

Once the system had been designed, it was necessary to prove its value to retailers. To do this, the system was evaluated in terms of what the average inventory investment, number of days out-of-stock, and number of orders written would have been in the departments studied if the proposed system had been used during the year prior to our study. The Operations Research technique of "System Simulation" was used in this evaluation which was carried out using a randomly selected sample of items from each department studied.

For each of the items in the sample, historical stock data were obtained and plotted to show the item's inventory history during the test period. Average inventory investment, number of days out-of-stock, and number of orders placed were determined for each item. Totals for each of these factors were obtained for all items in the sample.

After the actual inventory histories were plotted, a simulated history was determined for each of the items based upon the reorder quantities and reorder points established by the formulas but using actual lead times and sales rates. Average inventory investment, number of days out-of-stock, and number of orders placed were determined for each simulated history. Totals of each of these factors were obtained for all simulated histories and compared with the actual histories.

The results of the evaluation showed a reduction in all three factors from the use of the proposed system. Days out-of-stock were reduced by 66 per cent in one of the departments studied and by 20 per cent in the other department. At the same time, average inventory investment was reduced by 22 per cent in the first case and by 31 per cent in the other. Number of orders written was reduced slightly in each instance.

Through the system simulation, we were able to demonstrate to the retailer that by using an inventory management system which utilized mathematical formulas, within a system design based upon the concept of selectivity, he would be able to achieve reductions of both average inventory and number of days out-of-stock. Furthermore, he would be able to do this with an inventory system designed to be operated by his present personnel.

Several of the retailers were somewhat skeptical that the proposed system could achieve a reduction of both average inventory and number of days out-of-stock. In order to understand how the use of mathematical formulas made this improvement possible, it is necessary to understand how changes in inventory affect days out-of-stock. As average inventory increases, the expected number of days out-of-stock will decrease, *but not in direct proportion*. The converse is true for a decrease in average inventory. As a result, the mathematical formulas will reduce inventories of items which were overstocked and increase inventories of items which were critically understocked. Because of this nonlinear (not in direct proportion) relation between average inventory and days out-of-stock for each item, the net result can be a decrease in both inventory investment and days out-of-stock for the aggregate inventory.

Other Benefits

It is also important to recognize that by the use of the formulas it is possible for management to trade off inventory investment against stock-outs. The retailer may specify the desired in-stock condition for a department and the system will provide the minimum level of inventory investment and the fewest number of orders written consistent with this decision.

In addition to the potential improvement in customer service brought about by a reduction in stock-outs and the cost savings realized from the reduction in inventory investment, there are many other benefits which are by-products of the system. The most apparent of these are the improvements in the administrative procedures of the department as they relate to inventory management. The establishment of a disciplined manual system for the management of inventory also provides a sound basis for the extension into the use of electronic data processing equipment. As another by-product of the system, buyers are furnished with more item information on which to base promotional decisions and decisions with respect to items to be added or dropped from the inventory.

What a client thinks of SIM

The following comments setting forth many of the benefits which are by-products of a SIM installation have been extracted verbatim from an internal memorandum prepared by the Divisional Merchandise Manager of the Housewares Division at one of our clients where an installation of SIM is being made in selected departments in the Housewares Division. The memorandum was addressed to the Merchandise Manager of the Home Division.

"The many unexpected and cost reducing benefits resulting from the as yet unfinished first year plan promise favorable budget reductions. Here, aside from the high 'in stock' position already achieved by Selective Inventory Management, is a list of the known benefits:

1. The Dennison stock control system is not needed in Paints, since the high 'in stock' position permits us to forward all send saleschecks to the warehouse without the need for attaching a Dennison sticker.
2. As an indication of the systems efficiency, we are pleased to report that the average number of daily unfillable warehouse sales tips is less than one per day per store.
3. While this is difficult to measure (we'll have actual figures after the completion of a full year) we have reduced paint transfers to each store, for further delivery to customers, by well over 20% compared to 1958.

   In other words, more deliveries are being effected through warehouse stocks, instead of store stocks, since all salesforces are now confident saleschecks will be filled promptly. This really results in a double saving — (1) eliminating many transfers to the stores and (2) returning sends to the delivery stations.
4. Mr. ____, the Assistant Buyer, estimates that SIM reduced the time he gives to reordering merchandise by two hours a day, freeing him for other supervisory work.
5. Mr. ____ further reports an intangible but still considerable clerical time saving in order writing. This amounts to approximately an

hour per day. In addition, another hour per day is saved by eliminating the posting of receipts in branch store books.

6. Since orders are written based on warehouse stock only, orders can be written the same day as the count is taken and confirmed the following day, whereas in the past it took some time to get stock counts from all locations before orders could be written.
7. Everyone concerned also agrees that counting of inventories is not only more efficient and accurate (something rarely achieved under other systems) but this too reduces costs through time saved. Considerable time is saved for improved customer service and more effective selling, because demonstrators no longer maintain their own stock books, go to the warehouse to take stock counts, and fill their own requisitions at the warehouse as they customarily did. This savings amounts to approximately four hours daily.
8. Perhaps most important of all is the excellent morale of our salespeople. They now know that stocks are in good condition, and that promises of delivery to customers can be confidently made and fulfilled.

Jack K. Wirth
Detroit

After receiving his MBA from the University of Michigan and spending three years in the Air Force, Jack Wirth joined TRB&S in 1954. On February 29, Mr. Wirth left to accept a position with the Continental Aviation and Engineering Corporation.

Nicholas J. Radell
Management Sciences

Both a CPA and a registered Professional Engineer is Nick Radell, a graduate of the University of Michigan. In his work he has been concerned mostly with the application of Operations Research techniques to the retail industry.

9. The requisition-count sheet form, replacing the branch stock books and the inter-store requisition, designed for the SIM system is so efficient and carries so much more information than the inter-store transfer, that every buyer in this division wishes to adopt this form. Unfortunately, this is not possible for wide acceptance since the warehouse sequence stocking of reserves is not coordinated with the item listing on the requisition-count sheet requisition."

Development effort is being continued to further refine SIM and add more sophisticated OR techniques to its design. In addition, consideration is being given to the eventual adaptation of the system to electronic data processing equipment.

Members of our Audit and Management Services staffs are encouraged to become familiar with the basic principles of SIM and what it can offer our clients in retailing and in other areas. We can perform a real service for our clients by making them aware of this improved system for the management of their inventories.

Executive Partners Meet in New York

Kenneth Mages points out needed change in executive office's new layout to Managing Partner John W. McEachren and Robert Beyer (both seated). Looking on are (from left) Wallace M. Jensen, Thomas J. Ennis and Donald J. Bevis.