SIMCON I: A COMPUTER BASED SIMULATION MODEL FOR EVLUATING PHYSICAL DISTRIBUTION
STRATEGIES INVOLVING ORDER CONSOLIDATION

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ABSTRACT

Business firms selling to customers buying in small quantities are faced with the problems of rising transportation costs and record high interest rates on capital used to finance inventories and warehouses. One method for dealing with these problems is to consolidate small customer orders into volume shipments for transportation to breakbulk points located within clusters of customers. The following article describes a simulation model which has been used to evaluate the effects of major variables influencing the cost and service performance of a physical distribution system employing an order consolidation strategy.

INTRODUCTION

Many business firms, especially those marketing packaged consumer goods, must ship large numbers of small orders to their customers. Small shipments are a problem because per unit transportation costs are much higher for smaller shipments than for larger ones and because future cost increases are expected to be disproportionately borne by small shipments [4, p. 47]. Thus, shippers are feeling increasing pressure to ship in larger volumes. However, due to rising capital costs, customers are ordering in smaller quantities in order to reduce their inventory and storage facility investments [1, p. 1]. Customer ordering practices are therefore frustrating the efforts of sellers to ship in larger quantities.

SMALL SHIPMENT STRATEGIES

There are three basic distribution strategies which are employed by business firms to distribute small customer orders [3, p. 32]. The basic strategies are (1) less-than--truckload (LTL) shipments directly from the plant warehouse to the customer, (2) field warehousing where the product is shipped in volume to a warehouse in anticipation of demand, and (3) order consolidation, whereby less-than-volume orders destined for the same geographic area are combined to form volume, intercity shipments to a centrally located breakbulk or pool point in that area. From the breakbulk point they are distributed in less-than- volume quantities to their final customer destination. Order consolidation differs from field warehousing in that inventory is not moved to the market in anticipation of demand. Goods are only shipped when a customer order is in hand.

Order consolidation compared to LTL direct has certain advantages and disadvantages. The primary advantage is that order consolidation can result in lower transportation costs than shipping LTL direct. Unfortunately, cost savings may be secured by increasing the length and variability of the order cycle thereby downgrading the customer service level. The customer service level nay suffer because consolidation is achieved by accumulating orders over a period of time which may vary depending on the uncertain time of arrival and size of incoming orders. However, order consolidation offers faster transit times which may offset the time required to consolidate the orders and fewer handlings which produce lower risk of loss and damage. The disadvantage of order consolidation, besides possibly increasing the length and variability of the order cycle, is the administrative effort required to plan, operate and maintain an order consolidation system.

Field warehousing, where product is shipped to a forward position in the market and stored in anticipation of demand, compared to order consolidation, produces shorter order cycle times but results in higher inventory levels, increased storage costs and extensive administrative efforts. The disadvantage of order consolidation may be the order accumulation period necessary to combine orders for shipment.

For the shipper faced with rising transportation, capital and inventory costs, declining service and increasing numbers of small shipments, order consolidation offers advantages over both LTL direct and field warehousing.

The challenge in designing an order consolidation system is to reduce transportation and inventory costs without unreasonably damaging the customer service level of the existing system. To properly plan and analyze possible system designs several conditions must be met.

1. The technique chosen must be able to handle a level of detail equal to individual orders and on a daily basis to capture the interdependence of individual orders and days.

2. The stochastic nature of the problem must be captured including the number of orders received per day, the weights of these orders and their origins.

3. Both cost and service measurements must be possible since they represent the primary trade-offs in a consolidation system. That is, costs can be reduced by lengthening order cycle time.

4. Customer locations cannot be aggregated beyond a level which will provide reasonably accurate results. There is a trade-off between accuracy and complexity since most firms will have thousands of customers with each location requiring freight rates and some measure of service tine.

5. It must be possible to manipulate the major variables in the system such as redistribution points, holding times for orders, order frequency and weight and shipment dispatching rules.

Considering the above requirements for planning an order consolidation system it appears that the problem is too large and complex to be handled efficiently by means of a manual technique and the stochastic nature of the problem precludes the use of a mathematical programming technique. The technique chosen to analyze the order consolidation system was a computer- based Monte Carlo simulation model.

DESCRIPTION OF THE MODEL

SIMCON I is a large scale computer-based Monte Carlo simulation model programmed in FORTRAN which is capable of simulating a national packaged goods physical distribution system employing shipment consolidation and! or an LTL direct strategy.

The major features of the model are:

1. SIMCON I is an order by order, day to day simulation model.

2. SIMCON I is stochastic, employing user defined probability distributions to determine the weight of each order and its origin.

3. Temporal and economic measures of system performance are incorporated in the model, e.g., the transportation cost and order cycle time of each order is determined.

4. SIMCON I is capable of modelling networks consisting of from 1-20 plants, 0 to 72 redistribution points, and 399 markets.

The following sections describe the inputs required by the model and how it operates.

Model Inputs

SIMCON I requires several sets of data which are dependent on the network of plants (origins), and pool points specified by the user, and on the characteristics of the order stream of the system to be simulated. The network inputs will be discussed first.

For the purposes of the model, the U.S. market is divided into 399 sub-markets corresponding to the U.S. Postal System's three digit zip codes. Each of these 399 points can be specified as a plant or a pool point.

Once the user specifies the plants, the pool points to be included in the network, and the markets assigned to each pool point, the freight rates and miles linking the points in the network must be provided. Freight rates are needed to calculate transit times. SIMCON I is structured to handle actual freight rates, but if desired, it could estimate freight rates based on regression analysis.

Markets are assigned to pool points on the basis of least cost. All orders destined for a particular market can be assigned to a single pool point or to a variety of pool points based on their weight. For example, it may be cheaper to ship orders in the 10,000 to 15,000 lb. weight group destined for Market A through pool point X while orders weighing less than 10,000 lbs. are shipped through pool point Y.

The user must also specify the following characteristics of the order stream to be simulated:

1. The number of orders to be generated each day.

2. The probability of an order being generated for each of the 399 markets. In other words, for each of the 399 markets, what is the probability that a particular order originated from that point?

3. A probability distribution of order weights. In other words, given a particular order, what is the probability that it has a certain weight?

4. The number of days orders should be generated. That is, the length of the simulated period, typically 40 to 60 days, is sufficient to provide reliable information.

Once the inputs are available the model can be used to simulate the operation of the particular order consolidation system specified. The operation of the model is described next.

Operation of SIMCON I

SIMCON I is composed of the following four components: (1) order generation and pool point assignment, (2) order shipment, (3) shipment arrival, and (4) output data. Figure 2 presents a simplified flow chart of SIMCON I. Each of these components is discussed below.

FIGURE 2
FLOWCHART OF SIMCON I
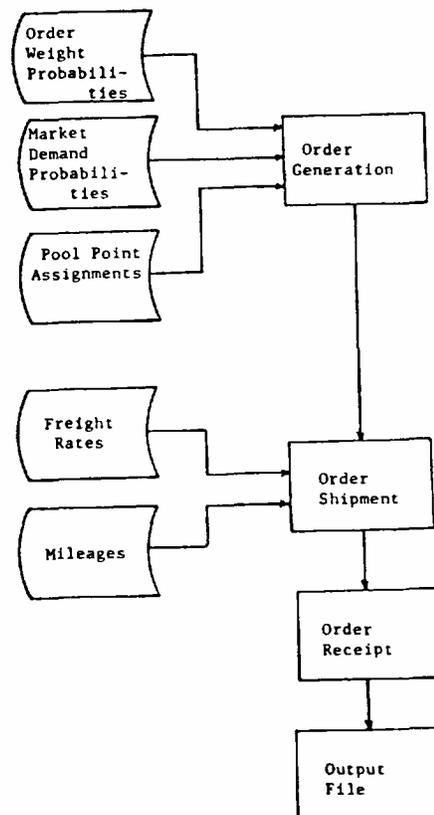
SIMCON I begins the simulation by generating an order. For each order, the location or source and the weight are determined using the probability distributions provided by the user and a random number generator. Once the location of the order is known, it is assigned to a pool point or to the plant for LTL direct delivery. When the specified number of orders has been generated, processing moves to the shipping component of SIMCON I.

There are several steps involved in shipping an order. First, a decision must be made whether, on a particular day, an order should be released. If the decision is made to release it, the transportation costs and transit time must be determined. The order release decision will be discussed first.

There are several alternative strategies available in

determining when orders should be released for shipment. These optional order release strategies are described below:

1. Scheduled Sailing. With this strategy, all orders which can be consolidated are held until a predetermined date. On the shipping date all orders are released regardless of their consolidation status. This strategy has the advantages of ease of application and order cycle consistency but many orders may not be consolidated.

2. Scheduled Sailing and Volume. This strategy is a variation of Scheduled Sailing described above and is the same except that if a pool point accumulates sufficient orders to reach a predetermined weight, the pool shipment is released prior to the scheduled sailing date. This strategy has the advantage of speeding up shipments but it will increase the variability of the order cycle and it may strand some orders which would have been consolidated if the pool shipment had waited until the scheduled sailing day.

3. Maximum Holding Time. The firm using this strategy will hold all orders for a pool point until the oldest order reaches a predetermined maximum age at which time the shipment is released.

4. Minimum Weight. With this strategy all orders to be moved through a particular pool are held until their combined weight exceeds a certain minimum weight.

It is also possible to develop several hybrid order release strategies from these primary strategies. Combining strategies 3 and 4 above is probably the most likely.

Once the decision is made to ship an order, the transportation charges and transit time associated with it must be determined.

If the order has been consolidated, the freight charges from the plant to the pool point, using the consolidated shipment's weight, and the freight costs from the pool point to the customer, using the individual order's weight, must be determined. If the order was not consolidated, the rate from the plant to the market is determined. These costs can be determined using actual or estimated freight rates. Actual freight rates can be more expensive to obtain and are more cumbersome to handle but they are more accurate.

Transit time calculations are based on the weight of the shipment and the distance it must travel. For example, an LTL shipment traveling the same distance as a TL shipment would be expected to experience a longer transit time than the TL shipment. Likewise, for two shipments of equal weight traveling unequal distances, the one traveling the shorter distance could be expected to experience a faster transit time. Also, LTL shipments may suffer greater variability in transit times. All of these factors are built into the transit time calculation and can be determined either from an individual firm's records or from other sources [2].

The order which is consolidated will experience two transit times: the time from the plant to the pool point and from the pool point to the market. The LTL direct shipment will have one transit time from plant to market but it may be longer than if it had been consolidated because of the faster TL movement from the plant to the pool point for the consolidated movement.

The transit time is used to determine the date the order will arrive at the customer's receiving location.

At the end of each simulated day, SIMCON I looks through the order file for those orders due to arrive on that day. The orders due to arrive are transferred to the output file.

Output Data

For each order which has reached its final destination, the following information is collected:

1. Ship to location of the order.

2. Pool point the order passed through if it was consolidated.

3. Plant (shipment origin).

4. Total transportation cost per hundredweight per order.

5. Order weight in hundredweight.

6. The weight of the consolidated shipment the order was part of.

7. The day the order was generated.

8. The day the order was shipped.

9. The day the order was received by the customer.

From this data base, statistics can be computed to answer virtually any question concerning the transportation cost and service performance of the consolidation system by plant, pool point, region, individual market or other factor. Service performance can be evaluated by computing the length and variability of the order cycle and transportation cost is merely the total transportation rate multiplied by the weight in hundredweight.

APPLICATIONS

SIMCON I has been used to investigate the following relationships:

1. The effect on cost and service of increasing the number of redistribution points.

2. The effect on cost and service of varying the volume of orders flowing through the firm.

3. The effect on cost and service of varying the amount of time orders are held to achieve consolidation.

4. The effect on costs of different order stream distributions having the same average and variance but skewed to the left, the right and normal.

5. The effect on costs of using different dispatching rules. For example, releasing consolidated orders as they reached a minimum weight or releasing on a strict schedule such as every third day.

SUMMARY AND CONCLUSION

Order consolidation has been recognized as a very important distribution strategy for dealing with the problems of rising LTL freight rates, inventory carrying costs, increasing capital costs, and the tendency for customers to place smaller orders. A computer-based simulation model, SIMCON I, was developed to provide a flexible and practical method for evaluating order consolidation strategies in a physical distribution system. The model has thus far been used to investigate in an experimental environment a number of major variables and relationships which are important to the design of an order consolidation system.

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