INVENTORY COST DEFINITION IN AN EOQ MODEL APPLICATION

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Although EOQ is robust to errors in its parameters (annual demand, order cost, and carrying cost), application of this lot-sizing method has sometimes led to results that range from "disappointing to disastrous" according to Adkins [1]. When applying the EOQ methodology in materials management and procurement, the validity of the input parameters to the model is often taken for granted, or their need for accuracy discounted because of the "robustness" of the model. In fact, very often substantial miscalculations or misinterpretations occur when determining these parameters (more specifically, carrying cost and order cost), particularly when based on average cost rather than marginal cost estimates.

Finding carrying and order cost inputs for EOQ lot sizing leads to the problem that financial accounting does not accumulate these costs. Instead, they must be reconstructed by management accountants if they are to be supplied from past accounting data. This process of reconstructing costs for use in inventory models may be difficult when a communications gap exists between materials management or procurement and accounting. When requesting relevant cost information it is not sufficient to communicate so you can be understood; one must, especially when dealing with accounting, communicate so one cannot be misunderstood.

Cost definition in terms of what should be supplied to inventory models, what will probably be supplied by indistinct cost definitions, and the possible impact both in general and for one specific example are described.

MODEL REQUIREMENTS

The lot-sizing problem is basically a decision on how much to order rather than how much inventory to hold, where to hold it, or how to supply inventories to production or marketing. The optimal size per order is a matter of the costs related to lot size, and in the classic model there are only two. One is the cost of order processing, which can be reduced by having few orders of large size, and the other is holding (carrying) cost, which is proportional to the average inventory on hand and is thus reduced by having frequent (small) orders. The model is traditionally solved for a year-long planning horizon by assuming (1) that the number of orders (units demand over units per order) times cost per order is total ordering cost and (2) that one-half the units per order is average inventory held. In the classical formulation two accounting numbers are required: cost per order processed and cost of holding the average inventory on hand (usually expressed per unit per year or as a percentage of unit cost).

The communication failure of accountants trying to provide relevant information to materials management, or of materials managers trying to make sense of accounting data, can make determining these costs difficult. In either case, both the inventory function and the whole firm may be victim to a costly accounting pitfall.

THE ACCOUNTING PITFALL

Consider the case where you would like an order cost to determine the EOQ. The controller does not have an order cost figure already prepared for you, but after some investigation and consultation with the purchasing department it is found that approximately 80% of the purchasing department costs are for materials order placing, follow-up, and receiving. Next the stationery accounts are consulted, and 25% is prorated (allocated) as the portion of paper costs being used for processing. Likewise, other accounts such as telephone, telex, telegram, and postage might also be prorated based on the share of costs which are assumed to involve order processing.

Suppose that eventually all relevant accounts are considered and that your allocations are not far from the true share attributable to order activities. You
would then have the total cost of all orders processed during the accounting period. Dividing that cost total by the number of orders placed that period yields a rough estimate of average order cost which, as St. John [2] notes, is not appropriate for the EOQ formula. Instead, we want the marginal or incremental cost of placing an order. In other words, we want the amount ordering cost would increase if we placed one more order per period, or the amount we would save if we placed one less order per period.

The optimality of the EOQ model is based on the trade-off between marginal order cost versus marginal carrying cost, making up marginal total cost. Any fixed costs of the ordering function or of the carrying function are irrelevant to the lot-sizing question, but would be left in an average cost estimate. Fixed costs are expenditures that do not change with the volume of orders placed or, conversely, with the size of each order. Fixed costs of ordering include all the investment in equipment, staff, and supplies we must have to do ordering at all. Since the EOQ is computed for each stock-keeping unit (SKU) separately, it is obvious that most of the ordering function costs (typewriters, computers, staff on contracts, etc.) are fixed and hence not affected by placing one more order.

Likewise, carrying costs, if calculated for the marginal unit held of a particular item, must consider the warehouse building, equipment, staff, and such costs, as fixed. Averaging fixed costs is required by some financial accounting regulations, but is often distorting in management accounting applications. Averaging total costs is an easy solution to the cost estimation problem but may provide obviously irrelevant figures, or more dangerously, figures apparently good enough for use. Demonstration of this pitfall by means of an example follows.

EXAMPLE PROBLEM

The following data are used for calculation of order costs using the average and marginal methods, respectively. A similar approach can be taken to demonstrate the effect on carrying cost.

<table>
<thead>
<tr>
<th>Relevant Expenditures</th>
<th>Number of Orders Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year one</td>
<td>$ 253,355</td>
</tr>
<tr>
<td>Year two</td>
<td>250,214</td>
</tr>
<tr>
<td>Year three</td>
<td>256,337</td>
</tr>
<tr>
<td>Year four</td>
<td>261,440</td>
</tr>
<tr>
<td>Total</td>
<td>$1,021,346</td>
</tr>
</tbody>
</table>

Average Method

Average cost per order = $1,021,346/8236
= $124/order

Average number of orders = 2059

Average purchasing expenditure = $255,336.5.

Marginal Method

Simple linear regression would be the most straightforward technique to separate fixed from variable order costs, where the estimated regression line would be:

Total estimated order cost = Fixed order cost
+ (Variable order cost/order) \times \text{ (number of orders)}

Using the above data we obtain:

Total estimated order cost = 139,919
+ (28.37) \times \text{ (number of orders)}

(See Figure 1.) For example, total estimated order cost for year 4 would be 196,919 + 28.37(2259) = $261,010.

Comparative Results

Notice the difference in predicted order cost using the average and regression methods:

<table>
<thead>
<tr>
<th>Orders</th>
<th>Actual Cost</th>
<th>Average Estimate</th>
<th>Regression Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>353,355</td>
<td>247,400</td>
<td>253,520</td>
</tr>
<tr>
<td>1845</td>
<td>230,205</td>
<td>228,798</td>
<td>249,264</td>
</tr>
<tr>
<td>2137</td>
<td>256,337</td>
<td>265,009</td>
<td>257,549</td>
</tr>
<tr>
<td>2259</td>
<td>261,440</td>
<td>280,138</td>
<td>261,010</td>
</tr>
</tbody>
</table>

The average method provides reasonable estimates for order volumes near the average of the four periods used in computing the average cost. However, it overestimates order cost in years with more orders and underestimates it in years with fewer orders. Not only is the average method less accurate in individual years, but its errors have a pattern which statisticians call "bias." The regression estimates are fairly good in all four years and also about equally good across those years, a property which lends some credence to the assumption that the estimate for next year will also be reasonable.
For application of these alternative cost figures in the EOQ model a few assumptions are necessary but reasonable:

* Demand = 1,000,000 units per year

* Variable holding cost = 15% (cost of money)

* Purchase price of units = $10

Average method EOQ

\[ = \sqrt{\frac{2 \times 1,000,000 \times 124}{10 \times 0.15}} = 12,858.2 \]

Regression method EOQ

\[ = \sqrt{\frac{2 \times 1,000,000 \times 28.37}{10 \times 0.15}} = 6150.33. \]

Since the fixed costs are the same under the two proposed methods of cost estimation and are not affected by the order lot size, one might just compare the relative impact of both estimation methods on the controllable portion of inventory cost.

Under the EOQ model the relevant inventory costs are

\[ RIC = VO(D/Q) + VH(Q/2), \]

where

* VO = variable order cost per order,

* D = annual demand in units,

* VH = variable holding cost per unit per year,

* Q = order lot size in units.

We would then obtain:

Average method RIC = \[ 28.37(1,000,000/12,858.2) + 10(0.15)(12,858.2/2) \]

\[ = $11,849 \]
Marginal method \[ \text{RIC} = 28.37(1,000,000/6,150.33) + 10(0.15)(6,150.33/2) \]
\[ = $9,225. \]

While at first glance we may say it was only a difference of a few thousand dollars for improperly using the model, it can be noted that the difference is 28% above the cost of the real EOQ.

CONCLUSION

While robust to estimation errors, the common EOQ model and others like it are not prepared for accounting definition errors which are often relatively high. Using the EOQ-type lot-size model is bound to provide frustration when the model's inputs are poorly defined. Using correct estimates of input parameters to the EOQ lot-sizing model can only give better results relative to overall improved company performance. A clear channel of communication and information between the materials management and accounting functions may well be the key to success.

REFERENCES


About the Authors—

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