

Exploring Inventory Models with SAS/AF® software FRAME Entry

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Abstract

When considering the optimal inventory to keep in stock, managers are faced two conflicting objectives. Sufficient inventories must be maintained to meet the demand for goods, while simultaneously keeping the inventory holding cost incurred at the lowest possible level. Various quantitative models have been developed to assist managers in determining when and in what quantity to order replacement stock. Of these models, the deterministic and the probabilistic are the most common. This paper will demonstrate how SAS/AF® software FRAME can be used to develop an interactive application that can be utilized to illustrate the salient features of these two models.

Introduction

The typical four year undergraduate degree program in information systems consists of supporting business courses in accounting, economics, finance, management and marketing as well as the technical courses related to fundamental computer concepts, information technology, data communications, and systems theory and development (Data Processing Management Association, 1991). It is assumed that exposure to both the business and technical environments will lead to an integration of these two areas of study. Students as well as the business community indicate that this integration is perhaps not as complete as it should be (Wang, 1995; Wakin, 1995).

This application was developed to address two distinct objectives. The first and foremost objective is to teach SAS/AF, and SAS/SCL® software as they are utilized in the business environment. This application is introduced in a senior level software development class, where SAS is the primary language. The students are all majors in information systems and have completed one semester of COBOL and at least one semester of object-oriented programming with C++. Because this application is introduced in the middle of the course they have also written numerous applications using other components of the SAS system, such as SAS/STAT®, SAS/GRAPH®, and SAS/OR® software. Restated, this first goal is to teach students another development tool that can be applied to problems that are inherent in a business enterprise.

The second objective is to reinforce the material that was learned in management science related to inventory control. The incorporation of various aspects of inventory control

models in the SAS application requires that the student be proficient at software development and understand the fundamentals of quantitative approaches to decision making.

Inventory Control Models

Although the primary purpose is to demonstrate the utility of the SAS system, a brief introduction to several common inventory models is given. Inventories represent the resources and material maintained by companies that are not currently being used. While these idle resources possess potential economic value, there are also costs. These costs include insurance, taxes, breakage, pilferage, warehouse overhead and last, but not least is the cost of capital. Reducing inventories generally reduces these costs, but can lead to disrupted production activities and poor service for customers. Therefore a balance must be maintained. The most common models to address this problem are the deterministic and probabilistic inventory models.

The deterministic models assume that the demand for goods or services is constant over time. The Economic Order Quantity (EOQ) model is the most fundamental model that makes this assumption (Anderson, Sweeney, & Williams, 1992; Monks, 1994). Total annual cost is viewed as a function of the annual order cost and the annual inventory holding cost. There is an inverse relationship between the last two costs. Increasing the order size reduces the annual order cost because fewer order will be placed, but increases the annual holding cost because there will at any given point in time be more stock in inventory. When these last two costs reach an equilibrium the annual total cost is minimized. The order quantity at this point is the economic order quantity. Once this figure has been derived, the reorder point and the cycle time can be established.

A variation of the EOQ model is utilized where there are discounts for large quantity purchases. Frequently suppliers provide an economic incentive for large orders by reducing the cost per unit. Once again the primary objective is to minimize the annual total cost. The calculations require several iterations, but the goal is the same.

Another variation of the EOQ model is where it is desirable, from an economic viewpoint, to have planned shortages or stockouts. This situation most frequently occurs when the unit cost per item is extremely high and hence the inventory holding cost is high. Examples might include luxury automobiles or jet liners. In this situation it is assumed that

the customer will not withdraw the order if the stock is not on hand. In addition to order cost and inventory holding cost, this model also incorporates the cost associated with back orders.

The probabilistic models assume that the demand and the lead time may be uncertain. The common approaches employ safety stock, expected value, a balance between incremental cost and incremental gain. For this application only the safety stock approach is applied. It requires that demand or lead time can be approximated by a known statistical distribution or that there is empirical data which will allow the appropriate probability distribution to be generated. Once a desired service level has been stated, statistical techniques can be used to determine the appropriate safety stock and order points.

The Inventory Control Application

The inventory control application consists of fourteen FRAME entries as shown in Figure 1.

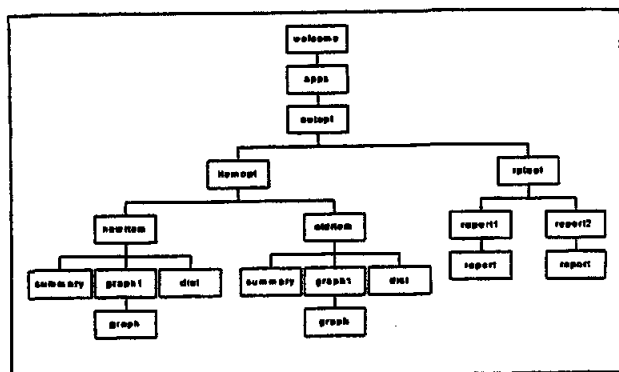


Figure 1. Inventory models

Each of the FRAME entries is associated with a corresponding SCL entry. The SCL entries are comprised of sections labeled INIT, MAIN, and TERM. In addition, most of the SCL entries have additional sections with names that correspond to the push button control objects that are defined in the FRAME entries. The welcome screen, shown in Figure 2, simply displays a text label for the title,

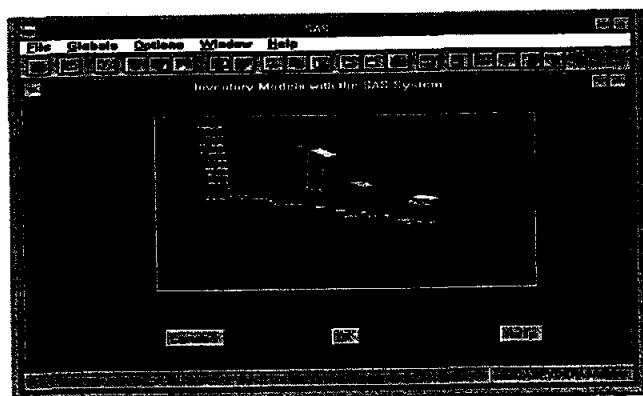


Figure 2. The welcome screen

a graphic OLE® paste object originally created in CorelDRAW® and three push buttons. This particular screen is typical of most of the FRAME entries in this application in that they incorporate imported graphics and have three or more control buttons. The "Cancel" push button always issues a cancel command, while the "Help" push button always issues a simple message that is then displayed in a text entry box. The help message varies from FRAME to FRAME, but is always at most one line of text. The "OK" push button usually initiates the processing and frequently invokes another FRAME entry. In this case selecting the "OK" button causes the "apps" FRAME entry to appear.

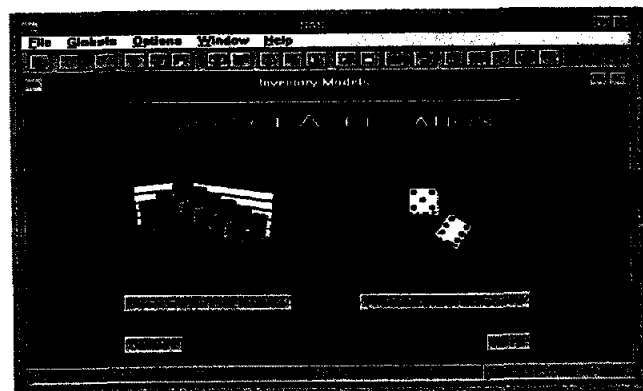


Figure 3. The initial menu screen

As can be seen from Figure 3, this is where the decision is made between using a deterministic or a probabilistic model. If the demand and the lead time are known, the deterministic model would be appropriate. The impact of this decision will be reflected in the options that are presented on future screens. If a probabilistic model is selected for instance, then at some point in time the appropriate probability distribution must be determined. If a deterministic model is selected, then probability distributions are not utilized.

The next FRAME is used to ascertain the type and media for the applications output. As Figure 4 shows, a graph can be generated for a specific item or a report can be created for the 200 items that are included in the default inventory

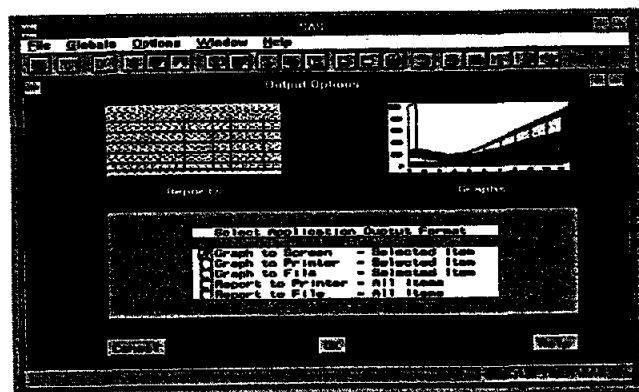


Figure 4. Output options

file. The choices that can be made are represented by a series of radio buttons. Each button represents one of the mutually exclusive options. One of the benefits to radio buttons is that additional options can be added with very minor modification to the FRAME entry or SCL program.

If a report is the desired output, then the FRAME entry titled "rptopt" is invoked to determine the options for the reports. The default inventory file has the necessary information for each of the 200 items to calculate the appropriate order quantity and the reorder point using either a deterministic or probabilistic model. Options for quantity price discounts and planned shortages can also be selected. The options once selected are applied to all the items in the file. The reports are created in essentially a batch environment and are as such not the major focus of the application.

If on the other hand graphs are selected to be form for the output, information about the individual item must be gathered. The screen shown in Figure 5 is the initial vehicle

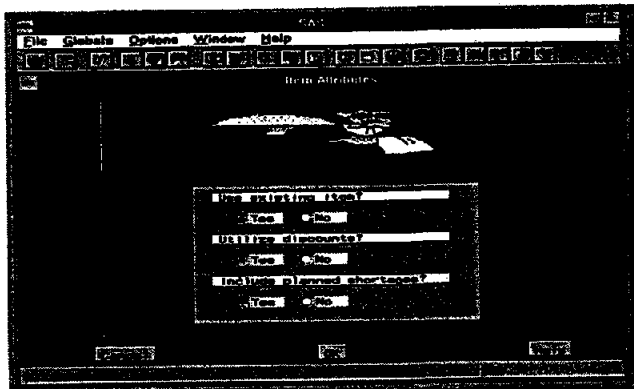


Figure 5. The item attributes screen

for accomplishing this task. This screen is used to determine if the item exists, whether discounts for large quantity purchases should be taken into consideration, and whether planned shortages should be anticipated. At this juncture a data entry screen would appear for either a new or an existing item. The simpler of the two is data entry screen for an existing item as depicted in Figure 6. Because this item and the necessary data elements are present in the

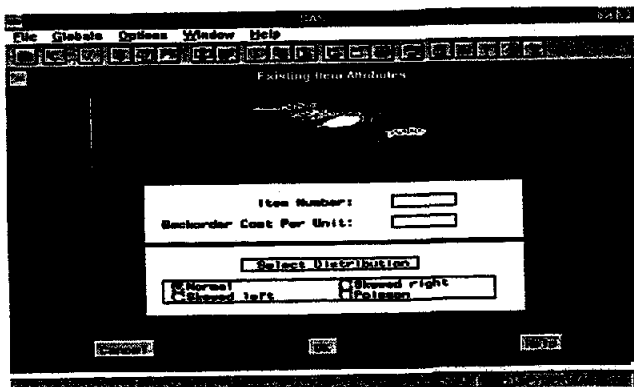


Figure 6. The existing item data entry screen

default inventory file the only item that is required is the item number. The last two items are hidden and do not appear unless the type of model to be generated requires them. For example, if there are no planned shortages, then there is no cost associated with back ordered items. By the same token, if a deterministic model is desired, then the demand and the lead time are assumed to be constant and a probability distribution is not used.

If the item does not exist more information about the item is needed. Figure 7 shows the data entry screen for a new item. As with existing items, only the fields that need to be

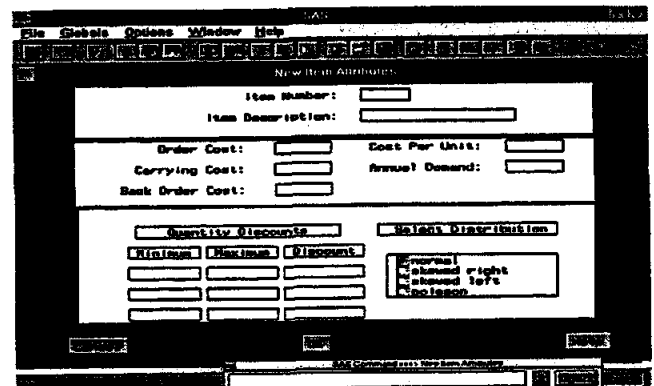


Figure 7. New item data entry screen

filled in will appear. Those entries that are not relevant for the particular type of model that is being developed are hidden when the FRAME is initialized. After either the existing or new item data entry screen is completed the existing is ready to be produced. Selecting "OK" from either of these screens starts this process in motion. In actuality there are two screens that depict the output for a single item. The first is a graph similar to that shown in figure 8. The

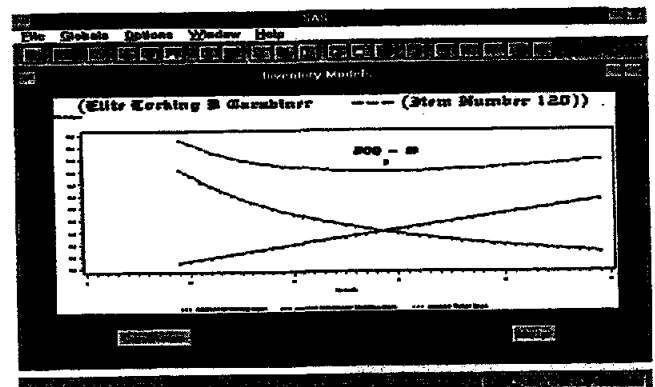


Figure 8. A typical graphic output screen

actual format will vary from one type of model to another. The details of this particular graph will be discussed later, when an example and the actual data are presented. The

other output is a single screen that provides a text summary of all relevant data. Figure 9 is an example of this form of output. This output screen contains essentially the same information that is presented in the graph. The graph has

The screenshot shows a software window titled 'Elite Global Options Window Help'. Below the title bar is a menu bar with 'File', 'Global', 'Options', 'Window', and 'Help'. The main area is titled 'Inventory Summary'. It contains a form with the following fields:

- Item Number: []
- Item Description: []
- Order Cost: []
- Carrying Cost: []
- Planned Shortage: []
- Cost Per Unit: []
- Annual Demand: []
- Distribution: []
- Order Quantity: []
- Lead Time: []
- Reorder Point: []
- Cycle Time: []
- TOTAL ANNUAL COST: []

Figure 9. Sample output screen for a single item

the advantage of being easy to interpret, while the text output contains more detail.

The prior discussion has focused on the SAS/AF software FRAME entry interface. The next section uses two examples with actual data to show how the SAS system can be used to facilitate an understanding of inventory models.

Examples

For the first example assumes that an inventory item is currently being stocked with the following characteristics.

Item number:	120
Description:	Elite Locking D Carabiner
Cost per order:	\$2.00
Carrying charge:	.40
Annual demand:	960 units
Unit cost:	\$6.40
Lead time:	90 days

The program would generate the following information:

EOQ:	39 units
Reorder point:	237 units
Cycle time:	11 days
Annual total cost:	\$6281.86*

The graph in Figure 8 is for this item. Note as the size of the order increases the annual order cost decreases. The decrease is most noticeable where order quantities are small. Also note that as the order size increases the annual inventory holding cost increases in a linear fashion. Where the two lines intersect is the optimal order size. This corresponds to the point where the upper line which represents the annual total cost is asymptotic to the x axis. This is a deterministic model with no discounts for large

quantity purchases or planned shortages.

* Note: The annual total cost figure includes the annual order cost, the annual inventory holding cost and the cost of the inventory.)

The second example will utilize the same item, but the model to be generated will take into account a discount that is offered by the supplies for large orders. The discounts are as follows:

Order Size	Discount(%)
0 - 49	0
50 - 149	20
150 -	25

Based on these data the program would generate the following results:

EOQ:	150 units
Reorder point:	237 units
Cycle time:	39 days
Annual total cost:	\$4794.50

By increasing the order size to 150 units the 25 percent discounts is realized. This causes the following changes to the annual costs:

order cost decreases:	36.43
inventory holding cost increases:	94.69
cost of inventory decreases:	1,545.60

The net saving by taking the discount is \$1487.36. It is clear that there is an economic benefit to using a model that reflects the discounts. Figure 10 is the graph that is created

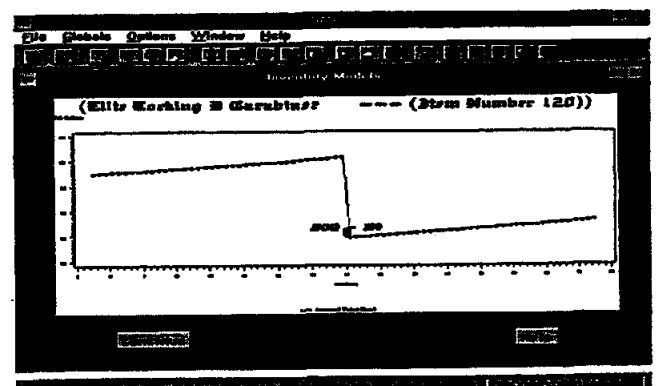


Figure 10. Graph for example 2

for this second example. The graph only shows order quantities immediately below and above the value determined to be the economic order quantity. This was done to maximize the visibility of the decrease in annual total cost that occurs at this point. If the resolution was sufficient, it could be seen that decrease shown represents

only \$241.34 and not the entire \$1487.36.

The difference of \$1,246.02 occurs when the 20% price discount becomes effective when order size increases above 50 units.

Conclusion

This application was developed to serve two purposes. The first was to introduce students to SAS/AF software FRAME entry. As such, an attempt was made to incorporate object from as many classes as possible. The complete application, some of which was outline here, includes examples of:

- frame class objects
- check box objects
- container box objects
- control objects
- extended table objects
- graphic text objects
- graphics objects
- list box objects
- push button objects
- radio button objects
- SAS/GRAPH output objects
- scroll bar objects
- text entry objects
- text label objects

An understanding of the these objects and the underlining SCL programs should permit students to develop business application using the SAS system.

The second goal was to provide a framework which would allow various inventory models to be explored. When students are first introduced to inventory models in an introductory management science class the majority of the calculations are done by hand. The best model is frequently considered the one that requires the fewest calculation. While this selection criteria may lead to an acceptable model, the most appropriate model is often overlooked because of the complexity of the calculations involved. Because this application performs the necessary calculations, students now focus on which model most closely matches the business environment and provides managers the necessary information to make the critical quantitative decisions related to inventory control.

Although the application has only been used for two semesters, it appears to easily meet the objectives specified.

References

Anderson, D.R., Sweeney, D. J., & Williams, T. A. (1992). An introduction to management science - Quantitative approaches to decision making. St. Paul: West.

Data Processing Management Association. (1991). The DPMA model curriculum for a four year undergraduate degree. Park Ridge, IL: Data Processing Management Association.

Monks, J. G. (1992). Operations management - Theory and problems. New York: McGraw-Hill.

Wakin, E. (1995, May). The multifaceted CIO. Beyond Computing, pp. 36-41.

Wang, C. (1994). Techno Vision. New York: McGraw-Hill.

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