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Project 4:   
Decision Making

ALY 6050\_Introduction to Enterprise Analytics

# **Introduction**

In project 4, we are going to make some calculation on inventory costs for a manufacturing company. We are going to help them to make decision of order quantities and order timing to achieve the lowest inventory costs by adding up holding costs and ordering costs. We have known the annual demand, unit costs, holding costs per unit, and costs per order. In following two parts of calculation, we are going to get the number of order quantity, minimum total cost, annual number of orders, etc. In the end, we would provide advices on inventory management.

# **Analysis**

## **Part I**

### Define the data, uncontrollable inputs, model parameters, and the decision variables that influence the total inventory cost.

|  |  |
| --- | --- |
| **Inventory Cost Model** |  |
|  |  |
| **Data** |  |
| Annual Demand | Model Parameters |
| Unit Cost | Model Parameters |
| Holding Cost per Unit | Model Parameters |
| Cost per Order | Model Parameters |
|  |  |
|  |  |
| **Model** |  |
| Annual Holding Cost |  |
| Order Quantity | Decision Variables |
| Annual Number of Orders | Uncontrollable Inputs |
| Holding Cost per Order | Uncontrollable Inputs |
| Annual Holding Cost | Uncontrollable Inputs |
|  |  |
| Annual Ordering Cost |  |
| Ordering Cost | Uncontrollable Inputs |
| Purchasing Price | Model Parameters |
| Annual Ordering Cost | Uncontrollable Inputs |
|  |  |
| Total Inventory Cost | Objective |

*Table 1*. Inventory Cost Model

Data are constant numbers assumingly. Therefore, all the known values are data values, also are model parameters. Uncontrollable variables are the values that would be changed along with model parameters. In another word, they cannot be directly controlled by decision makers. Decision variable is the one affects many other aspects and could be directly controlled by decision makers.

### Develop mathematical functions that compute the annual ordering cost and annual holding cost based on average inventory held throughout the year and use them to develop a mathematical model for the total inventory cost.

|  |  |  |
| --- | --- | --- |
| **Inventory Cost Model** |  |  |
|  |  |  |
| **Data** |  |  |
| Annual Demand | 14,000 | Model Parameters |
| Unit Cost | $ 60.00 | Model Parameters |
| Holding Cost per Unit | $ 9.60 | Model Parameters |
| Cost per Order | $ 210.00 | Model Parameters |
|  |  |  |
|  |  |  |
| **Model** |  |  |
| Annual Holding Cost |  |  |
| Order Quantity |  | Decision Variables |
| Annual Number of Orders | 25 | Uncontrollable Inputs |
| Holding Cost per Order | $ 210.00 | Uncontrollable Inputs |
| Annual Holding Cost | $ 5,312.63 | Uncontrollable Inputs |
|  |  |  |
| Annual Ordering Cost |  |  |
| Ordering Cost | $ 5,312.63 | Uncontrollable Inputs |
| Purchasing Price | $ 840,000.00 | Model Parameters |
| Annual Ordering Cost | $ 845,312.63 | Uncontrollable Inputs |
|  |  |  |
| Total Inventory Cost | $ 850,625.25 | Objective |

*Table 2*. Inventory Cost Model

Based on data, the inventory cost model is conducted as above.

### Use data tables to find an approximate order quantity that results in the smallest total cost.

|  |  |
| --- | --- |
| Order Quantity | Total Inventory Cost |
| 400 | $ 851,190.00 |
| 500 | $ 850,680.00 |
| 600 | $ 850,660.00 |

*Table 3*. Approximate order quantity

Input three test order quantity numbers into the model and get associated inventory costs.

### Plot the Total Cost versus the Order Quantity

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*Figure 1*. Plots of Total Cost vs. Order Quantity

Based on three numbers in the precious question, Excel plotted and draw a trendline. In this chart we could see a part of parabola. Excel also provide an equation of this parabola,

The minimum point of the function would be in between 500 to 600 order quantity.

### Use the Excel Solver to verify your result of part 4 above.

|  |  |  |
| --- | --- | --- |
| **Inventory Cost Model** |  |  |
|  |  |  |
| **Data** | Excel Solver |  |
| Annual Demand | 14,000 | Model Parameters |
| Unit Cost | $ 60.00 | Model Parameters |
| Holding Cost per Unit | $ 9.60 | Model Parameters |
| Cost per Order | $ 210.00 | Model Parameters |
|  |  |  |
|  |  |  |
| **Model** |  |  |
| Annual Holding Cost |  |  |
| Order Quantity | 553 | Decision Variables |
| Annual Number of Orders | 25 | Uncontrollable Inputs |
| Holding Cost per Order | $ 210.00 | Uncontrollable Inputs |
| Annual Holding Cost | $ 5,312.63 | Uncontrollable Inputs |
|  |  |  |
| Annual Ordering Cost |  |  |
| Ordering Cost | $ 5,312.63 | Uncontrollable Inputs |
| Purchasing Price | $ 840,000.00 | Model Parameters |
| Annual Ordering Cost | $ 845,312.63 | Uncontrollable Inputs |
|  |  |  |
| Total Inventory Cost | $ 850,625.25 | Objective |

*Table 4*. Order Quantity Calculated by Solver

The minimum inventory cost is $850,625.25, when order quantity would be 553.

### Conduct what-if analyses by using two-way tables in Excel to study the sensitivity of total cost to changes in the model parameters.



*Table 5*. Two-way Data Tables

Two-way data tables are used to test the sensitivity by changing two specified key model inputs and see their impact on the outputs. In this case, we decided to test unit cost and annual demand. Put a range of values for them and combination of outputs for inventory costs and would be able to see when the minimum value pops up.

## **Part II**

### Perform a simulation consisting of 1000 occurrences and calculate the minimum total cost for each occurrence.

Perform simulations by rtriangle() to get a sector of 1000 random variables that consist with the triangular probability distribution. Use ‘for loop’ to put all this numbers into the formula that we’ve calculated in the previous part and use optimize() to get the minimum point of the function. All the minimum values of inventory costs are stored in inv1000.

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*Figure 2*. R result of Inventory Costs

### Determine the probability distribution that best fits the minimum total cost.

Based on the total cost that we’ve calculated from the previous question, we’ve got a sector of minimum total cost for each occurrence. Plot the histogram shown as below,

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*Figure 3*. Histogram of Minimum Total Cost

Through a chi-squared test we’ve know that minimum total cost is normally distributed. It is skewed to the left with very few outliers. The distribution is unimodal with only one main cluster, which is be around 850,000. The mean value is $870,202 and the standard deviation is 38,503.

### Determine the probability distribution that best fits the order quantity.

Based on the order quantity data that we’ve calculated a sector of order quantity that would leads to a minimum inventory of each simulation. The histogram chart is shown as below,

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*Figure 4*. Histogram of Order Quantity

According to the chi-squared test, order quantity is normally distributed. In this formula, it is also skew to the left with extremely few outliners. The mean value is 559.63, and the standard deviation is 12.42.

### Determine the probability distribution that best fits the annual number of orders.

The equation for Annual number of orders is shown as below,

So the annual number of orders is calculated in R as ordern1000 = ad1000 / orderq1000. The histogram is plotted as below,

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*Figure 5*. Histogram of Annual Number of Orders

According to chi-squared test, the annual number of orders are normally distributed. This chart is skewed to the right with few outliers. Mostly the orders number would be 25 or 26 annually. The mean value is 25.583, standard deviation is 0.568. But in this case, we are going to round up the number when suggest numbers to managers.

# **Conclusions**

When the key engine component demand is 14,000 annually for the manufacturing company, the minimum totally inventory cost could be $850,625.25 when place order at predetermined reorder point 276. The order quantity would be 553. Lower or higher than this point would result a higher cost for inventory. Change of unit cost or annual demand would cause a change in inventory cost.

If the annual demand is triangular distributed, then the minimum total cost, order quantity and the annual number of orders are all normally distributed. And the mean value of them are all around the value when the annual demand was 14,000.

# Reference

1. Evans, J.(2012). *Statistics, Data Analysis and Decision Making*. Chapters 9 and 10.