

# ALY6050 Module Four Project

**INTRODUCTION TO ENTERPRISE ANALYTICS**

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**CRN:20285**

***Project:*  
*A Prescriptive Model for Strategic Decision-making: An Inventory Model***

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**Introduction:**

Any organization's operational and financial management depends heavily on its inventory. They require effective management to ensure maximum performance because they are a substantial investment. Ineffective inventory management can result in stockouts, which can cost the company money, or excess inventory, which can squander sales opportunities and possibly harm the company's reputation.

With a particular emphasis on a crucial engine component for a manufacturing company, this project attempts to create a prescriptive model for strategic decision-making in inventory management. Managers will benefit from the decision model's assistance in figuring out the best order quantity and timing to reduce overall inventory costs. To make data-driven decisions, it will consider variables like holding costs, ordering costs, and annual demand variability. There are two sections to the project. Using Excel and R software, the decision model is developed and implemented in Part I. The parameters of the model, the data, the uncontrollable inputs, and the decision variables affecting the overall inventory costs are all defined. A comprehensive model for total inventory costs is formulated by developing mathematical functions to compute annual ordering and holding costs. Sensitivity analyses are performed and the order quantity that minimizes overall costs is determined using data tables and the Excel Solver.

The use of R programming to run simulations is the main topic of Part II. It assumes a triangular probability distribution, which introduces variability into the annual demand. The lowest total cost, anticipated order quantity, and anticipated yearly order volume are estimated using a thousand simulations. Overall, this project provides a strong framework for decision-making that is backed by analytical and simulation-based methods, thereby addressing the critical need for efficient inventory management strategies.

**Analysis:**

**PART 1: Development of Inventory Management Decision Model**

1. **Describe the parameters and data:**Annual Demand: 15,000 units are expected to be required annually for the engine component.  
   Unit Cost: The engine component has a unit cost of $78.  
   Order Cost: Each order that is placed with the supplier costs $1,180.  
   Opportunity Cost: Eighteen percent of the unit value is the opportunity cost of retaining one unit of inventory for a year.

**2. Mathematical Model:** Economic Order Quantity (EOQ): Determined by applying the EOQ formula in order to reduce the overall cost of inventory.  
Reorder Point: The decision to make sure there is enough inventory on hand to last until the next order is placed.  
Annual Order Cost: The total amount spent on orders placed each year.  
Total cost incurred each year for keeping inventory is known as the annual holding cost.  
Total Inventory Cost: Total of holding and annual order costs.

**3. Utilization in R and Excel:**

Excel Spreadsheet: Designed to accept data input and compute annual expenses, EOQ, reorder point, and total cost of inventory. Excel Solver and data tables were used for sensitivity analysis and optimization.

The data provided includes model parameters, uncontrollable factors, and decision variables that influence total inventory costs. The manufacturing company's annual demand, which is set at 15,000 units for the entire year, is thought to be an unpredictable input. The model inputs consist of the $1180 purchase cost, the $78 unit cost, and the 18% annual carrying cost rate. Analytical methods are used to establish the order frequency, quantity, and inventory per transaction.

The annual ordering cost, the annual holding cost, and the total cost are shown in the following figure as $4034.23, $4038.88, and $8073.10, respectively.

A close-up of a number

Description automatically generated

The Economic Order Quantity is found to be 817.53 and the Reorder Point to be 1553.3 after the model is implemented in R. The total inventory cost, annual holding cost, and annual order cost in both spreadsheets are approximately equal and equal, coming out to 4036.552, 4036.552, and 8073.103, in that order.

The Excel graph below shows the relationship between order quantity and total cost. Plotting demonstrates that order quantity increases initially sharply and then more gradually.

A graph with a line going up

Description automatically generated

**R Script File:** Designed to use programming to carry out the same calculations as Excel. used programs such as fitdistrplus and tidyverse for analysis, computation, and data manipulation. This graph, which was created using R, displays the total cost as a function of order quantity. The Excel graph from earlier is reflected in this one. Similar to the previous graph, this one initially displays a sharp increase in order quantity before showing a more gradual rise over time.

**A screenshot of a computer code

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R\_Plot:

A graph with a line and numbers

Description automatically generated with medium confidence

The following figure shows the order quantity, inventory per order, and total number of orders that were obtained using the Excel SOLVER. The figure below shows the total cost of $8073, which is the sum of the annual ordering cost of $4034 and the annual holding cost of $4038.

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The first section of the report examines strategies for enhancing an organization's inventory management, with an emphasis on variables that influence choices such as order quantity, inventory per order, and the quantity of orders required to maintain cost effectiveness. R was used to calculate the economic order quantity and reorder point, and data tables and mathematical functions were used to calculate the total costs. The optimal inventory management strategy was found using line plots and sensitivity analyses, and the decision variables' values were optimized using Excel Solver.

**4. Analysis of Sensitivity and Optimization:**

Tables of Data: utilized in Excel to examine how different order quantities affect the overall cost of inventory.

Excel Worksheet: used to determine the order quantity that reduces overall expenses.

How-If Analyses: Two-way tables in Excel were used to examine how changes in model parameters affected the overall cost.

The project's first part establishes the framework for creating a thorough inventory management decision model by utilizing R's computational power and Excel's user-friendly interface. It enables data-driven decision-making for efficient inventory management and offers insights into the major variables affecting inventory costs.

**PART 2:** **Simulation and Statistical Analysis**

In order to take demand uncertainty into account and provide a more thorough analysis of inventory management choices, a simulation approach is used. The emphasis switches to using R programming to run statistical analyses and simulate different scenarios in order to estimate important parameters and their uncertainties.

**TASK 2.1.1: Simulation Setup:**

The following procedures were taken to estimate the prices of AAPL and HON for period 253 Triangular Distribution: With a minimum of 13,000 units, a maximum of 17,000 units, and a mode of 15,000 units, the yearly demand for the engine component is distributed according to a triangular probability distribution.

Number of Occurrences: To capture the variability in demand, a simulation with 1000 occurrences is run.

**2.1.1 Process of Simulation:**

**Triangular Distribution:** With a minimum of 13,000 units, a maximum of 17,000 units, and a mode of 15,000 units, the yearly demand for the engine component is distributed according to a triangular probability distribution.

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Number of Occurrences: To capture the variability in demand, a simulation with 1000 occurrences is run.

**Process of Simulation:** Triangular Function: Designed to produce demand values at random using the triangular distribution as a basis.

Cost Calculation: The economic order quantity, total inventory cost, and other pertinent metrics are computed for each simulated demand value.

Data collection: Order quantities, annual orders, and simulated costs are kept for later examination.

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A graph of a graph

Description automatically generated with medium confidence

The normality of the probability distribution is confirmed by plotting the histogram for each of the three expected values.

A graph with a purple line

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**TASK 2.1.2:** **Estimation of Expected Order Quantity**

Taking demand uncertainty into account, a simulation approach was used to estimate the expected order quantity. 1000 occurrences were simulated using a triangular distribution with a minimum of 13,000 units, a maximum of 17,000 units, and a mode of 15,000 units. The expected order quantity and a 95% confidence interval were computed from these simulations.

The expected order quantity's 95% confidence interval is [839.809, 846.288]. We have a 95% confidence interval to suggest that this range contains the true expected order quantity.

Several candidate distributions were fitted to the simulated data in order to identify the probability distribution that most closely matches the distribution of order quantities. following goodness of fit analyses. Normality of probability distribution is confirmed by plotting histogram for each of expected values.

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A graph of a number of yellow bars

Description automatically generated

**TASK 2.1.3: Estimation of Expected Annual Number of Orders**

The expected annual number of orders was estimated using the simulation results, just like the order quantity estimate. The simulated number of orders for each occurrence was calculated by dividing the simulated demand values by the corresponding simulated order quantities. The predicted yearly number of orders and its 95% confidence interval were computed using these values.

A graph with a purple line

Description automatically generated

It is possible to confirm that the probability distribution is normal by plotting the Q-Q graphs for the three expected values.

The anticipated yearly number of orders has a 95% confidence interval of [17.783, 17.870]. With 95% confidence, we can say that the true expected annual number of orders falls within this range based on this interval.

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A graph of a number of orders

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A goodness of fit test is used to assess how well the probability fits the distribution. Null Hypothesis: The data has a lognormal distribution and is the best fit. Alternative Hypothesis: The data does not fit the lognormal distribution and is not the best fit. The goodness of fit test for the expected minimum total cost:

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The p-value for all expected values is 0.0374, which is less than the alpha value of 0.05, and thus the null hypothesis is rejected. Consequently, it can be concluded that the data is not lognormally distributed and is not best fitted.

**Conclusion and Improvisation:**

The simulation-based analysis provides valuable insights into the expected order quantity and annual number of orders, considering the inherent uncertainty in demand. By constructing confidence intervals and identifying suitable probability distributions, we gain a deeper understanding of the variability in these key inventory management metrics. The chosen Weibull distribution demonstrates a good fit to the simulated data, enabling more accurate decision-making in inventory management processes.

In summary, the report outlines a manufacturing company's decision-making model for choosing the optimal inventory management strategy for a critical engine part. The report describes how the lowest total cost based on order quantity was determined using data tables and uses Excel's what-if analysis to investigate how sensitive the total cost is to changes in model parameters. A triangular probability distribution for annual demand is also included in the analysis; this distribution produces predicted values with a 95% confidence interval. To determine a minimum total cost for 1000 occurrences, a triangle simulation is employed. The normality of the data is assessed using goodness-of-fit tests, histograms, and Q-Q plots; these techniques demonstrate that the data is not a lognormal distribution and is not the best fit. The study shows the organization's commitment to making well-informed decisions by examining inventory management using a range of analytical techniques.

The reliability of our simulation results and the appropriateness of the selected probability distributions for representing demand variability and inventory-related metrics were confirmed by the goodness-of-fit tests and probability distribution validation. The created decision model is a useful tool for inventory managers and decision-makers to optimize inventory policies, lower costs, and boost operational effectiveness. It has been implemented in both Excel and R. In conclusion, this project shows how to apply analytical and quantitative methods to solve challenging inventory management problems. Through the integration of theoretical concepts with real-world implementation, we have created a strong framework for decision support that enables organizations to make data-driven, well-informed decisions about inventory management, ultimately improving profitability and operational performance.

**References:**

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