Inventory Management Decision and Optimization Modelling

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Introduction

Optimization is the way of life. Just about every business and industry are seeking to achieve a maximum profit with the lowest maintenance and operating cost. While at the same time, many of the enterprises are facing problems with limited resources, including materials, manpower, production machines, inventory spaces and many more. For this reason, being able to find the most optimal solution for resource allocating, scheduling, routing, planning and management, became such an urge and extremely important for many firms. Inventory management, for instance, is a field that could highly benefit from the optimization modelling to help reducing risks and minimizing the operating cost during the process of decision making and strategic development.

The goal of this report is to developed and propose an optimal order and inventory management solution, in order to help the manufacture, that I'm consulting for, making decisions about the amount of units to place in an order to minimize the total inventory cost. With the current situation, some limits are the annual demands is estimated to be 14,900 units, each unit cost $75, the holding cost is at 18% of the unit value, and lastly, the supplier charges $225 for each order placed. Our objective for this management problem is to reduce the inventory cost, which includes both holding cost and ordering cost. The decision variable here is the number of units that we need to place in an order. Therefore, we have to figure out the optimal number of units per order, it is also known as Economical Ordering Quantity (EOQ).

Analysis

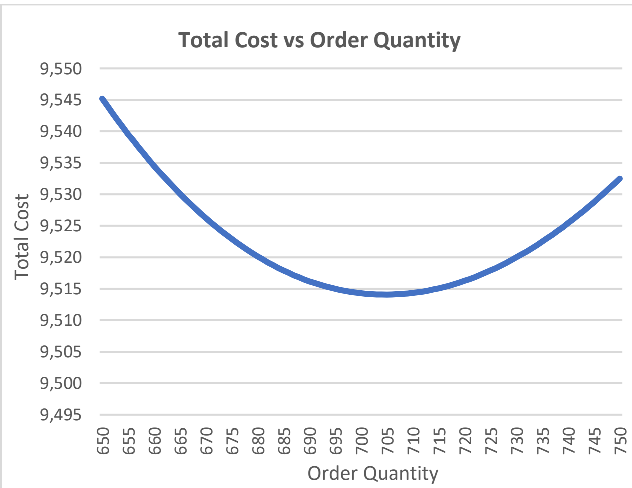
To solve this business problem, we first need to find out the relationship between inventory cost and the known and unknown factors (annual demand, unit cost, holding rate, order cost, and order quantity) . This is done by developing a mathematical function of the inventory cost, expressed by the factors mentioned above. Secondly, differentiate the expression for total inventory expense with respect to order quantity, to find out how the change of order quantity affects the total annual inventory cost. After implementing the model, we have acquired the following solution:

INPUTS & CONSTRAINTS:	
Annual Demand (D)	14900
Unit Cost (C)	$75
Holding Rate (H)	18%
Order Cost (O)	$225

DERIVED INPUTS & OUTPUTS:	
Quantity per Order (x)	**704.75**
Average Inventory	352.37
Annual Holding Cost	$4,757.03
Annual Ordering Cost	$4,757.03
Total Inventory Cost (T)	**$9,514.07**

This model and the result had also been validated through 3 different methods: using data tables, using line chart, as well as the Excel add-in analysis tool – Slover. The results of each of the three method are shown as follows:

Order Quantity	Annual Holding Cost	Annual Ordering Cost	Total Inventory Cost (T)
650	4,387.50	5,157.69	9,545.19
…	…	…	…
702	4,738.50	4,775.64	9,514.14
703	4,745.25	4,768.85	9,514.10
704	**4,752.00**	**4,762.07**	**9,514.07**
705	**4,758.75**	**4,755.32**	**9,514.07**
706	4,765.50	4,748.58	9,514.08
707	4,772.25	4,741.87	9,514.12
…	…	…	…



Microsoft Excel 16.0 Answer Report
Worksheet: [EOQ.xls]Sheet1
Report Created: 4/12/2021 3:08:44 PM
Result: Solver has converged to the current solution. All Constraints are satisfied.
Solver Engine
Solver Options

Objective Cell (Min)

Cell	Name	Original Value	Final Value
G	#DIV/0!	$3,352,506.75	$9,514.07

Variable Cells

Cell	Name	Original Value	Final Value	Integer
G	Quantity per Order (x)	1.00	704.75	Contin

Constraints

NONE

All four methods, including the one that I established myself, are showing the same results. Although the order quantity is showing a value of 704.45, the quantity of units can only be whole numbers, we have to manually round it to the nearest integer. But since we have limits on the annual demand, rounding up will have our units in stock exceed the estimated demand number. So, in this case, we have decided to round down the number of order quantity to 704. Therefore, we could conclude with the following results: orders that are placed with 704 units will provide the company with the lowest inventory while still providing sufficient stock to meet the annual demand.

Quantity per Order (x)	**704.00**
Average Inventory	352.00
Annual Holding Cost	$4,752.00
Annual Ordering Cost	$4,762.07
Total Inventory Cost (T)	**$9,514.07**

In addition to the optimization model, we have also applied a two-variable and scenario testing to our model. These are done in order to explore the relationship and the sensitivity of the total annual inventory cost to changes in different model parameters, or also called uncontrollable. As mentioned above, our model has four parameters in total: annual demand, unit cost, holding rate, and order cost. In the first what-if **scenario testing** method, we have defined a series of scenarios / conditions that we would want to explore. These are basically defined as setting a pair of two values for each of the four parameters, one higher and one lower than the current situation. Each scenario we are only changing one variable, by put control on the rest three. Then the testing had been run 8 times (2 times for each variable), the results are then finalized and put into one table which is shown below.

Scenario Summary	Current Values:	Demand = 14500	Demand = 15300	Unit Cost = 70	Unit Cost = 80	Holding Rate = 17%	Holding Rate = 19%	Order Cost = 220	Order Cost = 230
Changing Cells:									
D141	$14,900.00	$14,500.00	$15,300.00	$14,900.00	$14,900.00	$14,900.00	$14,900.00	$14,900.00	$14,900.00
D142	$75	$75	$75	$70	$80	$75	$75	$75	$75
D143	18%	18%	18%	18%	18%	17%	19%	18%	18%
D144	$225	$225	$225	$225	$225	$225	$225	$220	$230
Result Cells:									
D147	$9,514.07	$9,386.36	$9,641.77	$9,196.93	$9,831.20	$9,249.79	$9,778.35	$9,408.36	$9,619.78

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

From the table we can see that all four parameters have positive linear correlation with the total inventory cost, meaning the increase in any of the variable will results in an increase in the inventory cost, and any decrease in the variables will causing the inventory cost to drop. This way we have grasped a general relationship of the inventory cost with each one the parameters. Next, we are moving on to see how sensitive the change of the inventory cost would be in regard to the variables.

This could be achieved with a what-if **two-way model**. In this model, we had put the four parameters in pairs, then increase or decrease each of the parameters in increments of 1 numerical value. This is then be put into two table of matrixes with all the total inventory value shown along with each if the change in the parameters. As shown below, each table only has two variables changing with the other two variables controlled and set to the current state of situation.

What-if Two-way Table Results

What-if Two-way table results (Annual Demand vs Unit Cost)

$9,514.07	**$14,600.00**	**$14,700.00**	**$14,800.00**	**$14,900.00**	**$15,000.00**	**$15,100.00**	**$15,200.00**
$72	$9,228.01	$9,259.93	$9,291.86	$9,323.79	$9,355.71	$9,387.64	$9,419.57
$73	$9,291.44	$9,323.36	$9,355.29	$9,387.21	$9,419.14	$9,451.07	$9,482.99
$74	$9,354.86	$9,386.79	$9,418.72	$9,450.64	$9,482.57	$9,514.49	$9,546.42
$75	$9,418.29	$9,450.22	$9,482.14	**$9,514.07**	$9,545.99	$9,577.92	$9,609.85
$76	$9,481.72	$9,513.64	$9,545.57	$9,577.50	$9,609.42	$9,641.35	$9,673.27
$77	$9,545.14	$9,577.07	$9,609.00	$9,640.92	$9,672.85	$9,704.78	$9,736.70
$78	$9,608.57	$9,640.50	$9,672.42	$9,704.35	$9,736.28	$9,768.20	$9,800.13

What-if Two-way table results (Order Cost vs Holding Rate)

$9,514.07	**$222.00**	**$223.00**	**$224.00**	**$225.00**	**$226.00**	**$227.00**	**$228.00**
15%	$8,657.80	$8,678.94	$8,700.09	$8,721.23	$8,742.37	$8,763.51	$8,784.66
16%	$8,922.08	$8,943.22	$8,964.37	$8,985.51	$9,006.65	$9,027.79	$9,048.94
17%	$9,186.36	$9,207.50	$9,228.65	$9,249.79	$9,270.93	$9,292.07	$9,313.22
18%	$9,450.64	$9,471.78	$9,492.93	**$9,514.07**	$9,535.21	$9,556.35	$9,577.50
19%	$9,714.92	$9,736.06	$9,757.21	$9,778.35	$9,799.49	$9,820.63	$9,841.78
20%	$9,979.20	$10,000.34	$10,021.49	$10,042.63	$10,063.77	$10,084.91	$10,106.06
21%	$10,243.48	$10,264.62	$10,285.77	$10,306.91	$10,328.05	$10,349.19	$10,370.33

The current state of situation is highlighted with light purple for each table, the intersection shows the lowest possible inventory cost with our current model that we had calculated before. Both matrixes had confirmed the finds that we concluded from the scenario testing, that all parameters hold a positive correlation with the total inventory cost. But what more this table tells us is that how much the change in each parameter is affecting the total cost. As what we can see from the table, inventory cost is most sensitive to the change in holding rate, 1% of change in holding rate is changing the inventory cost by 5.7%. Unit cost, holding rate and annual demand are all having pretty similar impact to the total cost of inventory, which is 1.33% of change in any of these three variables are affecting the inventory cost by 0.67%, we can see that this percent of change much lower than the holding rate.

Conclusion

With all the information above in mind, we grasped quite a lot knowledge and insights of our current business model and could help the management team to make wise inventory decisions.

Therefore, we could conclude that with our current state of business scenario, **we should have orders placed for 704 units each time to minimize the total annual inventory cost at a number of $9514.07**, while still providing sufficient stock to meet the annual demand. This includes a $4752 holding cost, and a $4762.07 ordering cost annually. Total inventory cost will be at the lowest if the holding cost and the ordering cost are kept at great balance.

In addition, we have found out that the inventory cost is most sensitive to holding rate. 1% of change in holding rate is changing the inventory cost by as much as 5.7%. **Hence, if we want to lower the total annual inventory rate for the future, the best and most effective way is to lower the holding rate if possible.**