Using GRG Non-linear optimization for Pricing Decisions at Clothing Company

I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination. I further pledge that I have not copied any material from a book, article, the Internet or any other source except where I have expressly cited the source.

Name: Asad Sajid Awan

Signature: Asad Sajid Awan Date: 22nd November 2022

Project Introduction:

I work in a major clothing retail company as a data analyst and am responsible for forecasting the demand, optimizing the processes, and deciding price points for the clothing lines. I have been given the task to maximize the profit margin of a clothing line launched in the November of previous year. This particular clothing line has 9 style variants and is a winter wear. The production of the entire clothing line happens at the start of the season hence the production cost remains the same, and the entire inventory should be finished by 36th week.

Project Approach:

The objective of the project is to maximize the profit margin given the constraint that the inventory should be finished by the 36th week. Since these are seasonal products i.e., winter clothes, we know that the demand for these clothes will decline over time. Hence, we will use the price-demand elasticity function to vary price so we can affect the demand and eventually sell the units before the 36th week. We will use non-linear programming to achieve the objective given the constraints.

We can assume that if my company charges P dollars per unit when the cost per unit is C and D represents the demand, then the profit is (P – C) * D. The problem however is that D depends on P. As the price P increases, the demand D decreases. Therefore, the first step is to estimate how D varies with P—that is, to estimate the demand function, for which we will need the historical data on demands and prices of the products. We will then use Excel trend lines to estimate the parameters of the demand curve, parameters being a and b. We can use either of the two, linear demand function of the form D = a – b * P or a constant elasticity demand function of the form D = a * P^b. Once we have the demand curve, it becomes easier to determine the price at which units can be sold to maximize profit margin.

Dataset:

The data we have captures demands and prices of the products in different intervals of time. For example, on 29th March, the units we sold are 407 for style variant 1, and the revenue is $7387.32 which gives us a per unit price of $18.15. For the sake of simplicity, we assume that the total units sold on 29th March, which are 407, are distributed uniformly over total number of weeks between the launch till 29th March. That gives us the unit sold in the week of 29th March to be 21. Next, till 4th April, the units we sold are 70 (units sold just this week), while the revenue is $928.78 which gives us the per unit price of $13.26 (please refer to the attached excel sheet for the calculations).

We now have two demand and corresponding price points to create demand function. Apart from this information, we are also given inventory level details for each week, which are to be used as a constraint. We have cost per unit which remains constant throughout this period.

Input Variables:

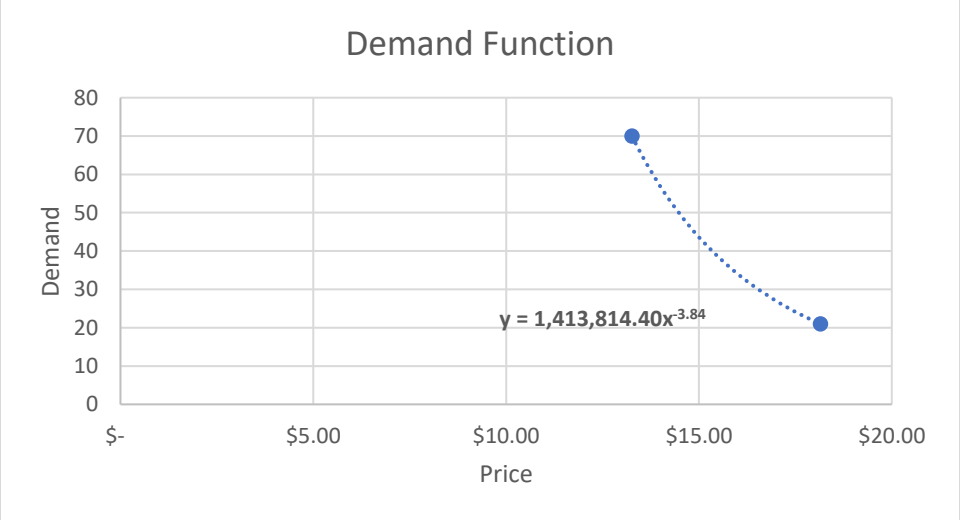
Per unit price on 29th March and 4th April (US Dollars)
Quantity sold on 29th March and 4th April (Number of units)
Cost per unit (US Dollars)
Revenue incurred in the weeks of 29th March and 4th April (US Dollars)
Inventory levels on 29th March and 4th April (Number of units)

Output variables:

Profit Margin (US Dollars)

Model Development:

Based on the two price and demand points, we can develop a demand function like this which can be then used to estimate the demand for any given price.

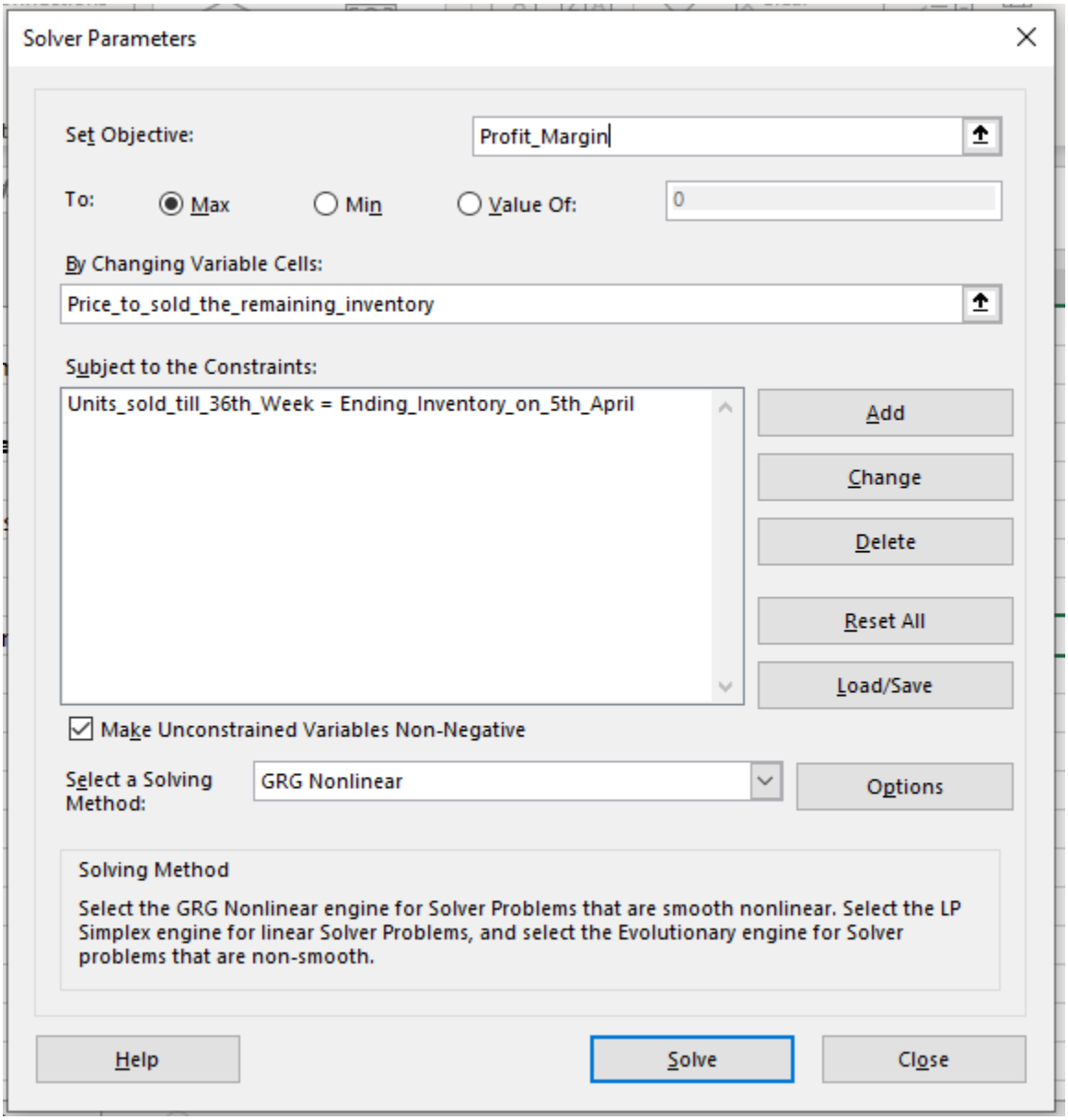


Please note that we can also use linear demand function for this estimation.

Here is the equation for the demand curve is **$y = 1{,}413{,}814.40x^{-3.84}$**

With a (constant) = 1413814.40 and b (Elasticity) = -3.84.

This will give us the quantity demanded for one week at any given price. We know that at this point in time, we are on 5th April 2022 with 16 more weeks to go till we arrive at 36th week at which the remaining inventory, which is currently 1451, should be 0. Our decision variable (marked in red) here is price, which will determine the quantity to be sold. The constraint here is that at the end of the 36th week, the units sold till 36th week should equal the ending inventory on 5th April, with objective (marked in grey) of maximizing the profit margin.



Conclusion:

We are maximizing the profit margin which is given as 100* (Price – Cost)/Price. Solving for this using GRG non-linear optimization, we arrive at a price level of $12.27 with profit margin of 35%. Our recommendation to the management will be to price the style variant 99999 at $12.27 after 5th April to make sure that the inventory for this variant is finished by 36th week, achieving the profit margin of 35%.

From here onwards, we will proceed with only one Style as the sample		
	Constant	Elasticity
Estimates of the demand curve for style variant 99999	1413814.4	-3.84
Decision Variable		
Price to sold the remaining inventory	$ 12.27	
Estimated Demand at this price	93	
Remaining weeks till 36th week	16	
Units sold till 36th Week	1451	
Objective		
Profit Margin	35%	

Decision Support System:

We also aim to provide the management of the company with a decision support system, in which they will only need to change a few inputs to reach the optimal output.

Our DSS spreadsheet will be divided in 2 parts:

1. Front-end part
2. Back-end part

The front end will allow the user to give different input values, and to get optimal solution based on these input values.

Our front end will have a greeting screen with a description of what this DSS is about, which is to find optimal pricing for a product given the constraint of finishing the inventory till a particular point in time, with the objective of maximizing the profit margin. Our front end will also display two buttons:

1. Set up problem
2. Solver

Once then user clicks on the set-up problem, he can change the inputs. Under this button, user will have the option to delete and add the value of inputs and constraints.

For example, let's assume that instead of finishing the inventory by 36th week, we decide to finish it by 40th week. So, the user will have to enter the date by which inventory needs to finish. If they want to change the unit production cost, they can do that. They can also change the number of units remaining in the inventory.

After making these adjustments in inputs, the user will click on the Solver button, which will be pre-formulated as formulated in the excel to get the new profit margin. This excel sheet is our back-end part of the DSS. In this way, just by making the needed adjustments the user can get an optimal solution.

References

- Practical Management Science, 4th edition, by Winston and Albright (Chapter 3 and Chapter 7)