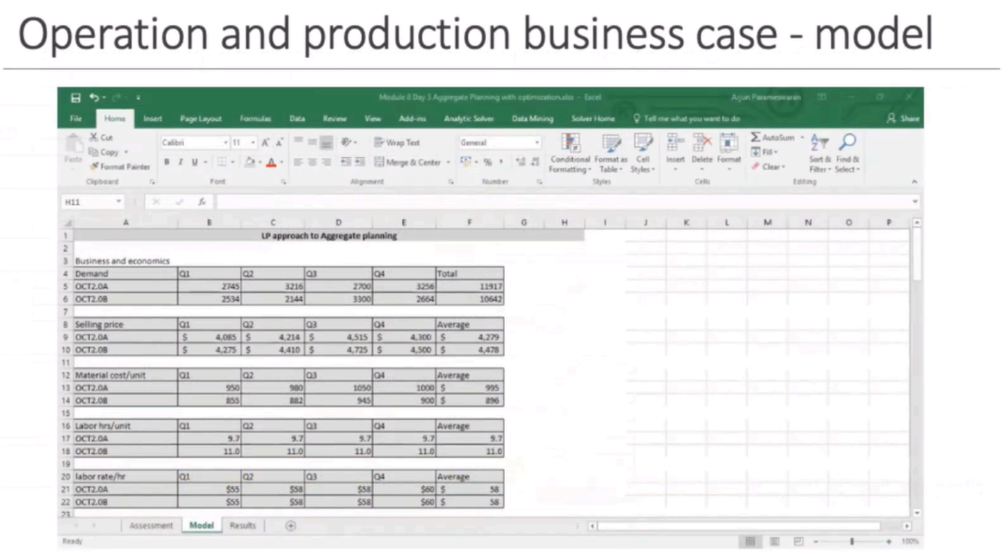
M7L7b. Optimization Business Case

Slide #1

Slide #2



The video clip demonstrates the business model in Microsoft Excel.

Linear programming approach to aggregate planning.

This problem is similar to the problem that we saw in Module 1, where we had to estimate the number of units of Model A and B to be produced to achieve maximum profit.

The only difference is that the previous problem was done for a single period of time, while this solution would be found over a period of four quarters, that is one full year.

This is an aggregate planning problem.

We will solve it using a linear programming approach.

Let us take a look at the problem.

We have two different models of the product that the company sells, that is OCT 2.0A and OCT 2.0B.

The demands over a period of four quarters is provided to us.

The demand for model A for the four quarters is as follows: for quarter 1, it is 2,745, for quarter 2, it is 3,216, the demand for quarter 3 is 2,700, and for quarter 4, it's 3,256.

Similarly, the demands are provided for model B over a period of four quarters.

The selling price of each of the models varies slightly in each quarter.

Pricing is also somewhat seasonal.

You have different selling prices for quarter 1, 2, 3, and 4 for both the models.

The prices are displayed in this table here.

Material cost is assumed to be varying and the material cost per unit is provided in this table.

You can see that producing one unit of model A in quarter 1 costs $950.

In quarter 2, the material cost is $980 and increases to $1050 in quarter 3.

The cost to procure material for a single unit of Model A in quarter 4 is $1,000.

Similarly, the costs for material for single unit of

Model B are provided over here.

The labor hour is not varying.

It remains stable throughout the four quarters.

This value, 9.7, indicates that it takes 9.7 hours of labor to produce one unit of model A, whereas it takes 11 hours of labor to produce one unit of model B.

Now, we will discuss the labor rate.

The labor rate per hour is variable, and the different labor rates for each of the quarters are given to us.

In quarter one, one hour of labor costs $55, and is the same for both the models.

Irrespective of which model you're producing, you're paying your labor according to different quarterly rates, and not according to what model is being produced.

This is constant over different models, but varies over a period of four quarters.

In quarter two and three for one hour of labor, it costs $58, while in quarter four it rises to $60 per hour of labor.

Next, we will calculate the total labor required per unit of Model A and Model B.

It is simply the product of labor hours per unit and the labor rate per hour.

We have similar formulas for all these cells, and we calculate the total labor cost per unit in dollars for each model over a period of four quarters.

The total unit cost is the sum of material costs and labor costs per unit.

The material cost of quarter 1 model A is 950.

The labor cost for quarter 1 model A is 534, the sum of which is $1,484.

Similarly, we have calculated the total cost for producing one unit of the product over a period of four quarters.

Now, there is some inventory cost as well in order to store the product that you produced in the past.

Inventory cost is given in dollars per unit, and it varies over a period of four quarters.

Again, it is the same, irrespective of which model you want to have as inventory, but then it varies over the quarters.

For the first quarter, it is $22 per unit, $24 per unit for the second quarter, $25 per unit for the third quarter, and $26 per unit for quarter four.

There are certain constraints that we have to follow or satisfy while we achieve the optimum solution.

The first constraint is the production capacity of the plant, which is different for different quarters.

For the first quarter, the plant cannot produce more than 5,462 units, and 6,325 units is the capacity limit for quarter two.

For quarter three, it's again 5,462 and quarter four it's 6,325.

We need to ensure that the number of units produced are within these limits because this is the plant capacity.

Also, we have an upper limit on the number of labor hours available, and those values are provided for each quarter in this particular table.

There are certain inventory requirements that could be based on some forecasting by the management.

We have a minimum inventory requirement of 200 units throughout all quarters for both models each.

This is the same overall for all these quarters and both models.

That is, for each quarter, you need to have a minimum inventory of 200 units of Model A and a minimum inventory of 200 for Model B.

The upper limit of inventory is also specified to us.

We need to ensure that our inventory over a period of four quarters does not exceed 1,000 units each.

This is the inventory requirement.

Now let us see how the model is set up and how the formulas are used in Excel.

We have been given a certain beginning inventory as well.

For the first quarter, it is assumed that you begin with 500 units of model A and 400 units of model B.

Now, let us take a look at what we need to do with this problem.

Our objective is to find out how many units of model A and model B should be produced in each quarter such that the company achieves a maximum profit.

These are the blank cells for which we need to find the values.

Let us add sample values to these cells so that we can understand how the Excel sheet is set up.

Let's say I produce 1000 units of model A. and 1,200 units of Model B for the first quarter.

This cell total indicates the total number of units produced for that particular quarter.

It is the sum of these two cells, and as per capacity constraints, it should be less than 5,462.

Similar calculations are done for the rest of the quarters.

And we need to ensure that the capacity constraints are met.

For labor constraints, now we calculate the hours of labor needed to produce a thousand unit.

That is, this is the product of the number of units produced and the labor hours per unit.

We have the total labor hours needed.

We're producing model number A for quarter one, and similarly for model number B for quarter one as well.

The total number of labor hours is the sum of these two values, which should not exceed this limit.

This is the labor limit that was given to us in the problem.

We should ensure that the labor hours needed to produce is always within this limit.

Similar formulas are applied to the rest of the quarters, and these are the respective labor hour limits.

Now, this is again a demand.

This shows the number of units that are demanded for each quarter.

This is just a reference to the cells above that was provided in the problem.

It is repeated here just for reference.

These are the values that were provided in the problem for each quarter for each model.

Now, ending inventory is calculated as the beginning inventory plus the number of units produced minus the demand.

You have your beginning inventory, then you produce n number of products, and then you sell off the number of products that were demanded.

This is your ending inventory.

Similar formulas are applied for quarter 2, quarter 3, quarter 4, and for model B.

As per the management directives, you need to ensure that your inventory is at least 200 for each quarter and does not exceed 1,000 for each quarter.

These are the constraints that put a limit on your inventory, which we need to follow or satisfy.

Now we have the production cost.

Production cost is nothing but the product of number of units produced and cost of production per unit that we had calculated earlier.

We have the total cost of production for quarter 1 for model A, and for model B, a similar formula is used, and we have the total cost.

The formulas are similar across all quarters, and these are the row wide subtotals.

And this is the subtotal for the production cost.

We calculate inventory cost as the sum of the beginning inventory and the ending inventory.

We take an average of the beginning and ending inventory, which depicts the average inventory, and then we multiply it by the inventory cost.

We take an average inventory for the quarter that is the average of the beginning and ending inventories and then multiply it by the inventory cost per unit for each quarter.

That is how we arrive at the quarterly inventory cost.

A similar calculation is done for the rest of the cells to obtain the subtotal.

The quarterly total cost is nothing but the sum of the inventory cost and the production cost for each quarter.

Again, similar formulas are applicable for the rest of the cells to get the subtotals.

So what is the revenue?

The revenue is the number of units demanded that is actually sold and the sales cost of one unit.

It is the product of the number of units that were actually demanded, not produced, because all that you produced was not sold, only how much demand was there in the market, that many units were sold.

You have your quarterly revenue as the product of the number of units demanded and the sales price of each unit.

Similarly, it is calculated for the rest of the cells and we have the subtotal cells as well.

Quarterly profit.

Now we have the quarterly total cost and the quarterly revenue.

The quarterly profit is basically the difference between the total cost and the revenue.

Now we have all our formulas in place and this is the cell that we are interested in.

This is the total profit over the period of four quarters.

We need to maximize this particular value.