Tips for OMGT2105 Assignment 2 – New Bakery for Oz Bread

Dear Students,

Here are some tips to help you complete the quantitative assignment of the course. The assignment is about network optimization and will require the use of Solver to find the optimal solutions.

For this assignment, you will need to first develop a generic model on a spreadsheet and validate it. Then, with proper modifications in terms of model input, *e.g.*, demand figures of a particular year, and constraints in Solver, *e.g.*, conditions that reflect the requitement of a particular scenario, the model can be used as a tool to help find the optimal solution for a particular year under a particular scenario.

You can set up the model using the SunOil example as a reference. Despite the fact that there is only one product in the SunOil example but two in the Oz Bread case, both problems are identical in nature and are categorized as Capacitated Facility Location Problems. It means that their mathematical formulations are very similar. Basically, the objective function is a cost functional comprising fixed and variable operating costs. The constraints include demand constraint (*i.e.*, all demand must be met), capacity constraint (*i.e.*, available capacity cannot be exceeded), non-negativity constraint (*i.e.*, values of all variables cannot be negative), binary constraint (*i.e.*, facilities can either be open or close only) or integer constraint (number of facilities must be in whole number).

The best way to go is to first create a model to represent the current or the as-is situation, *i.e.*, Year 0. This will be needed to answer Case Question 1. To work out the total operating cost for Year 0, you do not need Solver at all. However, it will be good to use Solver to find the solution for you as well. This will allow you to (i) cross-check if your cost figure is correct and (ii) have a generic model that can be copied and modified for scenario testing. As the layout of all the other models will be the same as that of the generic model, and the Solver setups will be quite similar, you can simply copy the generic model and rename it to become another model for a particular scenario.

<u>For each year (Year 1 to Year 3) of each scenario (A, B and C), you will need one model to find the optimal network configuration</u>. As mentioned above, this can be done easily by copying the validated generic model to a new spreadsheet and rename it. Next, alter the input parameters of the model and revise the constraints in the Solver dialogue box where appropriate to reflect the conditions of the scenario. Then, run Solver to get the optimal solution for that scenario. Basically, the workbook should comprise the at least 11 worksheets. Ten (10) of them should be models, each representing a particular situation or scenario in a particular year:

(1) One (1) model showing the current delivery arrangement and the total annual production and transportation cost (*i.e.*, the as-is situation with only one baking facility in Mentone serving all shops);
(2) Three (3) models, one for each of the next three years, showing the optimal network configurations and total annual production and transportation costs under Scenario A (*i.e.*, keeping the existing baking facility at Mentone);
(3) Three (3) models, one for each of the next three years, showing the optimal network configurations and total annual production and transportation costs under Scenario B (*i.e.*, closing the existing baking facility in Mentone and setting up new plants in other suburbs); and
(4) Three (3) models, one for each of the next three years, showing the optimal network configurations and total annual production and transportation costs under Scenario C (*i.e.*, Setting up only one production line at each baking facility, existing and new facilities alike).

As Case Question 5 requires you to prepare a year-by-year action plan, *i.e.*, what facilities are to be built in which suburbs in which year, you will need to use one (1) worksheet as a summary of the findings. The sheet should detail the recommended action plan for Oz Bread in terms of the number and location of the new baking facilities to be built, existing facilities to be shut down, production lines to be set up, total amount of excess capacity, and total cost incurred (including construction, fixed, production and transportation costs less scrap value) on a year-by-year basis for the next three years.

NOTE: DO NOT use only one single spreadsheet or a summary report in the Excel workbook for everything and expect the assessor to create the models for the different scenarios from scratch to check your answers. Marks will be significantly deducted if the required ten models and one summary sheet are not provided.

Unlike the SunOil example in which only operating cost is considered, we have to take into account construction cost of the new plants in the Oz Bread case in deciding on the final long-run network configuration. Since for simplicity reason we are use the same formulation of the SunOil example for the Oz Bread case, it means the model we created for the Oz Bread case does not have construction cost in the objective function. Therefore, we cannot take the Solver solutions as the final configurations. It is because to minimize total operating cost, Solver may recommend the use of multiple facilities thus incurring a very large construction cost. In practice, we will try to minimize the total cost of both the long-run operation as well as the construction cost of the new plants. In other words, we do not want to have waste. Any configuration with plants that are not fully utilized or needed in the long run should be avoided. In other words, we would need to modify some of the Solver solutions (which focus entirely on minimizing total operating cost) and come up with a plan that could minimize the long-run operating cost (refer to that or Year 3) and the total construction cost during the first three years. As such, apart from the above 11 worksheets, you will probably need to make use of the generic models to create some additional models to test the revised configurations.

Here are some suggestions for you to set up the model:

1. There are many ways to build the model. You are encouraged to use your own design keeping in mind that the model logic needs to be easy to follow and understand while the model layout is simple and clear. Proper colour scheme and legend should be used where appropriate to make the model self-explanatory. As an example, the tables for the input parameter, such as unit cost, plant capacity, and shop demand, could be set up as shown in Figure 1. To fill in the input parameter tables, you would need to study the case carefully and make full use of the data and information provided therein. Again as an example, the decision variable tables, one for breads and one for pies, together with the constraints and the cost items, could also be set up as shown in Figure 2. Of course, you can combine the two tables into one if you wish. I am just of the opinion that calculating the cost of the two products in separate tables may make the model easier to understand and follow. To calculate the fixed, variable, and transportation cost, the Excel SUMPRODUCT spreadsheet function could be used (refer to the SunOil example for how the formulas should be set up). You would need to include the cost of both breads and pies in the calculation. The total cost (on an annual basis) is just a summation of the fixed (i.e., maintenance and overhead cost), the variable (*i.e.*, production cost), and the transportation cost. This will be the Objective cell referred to in the Solver dialogue box.

Plant Cost and Capacity

	Breads			Pies		
Plant	Annual Fixed Cost	Variable Cost/unit	Daily Capacity	Annual Fixed Cost	Variable Cost/unit	Daily Capacity
Mentone						
Prahan						
Northcote						
Laverton North						

Daily Demand by Product

Shop	Glen Waverley	Doncaster	Melbourne CBD	Thomas-town	St. Albans	Hoppers Crossing
Breads						
Pies						
Annual Growth						

Transportation Cost per Unit

Shop / Plant	Glen Waverley	Doncaster	Melbourne CBD	Thomas-town	St. Albans	Hoppers Crossing
Mentone						
Prahan						
Northcote						
Laverton North						

Legend

	Input Parameter

Figure 1 – Possible design of input parameter tables for the Oz Bread case

Daily Production and Distribution of Breads

Plant \ Shop	Glen Waverley	Doncaster	Melbourne CBD	Thomas-town	St. Albans	Hoppers Crossing	Line Open (1) or Close (0)	Total Daily Production	Excess Capacity
Mentone									
Prahan									
Northcote									
Laverton North									
Total Daily Supply									
Unmet Demand									

Daily Production and Distribution of Pies

Plant \ Shop	Glen Waverley	Doncaster	Melbourne CBD	Thomas-town	St. Albans	Hoppers Crossing	Line Open (1) or Close (0)	Total Daily Production	Excess Capacity
Mentone									
Prahan									
Northcote									
Laverton North									
Total Daily Supply									
Unmet Demand									

Annual Cost

Fixed Cost	
Variable Cost	
Transportation Cost	
Total Cost	

Legend

(yellow)	Decision Variable
(pink)	Constraint
(green)	Cost Item

Figure 2 – Possible design of decision variable and cost tables for the Oz Bread case

2. The major decision variables in this case should include the following:

- **which plants (or baking facilities) to open and which ones to shut down** (Note: Building new facilities would incur significant construction cost while permanently shutting down existing facilities, even they were only built recently, would acquire some scrap value); and
- **which plants should produce both breads and pies** (in that case, there is no savings in construction cost) **and which ones should only produce one product** (in that case, there will be a 30% savings in construction cost for not setting up the facility to produce the other product). (Note: The decision of setting up a single or dual production line facility has to be made when the plant is constructed. Once built, a single production line facility cannot produce both products. However, a dual production line facility can be used to produce one product only if needed.)

3. Obviously, these decision variables are binary variables similar to those in the SunOil example (see Chapter 5 of the prescribed textbook) except that in the SunOil example there are two types of plants whereas in the Oz Bread case there are two production lines instead. If considered easier to understand, you could use a separate binary variable to represent the state of a plant, *i.e.*, open or close, and another two binary variables – one for breads and one for pies – to represent whether only one or two production lines are open. I am just of the view that using the latter two binary variables would suffice in this case as whether a plant is open or close can be worked out using the values of the two binary variables. Getting these numbers correctly would help you work out the total fixed cost as mentioned in (1) above.

4. Please note that for those plants that need to be shut down in the long run (*i.e.*, not included in the network configuration for many years), there would be scrap value. However, if the plant is just not operational for one year and then becomes operational again in another year, it is not a permanent shutdown but temporarily being laid idle. There would not be any production of either products, and consequently there would be no fixed cost. But there would not be any scrap value either. These considerations are useful to help you develop the action plan for Oz Bread, *i.e.*, answering Case Question 5.

5. The other decision variables are of course the units of products (both breads and pies) to be produced from the opened plants and delivered to the different shops. Getting these numbers correctly would help you work out the total variable cost and the total transportation cost as mentioned in (1) above. Please note that the values of all decision variables are to be determined by Solver. If you have to manually set the values of any of these variables to reflect certain conditions, they are no longer variables and should not be included in

the set of Decision Variables in the Solver dialogue box. Alternatively, you would have to use additional constraints in Solver to specify their values (see 10 below).

6. The constraints in this case are exactly the same as those in the SunOil example, *i.e.*, capacity and demand constraints. First, total production from all plants that are open should not exceed total available capacity. We would tolerate some excess capacity as it is unlikely that the total demand would exactly match the available capacity bearing in mind that new facilities are set up to cater for the continuous growth in demand which would only materialize gradually. However, total production for (or supply to) a shop should be exactly equal to the expected demand as we do not want excess inventory (*i.e.*, breads and pies which are not sold on the day) which is costly. Unmet demand is also undesirable as there would be cost of lost sales. Just refer to the SunOil example and you should see how to set up these two constraints on the spreadsheet and in the Solver dialogue box. There are other constraints such as non-negative value and binary value constraints to be set up. Again, they are very similar to those in the SunOil example.

7. Once the model is properly set up, you can use it to work out the optimal network configuration and the total cost in different years under the three scenarios using the information provided in the case. Obviously in the as-is situation, *i.e.*, Case Question 1, you do not need Solver to work out which plant should be open or shut down or how the production of breads and pies should be allocated to the different shops. The information is given in the case and a simple calculation would suffice to answer this question. That is to say, Case Question 1 is not an optimization problem and therefore Solver is not required to find the optimal solution although there is no harm to set up Solver in this model to make it a generic model. If done properly, you should be able to get a total cost of $2,261,840. Please note that this is the sum of the annual fixed, variable, and transportation cost of the operation in the current year, *i.e.*, Year 0. If you decide to build a new plant to be available next year, *i.e.*, Year 1, the construction cost will be incurred in this year and is additional to the operational cost.

8. Once you have obtained the total cost of the as-is situation, you can use the model (with Solver set up and duly revised to reflect the scenario setting) to work out the optimal configurations in other years, *i.e.*, Years 1, 2 and 3, under the different scenarios, *i.e.*, A, B and C, and see what the new operational costs will be. An important point to note is that optimal solutions based entirely on operational cost are unlikely the true optimal solutions as we need to take into account the construction costs for new plants and the total excess capacity. While from an operational point of view, the more plants and capacity there are the easier to find the least cost distribution arrangement. But then it will incur a huge amount of construction cost and generate a lot of excess capacity which is a waste. One way to address this issue is to incorporate construction cost and scrap value in the mathematical program. But the complexity might be beyond the scope of this course. Therefore, an alternative way to find a better solution is to examine the optimal solutions recommended by Solver on the basis of operational cost only and make necessary adjustment to minimize construction cost and excess capacity. This will require some careful analysis of the pros and cons of various alternatives which is what logistics managers are doing in practice. In short, Solver may provide an empirical basis to facilitate analysis but the final decision has to be made by the decision maker taking into account other factors, both qualitative and quantitative, that have not been considered or formulated in the mathematical program.

9. For Case Questions 2, 3 and 4, it is recommended that you should first use Solver to churn out the optimal network configurations on a year-by-year basis based entirely on operational cost. Then, you could examine the recommended solutions and see how a near optimal solution (*i.e.*, slightly higher total operational cost but lower total cost including construction cost) can be obtained by fully utilizing the available capacity thereby reduces the number of new plants required. One principle that you may wish to adhere to is that the Solver solution for Year 3 should be the long-run optimal configuration entirely from an operational perspective. Therefore, keeping this configuration has the merit of having the lowest operating cost in the long run. As such, if we consider cost only, the Year-3 configuration should be the final optimal configuration in each of the scenarios. Any modification of the Year-1 and Year-2 configurations should lead to the Year-3 configuration in the end unless there is such a big saving in construction cost in using an alternative configuration that can fully justify a higher long-run operating cost.

10. To revise the network configurations recommended by Solver, the appropriate approach is to insert additional constraints in the Solver dialogue box and rerun Solver. For example, you can stipulate certain plants to be open or close according to your strategy by setting the corresponding binary variables to 0 or 1. Instead of hardwiring the value in the variable, you can add a constraint in the Solver dialogue box to implement it. In so doing, Solver would find the new optimal configuration for you taking into account the new constraints. The total operational cost of your revised network might be slightly higher than the original recommended solution. However, the saving in construction cost as a result of opening few plants would certainly help to reduce the total cost – operating plus construction costs – in the long run.

11. Once you have worked out the best way to expand the production network for Oz Bread in the next three years (*i.e.*, choosing among the three scenarios), you could develop an action plan to answer Case Question 5 by summarizing the revised optimal network upon considering the various scenarios and support your argument using the relevant cost figures.

Finally, you may wish to note that the assessment of this assignment is not based entirely on the Excel model or the correctness of the total cost figures. I will also look at the model logic, the model structure, the layout design (*e.g.*, use of colour to clearly demarcate the various sections of the model for easy tracking), the depth of the analysis, and the organization and presentation of the report, among other things, to give the final marks. **The weight of the model and the report is 50%-50% although on Canvas a whole number must be used, *i.e.*, submitting a report without the model or vice versa will have a maximum of 12 or 13 marks only.** Therefore, both the report – a Word file (no PDF file) – and the model – an Excel file (no PDF file) – must be submitted.

The Oz Bread case is very similar to the SunOil example with the same model logic although modification to the model is required. The only differences are that (1) there are two types of plants in the SunOil example but only one in the Oz Bread case, and (2) there are two products in the Oz Bread case whereas there is only one in the SunOil example. These differences require a slightly different setup in decision variables and constraints. But once you understand the model logic, the modification should not be difficult at all.

For the model component, as long as your model logic (basically the way to work out the answer including the formula set up) is correct and the model is well structured and designed which is easy to understand and follow, there should not be a big penalty even though your figures are not exactly the same as the optimal ones. Even if the model logic is not correct and basically your model is wrong and useless as a tool for analysis, you can still get some marks if you really put in effort to churn out a very good report. In this regard, please read the assignment document and the assessment rubrics (available on Canvas) in detail and make sure you complete all the required tasks. Effort and sincerity can be easily witnessed if you do have invested in your work. That is to say, you can still prepare a good report and try to answer the case questions from a qualitative perspective through analysis using the information provided in the case and from other sources. You will probably fail this assignment without the modelling part. But if you get enough marks from the other assessment tasks and good result in the final examination, you will still pass the course.

NOTE: It is unacceptable to submit a model or solution downloaded from the publisher or the Internet without adequate understanding of the model logic and appropriate modifications to the model design to incorporate the scenarios of the case questions. Even though there might be published solutions, you still need to put in adequate effort to create a base model of your own with variations for scenario analyses. Otherwise, there will be significant deduction in marks and possible hearing for suspected plagiarism in severe cases.

I hope the above is useful.

Regards,
Charles