McGill University

Decision Analytics MGSC 662

Assignment 1

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(a) Formulate Filatoi Riuniti's purchasing problem for the coming month (March):

1. Write down the formula for the objective function of your model.

Objective Formula That minimizes costs

OF= Production cost + Transportation cost

Objective function →=$\Sigma Xi*CTi+Xi*CPi$

Decision Variables $4*7 = 28$

- X indicates the quantity of each type of product from the suppliers
  X_{ji}

  X_{a1}, X_{a2}, X_{a3},…… X_{g1}, X_{g2}, X_{g3}, X_{g4}
- CT is the per unit cost of transportation for every product from the different suppliers
  CT_{ji}

  CT_{a1}, CT_{a2}, CT_{a3},…, CT_{g1}, CT_{g2}, CT_{g3} , CT_{g4}
- CP is the per unit cost of production for every product from different suppliers
  CP_{ji}

  CP_{a1}, CP_{a2}, CP_{a3} …., CP_{g1}, CP_{g2}, CP_{g3} , CP_{g4}

2. Your model must have a capacity constraint for each local spinning mill. Write down the capacity constraints for all the mills as well as Filatoi Riuniti.

Capacity Constraints

Ambrosi	<=	2,500
Bresciani	<=	3,000
Castri	<=	2,500
De Blasi	<=	2,600
Estensi	<=	2,500
Filatoi	<=	38,000
Giuliani	<=	2,500

3. Filatoi Riuniti must meet demand for each of the four sizes of yarn. Your model must have a constraint for the demand for each of the four sizes of yarn. Write down the constraint for the demand for all types of yarns including extra fine, fine, medium and coarse yarns.

Demand Constaints

Extra fine	>=	25,000
Fine	>=	26,000
Medium	>=	28,000
Coarse	>=	28,000

(b) Construct the code for your optimization model. First, open a Jupyter Notebook. Then, read the spreadsheet FILATOIR.XLS (or you may want to copy and paste the data into your code, as you wish). You can do it in any way you prefer. Finally, implement your model and optimize it using the packaged GUROBI. You will need to:

• create the objective function and the constraints, and

• optimize your model. Can you assume a linear model? What is the optimal supply strategy?

The Final Cost Optimal Solution: $1382544.33

	Extra Fine	Fine	Medium	Coarse
A	0.0	6250.0	0.0	0.0
B	4285.7143	0.0	0.0	0.0
C	3703.7037	0.0	0.0	0.0
D	0.0	0.0	2040.1255	0.0
E	3846.1538	0.0	0.0	0.0
F	13164.428	19750.0	18817.017	28,000
G	0.0	0.0	7142.8571	0.0

We will assume that it is a linear model since the objective function and constraints have linear equations.

(c) Filatoi Riuniti should obviously consider increasing its spinning machine capacity. They could slightly expand the production capacity of the existing machines by renting an upgrade. This would increase their spinning production capacity by 600 hours/month. The monthly rental cost is $1,500/month. Would you recommend that they rent the upgrade? (Try to answer this question without re-optimizing your model.)

After generating a report for constraints

a- After generating the sensitivity report using spyder code, we notice that the shadow price for 7th constraint representing factory ProductionFilatoi is -2.117647
Increasing 600 hours/month=-2.117647*600=1270.6<1500
When comparing the two costs, it will not be effective to upgrade due to the additional cost of 229.4$ (1500-1270.6).

Conclusion: No upgrade with rent as shadow price is lower than rent cost.

(d) Alternatively, Filatoi Riuniti could increase its spinning machine capacity by renting another spinning machine for the production of only medium size yarn, for a monthly rental cost of $3,000. **The machine has a production capacity of 300 hours per month (the machine would run at the same rate of 0.425 hours/Kg).** Suppose that the estimated production cost of running this machine is less than for Filatoi Riuniti's existing machines and is estimated to be $5.70/Kg (as opposed to $11.40/Kg for their existing machines according to Table 2). Would you recommend that Filatoi Riuniti rent the machine? (Try to answer this question without re-optimizing your model.)

With the purchase of a new machine the new rate is 300 hours/month, the machine will run at 0.425 hours per kilogram.

By divide the numbers, I can conclude that the extra productivity will be from the following calculations.

- Extra productivity=300/0.425=705.9 kg
- We will be saving 5.7$/KG due to the new cost since it will be different given the cost/kg * extra productivity
- The costs 5.7 incurred is 5.7$/kg, savings due to the new cost will be the difference in cost/kg multiplied by the extra productivity
- Cost at 11.4= 705.9x11.4=8047.26$
- Cost at 5.7=705.9x5.7+3000=7023.63$
- 8047.26>7023.63

Therefore, the new cost is less than the old cost.

(e) A new client is interested in purchasing up to 6,000 Kg/month of medium size yarn. What is the minimum price that Filatoi Riuniti should quote to this new client? Would it be a fixed price per Kg? Which additional question(s) might you ask this client? (In answering this question, assume that Filatoi Riuniti has not decided to expand its spinning machine capacity, and that Filatoi Riuniti does not want to change the prices that they currently charge their existing clients.)

See model in python file

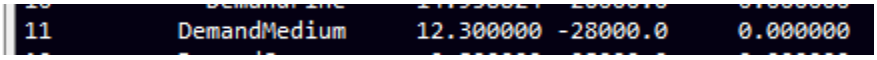
New optimal:$1457237.88

Cost2-cost1=: 1457237.88-1382544.33=74693.6$ more cost per 6000 kg

Cost/kg=74693.6/6000=12.45 $/kg

if we look at the shadow price, we see that the minimum price should be at least 12.3$

Old Model 28k Medium



New Model 34k Medium

Given the new model, I believe that the minimum allowable price should be 13.76$. We do not have a allowable increase and decrease in python gurobipy however if we are allowed to use excel we can then further predict the allowable increase and decrease. I believe it will not a be fixed price as it depends on if the exact quantity doesn't change & also depends on length of contract. So I would need to ask the client if 6000 kg/Month is the exact quantity required and I would like to know the length of the contract.

(f) You estimate that the production capacity of one of your local mills, De Blasi, could vary within a 20% range of the figures shown in Table 2. Would your recommendations change in the extreme cases? Why or why not? (Try to answer this question without re-optimizing your model.)

Based on the table from the gurobipy code, I believe that “De Blasi’s” capacity is at 2600 therefore De Blasi’s capacity can potentially vary in the range of 2080 to 3120. If we consider the shadow price of De Balsi is 0, which can mean that it is not a binding constraint, then a 20% increase or decrease will not cause changes to our optimal solution. If given an excel model we can use a sensitivity analysis to see the allowable increase and decrease.

(g) Suppose that you present your proposed outsourcing plan to the owners of the Ambrosi mill. They complain to you that their mill cannot easily produce fine size yarn; in fact, they presently can only produce medium and coarse size yarn, and they would incur substantial one-time set-up costs to ramp up for the production of fine size yarn. However, the optimal solution of the model indicates that it would be in Filatoi Riuniti's interests for the Ambrosi mill to produce fine size yarn. The owners want to maintain good business relations with Filatoi Riuniti, but they do not want to bear the full cost of ramping up for production of fine yarn. The contracts that Filatoi Riuniti currently has with its customers will not expire for at least another 12 months. Up to what amount would you be willing to share the

According to the new model with the extra constraint, the optimal cost will change to 1384912. So New vs Old → 1384912-1382544= $2368. Given the difference fillatoi is willing to share the one time cost of 2368.

(h) Suppose that you find out that one of the local mills, Giuliani, has the possibility of running an overtime shift (which would double their capacity) by paying its workers only 13% more the normal wage (it is a family-owned business). You know that the workers' salaries contribute to approximately 50% of the prices that the Giuliani mill charges Filatoi Riuniti for spinning yarn. The transportation cost component of the objective function would not change, of course. Modify the model in order to take into account this possibility and re-optimize. Does the optimal solution change? Why? [Helpful modeling hint: Think of the ''overtime" part of this mill as a new mill with higher product costs.]

1382340.322

If we reoptimize the model, I will add additional production costs to keep the matrices consistent.

Therefore this is the overtime extra

Machine_Hours=[0.700,0.450,0.350,0.400]

Cost_of_transport= [0.5, 0.5, 0.75, 0.75]

Cost_of_product= [21.03,14.80,11.45,10.01]

OverTime calculation → 19.75*1.13+19.75*0.5=21.03… did it for fine,medium,and coarse as well

With the necessary constraints into the Gurobipy model I get the optimal solution $1382340.322 which is greater than our original solution of $1382544.33. So $1382340.322-$1382544.33 is 204.008 dollars less which means that with overtime there is a cost decrease. The shadow price should be 0 for overtime.