Filatoi Riuniti

Read the case Filatoi Riuniti provided on pages 3-8 (the tables in the case are available electronically on Canvas). Then, answer the following questions.

Questions

1. What is the optimal supply strategy for the month of March? What is the optimal cost?
    a. Formulate (**in math**) a linear program model for this problem. That is, specify the *decision variables*, the *objective function*, and the constraints of the model in the **summary report**. *(Legible, hand-written math formulation is acceptable. Mathematical shorthand is acceptable. That is, expressions like $\sum_{\substack{i=1,\dots,m,\\ j=1,\dots,n}} c_{ij}x_{ij}$ are acceptable, and a definition of what parameter c_{ij} represents should be provided.)*
    b. Construct a spreadsheet model of your formulation and solve it using **Excel's Solver**. Please make sure that
        i. Simplex LP is the solution method for the problem
        ii. **No integer constraints** should be added to the formulation (Solver will not provide a sensitivity report if an integer constraint is added).
    c. Present the optimal supply strategy in a table format.

   a. **The decision variable** is the size produced by each supplier, which we use $X_{i,j}$ as the symbol of it.

i = 1, 2, 3, 4, and means "extra fine," "fine," "medium," and "coarse," respectively.

j = A, B, C, D, E, F, G, which mean Ambrosi, Bresciani, Castri, De Blasi, Estensi, Filatoi Riuniti, and Giuliani.

The objective function is min($\sum_{j=A,B,C,D,E,F,G}^{i=1,2,3,4} CijXij$).

Cij means the cost of producing each amount of size produced by each supplier.

There are transportation cost and production cost, so Cij contains both transportation cost and production cost. Multiplying Cij with the corresponding Xij and summing them all is the total cost.

The constraints are as below:

Productions by suppliers

      All yarn produced by each supplier should greater than 0

      Extrafine produced by Ambrosi and De Blasi should be 0

Producion Capacity(Machine hours by each supplier)

      Ambrosi <= 2500; Bresciani <= 3000; Castri <= 2500; De Blasi <= 2600

      Estensi <= 2500; Filatoi R. <= 38000; Giuliani <=2500

Demand to meet

      Extrafine = 25000; Fine = 26000; Medium = 28000; Coarse = 28000

   b.

DECISION VARIABLES						MACHINE HOURS REQUIRED FOR PRODUCTION						PRODUCTION	
Yarn produced by each factory (Kg/month)						(Hours/Kg)						CAPACITY	
		Size						Size				(Machine hours)	
Supplier	Extrafine	Fine	Medium	Coarse		Supplier	Extrafine	Fine	Medium	Coarse		per month)	Actual Prod Hour
Ambrosi	0.00E+00	6,250	-	-		Ambrosi		0.400	0.375	0.250		2,500	2500
Bresciani	4,286	-	-	-		Bresciani	0.700	0.500	0.350	0.250		3,000	3000
Castri	3,704	-	-	-		Castri	0.675	0.450	0.400	0.250		2,500	2500
De Blasi	0.00E+00	-	2,040	-		De Blasi		0.450	0.350	0.200		2,600	714.0439082
Estensi	3,846	-	-	-		Estensi	0.650	0.450	0.400	0.250		2,500	2500
Filatoi R.	13,164	19,750	18,817	28,000		Filatoi R.	0.625	0.500	0.425	0.425		38,000	38000
Giuliani	-	-	7,143	-		Giuliani	0.700	0.450	0.350	0.400		2,500	2500
Production	2.50E+04	2.60E+04	2.80E+04	2.80E+04									

COST OF PRODUCTION						COST OF TRANSPORTATION						Round trip distance	
($/Kg)						($/Kg)							
		Size						Size					
Supplier	Extrafine	Fine	Medium	Coarse		Supplier	Extrafine	Fine	Medium	Coarse		(Km)	Total transportation cost
Ambrosi	0.00E+00	13.00	10.65	9.60		Ambrosi	0.30	0.30	0.45	0.45		30	1875
Bresciani	17.40	14.10	11.20	9.45		Bresciani	0.40	0.40	0.60	0.60		40	1714.285714
Castri	17.40	14.22	11.00	9.50		Castri	0.80	0.80	1.20	1.20		80	2962.962963
De Blasi	0.00E+00	14.30	11.25	9.60		De Blasi	0.70	0.70	1.05	1.05		70	2142.131724
Estensi	17.50	13.80	11.40	9.60		Estensi	0.70	0.70	1.05	1.05		70	2692.307692
Filatoi R.	18.25	13.90	11.40	8.90		Filatoi R.	-	-	-	-		-	0
Giuliani	19.75	13.90	10.75	9.40		Giuliani	0.50	0.50	0.75	0.75		50	5357.142857
						($/Kg/Km)	0.010	0.010	0.015	0.015			

DEMAND TO MEET						Objective Function		
(Kg/month)						Production Cost		1365801
	Extrafine	Fine	Medium	Coarse		Transportation Cost		16743.8
	25,000	26,000	28,000	28,000		Total		1382544

Constraints

Productions by suppliers

All yarn produced by each suppli	Xi,j	>=	0
Extrafine produced by Ambrosi	0.00E+00	=	0
Extrafine produced by De Blasi	0.00E+00	=	0

Producion Capacity	LHS		RHS
Machine hours			
Ambrosi	2500	<=	2500
Bresciani	3000	<=	3000
Castri	2500	<=	2500
De Blasi	714.044	<=	2600
Estensi	2500	<=	2500
Filatoi R.	38000	<=	38000
Giuliani	2500	<=	2500

DEMAND TO MEET			
Extrafine	25000	=	25000
Fine	26000	=	26000
Medium	28000	=	28000
Coarse	28000	=	28000

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B5	Ambrosi Extrafine	0	0	0.3	1E+30	1E+30
C5	Ambrosi Fine	6250	0	13.3	0.378823529	1E+30
D5	Ambrosi Medium	0	0.355147059	11.1	1E+30	0.355147059
E5	Ambrosi Coarse	0	1.286764706	10.05	1E+30	1.286764706
B6	Bresciani Extrafine	4285.714286	0	17.8	0.773529412	1E+30
C6	Bresciani Fine	0	0.807983193	14.5	1E+30	0.807983193
D6	Bresciani Medium	0	0.386764706	11.8	1E+30	0.386764706
E6	Bresciani Coarse	0	0.883403361	10.05	1E+30	0.883403361
B7	Castri Extrafine	3703.703704	0	18.2	1.204779412	1E+30
C7	Castri Fine	0	0.976862745	15.02	1E+30	0.976862745
D7	Castri Medium	0	0.713943355	12.2	1E+30	0.713943355
E7	Castri Coarse	0	1.408714597	10.7	1E+30	1.408714597
B8	De Blasi Extrafine	0	0	0.7	1E+30	1E+30
C8	De Blasi Fine	0	0.041176471	15	1E+30	0.041176471
D8	De Blasi Medium	2040.125452	0	12.3	0.035	0.8
E8	De Blasi Coarse	0	0.85	10.65	1E+30	0.85
B9	Estensi Extrafine	3846.153846	0	18.2	0.710784314	1.28154E+15
C9	Estensi Fine	0	0.492081448	14.5	1E+30	0.492081448
D9	Estensi Medium	0	0.995248869	12.45	1E+30	0.995248869
E9	Estensi Coarse	0	1.378280543	10.65	1E+30	1.378280543
B10	Filatoi R. Extrafine	13164.42816	0	18.25	2.276470588	0.710784314
C10	Filatoi R. Fine	19750	0	13.9	0.041176471	0.378823529
D10	Filatoi R. Medium	18817.01741	0	11.4	0.322	0.035
E10	Filatoi R. Coarse	28000	0	8.9	0.85	1E+30
B11	Giuliani Extrafine	0	2.276470588	20.25	1E+30	2.276470588
C11	Giuliani Fine	0	0.469747899	14.4	1E+30	0.469747899
D11	Giuliani Medium	7142.857143	0	11.5	0.365359477	1E+30
E11	Giuliani Coarse	0	1.264285714	10.15	1E+30	1.264285714

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
K36	Extrafine produced by Ambrosi Xi,j	0	-19.27352941	0	1387.285307	0
K37	Extrafine produced by De Blasi Xi,j	0	-18.87352941	0	1387.285307	0
K41	Ambrosi LHS	2500	-4.147058824	2500	693.6426536	1832.071632
K42	Bresciani LHS	3000	-2.533613445	3000	971.0997151	2564.900285
K43	Castri LHS	2500	-2.034858388	2500	936.4175824	2473.296703
K44	De Blasi LHS	714.0439082	0	2600	1E+30	1885.956092
K45	Estensi LHS	2500	-2.113122172	2500	901.7354497	2381.693122
K46	Filatoi R. LHS	38000	-2.117647059	38000	867.0533171	2290.08954
K47	Giuliani LHS	2500	-2.285714286	2500	714.0439082	1885.956092
K50	Extrafine LHS	25000	19.57352941	25000	3664.143264	1387.285307
K51	Fine LHS	26000	14.95882353	26000	4580.17908	1734.106634
K52	Medium LHS	28000	12.3	28000	5388.445977	2040.125452
K53	Coarse LHS	28000	9.8	28000	5388.445977	2040.125452

c. **The optimal solution:**

DECISION VARIABLES

Yarn produced by each factory (Kg/month)

Supplier	Extrafine	Fine	Medium	Coarse
		Size		
Ambrosi	0.00	6250.00	0.00	0.00
Bresciani	4285.71	0.00	0.00	0.00
Castri	3703.70	0.00	0.00	0.00
De Blasi	0.00	0.00	2040.13	0.00
Estensi	3846.15	0.00	0.00	0.00
Filatoi R.	13164.43	19750.00	18817.02	28000.00
Giuliani	0.00	0.00	7142.86	0.00

2. <u>Assess production capacity opportunity.</u> Filatoi could slightly expand the production capacity of its existing spinning 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? Why or why not?

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
K36	Extrafine produced by Ambrosi Xi,j	0	-19.27352941	0	1387.285307	0
K37	Extrafine produced by De Blasi Xi,j	0	-18.87352941	0	1387.285307	0
K41	Ambrosi LHS	2500	-4.147058824	2500	693.6426536	1832.071632
K42	Bresciani LHS	3000	-2.533613445	3000	971.0997151	2564.900285
K43	Castri LHS	2500	-2.034858388	2500	936.4175824	2473.296703
K44	De Blasi LHS	714.0439082	0	2600	1E+30	1885.956092
K45	Estensi LHS	2500	-2.113122172	2500	901.7354497	2381.693122
K46	Filatoi R. LHS	38000	-2.117647059	38000	867.0533171	2290.08954
K47	Giuliani LHS	2500	-2.285714286	2500	714.0439082	1885.956092
K50	Extrafine LHS	25000	19.57352941	25000	3664.143264	1387.285307
K51	Fine LHS	26000	14.95882353	26000	4580.17908	1734.106634
K52	Medium LHS	28000	12.3	28000	5388.445977	2040.125452
K53	Coarse LHS	28000	9.8	28000	5388.445977	2040.125452

600 is less than the allowable increase 867, which means we can use shadow price to predict. By expanding the production capacity, the cost would decrease by about $1,272 ($2.12*600). However, there is an additional monthly rental cost $1,500. The net change of the cost would increase by $228($1,500-$1,272). Thus, I would not recommend doing so.

3. <u>Assess impact of information update.</u> Your outsourcing production strategy optimization model is based in part on the prices charged by the local mills to Filatoi and on an estimate of Filatoi's internal production costs. The plant manager, the accounting department, and you estimate that <u>Filatoi's internal production costs </u>could vary within a 5% range of the figures originally estimated. Consider the following two cases:

   a. All of Filatoi's internal unit product costs increase by 5%
   b. All of Filatoi's internal unit production costs decrease by 5%
   Would your recommendation in Question 1 change? Why or why not?

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B10	Filatoi R. Extrafine	13164.42816	0	18.25	2.276470588	0.710784314
C10	Filatoi R. Fine	19750	0	13.9	0.041176471	0.378823529
D10	Filatoi R. Medium	18817.01741	0	11.4	0.322	0.035
E10	Filatoi R. Coarse	28000	0	8.9	0.85	1E+30

$18.25*0.05=$0.9125; $13.9*0.05=$0.695; $11.4*0.05=$0.57; $8.9*0.05=$0.445

a. If the internal production costs increase by 5%, the **fine** size produced by Filatoi**(0.695>0.041)** and the **medium** size produced by Filatoi**(0.57>0.322)** cannot be accurately predicted. This is because its increasing coefficient are out of allowable increase range. Hence, by predicting the cost from the chart above, I cannot make recommendations.
b. If the internal production costs decrease by 5%, the **extrafine** size produced by Filatoi**(0.9125>0.711)**, the **fine** size produced by Filatoi**(0.695>0.379)** and the medium size

produced by Filatoi**(0.57>0.305)** cannot be accurately predicted. This is because its increasing coefficient are out of allowable decrease range. Hence, by predicting the cost from the chart above, I cannot make recommendations.

4. <u>Assess impact of information update.</u> You estimate that the production capacity of **De Blasi** could vary within a 20% range of the figure shown in Table 2. Would your recommendation change in the two extreme cases: Why or why not?

   (a) +20% increase,
   (b) -20% decrease.

   a. I would not recommend an increase because De Blasi did not reach its production capacity. Thus, increasing the capacity is futile.
   b. 2600*(1-0.2) = 2080. De Blasi's production hour is only about 714, so decreasing 20% of capacity is acceptable(2080 > 714). It can even be decreased by about 72.54%, so the capacity will be about 714.

5. <u>Use the model to support the available-to-promise function.</u> A client has just called asking for an additional 5,000 kg of the medium size yarn. The original demand still has to be met but Filatoi is considering whether it should accept the new order and <u>what is the minimum price ($/kg) it should charge for it</u>. You can assume that Filatoi <u>can</u> adjust its outsourcing orders with the suppliers.

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
K52	Medium LHS	28000	12.3	28000	5388.445977	2040.125452

5,000 is less than the allowable increase 5388, which means we can use shadow price to predict. By expanding the demand of medium size yarn, the cost would be increased by $61,500 ($12.3*5000).

DECISION VARIABLES
Yarn produced by each factory (Kg/month)

Supplier	Extrafine	Fine	Medium	Coarse
Ambrosi	0.00	6250.00	0.00	0.00
Bresciani	4285.71	0.00	0.00	0.00
Castri	3703.70	0.00	0.00	0.00
De Blasi	0.00	0.00	2040.13	0.00
Estensi	3846.15	0.00	0.00	0.00
Filatoi R.	13164.43	19750.00	18817.02	28000.00
Giuliani	0.00	0.00	7142.86	0.00

COST OF PRODUCTION
($/Kg)

Supplier	Extrafine	Fine	Medium	Coarse
Ambrosi	0.00	13.00	10.65	9.60
Bresciani	17.40	14.10	11.20	9.45
Castri	17.40	14.22	11.00	9.50
De Blasi	0.00	14.30	11.25	9.60
Estensi	17.50	13.80	11.40	9.60
Filatoi R.	18.25	13.90	11.40	8.90
Giuliani	19.75	13.90	10.75	9.40

COST OF TRANSPORTATION
($/Kg)

Supplier	Extrafine	Fine	Medium	Coarse
Ambrosi	0.30	0.30	0.45	0.45
Bresciani	0.40	0.40	0.60	0.60
Castri	0.80	0.80	1.20	1.20
De Blasi	0.70	0.70	1.05	1.05
Estensi	0.70	0.70	1.05	1.05
Filatoi R.	0.00	0.00	0.00	0.00
Giuliani	0.50	0.50	0.75	0.75

The original production costs of medium size yarn:
     2040.13*$11.25 + 18817.02*$11.4 + 7142.86*$10.75 = $314,251.24
The original transportation costs of medium size yarn:
     2040.13*$1.05 + 18817.02*$0 + 7142.86*$0.75 = $7,499.28
Total Cost = Sum of original production costs, transportation costs, and the additional cost
     $314,251.24 + $7,499.28 + $61,500 = $383,250.52

The minimum price should be about **$11.61($/kg). ($383,250.52/(28000+5000))**

6. <u>Use the model to support the outsourcing negotiation.</u> Suppose you presented 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 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 Ambrois mill to produce fine size yarn. The owners want to maintain good relations with Filatoi Riuniti, but they do not want to bear the full cost of ramping up for production no fine yarn. The contracts that Filatoi Riuniti currently has with its customer will not expire for at least another 12 months. Up to what amount would you be willing to share the one-time set-up costs for production of fine yarn with the owners of the Ambrosi mill?

We should add one more constraint to the new model, which is the production of the extra fine and fine size yarn by Ambrosi should be 0.

Initial Decision:

Yarn produced by each factory (Kg/month)

Supplier	Extrafine	Fine	Medium	Coarse
Ambrosi	0.00	6250.00	0.00	0.00
Bresciani	4285.71	0.00	0.00	0.00
Castri	3703.70	0.00	0.00	0.00
De Blasi	0.00	0.00	2040.13	0.00
Estensi	3846.15	0.00	0.00	0.00
Filatoi R.	13164.43	19750.00	18817.02	28000.00
Giuliani	0.00	0.00	7142.86	0.00

Objective Function

Production Cost	1365801
Transportation Cost	16743.83
Total	1382544

New Decision:

Yarn produced by each factory (Kg/month)

Supplier	Extrafine	Fine	Medium	Coarse
Ambrosi	0.00	0.00	6666.67	0.00
Bresciani	4285.71	0.00	0.00	0.00
Castri	3703.70	0.00	0.00	0.00
De Blasi	0.00	0.00	2726.40	0.00
Estensi	3846.15	0.00	0.00	0.00
Filatoi R.	13164.43	26000.00	11464.08	28000.00
Giuliani	0.00	0.00	7142.86	0.00

Objective Function

Production Cost	1366323
Transportation Cost	18589.42
Total	1384912

The cost will be increased by $2,386($1,384,912 - $1,382,544)

The initial cost of Ambrosi producing fine size: 6250*($13+$0.3) = $83,125

To avoid the additional cost, we should share $83,125 as an one-time set-up costs to Filatoi R.