Final Project

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DS 806.02

a) One of the main agenda items for the meeting with Eddy is the faux leather products. Eddy has calculated that $500,000 of the design and other costs are attributable to faux leather shirts. He argues that the net contribution of these items should at least cover these fixed costs. Net contribution of a product is found by subtracting the variable costs (material, labor and equipment) from the price of an item. This corresponds to $22 for a faux leather shirt. Eddie argues that given this number and the demand forecasts it is not worthwhile to produce faux leather shirts and that they should be taken out from the product line up. What do you think of his argument? Explain?

Eddy has a very strong argument for shifting away from this product due to more profit with another, however, with the strict constraints being applied to this production model, I do not see any better options to shift the production and resources to. Using Solver for optimization, we see that five of the seven materials are at the maximum quantity. And while costs would decrease due to the higher price of leatherette, the demand constraints are already met on five of the eight products. The unique part is that for products below the maximum demand, the materials required to make those products are at the supply limit. A new product which requires only wool would be an interesting opportunity to find a better net contribution within the clothing line.

b) Formulate and solve linear programming model(s) to maximize profit. (Note you may be able to simplify your models by solving multiple smaller LP's). Clearly define your variables, objective function and constraints. **Include a LEGIBLE screen shot of your Excel/AMPL models and sensitivity reports.**

Project															
	Material Requirements	Price	Labor & Equipment Cost	Min Demand Contraints:		Demand Constraints:			Wool:	Lining:	Silk:	Rayon:	Cashmere:	Leatherette:	Cotton:
Wool Pants	3 Yard Wool	300	160	4200	7000	<=	7000		3	0	0	0	0	0	0
Wool Jacket	2.5 Yard Wool & 1.5 Yard Lining	320	140	3000	3200	<=	5000		2.5	1.5	0	0	0	0	0
Cashmere Long Sleeve	1.5 Yard Cashmere	450	150		4000	<=	4000		0	0	0	0	1.5	0	0
Silk Shirt	1.5 Yard Silk	180	100		7000	<=	12000		0	0	1.5	0	0	0	0
Silk Cami	0.5 Yard Silk	120	60		15000	<=	15000		0	0	0.5	0	0	0	0
Rayon Skirt	2 Yard Rayon & 1.5 Yards Lining	270	120		2800	>=	2800		0	1.5	0	2	0	0	0
Faux Leather Pants	3 Yard Leatherette	350	178		5000	<=	5000		0	0	0	0	0	3	0
Faux Leather Shirt	1.5 Yard Leatherette	200	160		3333.33333	<=	6000		0	0	0	0	0	1.5	0
Blouse	1.5 Yard Rayon	120	90		16266.6667				0	0	0	1.5	0	0	0
Cotton Wrap Sweater	1.5 Yard Cotton Fabric	130	60		0				0	0	0	0	0	0	1.5
Cotton Shorts	0.5 Yard Cotton Fabric	75	40		60000				0	0	0	0	0	0	0.5
								Totals:	29000	9000	18000	30000	6000	20000	30000
				Profit:	6966333.33										

Inputs:				
Material Type:	Price/yard:	Quantity:	Amount Used:	
Wool	9	45000	29000	
Lining	1.5	9000	9000	
Silk	13	18000	18000	
Rayon	2.25	30000	30000	
Cashmere	60	9000	6000	
Leatherette	12	20000	20000	
Cotton	2.5	30000	30000	

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [Project.xlsx]Sheet1
Report Created: 3/15/2024 9:55:52 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
F4	3 Yard Wool	7000	113	113	1E+30	113
F5	2.5 Yard Wool & 1.5 Yard Lining	3200	0	155.25	1E+30	47.5
F6	1.5 Yard Cashmere	4000	210	210	1E+30	210
F7	1.5 Yard Silk	7000	0	60.5	100	60.5
F8	0.5 Yard Silk	15000	33.33333333	53.5	1E+30	33.33333333
F9	2 Yard Rayon & 1.5 Yards Lining	2800	-47.5	143.25	47.5	1E+30
F10	3 Yard Leatherette	5000	92	136	1E+30	92
F11	1.5 Yard Leatherette	3333.333333	0	22	46	22
F12	1.5 Yard Rayon	16266.66667	0	26.625	1E+30	26.625
F13	1.5 Yard Cotton Fabric	0	-35	66.25	35	1E+30
F14	0.5 Yard Cotton Fabric	60000	0	33.75	1E+30	11.66666667

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
D20	Wool Amount Used:	29000	0	45000	1E+30	16000
D21	Lining Amount Used:	9000	103.5	9000	2700	300
D22	Silk Amount Used:	18000	40.33333333	18000	7500	10500
D23	Rayon Amount Used:	30000	17.75	30000	1E+30	24400
D24	Cashmere Amount Used:	6000	0	9000	1E+30	3000
D25	Leatherette Amount Used:	20000	14.66666667	20000	4000	5000
D26	Cotton Amount Used:	30000	67.5	30000	1E+30	30000

c) The faux leather supplier has informed Elizabeth that the leatherette cannot be sent back, so there will be no refund for extra material. This means that 20,000 yards of leatherette at $12 per yard will have to be paid no matter what, it is a sunk cost. Does this change the production plan? Make sure to look at the sensitivity report, and only resolve if necessary. Explain your reasoning.

This does not change anything within the model as the maximum amount of leatherette is being consumed fully at 20,000 yards. The sensitivity report suggests that the amount used can be decreased by 5,000 yards and still be within the basis, but with the inability to return the material, this would not lead to a change in the quantity used.

d) Provide an intuitive explanation to the difference in your answers (if any) due to this change in refund policy.

With the maximization of profit, it would make the most sense to use the full total of leatherette as the faux leather pants and shirt each have a positive net contribution to the total profit, so there would be no reason to use less than 20,000 yards. Even though the profit for those two products is rather low compared to some others in the clothing line, any profit is better than no profit.

e) Assume, original problem (i.e. refund is all possible for leatherette). The sewing department has reported that due to the thickness of the fabric, it requires more sewing hours for each wool jacket, increasing the labor and equipment cost of each wool jacket by $40. How does your production plan change and profit change (if any). Only resolve if necessary. Explain your reasoning.

According to the sensitivity report, there is a $47.5 allowable decrease which means that the objective coefficient (wool jacket profit) can decrease by $47.5 before affecting the basis. Since the $40 increase in costs is within the allowable range, this would not have an impact on the production plan, but will decrease the profits.

f) Assume, original problem (i.e. refund is all possible for leatherette, no change to wool jacket costs). Elizabeth thinks that there is room for some price adjustments, without impacting demand. She proposes increasing the price of a jacket to $350. What will be the optimal production plan and profit (do not resolve, explain your answer)

The optimal production plan would not remain the same and would require adjustments to the original model as the allowable increase in the objective coefficient, or profit, is zero indicating that any increase would lead to a change that is outside the optimal basis. Since the maximum demand for wool jackets is not met, this would likely increase the amount of production towards the product. But if we kept the production and demand constant and consider only the increase in price, the current profit would increase by $96,000.

g) Assume, original problem (i.e. refund is all possible for leatherette, no change to wool jacket costs/price). The supplier has informed us that due to a cancellation 10000 additional yards of lining are available.

- If the cost is the same should Elizabeth purchase more lining? What will be resulting profit? Will the production plan change? (do not resolve, if you cannot say the resulting profit without resolving state that, explain your answer)

-if she has to pay $ 3.50 per yard of extra lining, should she all purchase the extra lining? What will be the resulting profit? Will the production plan change? (do not resolve, explain your answer)

With each quantity of lining purchased above the current quantity of 9,000, Elizabeth would expect to see an increase of $103.50 to Chakra's profits. Since the increase would be 1,000 yards, this would increase profits by $103,500 and bring the grand total to $7,069,833.33 ($103,500 + $6,966,333.33). The production model would change as more lining based products would be made, likely with the wool jacket as the only other product requiring lining is Rayon Shirts and rayon is already at it's supply maximum. With that being said, it would still remain in the current basis. Even if the extra 1,000 yards of lining cost $3.50 per yard, Elizabeth should purchase all of them as this would only decrease the profits by $3,500 to $7,066,333.33 ($7,069,833.33 - $3,500). Even with that, this would not change the optimal solution.

h) Elizabeth has made a new deal which will allow her to sell all items in unlimited quantity for a 40% discount (i.e. prices are decreased by 40%) at the end of the season (i.e. the upper bounds from the model are valid only for the original price). What should be the new plan? Your model(s) should only

include products that are all “profitable” at sale. Make sure to include your model and solution. Please state your solution. **Include a LEGIBLE screen shot of your Excel/AMPL models and the sensitivity reports.**

Project														
	Material Requirements	Price	Labor, Equipment Cost, and Material Cost	Min Demand Contraints:		Demand Constraints:			Wool:	Lining:	Silk:	Rayon:	Cashmere:	Leatherette:	Cotton:
Wool Pants	3 Yard Wool	180	187	4200	0	<=	7000		3	0	0	0	0	0	0
Wool Jacket	2.5 Yard Wool & 1.5 Yard Lining	192	164.75	3000	0	<=	5000		2.5	1.5	0	0	0	0	0
Cashmere Long Sleeve	1.5 Yard Cashmere	270	240		6000	<=	4000		0	0	0	0	1.5	0	0
Silk Shirt	1.5 Yard Silk	108	119.5		0	<=	12000		0	0	1.5	0	0	0	0
Silk Cami	0.5 Yard Silk	72	66.5		36000	<=	15000		0	0	0.5	0	0	0	0
Rayon Skirt	2 Yard Rayon & 1.5 Yards Lining	162	126.75		6000	>=	2800		0	1.5	0	2	0	0	0
Faux Leather Pants	3 Yard Leatherette	210	214		0	<=	5000		0	0	0	0	0	3	0
Faux Leather Shirt	1.5 Yard Leatherette	120	178		0				0	0	0	0	0	1.5	0
Blouse	1.5 Yard Rayon	72	93.375		0				0	0	0	1.5	0	0	0
Cotton Wrap Sweater	1.5 Yard Cotton Fabric	78	63.75		20000				0	0	0	0	0	0	1.5
Cotton Shorts	0.5 Yard Cotton Fabric	45	41.25		0				0	0	0	0	0	0	0.5
								Totals:	0	9000	18000	12000	9000	0	30000
				Profit:	874500										
Inputs:															
Material Type:	Price/yard:		Quantity:	Amount Used:											
Wool		9	45000	0											
Lining		1.5	9000	9000											
Silk		13	18000	18000											
Rayon		2.25	30000	12000											
Cashmere		60	9000	9000											
Leatherette		12	20000	0											
Cotton		2.5	30000	30000											

Please note that I added the material cost to the ”Labor and Equipment Cost” column to identify which products were not profitable so they could be kept separate when using Solver.

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [Project 1.xlsx]Discount
Report Created: 3/16/2024 6:46:59 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
F5	2.5 Yard Wool & 1.5 Yard Lining	0	-8	27.25	8	1E+30
F6	1.5 Yard Cashmere	6000	0	30	1E+30	30
F8	0.5 Yard Silk	36000	0	5.5	1E+30	5.5
F9	2 Yard Rayon & 1.5 Yards Lining	6000	0	35.25	1E+30	8
F13	1.5 Yard Cotton Fabric	20000	0	14.25	1E+30	3
F14	0.5 Yard Cotton Fabric	0	-1	3.75	1	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
D20	Wool Amount Used:	0	0	45000	1E+30	45000
D21	Lining Amount Used:	9000	23.5	9000	13500	9000
D22	Silk Amount Used:	18000	11	18000	1E+30	18000
D23	Rayon Amount Used:	12000	0	30000	1E+30	18000
D24	Cashmere Amount Used:	9000	20	9000	1E+30	9000
D25	Leatherette Amount Used:	0	0	20000	1E+30	20000
D26	Cotton Amount Used:	30000	9.5	30000	1E+30	30000

-For the products that are all profitable at 40% discount, if your model suggests not producing any, at what price points would you decide the produce them?

The model suggests that in order to maximize the profit during the 40% discount sale, Cashmere Long Sleeve, Silk Cami, Cotton Wrap Sweater, and Rayon Skirt will be the only products produced. Compared to the original profit of $6,966,333.33 the profit from the 40% discount was $874,500, which equates to a difference of $6,091,833.33. The reason for the large difference is because many of the products are no longer profitable due to the variable prices remaining unchanged during the discount period.

i) There is a new bold jacket design that requires 2 yards of wool, 1 yard of leatherette and 2 yards of lining, that requires $180 for labor and equipment costs. What is the minimum price it should sell for, for it to be a viable product?

In order for this product to be profitable for Chakra, the selling price must be higher than the labor and equipment costs ($180) combined with the cost of material inputs ($33). Knowing the total variable costs ($213), the new bold jacket would have to be sold for a price higher than $214. Since this product has the highest input cost, I would assume that Elizabeth would sell the product for around $400 or higher.

Aer providing answers to a-i, in part j, below, you are asked to prepare an executive summary report. Make sure you present your answers to above questions separately, before answering part j.

j) Please write an **executive report** about the results (recommended production plan, expected profits, etc.) based on initial problem data.

Your report should summarize your recommendations and address possible expansions based on the previous questions and any additional analysis you perform. Note that this is an **executive report** you are providing to assist in this year's planning, as well as, for future year's planning, assuming similar costs/prices.

As the primary consultant at Melda Capital analyzing the product line, production, and financial components with Chakra, this executive report will serve as a guide for optimizing your company's operations. Within this report, I will outline the methods that were applied and recommendations to the production model for maximizing profits. Using this information, Chakra can be as profitable as ever, while still keeping costs at a minimum based on the constraints for raw material and consumer demand.

To reiterate the purpose of this analysis, Chakra has eleven products in their clothing line for the Fall season and Elizabeth has ambitions of creating a production plan with the Production Manager that will maximize profit for next month. Some of the roadblocks that must be taken into consideration are specific raw material supply constraints, which limit the quantity used among the seven different types of materials. And there are also demand constraints observed, for maximum demand and minimum demand. For example, no more than seven thousand wool pants can be made due to a limit on the projected maximum demand, but Elizabeth needs at least sixty percent of the maximum demand to be produced. The scraps produced as a result of partially using a full yard of material (i.e. Cotton Shorts require half a yard) are not eligible to be returned to the supplier and is reflected as a full yard used unless the scrap can applied as an input for another product. Even with having many constraints for this problem, Excel Solver was used to initiate and generate the maximization formula to outline a potential model.

The initial optimized production plan presented today recommends the following quantities of product produced:

Wool Pants: 7,000
Wool Jacket: 3,200
Cashmere Long Sleeve: 4,000
Silk Shirt: 7,000
Silk Cami: 15,000
Rayon Skirt: 2,800
Faux Leather Pants: 5,000
Faux Leather Shirt: 3,333.33
Blouse: 16,266.67
Cotton Wrap Sweater: 0
Cotton Shorts: 60,000

For a total profit of $6,966,333.33.

To expand further on the abovementioned questions and explore the potential improvements that could be made to the production plan presented by Melda Capital, the model was adjusted to account for a forty percent price hike across all items. This model assumes that the demand forecast, input costs, and price did not change from the original data provided. When the discount was analyzed there was nearly a ninety percent decrease in profits than when the optimized production model is used, but with a forty percent price increase, the total profits balloon to fourteen million nine thousand dollars ($14,009,800) for a one hundred one and eleven tenths' percent (101.11%) increase (Appendix A). This simple and effective method may cause some demand to fall, but with such a loyal consumer base behind these products at Chakra, the chance for failure is minimal.

Since the optimized solution indicated that multiple product lines were not produced at their maximum predicted demand due to supply constraints, Chakra should look to improve their supplier network to increase the maximum quantity of materials they can purchase. By doubling the quantity available to purchase, the original solution changed with more products produced (Appendix B). This

new model created a production plan that would increase profits to ten million six hundred seventeen thousand dollars ($10,617,000), or a fifty-two and four tenths' percent (52.4%) increase from the original optimized production plan, assuming costs, price, and maximum demand forecasted did not change. Once the quantity of available materials is increased for all types, then Elizabeth will need to focus on improving consumer demand as the demand constraints will eventually restrict maximizing profits.

To conclude this executive report, Chakra should utilize the original optimized production plan outlined above even beyond the Fall season and focus time on working towards the other opportunities to maximize profit. Whether a price increase or supply increase, Chakra can improve their business model and identify the best methods to increase margins while adding new products to the clothing line.

Appendix A:

Project

	Material Requirements	Price	Labor & Equipment Cost	Min Demand Contraints:	Quantity	Demand Constraints:			Wool:	Lining:	Silk:	Rayon:	Cashmere:	Leatherette:	Cotton:
Wool Pants	3 Yard Wool	300	160	4200	7000	<=	7000		3	0	0	0	0	0	0
Wool Jacket	2.5 Yard Wool & 1.5 Yard Lining	320	140	3000	3200	<=	5000		2.5	1.5	0	0	0	0	0
Cashmere Long Sleeve	1.5 Yard Cashmere	450	150		4000	<=	4000		0	0	0	0	1.5	0	0
Silk Shirt	1.5 Yard Silk	180	100		7000	<=	12000		0	0	1.5	0	0	0	0
Silk Cami	0.5 Yard Silk	120	60		15000	<=	15000		0	0	0.5	0	0	0	0
Rayon Skirt	2 Yard Rayon & 1.5 Yards Lining	270	120		2800	>=	2800		0	1.5	0	2	0	0	0
Faux Leather Pants	3 Yard Leatherette	350	178		5000	<=	5000		0	0	0	0	0	3	0
Faux Leather Shirt	1.5 Yard Leatherette	200	160		3333.333333	<=	6000		0	0	0	0	0	1.5	0
Blouse	1.5 Yard Rayon	120	90		16266.66667				0	0	0	1.5	0	0	0
Cotton Wrap Sweater	1.5 Yard Cotton Fabric	130	60		0				0	0	0	0	0	0	1.5
Cotton Shorts	0.5 Yard Cotton Fabric	75	40		60000				0	0	0	0	0	0	0.5
								Totals:	29000	9000	18000	30000	6000	20000	30000

			Profit:	$6,966,333.33	
Inputs:			W/ 40% Price Hike:	$14,009,800.00	
Material Type:	Price/yard:	Quantity:	Amount Used:		
Wool	9	45000	29000		
Lining	1.5	9000	9000		
Silk	13	18000	18000		
Rayon	2.25	30000	30000		
Cashmere	60	9000	6000		
Leatherette	12	20000	20000		
Cotton	2.5	30000	30000		

Appendix B:

Project

	Material Requirements	Price	Labor & Equipment Cost	Min Demand Contraints:		Demand Constraints:			Wool:	Lining:	Silk:	Rayon:	Cashmere	Leatherett	Cotton:
Wool Pants	3 Yard Wool	300	160	4200	7000	<=	7000		3	0	0	0	0	0	0
Wool Jacket	2.5 Yard Wool & 1.5 Yard Lining	320	140	3000	5000	<=	5000		2.5	1.5	0	0	0	0	0
Cashmere Long Sleeve	1.5 Yard Cashmere	450	150		4000	<=	4000		0	0	0	0	1.5	0	0
Silk Shirt	1.5 Yard Silk	180	100		12000	<=	12000		0	0	1.5	0	0	0	0
Silk Cami	0.5 Yard Silk	120	60		15000	<=	15000		0	0	0.5	0	0	0	0
Rayon Skirt	2 Yard Rayon & 1.5 Yards Lining	270	120		7000	>=	2800		0	1.5	0	2	0	0	0
Faux Leather Pants	3 Yard Leatherette	350	178		5000	<=	5000		0	0	0	0	0	3	0
Faux Leather Shirt	1.5 Yard Leatherette	200	160		6000	<=	6000		0	0	0	0	0	1.5	0
Blouse	1.5 Yard Rayon	120	90		30666.66667				0	0	0	1.5	0	0	0
Cotton Wrap Sweater	1.5 Yard Cotton Fabric	130	60		0				0	0	0	0	0	0	1.5
Cotton Shorts	0.5 Yard Cotton Fabric	75	40		120000				0	0	0	0	0	0	0.5
								Totals:	33500	18000	25500	60000	6000	24000	60000

			Profit:	$ 10,617,000.00	
Inputs:					
Material Type:	Price/yard:	Quantity:	Amount Used:		
Wool	9	90000	33500		
Lining	1.5	18000	18000		
Silk	13	36000	25500		
Rayon	2.25	60000	60000		
Cashmere	60	18000	6000		
Leatherette	12	40000	24000		
Cotton	2.5	60000	60000		