Supply Chain Analysis

ISQA 410 HW 3

1. (5 points) Supply chain finance is a new and important field. Let's say you just got hired as a SCM analyst tasked with a finance initiative. You have to select a portfolio package from a set of alternative investments. Your goals are:
   - Maximization of the expected return or minimization of the risk
   - Not exceeding the available capital
   - Managing the company's (risk) policy
   - Consider the duration of investments' economic life, potential growth rate, danger, liquidity

   You have been given the following expected return information:

Investment	Expected annual return rate (%)
Share A – manufacturing sector	15.4
Share B - manufacturing sector	19.2
Share C - food and beverage sector	18.7
Share D – food and beverage sector	13.5
Mutual fund E	17.8
Mutual fund Z	16.3

   You also have the following requirements:

   - Total amount of capital= $90,000
   - Amount in shares of a sector no larger than 50% of total available
   - Amount in shares with the larger return of a sector less or equal to 80% of sector's total amount
   - Amount in manufacturing company B less or equal to 10% of the whole share amount
   - Amount in mutual funds less or equal to 25% of the amount in manufacturing shares

Therefore, you must:

a. Formulate the problem, complete with the objective function and appropriate constraints and be sure to clearly label your decision variables.

The objective of this problem is to maximize the return (Z) of the invested amount such that

$$Z = 0.154x_1 + 0.192x_2 + 0.187x_3 + 0.135x_4 + 0.178x_5 + 0.163x_6$$

With $x_{1\text{-}6}$ representing the portion of portfolio investment in the following options:

x_1 = Share A (manufacturing sector); x_2 = Share B (manufacturing sector);

x_3 = Share C (food/beverage sector); x_4 = Share D (food/beverage sector);

x_5 = Mutual Fund E; x_6 = Mutual Fund Z

Subject to:

Portfolio Constraints (ratios of total portfolio):

Total Portfolio	x_1	$+ x_2$	$+ x_3$	$+ x_4$	$+ x_5$	$+ x_6$	= 100%
Manufacturing Shares:	x_1	$+ x_2$					≤ 50%
Food/Beverage Shares:			x_3	$+ x_4$			≤ 50%
Company B (being highest yield within mfg. sector):		x_2					≤ 80% $(x_1 + x_2)$
Company B (within total portfolio):		x_2					≤ 10%
Company C (being highest yield within food/beverage sector):			x_3				≤ 80% $(x_3 + x_4)$
Mutual Funds (within total portfolio):					x_5	$+ x_6$	≤ 25% $(x_1 + x_2)$

and

$x_{1\text{-}6} \geq 0$

b. Solve this problem in excel with solver

Please see Excel sheet *P1.*

c. Write a few sentences describing what the results say, in plain language. Formulate the problem, complete with the objective function and appropriate constraints and be sure to clearly label your decision variables.

These results tell me that given an initial investment of $90k, and with the portfolio constraints outlined above, the optimal portfolio mix is as follows:

Investment	Share A Mfg	Share B Mfg	Share C Food/Bev	Share D Food/Bev	Mutual Fund E	Mutual Fund Z
% of Portfolio	30%	10%	40%	10%	10%	0%
Expected Return	15.4%	19.2%	18.7%	13.5%	17.8%	16.3%
Total Expected Return (Max. Objective)			17.2%	Return ->	**$15,435.00**	

Meaning that with the mix shown in the table above, my company can achieve a maximum return of 17.2%, or $15,435 during the first period return.

Some points of note with this model, the 10% constraint put on Share B is severely limiting, with Share A being the second least profitable of the whole portfolio mix. Because Share B is capped at only 10% of the whole portfolio, the model invests less than the 50% of the whole Portfolio allowed for the Manufacturing Sector in favor of the highest allowable investment in Share C of the Food and Beverage Sector.

2. (10 points) After your tremendously successful financial optimization skills have been showcased, management asks you to use this skillset to facilitate some production planning. The problem here is having a forecast for each period's demand, determine the products' quantities that can be produced with feasible methods in order to satisfy the total demand with the minimum cost. You have been given the following information:
   - For two products A and B, there are demand forecasts for January, February and March.
   - Initial stock: 100 units of product A and 120 units of product B.
   - Minimum total required stock: 130 units of product A and 110 of product B
   - Unit production cost: A=$20 and B=$25
   - Maintenance cost per period and per unit: 2% on the unit production cost
   - You also have the following demand and capacity information:

Bicycle Demand:

Month	Bicycle	
	A	B
January	700	800
February	900	600
March	1,000	900
Total	2,600	2,300

System Capacity:

Month	Machine Capacity (machine hours)	Available Work (man hours)
January	3000	2500
February	2800	2300
March	3600	2400

Required Resources:

Bicycle	Machine Hours	Man-hours
A	1.5	1.1
B	1.6	1.2

Therefore, you must:

a. Formulate the problem, complete with the objective function and appropriate constraints and be sure to clearly label your decision variables.

The objective of this problem is to minimize the production and holding costs (Z) of supplying bicycles A and B

$$Z = 20x_{11} + 25x_{12} + .02x_{13} + .02x_{14} + 20x_{21} + 25x_{22} + .02x_{23} + .02x_{24} + 20x_{31} + 25x_{32} + .02x_{33} + .02x_{34}$$

With $x_{11\text{-}34}$ representing the quantities of Bicycles A and B either in production or kept in stock:

$x_{11,21,31}$ = Bicycle A Production (January, February, March);

$x_{12,22,32}$ = Bicycle B Production (January, February, March);

$x_{13,23,33}$ = Bicycle A Stock (January, February, March);

$x_{14,24,34}$ = Bicycle B Stock (January, February, March)

Subject to:

Supply/Demand Constraints:

January:				
Bicycle A:	x_{11}			$= 730$
Bicycle B:	x_{12}			$= 790$
Machine Hours:	$1.5x_{11}$	$+ 1.6x_{12}$		≤ 3000
Man Hours:	$1.1x_{11}$	$+ 1.2x_{12}$		≤ 2500
February:				
Bicycle A:		$+ x_{21}$		$= 900$
Bicycle B:		$+ x_{22}$		$= 600$
Machine Hours:	$1.5x_{21}$	$+ 1.6x_{22}$		≤ 2800
Man Hours:	$1.1x_{21}$	$+ 1.2x_{22}$		≤ 2300
March:				
Bicycle A:			$+ x_{31}$	$= 1000$
Bicycle B:			$+ x_{32}$	$= 900$
Machine Hours:	$1.5x_{31}$	$+ 1.6x_{32}$		≤ 3600
Man Hours:	$1.1x_{31}$	$+ 1.2x_{32}$		≤ 2400
Stock Requirements:				
Bicycle A:	$X_{13,23,33}$			≥ 130
Bicycle B:	$X_{14,24,34}$			≥ 110
Holding Costs:				
	$.02(x_{13}+x_{14})$	$+ .02(x_{23}+x_{24})$	$+ .02(x_{33}+x_{34})$	≥ 14.4

and

$$x_{11\text{-}34} \geq 0$$

b. Solve this problem in excel with solver

Please see Excel sheet *P2.*

c. Write a few sentences describing what the results say, in plain language.

The model that I made in Excel gave the following results:

		Production Quantity	
	Month	A	B
Qty Prod	Jan	730	790
	Feb	900	600
	Mar	1000	900
Direct Cost/Unit:		$20.00	$25.00
Total Costs (Min. Obj.):		$109,864.40	

Cost Calculations				
		January	February	March
Production	Bike A	$14,600	$18,000	$20,000
Production	Bike B	$19,750	$15,000	$22,500
Total Production Costs		$34,350	$33,000	$42,500
*Maintenance Rate/Month/Unit:			2%	
Inventory	Bike A	$2.60	$2.60	$2.60
Inventory	Bike B	$2.20	$2.20	$2.20
Total Maint. Costs		$4.80	$4.80	$4.80

The optimal production plan is really straight forward, with production quantities determined by taking that month's demand plus minimum stock requirements minus the previous month's stock.

The total costs include the costs of production for Bicyces A and B plus 2% holding costs for each bike held as stock. This lead's to the optimized minimum cost of $109,864.40

3. (10 points) Turns out you were, once again, tremendously successful and now management wants to turn your attention to an even more complex problem: blending. Management has recently gotten into the fuel business. There are three products: super fuel, unleaded, super unleaded. You have to deal with certain constraints:
   - There exists a minimum required octane number
   - Of course, you must also consider how to achieve maximization of the total daily profit
   - You have to deal with available quantities of main ingredients
   - All while adhering to the minimum required product quantities

You have the following raw material data:

Main Ingredient	Octane Number	Cost Per Ton ($)	Maximum Daily Available quantity (tons)
A	120	38	1000
B	90	42	1200
C	130	105	700

You also have the following demand data:

Fuel	Octane Number	Cost Per Ton ($)	Daily Demand
A	94	85	800
B	92	80	1100
C	96	88	500

Therefore, you must:

a. Formulate the problem, complete with the objective function and appropriate constraints and be sure to clearly label your decision variables.

The objective of this problem is to maximize the total contribution (Z) of the fuel blends:

$$Z = 85x_1 + 80x_2 + 88x_3$$

With decision variables $x_{1\text{-}3}$ representing the tonnage of fuels:

x_1 = Tonnage of Super Fuel blend; x_2 = Tonnage of Unleaded blend;

x_3 = Tonnage of Super Unleaded blend;

and variables $c_{1\text{-}3}$ representing the tonnage of ingredients blended to make the fuel:

$c_{1,4,7}$ = Tonnage of ingredient A; $c_{2,5,8}$ = Tonnage of ingredient B;

$c_{3,6,9}$ = Tonnage of ingredient C

Ingredient Constraints:

Ingredient A: $c_1 + c_4 + c_7 \leq 1000$

Ingredient B: $c_2 + c_5 + c_8 \leq 1200$

Ingredient C: $c_3 + c_6 + c_9 \leq 700$

Fuel Blend Constraints:

Super Fuel:	$\dfrac{(120c_1 + 90c_2 + 130c_3)}{(c_1 + c_2 + c_3)} \geq 94$ $c_1 + c_2 + c_3 = 800$
Unleaded:	$\dfrac{(120c_4 + 90c_5 + 130c_6)}{(c_4 + c_5 + c_6)} \geq 92$ $c_4 + c_5 + c_6 = 1100$
Super Unleaded:	$\dfrac{(120c_7 + 90c_8 + 130c_9)}{(c_7 + c_8 + c_9)} \geq 96$ $c_7 + c_8 + c_9 = 500$

and

$$x_{1\text{-}6} \geq 0$$

b. Solve this problem in excel with solver

Please see Excel sheet *P3.*

*Note: the formulas for blending the fuel are nonlinear, however they were converted to linear form by multiplying both sides of the equation by the denominator for calculations, then divided again to derive the octane value shown in the table (for intermediate calculations, scroll just to the right of the main part of sheet *P3*).

c. Write a few sentences describing what the results say, in plain language.

This model was a little tricky to develop for a couple of reasons. The problem statement is to maximize profit, however the demand is constant, as is the revenue per ton of fuel sold. The actual problem is to minimize the costs of the raw ingredients while still meeting the fuel's minimum octane constraints and making enough fuel to satisfy demand.

The model is optimized to provide a total contribution of $90,600. This could be increased if more of raw ingredient B was available. Then the company could produce fuels at the exact octane for the fuel class at a reduced cost.

4. (5 points) Marketing heard how useful linear programming is and they now want your help on a problem that they have. They have the following data:

Advertising Media	Cost of one View ($)	Units of expected audience rate of one view
Friday-Day	400	5000
Saturday-Day	450	5500
Sunday-Day	450	5700
Friday-Night	500	7500
Saturday-Night	550	8200
Sunday-Night	550	8400

- Their goal: Determination of views / records in order to maximize the total audience rate
- Total available amount: $ 45,000
- Maximum amount for Friday: $ 11000
- Maximum amount for Saturday: $ 14400
- Total daily view number: at least 20
- Total nightly view number: at least 50% of the total
- Maximum view number: each day 12, each night 18

Therefore, you must:

a. Formulate the problem, complete with the objective function and appropriate constraints and be sure to clearly label your decision variables.

The objective of this problem is to maximize viewership (Z) of the company's weekend advertising campaign:

$$Z = 5000x_{11} + 7500x_{12} + 5500x_{21} + 8200x_{22} + 5700x_{31} + 8400x_{32}$$

With $x_{11\text{-}32}$ representing the number of advertising spots purchased during the day or night time frames:

$x_{11,12}$ = Friday time-slots (Day time, night time);

$x_{21,22}$ = Saturday time-slots (Day time, night time);

$x_{31,32}$ = Sunday time-slots (Day time, night time);

(continued on next page)

Subject to:

Daily Budget Constraints:

Friday:	$400x_{11}$	$+ 500x_{12}$	≤ 11000
Saturday:	$450x_{21}$	$+ 550x_{22}$	≤ 14400
Sunday:	$450x_{31}$	$+ 550x_{32}$	≤ 19600

Daily Total Constraints:

Friday:	x_{11}	$+ x_{12}$	≥ 20
Saturday:	x_{21}	$+ x_{22}$	≥ 20
Sunday:	x_{31}	$+ x_{32}$	≥ 20

Daytime Max Constraints: $x_{11,21,31} \leq 12$

Nightly Max Constraints: $x_{12,22,32} \leq 18$

Nightly Min Constraints:

Friday:	x_{12}	$\geq 50\% (x_{11} + x_{12})$
Saturday:	x_{22}	$\geq 50\% (x_{21} + x_{22})$
Sunday:	x_{32}	$\geq 50\% (x_{31} + x_{32})$

Additional Constraints:

$x_{11\text{-}32} \geq 0$

b. Solve this problem in excel with solver

Please see Excel sheet *P4.*

c. Write a few sentences describing what the results say, in plain language.

The results in the excel model tell me that to optimize weekend viewership, it is best to purchase the maximum allowable night time spots, with secondary preference for the day time spots with higher relative viewership. This strategy allows us to reach an estimated total of 582,200 viewers over the weekend.

BONUS QUESTION (2 Points):

How much wood would a woodchuck chuck if a woodchuck could chuck wood? STATE YOUR REASONING CLEARLY!

According to this article on Futurism.com, there are some definitions of terms that need to be clarified before this question can be answered accurately. First, a woodchuck (a small rodent more commonly called a *groundhog,* with the scientific name *Marmota monax*), doesn't actually eat wood, they don't "chuck" wood in the same way that a person "chucks" a football. However, if we were to define "chuck" as closely to the more familiar use of the term, then we could say that when a woodchuck "chucks" wood, it is digging out a burrow in a woody substrate.

So, let's say that a woodchuck is digging out a burrow in a playground which uses a very thick top layer of wood chips. According to the Adirondack Almanack, woodchuck burrows may be up to five feet deep and 40 feet long, with 35 cubic feet of substrate excavated in the process of digging out the burrow. Therefore, my answer is that if a woodchuck could chuck wood, it would chuck 35 cubic feet of it.