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BAN-501

Final Project

ABC, which is an automobile industry company, is wanting to figure out what their optimal demand satisfaction with the minimum cost of production from their two plants, Kansas City and Santiago to their distribution centers. The company is presenting two new ideas for improving the capacity to meet its future demand. The options being either expand one of the current production plants or establish a new one in an appropriate location. This company also wants to know which new plant(s) would be most effective if this route was taken. As well as the optimal capacity for a variety of demands at the Shanghai distribution center to observe different options for the longevity to this location.

Prescriptive analytics is crucial for the discovery of optimal decisions that organizations need to know by efficiently providing the best-case scenario given proper constraints for said question/problem. This could be a multitude of events whether to compensate for short- or long-term events that can provide insight on the correct path to pursue. The complexity of prescriptive analytics allows it to operate with multiple variables and objectives to suggest favorable actions that we allow could not compute. For this exact problem prescriptive analytics is used to compute the superb solution for the expansion of company ABC. Using prescriptive analytics, I was able to program and observe many different findings in real time using proper constraints to reveal the optimal solution.

After computing the data for the transportation costs efficiently amongst the distribution center, the optimal cost is $210,570. Considering the capacity was not enough to meet all the demands I ensured to calculate the cost with that in mind leaving the Melbourne and Shanghai centers short, which is something to investigate to satisfy the demand to maximize profits.

This first option wants to find the optimal choice of expanding either the Kansas City or Santiago plants' capacity by 50,000. Within this choice, I conducted an assessment to determine the most financially prudent path, ultimately leading to my decision. Upon analyzing the initial construction expenses for new capacity, a distinct advantage becomes evident: the Santiago plant's costs are nearly $500,000 lower, coupled with its marginally more cost-efficient average production at 0.13 cents compared to Kansas City. Given these considerations, the optimal course becomes evident – the expansion of the Santiago plant, which yields a total cost of $2,371,920.

The exploration of the second option revolved around the potential establishment of new manufacturing plants, while ensuring the ongoing operation of Santiago and Kansas City facilities. Within this option there were five new distinct locations, each presenting unique production costs and fixed construction expenses. Following the formulation of an optimal solution, I was able to discern cost-efficient scenarios for the proposed branches, culminating in a total expenditure of $3,114,480, which added the construction of Auckland, Birmingham, and Mumbai facilities.

Among the multiple choice strategies to address the varying demands at the Shanghai center, I've arrived at a discerning decision that emphasizes the company's enduring success in light of dynamic demand shifts. Referencing the provided table, both options exhibit optimal outcomes in two out of four scenarios. However, upon a comprehensive evaluation, option one emerges as the more astute selection. This decision aligns with the company's growth trajectory, while also preparing to promptly accommodate a potential surge in demand, specifically a scale-up to 90,000 units. This scalability would be achieved through the strategic expansion of the Santiago and Kansas City facilities.

Shanghai Demand Potential Costs			
Demand:	Option 1 Cost:	Option 2 Cost:	Decision:
20,000	$2,320,270	$1,200,670	Mumbai constructed
50,000	$2,371,920	$3,114,480	Santiago expansion

70,000	$5,014,170	$4,201,280	Auckland, Birmingham, Mumbai, Singapore constructed
90,000	$5,055,970	$5,326,280	Santiago, Kansas City expansion
Average Cost:	$3,168,533	$3,460,678	Santiago, Kansas City expansion

After an extensive analysis of the data from company ABC, I have come to a strategic and cost-effective path to pursue. With the constraints and objectives in mind I have concluded that the most optimal path would be to pursue option one, expanding the pre-existing plants. However, doing this research I have discovered that depending on Shanghai capacity the optimal solution varies quite. Keeping in mind that plant capacity expansion would be permanent, making this decision even more important. To further elaborate, I would like to hypothesize that if Option 1 was acted upon and the construction of both plants, Shanghai and Kansas City, expansion was to happen this would optimally satisfy Shanghai's 90,000 demands. Again, that was assuming Shanghai was to need 90,000 units, which I bring up to convey the comparison all costs of options depending on Shanghai demand. On average option 1 is roughly $300,000 cheaper than option 2, giving it the more cost-efficient choice. From a rational standpoint, recognizing the likelihood of demand growth rather than decline, it becomes evident that embracing larger demand sizes is essential to ensure the company's enduring prosperity and fortified strategic resilience. In summary, based on my research findings, I would recommend prioritizing the expansion of our current operational plants over the construction of new facilities that would allocate an expense of $2,371,920.

Parameters	*Definition*
I	= {KC, SA, AU, BI, FR, MU, SI}

J	= {T, S, MC, M, L, C, A}
Demand	= Demand at j, $j \in J$
Fixed{I} (Question 2)	= Fixed Cost for increased capacity i, $I \in I$
Fixed{I} (Question 3)	= Fixed cost for construction of new plant i, $i \in I$
Cap{I}	= Capacity limit for plant i, $i \in I$
C{I,J}	= Transportation cost between Plant i and center
newCap{I} (Question 2)	= Additional capacity if needed at SA and KC

Variables	*Definition*
Links	= {I,J}
X{Links}	>= 0
yi	= 1 if plant is operational, 0 if not

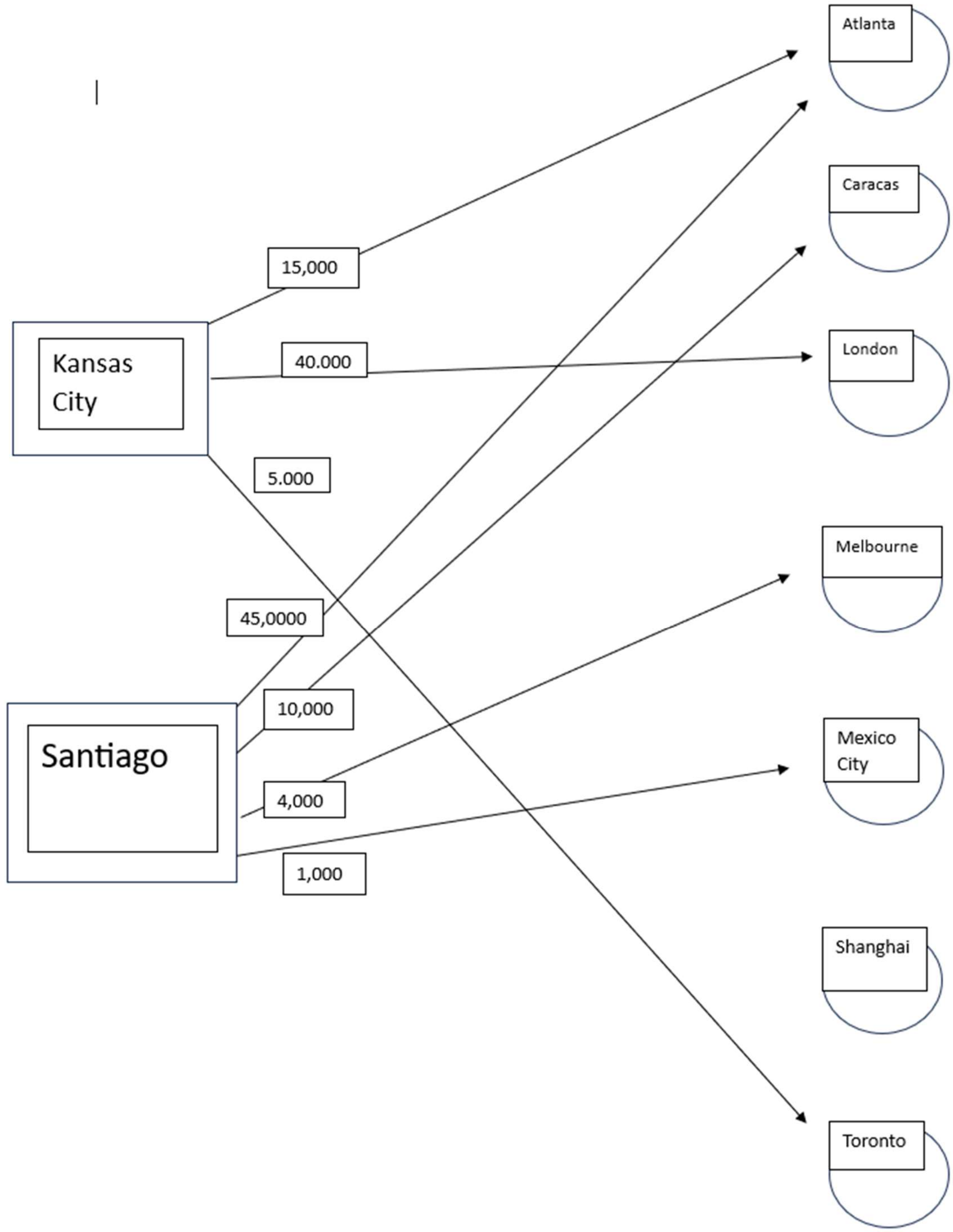
Obj Min: $\sum_{i \in I} {}^{*}F_i y_i + \sum_{i \in I} \sum_{j \in J} x_{ij} {}^{*} C_{ij};$

1. $\sum_{i \in I} xij = Cap[i] * y[i] \ \forall i \in I$
2. $\sum_{i \in I} xij = Cap[i] + (newCap[i] * y[i]) \ \forall i \in I$
3. $\sum_{j \in J} xij \leq demand[i] * y[i] \ \forall i \in I$
4. $y[KC] + y[SA] = 1$
5. $y[KC] + y[SA] = 2$
6. All x variables ≥ 0
7. $yi \in \{0, 1\} \ \forall i \in I$

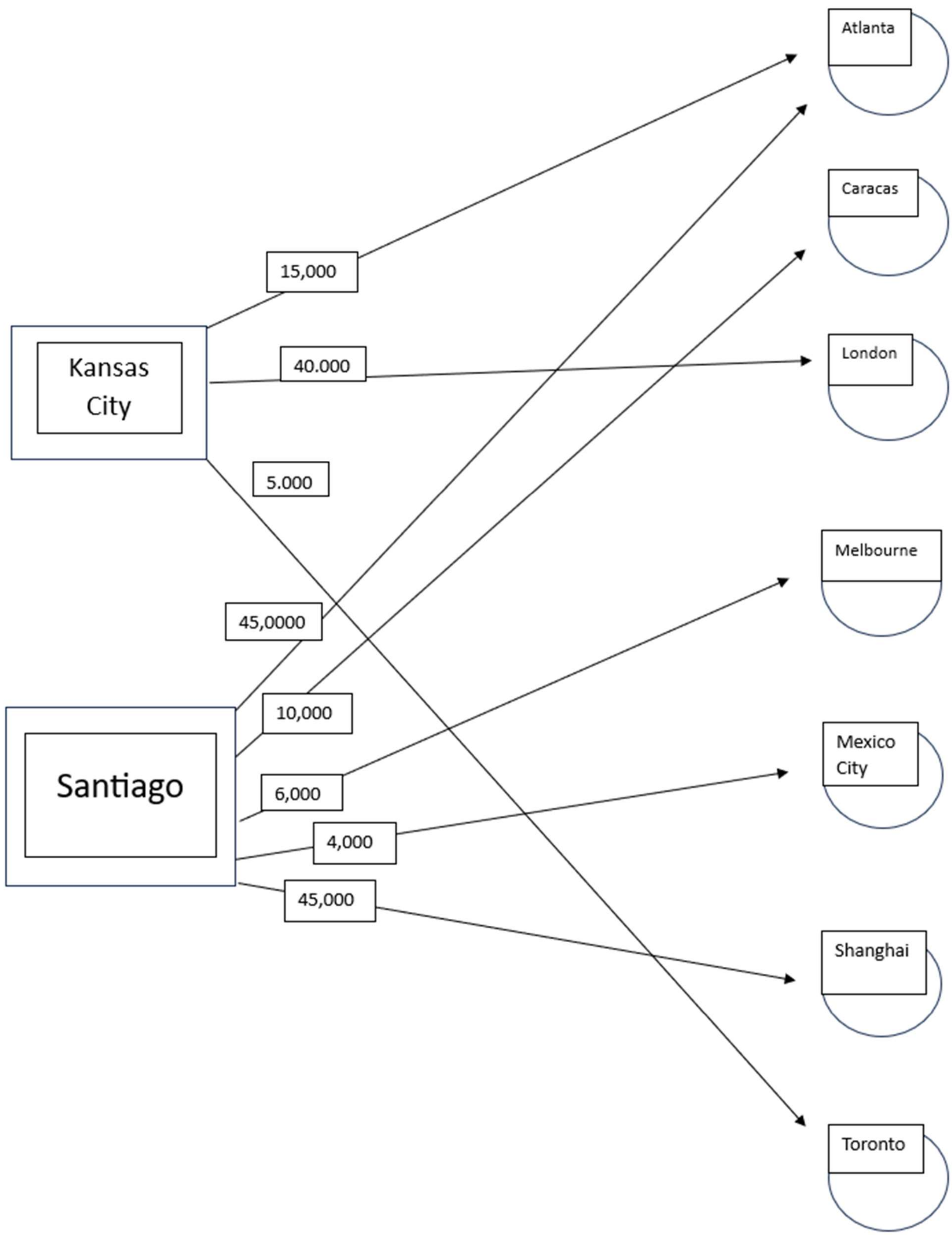
Constraint set (1) restricts the number of products transported from plant i to its capacity (Question 3). Constraint set (2) restricts the number of products transported from plant i with a possibility of expanding capacity if see fit (Question 2). Constraint set (3) attempts to satisfy the demand at center j if the capacity is available at plant i. Constraint set (4) implies that only one plant i (Santiago or Kansas City) could be expanded in capacity (Question 2). Constraint set (4) forces Santiago and Kansas City plants to remain open (Question 3).

Network Diagrams

Question 1

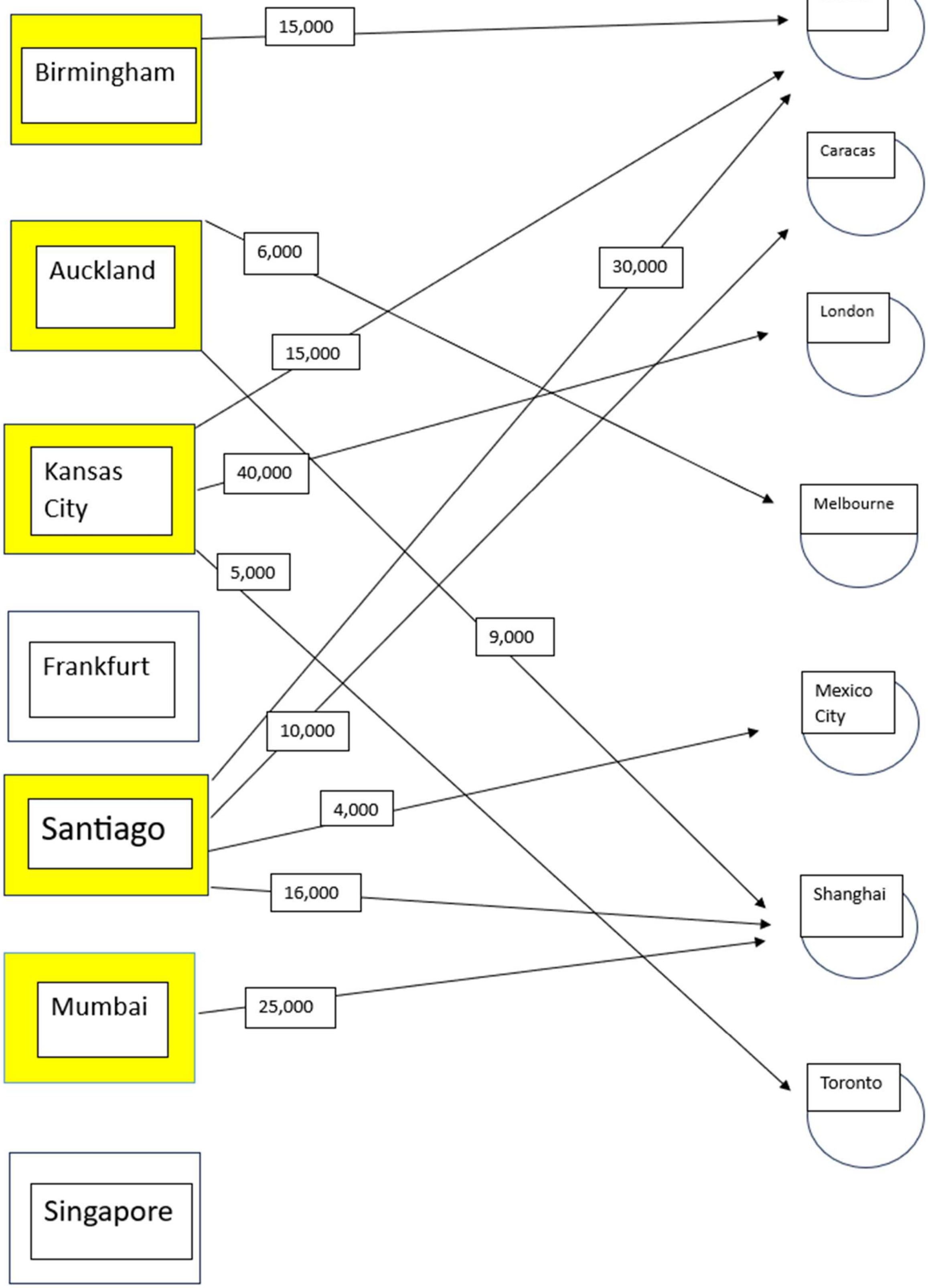


Question 2



Atlanta
Caracas
15,000
London
Kansas City
40.000
5.000
Melbourne
45,0000
10,000
Mexico City
Santiago
6,000
4,000
45,000
Shanghai
Toronto

Question 3


Birmingham
Auckland
Kansas City
Frankfurt
Santiago
Mumbai
Singapore
Atlanta
Caracas
London
Melbourne
Mexico City
Shanghai
Toronto
15,000
6,000
30,000
15,000
40,000
5,000
9,000
10,000
4,000
16,000
25,000

Appendix

Code for Problems 1&2:

```
set I:= {"KC","SA"}; # production plants
set J:= {"T","S","MC","M","L","C","A"}; # distribution plants


set Links= {I,J}; # creates the arcs for the flow of each node
var y{I} binary; # determines whether capacity expansion was used or not.
var x{Links} >=0; # transportation quantity from node set I to demand at set J

param fixed{I}; # set price for construction of capacity if necessary
param cap{I};  # max capacity of node
param demand{J}; # amount node requires in set J
param newcap{I}; # additional capacity if necessary

param C{Links}; # cost matrix

minimize z: sum{i in I} y[i]*fixed[i] + sum{(i,j) in Links} C[i,j]*x[i,j];

s.t. capacity {i in I}: sum{(i,j) in Links} x[i,j] = cap[i]+(newcap[i]*y[i]);

s.t. demand_con {j in J}: sum{(i,j) in Links} x[i,j] <= demand[j];

s.t. choice: y["KC"] + y["SA"] = 1; # constraint that allows for only one
                                                          # locations to get
expanded
# un/comment above for optimal plant expansion

param C: T S MC M L C A:=
KC 1.79 2.13 1.76 2.34 1.86 1.90 1.82
SA 2.13 2.03 1.58 1.80 2.14 1.26 1.76;

param cap:=
KC 60000
SA 60000;

param newcap:=
KC 50000
SA 50000;

param demand:=
T 5000
S 50000
#S 20000
#S 70000
#S 90000
MC 4000
M 6000
L 40000
C 10000
A 60000;

param fixed:=
```

```
KC 2590000
SA 2061000;
```

Code for problem 3:

```
set I:= {"KC","SA", "AU","BI","FR","MU","SI"};
set J:= {"T","S","MC","M","L","C","A"};


set Links= {I,J};
var y{I} binary;
var x{Links} >=0;

param fixed{I};
param cap{I};
param demand{J};
param C{Links};

minimize z: sum{i in I} y[i]*fixed[i] + sum{(i,j) in Links} C[i,j]*x[i,j];

s.t. capacity {i in I}: sum{(i,j) in Links} x[i,j] <= cap[i]*y[i];

s.t. demand_con {j in J}: sum{(i,j) in Links} x[i,j] = demand[j];

s.t. org: y["SA"] + y["KC"] = 2; # forces Santaigo and Kansas City plants to be used



param C: T S MC M L C A:=
KC 1.79 2.13 1.76 2.34 1.86 1.90 1.82
SA 2.13 2.03 1.58 1.80 2.14 1.26 1.76
AU 1.86 1.18 1.5 0.91 1.98 1.54 1.74
BI 1.34 1.6 1.29 1.52 1.47 1.37 1.02
FR 1.52 1.65 1.54 1.73 1.37 1.59 1.42
MU 1.67 1.21 1.56 1.38 1.44 1.61 1.57
SI 1.71 1.44 1.72 1.43 1.88 1.5 1.73;


param cap:=
KC 60000
SA 60000
AU 15000
BI 15000
FR 20000
MU 25000
SI 20000;
```

```
param demand:=
T 5000
S 50000
#S 20000
#S 70000
#S 90000
MC 4000
M 6000
L 40000
C 10000
A 60000;

param fixed:=
KC 0
SA 0
AU 917000
BI 962000
FR 1093000
MU 959000
SI 1058000;
```

Additional Assistance

Chat GPT - Employed this software to enhance the grammatical precision throughout the report, to assist me in conveying my ideas concisely and with heightened efficiency.