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BANA 640: Supply Chain Analytics
Fall 2024 Homework 1
Due: October 3, 2024, 7pm

1. Why does a push-based supply chain react more slowly to changing demand than a pull- based system? (0.25 points)

   Push-based supply chains react slower to demand because its production and distribution decisions are based on forecasts using historical data. Whereas pull-based systems only manufacture finished products when the customer requires them.

2. WhiteGlove House Call Health provides a service where patients within predefined service areas can receive primary health care visits at home or at work, 365 days per year, 8 am to 8 pm. Suppose WhiteGlove guarantees *same-day* service to all patients requesting visits during operating hours. (0.5 points)

   a. Describe an appropriate measure of the *effectiveness* of the WhiteGlove same-day service guarantee.

   Effectiveness measures how well a logistics system accomplishes their promises. In this scenario, you could measure the White Glove's effectiveness by analyzing the rate at which the company provides same-day service appointments compared to the amount of requests in a given day. $\left(\frac{\text{Appointments completed}}{\text{Appointments requested}}\right)$ per day.

   b. Describe two alternative measures of the *efficiency* of the WhiteGlove same-day service guarantee

   Efficiency measures how well the firm's resources are used to achieve what the company promises to do.
   In this scenario, the efficiency of the company's same-day service guarantee can be measured by the labor cost and transportation cost per each visit.
   Patients may possibly request different services, some of which may be costlier than others.
   There may be service areas that are a greater distance away than others, which would cost the company more in fuel, vehicle maintenance, and care provider labor hours.
   They can also try to analyze the most common hours for appointment requests to ensure they allocate labor hours efficiently.

3. A computer manufacturer ships partially assembled computers (hereafter called units from an assembly plant in Thailand to a distribution center in Oregon. We want to determine if it is more economical to ship in 40ft containers by ocean carriers or in airline containers by air carriers. Shipment by ocean costs $11,000 per container, and a 40ft container can hold 5,000 units. Handling cost is $2000 per 40ft container. The journey by sea takes 20 days on average. Shipment by air costs $20,000 per container, and an airline container can hold 1,400 units. Handling cost is $1000 per airline container. The journey by air takes 2 days on average (door to door). The forecasted demand is 120,000 units for the next year, which is also the planned production quantity. No safety stock is kept at the assembly plant, and a shipment is sent to the

(ocean = 24 shipments
q = 5,000 units

(air = 86 shipments
q = 1,400 units)

distribution center as soon as a container is filled. Safety stock of 1,000 units is kept at the distribution center. A unit is valued at $600 at the assembly plant and $800 at the distribution center. The inventory holding cost rate is estimated at 20% of value per year. The space cost is estimated as $30 / unit*year at the assembly plant and $40 /unit*year at the distribution center. (3 points)

a. What are the annual inventory holding costs at the assembly plant (include the space and holding cost in this calculation)?
b. What are the annual inventory holding costs at the distribution center (include the space and holding cost in this calculation)?
c. What are the annual in-transit inventory costs for each mode?
d. What are the annual transportation costs for each mode (don't forget to take the shipment handling cost into consideration when calculating these costs)?
e. What are the total annual cost equations for each mode of transportation?
f. Assume that the shipper will always ship full loads. Determine the most economical transportation service to use in this case.
g. Now assume that the shipper may use less than full loads. Determine the most economical transportation service to use in this case.

q = shipment size

a) Assembly Annual Inventory Holding Cost
unit cost = $600
space cost = $30/unit per year = $30q
holding cost = 20% of unit cost value per year
↳ $120/unit $(q/2)$ = $60q
space cost + holding cost = 90q

b) Distribution Annual Inventory Holding Cost
unit cost = $800
space cost = $40/unit per year = 40(1000+q) = 40000 + 40q
holding cost = 20% of unit cost value per year
safety stock = 1,000 units
↳ $160/unit $(1000 + \frac{q}{2})$ = $160000 + $80q
space cost + holding cost = 200,000 + 120q

c) Average value of units in transit = $\frac{600+800}{2}$ = $700
each unit charged at 20% = $700 (0.2) = $140/unit
demand for next year = 120,000 units

Annual in-transit cost (ocean)
= (120,000)(140)(20/365) = $920,547.90/yr

Annual in-transit cost (air)
= (120,000)(140)(2/365) = $92,054.79/yr

d) Number of shipments = $\frac{120,000}{q}$ = amt. per shipment

ocean Transportation cost = $(11,000)\left(\frac{120,000}{q}\right) = \frac{1,320,000,000}{q}$ ($/yr)
$= \frac{1320000000}{5,000}$
= $264,000/yr

air Transportation cost = $(20,00)\left(\frac{120,000}{q}\right) = \frac{2,400,000,000}{q}$ ($/yr)
$= \frac{2,400,000,000}{1400}$
= $1,714,285.71/yr

e) Total Annual Costs

ocean: $q = 5{,}000$

Total cost $= 90q + 200{,}000 + 120q + 920{,}547.90 + \frac{1{,}320{,}000{,}000}{q}$

air: $q = 1400$

Total cost $= 90q + 200000 + 120q + 92{,}054.79 + \frac{2{,}400{,}000{,}000}{q}$

f)

$= 210q + 1{,}120{,}547.90 + \frac{1{,}320{,}000{,}000}{q}$

$= 1{,}050{,}000 + 1{,}120{,}547.90 + 264{,}000$

Total cost ocean $= \$2{,}434{,}547.90/\text{yr}$

$= 210q + 292{,}054.79 + \frac{2400000000}{q}$

Total cost air $= 294{,}000 + 292054.79 + 1{,}714{,}286 = \$2{,}300{,}340.79/\text{yr}$

If the shipper always ships full loads, air would be the best choice.

g) find the optimum q for each mode of transportation to determine the most optimal mode

ocean: $210q + 1{,}120{,}547.90 + \frac{1{,}320{,}000{,}000}{q}$

derivative $= 210 - \frac{1{,}320{,}000{,}000}{q^2}$

$q^* = \sqrt{\frac{1{,}320{,}000{,}000}{210}}$

$q^* = 2{,}507$ units

minimized total ocean cost $= 210(2507) + 1{,}120{,}547.90 + \frac{1320000000}{2507}$

$= 526{,}470 + 1{,}120{,}547.90 + 526{,}525.73$

$= \$2{,}173{,}543.63/\text{yr}$

if the shipper optimizes to use less than full loads, the optimal mode of transportation would be ocean at 2,507 units per shipment

air: $210q + 292{,}054.79 + \frac{2{,}400{,}000{,}000}{q}$

derivative $= 210 - \frac{2{,}400{,}000{,}000}{q^2}$

$q^* = \sqrt{\frac{2{,}400{,}000{,}000}{210}}$

$q^* = 3{,}380.62$

greater than air container capacity, use 1,400

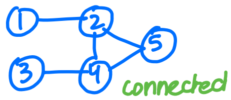
Total cost air $= \$2{,}300{,}340.79/\text{yr}$

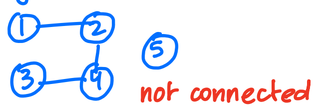
cost for air stays the same as part f since the derivative was greater then the air container capacity

4. How many arcs are included in a path that visits *n* nodes? (0.25 points)

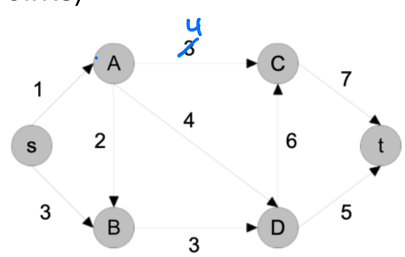
   There are (n-1) arcs included in a path that visits n nodes

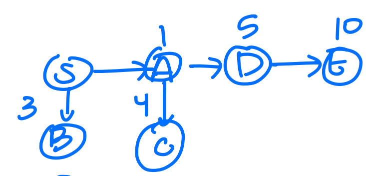
5. Can a graph be connected if it includes exactly 5 nodes and exactly 3 arcs? Why or why not? (0.5 points) No. A graph is connected if every pair of nodes in the graph are connected





6. The shortest path tree rooted at *s* for the graph depicted below includes the following arcs: *{*(s,A), (s,B), (A,C), (A,D), (D,t)*}*. Use this information to answer questions (a) through (d) below.
   a. Using the format *v*(*j*)[*pred*(*j*)], give the minimum cost path label of each node, as specified by the shortest path tree rooted as *s* described in the problem statement. To get you started, the label at node *s* is 0[0]. (1.5 points)
   b. If the cost on arc (A,C) increases from 3 to 4, what labels must be re-examined to test whether the set of minimum cost path labels is still optimal? Only specify those arcs which **must** be examined, and justify your answer for each arc you list. (0.5 points)
   c. If the cost on arc (A,B) increases from 2 to 3, what labels must be re-examined? Support your answer. (0.5 points)





a) steps

	S	A	B	C	D	t	P	PERM
initialize	0[0]	∞[-1]	∞[-1]	∞[-1]	∞[-1]	∞[-1]	–	{ }
1		1[s]	3[s]				s	{s}
2				4[A]	5[A]		A	{s, A}
							B	{s, A, B}
						11[C]	C	{s, A, B, C}
						10[D]	D	{s, A, B, C, D}
							t	{s, A, B, C, D, t}

b) if the cost on arc (A,C) increased to 4, the labels for c would change from 4[A] to 5[A]. No other labels would need to be re-examined because c is not part of the most optimal path to reach t.

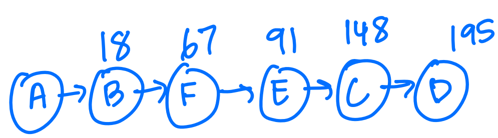
c) if the cost on arc (A,B) increased to 3, there would be no labels to be re-examined. The algorithm shows that the path from s to B is already the lowest cost. Node B also doesn't lead to other nodes on the most optimal path to t.

7. Using an appropriate algorithm that we discussed in class, identify the minimum spanning tree on the network and draw the graph. Determine the total cost of the minimum spanning tree. The travel cost matrix is provided for your reference.

From\To	A	B	C	D	E	F
A	0	18	85	57	84	66
B	18	0	71	53	65	49
C	85	71	0	47	57	68
D	57	53	47	0	89	83
E	84	65	57	89	0	24
F	66	49	68	83	24	0

using Dijkstra's Algorithm, we want to find which node to select w/ the minimum cost, starting from node A.

A	B	C	D	E	F		
0[0]							{A}
	18[A]						{A,B}
					67[B]	(49+18)	{A,B,F}
				91[F]		(67+24)	{A,B,F,E}
		148[E]				(91+57)	{A,B,F,E,C}
			195[C]			(148+47)	{A,B,F,E,C,D}



$\boxed{\text{Total cost of MST = 195}}$