OPRE 6366 : Quiz on 14 October 2009

This is an open textbook and open lecture notes exam. You may use a calculator although leaving quantities as fractions, additions or products is perfectly acceptable and preferable. **No cellular communication devices** (laptops, phones, etc) can be used during the exam. **Do not forget** to define any variables you introduce. This quiz has 4 bonus points. Good luck ...

NAME (please print): _____

Question	Out of	Points
1	20	
2	15	
3	13	
4	12	
5	20	
Total	80	

1. Put **T** before a statement if you think that statement is true. Otherwise put **X**.

   1. ( ) The tailored aggregation algorithm gives the optimal delivery frequencies. X
   2. ( ) For given relative frequencies, the tailored aggregation algorithm gives the optimal delivery frequency for the most frequently ordered product. T
   3. ( ) Set up time/cost reduction helps to decrease the optimal order size in the EOQ setting. T
   4. ( ) One of the roles of distributors in the supply chain is to provide economies of scale in transportation costs. T
   5. ( ) Economies of scale in construction/capacity expansion costs make us expand the capacity more than we would otherwise. T
   6. ( ) Decisions that are made at high frequency are non-anticipatory with respect to demands that materialize much less frequently. X
   7. ( ) The EOQ computed under each price range in all unit quantity discounts is implementable; we can buy the EOQ amount at the price corresponding to the price range. X
   8. ( ) Supply chain costs are less visible to consumers than the marketing costs. T
   9. ( ) Shipments with trucks are more economical than the shipments by boat. X
   10. ( ) The more the market growth due to discounting is, the more profitable the price discounting becomes. T

2. [*Facility Location with Demand Scenarios*] Consider the facility location formulation with fixed infrastructure costs.

$$\min \sum_{i=1}^{17} a_i b_i + \sum_{i=1}^{17} \sum_{j=1}^{8} c_{ij} d_{ij}$$

s.t.

$$\sum_{i=1}^{17} d_{ij} = D_j$$

$$\sum_{j=1}^{8} d_{ij} \leq C_i b_i$$

$$d_{ij} \geq 0,\ b_i \in \{0, 1\}.$$

This formulation does not have the variable and parameter names that you are used to. But you can correctly guess that $b_i = 1$ indicates that facility i will be opened while $b_i = 0$ when the facility is not opened. The other variable is d_{ij}, the amount of shipments from facility i to market j.

[3*pts*] a) The variables for the above formulation are given above. Express what the parameters a_i, c_{ij}, D_j and C_i represent. For example, parameter D_j represents the demand of market j.

ANSWER: a_i is the infrastructure cost for facility i; c_{ij} is the unit transportation cost; C_i is the capacity of facility i.

[2*pts*] b) How many facilities and markets are considered in the formulation above?

ANSWER: 17 facilities and 8 markets are considered.

[3*pts*] c) In some real-life contexts, the demand D_j can be random rather than a constant. To bring this randomness into the formulation, we can consider the demand scenarios along with the appropriate sequence of decisions and events. In most real-life contexts, we first decide on which facilities to open, then we observe the demand and eventually we decide on the shipment amounts from the facilities to the markets. On a timeline, depict the sequence of the events and decisions: facility location (b_i), demand realization (D_j) and shipment amount (d_{ij}).

ANSWER: Draw a timeline from left to right, put down b_i on the left, D_j in the middle and d_{ij} on the right.

[2*pts*] d) Determine which of the decisions is anticipatory and which is non-anticipatory.
ANSWER: Location decision is non-anticipatory while the shipment decision is anticipatory.

[5*pts*] e) Suppose that in demand scenario k the demands turn out to be D_j^k. Moreover, suppose that there are 10 possible demand scenarios and each of which happens with equal probability. Modify the facility location formulation by taking into account demand scenarios, anticipatory and non-anticipatory variables.

ANSWER:

$$\min \sum_{i=1}^{17} a_i b_i + \sum_{k=1}^{10} (1/0) \sum_{i=1}^{17} \sum_{j=1}^{8} c_{ij} d_{ij}^k$$

s.t.

$$\sum_{i=1}^{17} d_{ij}^k = D_j^k$$

$$\sum_{j=1}^{8} d_{ij}^k \leq C_i b_i$$

$$d_{ij}^k \geq 0,\ b_i \in \{0, 1\}.$$

3. [*Tailored Cargo Aggregation*] During a tailored aggregation computation dealing with placing three products (A, B and C) into the trucks, we find that A is the most frequently ordered product. In comparison to the frequency of product A, the relative frequency of product B turns out to be 3. Assume 360 days in a year.
[3*pts*] a) If A is delivered on alternating days, how many times is product B delivered in a year?
ANSWER: B should be delivered every 6=2*3 days, this makes 60=360/6 days per year.

[3*pts*] b) If C is delivered 90 times per year, what is the relative frequency of C?
ANSWER: 90 deliveries per year make a delivery every 4 days. Since A is delivered every two days, the relative frequency of C with respect to A is 4/2=2.

[3*pts*] c) If the annual demands are all the same and 18000 units for all three products, what is the shipment lot size for each product?
ANSWER: A is delivered in a lot size of 18000/180=100; For B, 18000/60=300; For C, 18000/90=200.

[4*pts*] d) Suppose that today is marked as the first day and today's truck delivery contains all three products A, B and C. What products would be inside the truck on each of the following days, the 5th day, 7th day, 9th day and 13th day?
ANSWER: Delivery schedule is (A-B-C); (); (A); (); Day 5 (A,C); (); Day 7 (A,B); (); Day 9 (A,C); (); (A); (); Day 13 (A-B-C).

4. [*Deducing Competitor's Demand*] Two retailers (say A and B) buy products from the same manufacturer and they sell these products in a market where the demand is constant. They also use and pay for the same trucking company to bring the product from the manufacturer to their own facilities. Since the retailers are operating in the same business, we can assume that their internal rate of return will be the same. Retailer A attempts to deduce the demand of Retailer B from the frequency of the truck shipments received by retailer B.
[2*pts*] a) Which inventory model would be appropriate for Retailer A to assume for Retailer B? Since Retailer A does not exactly know the model used by Retailer B, Retailer A must make an assumption regarding Retailer B's model.
ANSWER: We make the EOQ assumption as the question sets the case for constant demand, single product and a fixed cost.

[4*pts*] b) From its own accounting records, Retailer A finds out that the administrative and ordering costs (including trucking cost) from the manufacturer is $10,000, manufacturer charges $80 for each product and the weekly interest rate is 0.1%. Using these cost numbers and observing weekly deliveries to Retailer B, what does Retailer A estimate the weekly demand of Retailer B to be?
ANSWER: From

$$n = \sqrt{\frac{RhC}{2S}} = 1,$$

we obtain

$$R = \frac{2S}{hC} = \frac{2 \cdot 10000}{0.001 \cdot 80} = 250,000$$

[4*pts*] c) Retailer A observes weekly deliveries to Retailer B because of rounding up the optimal frequency of deliveries. The optimal frequency for Retailer B is not 1 per week but it is 0.9 per week. Since 1 delivery per week is much easier to implement than 0.9 delivery per week, Retailer B chooses to order/receive 1 delivery per week. This 1 delivery per week is not optimal for Retailer B but it is what Retailer A thinks is optimal for Retailer B. Find the actual weekly demand of Retailer B that corresponds to the frequency of 0.9.
ANSWER: From

$$n = \sqrt{\frac{RhC}{2S}} = 0.9,$$

we obtain

$$R = \frac{2(0.81)S}{hC} = \frac{2(0.81)10000}{0.001 \cdot 80} = 202,500$$

[2*pts*] d) Why would Retailer A want to know the demand at Retailer B?
ANSWER: Anything logical works here. The biggest reason to know the competitor's demand is to detect the success of own policies and programs. These could be pricing, service, maintenance policies of Retailer A, they affect the demand at Retailer A. It is useful to assess these effects not in isolation but in comparison to the demand at Retailer B.

5. [*Healthcare Supply Chain*] Consider the healthcare supply chain extending from the suppliers to the customers. In this supply chain **patients** receive treatment from **nurses** and **doctors**. The treatment can include a surgical procedure and/or an administration of medicine. The equipment and medicine used during a treatment are respectively manufactured by **healthcare supply manufacturers** and by **pharmaceutical companies**. These manufacturers ship their products to medical supply **distributors**. The distributors sell the products to **hospitals** and **clinics** but not directly. Hospitals and clinics group together to establish **group buying organizations (GBOs)**. A GBO negotiates prices for all of its members when it is buying medical supplies/medicine from a distributor. Since the GBO buys more than any one of its members, it has more purchasing power or leverage with the distributors to negotiate lower prices. Currently only a few GBOs handle about 80% of the pharmaceutical shipments in the healthcare supply chain.
For health care supply manufacturer, an example is Johnson and Johnson; for pharmaceutical manufacturer, it is Bristol-Myers; for distributor, it is McKesson; for GBOs, it is Broadlane (headquartered in Dallas).
A GBO is a virtual organization, it generally does not have warehouse space to hold medical supplies. However, the GBO owns the medical supplies for a very brief amount of time (usually less than 1 day). During this time the supplies are transshipped from the distributor to the hospitals and to clinics.
[4*pts*] a) Draw the flow of medical products in the healthcare supply chain (network) where the nodes should be chosen among the entities listed in boldface above.
ANSWER:

$$\left.\begin{array}{l}\text{Healthcare supply Manufacturers}\\ \text{Pharmaceutical companies}\end{array}\right\} \rightarrow \text{Distributors} \rightarrow \left\{\begin{array}{l}\text{Hospitals}\\ \text{Clinics}\end{array}\right\} \rightarrow \left\{\begin{array}{l}\text{Nurses}\\ \text{Doctors}\end{array}\right\} \rightarrow \text{Patients}$$

GBO should not appear above; even if it appears it should not be connected to the chain.

[4*pts*] b) Draw the flow of money in the healthcare supply chain.
ANSWER:

$$\left.\begin{array}{l}\text{Healthcare supply Manufacturers}\\ \text{Pharmaceutical companies}\end{array}\right\} \leftarrow \text{Distributors} \leftarrow \text{GBOs} \leftarrow \left\{\begin{array}{l}\text{Hospitals}\\ \text{Clinics}\end{array}\right\} \leftarrow \text{Patients}$$

You may insert Nurses and Doctors above as they collect the money in some cases.

[4*pts*] c) The profit margin for distributors is not very high in the healthcare supply chain. Before 2004, most distributors were buying a lot of inventory from the manufacturers/pharmaceutical companies and holding them in expectation of price increases. The prices of these supplies were generally going up. In a sense, distributors were speculating on the price of the medical supplies. This sort of purchasing practice can be called "investment buying". Before 2004, investment buying became so common that distributors were selling major amounts to each other rather than to the customers. This practice ended when a major medical supply manufacturer was audited. As a result of the audit, the Securities and Exchange Commission enforced an action against the major medical supply manufacturer. The action was settled when the manufacturer paid a fine of $150 million. The allegations included "a fraudulent earnings management scheme by, among other things, selling excessive amounts of ... products to its wholesalers [distributors] ahead of demand, improperly recognizing revenue from $1.5 billion of such sales to its two largest wholesalers ..." [1]. This allegation basically amounts to channel stuffing in the healthcare supply chain.
Consider the equipment and the medicine used during a treatment. Explain whether the equipment or the medicine is more appropriate to channel stuff. Also explain if a distributor's inventory turnover increase or decrease when it is channel stuffed by a manufacturer.
ANSWER: Since medicine can spoil when shipped earlier, it is better to channel stuff the medical equipment. Channel stuffing increases distributor's inventories and decreases its turnover rate.

[4*pts*] d) After 2004, the manufacturers started to collaborate more with the distributors under what is called Inventory Management Agreements (IMA). According to these agreements, the manufacturers limit the distributor purchases and the distributors report their sales and inventories. In return, the manufacturer pays a fee to the distributors. Compare investment buying practice with inventory management agreements and explain whether the manufacturers are exposed to more or less leftover inventory risk with IMAs.
ANSWER: Since the distributors do not hold much inventory now, they work more like a transit point. The bulk of the inventory is kept at the manufacturer. If the manufacturer were not to hold more inventory, then there would not be enough inventory in the supply chain as neither distributor nor GBO keeps a lot of inventory.

In general, when one of the parties holds less inventory in the supply chain, the other parties hold more inventory. This general principle can be invalidated when one of the parties have access to more customer demand information. Let us see if the manufacturer has more information on the demand in the IMA setting than the distributor in the investment buying setting. Even if the manufacturer knows as much as the distributor (all the inventory levels and shipments of the distributor), the manufacturer cannot know more than the distributor when it comes to the customer demand. Note that the distributor is closer to the customer. Thus, in the IMA setting, the manufacturer does not know more than what the distributor knows in the investment buying setting. In summary, we cannot argue that the manufacturer has more information than the distributor to reduce its own inventory when going from investment buying setting to IMA setting.

Another way to think about the argument above is to combine manufacturer and distributor into a single super entity. This super entity has the same amount of information under both IMA setting and investment buying setting. Then it should hold the same amount of the inventory. It holds the inventory at the distributor in the investment buying setting and at the manufacturer in the IMA setting. Once more, we conclude that manufacturer's inventory level increases when going from investment buying setting to IMA setting.

When the manufacturer keeps more inventory, it is more exposed to the leftover inventory risk.

If you argue that manufacturer's inventory level drops in the IMA setting, you will lose 2 points out of 4.

[1] www.sec.gov/news/press/2004-105.htm

[4*pts*] e) Consider two hospitals (big and small), each buying a particular supply in proportion to its size from a distributor. The distributor gives quantity based discounts: the more an entity (hospital or GBO) buys, the less the price is for the particular supply. These two hospitals join forces to make a GBO, which can negotiate a much lower single price from the distributors. If we compare the price that each hospital pays on its own with the price that it pays within a GBO, we find out that the former price is higher than the latter. The difference between these prices can be called the marginal value of participating in a GBO. Explain if this marginal value would be higher for a small or large hospital.

ANSWER: The marginal value would be higher for the small hospital. The small and large hospital are getting the same price from the distributor. The hospital which gets a higher price on its own will have a higher marginal value. Due to quantity based price discount, the small hospital gets a higher price on its own.