

OPRE 6366: Fall 2009 Final

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. **Do not forget** to define any variables you introduce. Good luck ...

NAME (please print): _____

Question	Out of	Points
1	20	
2	16	
3	20	
4	36	
Total	92	
Bonus	08	

- Put **T** before a statement if you think that statement is true. Otherwise put **X**.
 - Carbon footprint information posted on products can influence the product choice of some consumers. T
 - Optimal order quantity in the newsvendor problem is found by trading off only understocking and overstocking costs. T
 - Total holding and ordering cost in the EOQ model fluctuates dramatically around the EOQ with the order quantity. X, it changes very little because of the shape of the cost function.
 - To reduce the EOQ quantity by a factor of k , the fixed ordering cost S must be reduced by the same factor k . X
 - If the uncertainty in the demand decreases, so does the cycle stock. X, safety stock decreases.
 - Although a forward buy is often the retailer's appropriate response to supplier's discounts, it usually increases supplier's demand variability. T
 - When the manufacturer (supplier) buys the leftover inventory at the buyback price within a buyback contract, its profit is higher than that without a contract. X; Compare row 1 and 4 in the buyback profit table in scontract.ppt. Unfortunately, textbook says the supplier can use the buyback contract to increase its profit. This is not correct unless there is a transfer payment from retailer to the supplier. We discussed the amount of this payment during the lecture. Because of what the book says, an answer of T will be accepted in this question.
 - It is easier to run a Supply Chain with postponement (delayed customization) as opposed to one without postponement. X
 - Buyback contracts are used to motivate the retailer to order less. X
 - The cycle inventory exists to exploit economies of scale to lower the total cost. T

2. A BMW dealership has two retail outlets serving the entire Plano area (disaggregate system). Daily demand at each outlet is $N(\mu, \sigma^2)$. The lead time for replenishment from BMW's South Carolina plant is 9 days. Each outlet covers a separate area and the correlation of demand across two areas is $\rho = -0.5$. The dealership is considering the possibility of replacing the two outlets with a single large outlet (aggregate system). Assume that the demand in the central outlet would be the sum of the demand across both areas. The dealership is targeting a *CSL* of 95%.

[5pts] a) Express the total safety stock in the disaggregate system in terms of given parameters above and *normdist* or *norminv* functions.

ANSWER: Total safety stock = $2\sqrt{L} \sigma \text{norminv}(0.95, 0, 1) = 2(3)\sigma \text{norminv}(0.95, 0, 1)$.

[5pts] b) Express the total safety stock in the aggregate system in terms of given parameters above and *normdist* or *norminv* functions.

ANSWER: Total safety stock = $\sqrt{L} \sqrt{\sigma^2 + \sigma^2 + 2\sigma\sigma(-0.5)} \text{norminv}(0.95, 0, 1) = 3\sigma \text{norminv}(0.95, 0, 1)$.

[6pts] c) Is there a value of the correlation ρ for which the aggregate system keeps more safety stock than the disaggregate system? If yes, what is it? If no, how would you intuitively explain why the aggregate system always keeps less or equal amount of safety stock.

For all values of ρ the aggregate option has less or equal amount of safety stock. The aggregate option aggregates the demand whose extreme values cancel each other by yielding a small amount of standard deviation than the sum of their standard deviations.

3. Weekly demand for Motorola cell phones at a BestBuy store is $N(300, 20^2)$. Motorola takes 4 weeks to supply a BestBuy order. BestBuy is targeting a CSL of 90%¹ and monitors its inventory continuously.
[4pts] a) How much safety inventory of cell phones should BestBuy carry?

ANSWER: $norminv(CSL, 0, 1)\sqrt{L} \sigma = norminv(0.9, 0, 1)\sqrt{4} 20 = 40norminv(0.9, 0, 1)$.

[2pts] b) What should ROP be?

ANSWER: $ROP = (4)300 + 40 norminv(0.9, 0, 1)$.

[6pts] c) Motorola is working on reducing the replenishment lead time to 2 weeks. However, the lead time is not reliable yet; Half of the time, the lead time is 2 weeks, the other half of the time, it is 4 weeks. What should be the safety stock for 90% CSL with such an uncertain lead time?

ANSWER: Expected value of the lead time= $L = 3$.

Variance of the lead time= $s^2 = (0.5)(2 - 3)^2 + (0.5)(4 - 3)^2 = 1$.

$\sigma_L = \sqrt{L\sigma^2 + R^2s^2} = \sqrt{(3)20^2 + (300)^2 1} = \sqrt{91200}$

Safety stock= $\sqrt{91200} norminv(0.9, 0, 1)$.

¹Use normdist or norminv functions in your expressions

[5pts] d) Repeat the computation in a) and c) for demand of $N(500, 20^2)$.

ANSWER: With lead time of 4 weeks safety stock is $40 \text{ norminv}(0.9, 0, 1)$.

With lead time of 2 or 4 weeks, $\sigma_L = \sqrt{L\sigma^2 + R^2s^2} = \sqrt{(3)20^2 + (500)^21} = \sqrt{251200}$

Safety stock is $\sqrt{251200} \text{ norminv}(0.9, 0, 1)$.

Note that $\sqrt{251200} \text{ norminv}(0.9, 0, 1) > 40 \text{ norminv}(0.9, 0, 1)$.

[3pts] e) Compare the safety stocks found in d). Is it possible that more safety stock is required when Motorola pulls the lead time down to 2 weeks half of the time? Is it ever possible that shorter lead time in some occasions would require more safety stock? Briefly explain.

ANSWER: Occasionally shorter lead time, in spite of reducing expected lead time, increases the variance of the demand during the lead time. Thus, it leads to more safety stock.

4. [Nokia Corporation] Nokia is the third largest telecommunication equipment manufacturer, after Ericsson and Huawei ². The lifetime of Nokia cell phones are about 18 months, during which the sales are really strong only for 9 months. Nokia buys electronic components (chipsets, integrated circuits, microprocessors, sensors, memory devices, cameras, audio components, displays, batteries, chargers), mechanical components (covers, connectors, key mats, antennas), software and content (music, maps, games) from global suppliers.

In US, most content is hosted and provided by service providers (ATT, T-Mobile, Verizon) who own/operate the telecommunication network (communication towers, satellites). The operating system of cell phones need to be linked to the service providers' content database and network via specific software. Since the US telecommunication networks do not have the capacity demanded by the recent cell phones, some capabilities of the phones need to be turned off or limited before connecting them to the network. Otherwise, the phones will overwhelm the network and users will experience dropping calls, temporary inability to receive a call, long download times, restricted multitasking. As a matter of fact, these are already common complaints. For the purposes of linking a phone to service providers' databases and network, and limiting its capabilities, *bridging software* is installed on the phones. Development of this software and FCC (Federal Communications Commission) approval delays the release of new Nokia phones by about 6 months in US. In other words, lifecycles of Nokia phones in US are shifted forward by 6 months with respect to lifecycles in the other major markets.

Nokia operates ten manufacturing facilities in nine countries. Production at plants in Salo (Finland), Beijing, Masan (South Korea) is geared towards high value, low to medium volume mobile devices. Vertu business (luxury cell phone line) is served by the UK plant. Remaining six plants in Komarom (Hungary), Cluj (Romania), Dongguan (China), Chennai (India), Manaus (Brazil) and Reynosa (Mexico) concentrate on the production of high volume, cost sensitive mobile devices.

Cell phones sold in US are produced at the Reynosa plant and shipped to Nokia distribution center (DC) in Ft. Worth. Besides receiving, storage and shipping, the DC puts service provider logos on the phones. These phones are then shipped to US retailers (ATT device support centers and T-Mobile stores).

[3P] a) Why does not Nokia put service provider logos on the phones at the Reynosa plant but puts them on at the DC? Base your explanation on supply chain policies/tactics.

ANSWER: Nokia delays the customization of the phones for a service provider by putting logos at the DC. This is a postponement strategy.

[3P] b) Nokia can install bridging software at the Reynosa factory or at the DC. Which of these is a better place to install the software? Why? Base your explanation on supply chain policies/tactics.

ANSWER: Delayed customization requires installing the bridging software at the DC.

²This question is inspired by OPRE 6366 guest lecture on Nov 25, 2009, delivered by Ram Kuppuswamy, Director of North American Logistics at Nokia. However, the information given here does not necessarily represent Nokia's business practices.

[3P] c) Consider two cell phones, EB-66.A and EB-66.T, that Nokia produces respectively for ATT and T-Mobile. These phones are offsprings of the standard EB-66 model until they are customized at the Nokia's DC. EB-66 is produced at Reynosa plant. Draw the flow of EB-66 and its offsprings in the supply chain including the Reynosa plant, DC and the US retailers.

ANSWER: Draw a box for Reynosa plant; another for the DC; two more to represent ATT and T-Mobile retailers. Connect plant to DC with an arrow and put EB 66 on it. Connect DC to ATT retailers and put EB66.A on it. Connect DC to T-Mobile retailers and put EB66.T on it.

[3P] d) Nokia releases its production plans about 6 months in advance of production to its suppliers and knows that a particular cell phone model sells well for only 9 months. Nokia starts the production of a particular phone about 1-2 months before its release in the market. It is possible to alter these plans somewhat but not entirely. If Nokia realizes that sales for a certain model is higher than expected, can Nokia place a second, third or a fourth or more orders with the suppliers during 9 months of the sales season? Explain.

ANSWER: The question requires observing the sales of the phone before placing the second order with the suppliers. Therefore the order can be placed only after the first month of the sales season. Say that Nokia places the second order at the end of the second month of the sales season. That order cannot be received right away at the third month. Suppliers can accomodate that order into their production schedule by the 5th - 7th months, or perhaps by the 8th month. Say that the suppliers delivers the order in the sixth month of the sales season. Nokia will take another month to assemble the componenets to make phones. This takes us to the 7th month of the sale sseason. Nokia can perhaps place a second order with suppliers within the first few month of the sales season. It cannot place a third or fourth order, because it runs out of time in the sales season.

[3P] e) A display supplier has a contract with Nokia where Nokia releases production plans (Nokia's orders to the supplier) 6 months in advance and Nokia can afterwards make unlimited alterations to the plans by paying monetary penalties. These alterations give Nokia the flexibility it needs to meet its demand. Is the contract mentioned here an example of the quantity flexibility contracts studied in this course?

ANSWER: No. The contract mentioned here has monetary penalties for alterations. Quantity flexibility contract allows for free alterations provided that they are within certain limits.

Instructor's Note: Displays are mostly LCD (liquid crystal displays). Nokia's LCD suppliers include Toshiba, Hitachi, Samsung, Seiko Epson, Tatung, Phillips, AU Optronics, Chunghwa Picture Tubes, LG Display, Sharp. Some suppliers were found guilty of colluding to fix LCD prices by Justice Department in 2006. European Commission charged some suppliers for operating as a cartel in May 2009. ATT sued some suppliers for the same reason in October 2009. Finally, Nokia has sued its suppliers on Nov 25 in the U.S. District Court for the Northern District of California in San Francisco with the allegation that the suppliers raised "the price of LCDs above the price that would have prevailed in a competitive market" from at least Jan. 1, 1996 through Dec. 11, 2006.

Nokia and its LCD suppliers have a sour relationship.

[3P] f) Some integrated circuits used in EB-66 are manufactured in Finland and shipped to Reynosa to be used during the assembly. Nokia used a euro to dollar parity of 1.2 when it assigned the integrated circuit manufacturing to Finland. The parity first became 1.3 and then 1.4. Now it is at 1.5. Nokia's economists are expecting inflationary pressure due to loose monetary policies in US, as a result of which they think that the parity will converge to 1.6. This means a 33% increase in the integrated circuit prices when measured in dollars. Nokia can assign integrated circuit production to a supplier in Ireland or it can help a local supplier in Reynosa to build this capability. From a cost containment perspective, which of these options is desirable?

ANSWER: Reynosa option is more desirable as Ireland is subject to the same currency effects as Finland does.

[3P] g) Nokia is uncomfortable about helping a Reynosa supplier to design and build the integrated circuits. It is looking for examples of this kind of a set up between a supplier and a manufacturer. Give an example of a manufacturer with this set up.

ANSWER: Ford collaborates with its suppliers during the design phase; see course slides.

[3P] h) Due to various factors (related to service providers, competition, etc.), Nokia can end up with excess supply of a certain phone model in its US supply chain towards the end of the lifecycle of the model. At that time, Nokia will search for another major market for that model in the international markets. Do you think this search will be successful or not, explain?

ANSWER: Since the lifecycle for that model will be over in the international markets, this search will be unsuccessful.

[3P] i) Suppose now that Nokia ends up with excess supply of a certain phone model in its Japanese supply chain towards the end of the lifecycle of the model and searches for another major market. Do you think this search will be more successful than the one mentioned in h), explain?

ANSWER: Yes, because Japanese lifecycles starts before US lifecycles.

[3P] j) Suppose that selling excess Nokia phones in US to other markets is not possible, what can Nokia do clear out this excess?

ANSWER: Nokia reduces prices to get rid off excess supply in US.

[3P] k) Nokia phones are sold mostly by service providers in US. Service providers run special promotions during holiday season and at other times. Nokia is not made aware of these promotions in advance. How can service providers benefit by informing Nokia of the promotions in advance?

ANSWER: Service providers, by involving Nokia in advance, can ensure supply availability to reduce/avoid shortages.

[3P] l) Nokia sells most of its phones directly to consumers in international markets unlike in US. Nokia has attempted to use the same strategy in the US over the last 6 years and US market share dropped considerably. Apparently US consumers prefer to buy a phone with a calling plan, both from the service providers. The reasons behind this preference are not clear. Speculate on these reasons. You can also explain what you personally prefer and why?

ANSWER: Since this question is about speculation, everything logical is fine here. One reason could be that the US consumers want to have high-end phones that cost more than \$500. They want to pay for these phones in installments. Service provider calling plans make these installments possible.