OPRE 6366: Quiz 2 on Nov 30, 2011 - **TYPE A**

This is an open written/printed-material exam (any book, notes, lecture slides can be used). You **cannot** use a device with wired/wireless communication capability, so no laptops or phones are allowed during this 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	30	
3	22	
4	16	
5	24	
Total	112	
Bonus	12	

1. Put **T** before a statement if you think that statement is true. Otherwise put **X**.
   1. ( ) Medco Energi, wood and paper manufacturer of Indonesia, is working with University of Texas to decide on which rain forest areas in Papua island can selectively be cut and which should be protected for environmental reasons. When a book publishing house buys paper from Medco based on Medco's forest sustainment program, that publishing house is said to be using environmentally-friendly product design. X - This practice is environmentally-friendly sourcing.
   2. ( ) Information leakage is an important problem that concerns strategic supply chain partners but it can be mitigated by expediting the process of sharing information. X - Expediting information exchange expedites the leakage rather than mitigating it.
   3. ( ) European Union's environmental directives do not affect Texas Instruments. X - Texas Instruments produces and sells in EU and must abide by EU directives.
   4. ( ) Outsourcing production to overseas companies increases a company's ability to quickly respond to changing consumer demand. X - Outsourcing from overseas increases lead times and decrease responsiveness.
   5. ( ) Compared to a single order, multiple orders placed with a supplier in a single selling season increase the total quantity purchased from the supplier in that season. X - A retailer can use multiple orders to correct mismatches in the previous orders and reduce demand uncertainty, both decrease the total orders to the supplier.
   6. ( ) Compliance department in an oil & gas company checks that the company abides by regulations related to environment, health, customs, etc. T
   7. ( ) Movement of electrons in an electric grid is an example of a supply chain where the power suppliers are electric generation plants and consumers are residential, industrial or commercial customers. T
   8. ( ) When consumers produce electricity at their houses (through wind turbines or solar cells) and sell it back to utilities, the flow of electrons is reversed in the grid. The associated challenges to control and account for this reverse flow are similar to those found in reverse logistics. T
   9. ( ) Transportation of burnt-but-still-radioactive fuel rods from nuclear power plants to storage facilities is an example for transportation of hazardous materials. T
   10. ( ) JCPenney procures electricity from utilities and it is subject to electric price volatility. JCPenney can mitigate this price risk by buying electricity with long term fixed-price contracts. T
   Questions 6-10 show SCM applications to Energy sector.

2. **Multiple Choice Questions**:

1. An oil refinery in Houston brings crude oil from UAE (United Arab Emirates), the journey takes on average 36 days and it has a standard deviation of 1 day. The journey has become longer as the tankers started to take longer but safer routes to avoid pirates. The refinery's daily crude oil demand is 5 tons and the standard deviation is 2 tons. What cycle service level is achieved if a full tanker leaves UAE for Houston whenever the crude oil inventory drops to 200 tons at the refinery?

   (a) Less than Normdist(1,0,1,1)
   (b) Between Normdist(1,0,1,1) and Normdist(2,0,1,1)
   (c) Between Normdist(2,0,1,1) and Normdist(3,0,1,1)
   (d) More than Normdist(3,0,1,1)

   Answer: b. $L = 36,\ s = 1;\ R = 5,\ \sigma = 2.\ \ \sigma_L = \sqrt{L\sigma^2 + R^2 s^2} = \sqrt{36 * 4 + 25 * 1} = \sqrt{169} = 13.$ CSL=normdist(20/13,0,1,1). This is more than normdist(1,0,1,1) but less than normdist(2,0,1,1).

2. A cruise ship loads 600 kilograms of beef from Miami port and sails towards the Caribbean island of Nassau. The ship can load more beef in Nassau, but not during the trip between Miami and Nassau. The trip lasts 1 and a half day during which 2 breakfasts, 1 lunch and 2 dinners must be served. The expected value and standard deviation of beef demand for these meals are given below in kilograms.

	Breakfast	Lunch	Dinner
Expected value	80	120	120
Standard deviation	10	15	15

   What is the beef safety stock for the trip?

   (a) 80
   (b) 280
   (c) Safety stock cannot be determined without knowing the demand distribution
   (d) None of the above

   Answer: a. Safety stock=600-2*80-120-2*120=600-520=80.

3. A retailer has a flexible quantity contract to meet its demand D by ordering Q. The retailer thinks that its weekly demand can be met by ordering $q = 10$ for every week. Thus, the retailer passes this quantity as what is likely to be ordered to the supplier. However, depending on the circumstances the demand D turns out to be different than q. Demands over the last three weeks and the corresponding retailer's orders are given below.

	Week 1	Week 2	Week 3
Demand D	12	7	11
Order Q	12	8	11

   What are the contract's flexibility parameters (α, β)?

   (a) $(\alpha = 0.2,\ \beta = 0.2)$
   (b) α cannot be determined exactly with the given information but $\beta = 0.2$
   (c) $(\alpha = 0.0,\ \beta = 0.2)$
   (d) Neither α nor β can be determined exactly with the given information

   Answer: b. α cannot be determined as the retailer never had to buy less than its demand; $\beta = 1 - 8/10$ from month 2.

4. Annual US beverage milk sales is about 25 million tons. 1 kilogram milk has 1.3 kilogram carbon footprint, that is 1.3 kilogram carbon dioxide is emitted to produce, process, package, transport and retail 1 kilogram of milk in the dairy supply chain. How much carbon dioxide is annually emitted in the US dairy supply chains?

   (a) Less than or equal to (25/1.3) million tons
   (b) Between (25/1.3) million tons and 25 million tons
   (c) More than 25 million tons
   (d) None of the above

   Answer: c.

5. A truck going to a retailer has been observed over 3 weeks (21 days) and its contents are recorded in the table below. The truck contains either 4 Product A or 1 Product B. When the truck does not depart for the retailer on a certain day, the contents are recorded as 0 Product A and 0 Product B.

	Days of Week 1							Days of Week 2							Days of Week 3						
Product	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
A	0	0	4	0	0	0	4	0	0	0	4	0	0	0	4	0	0	0	4	0	0
B	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

   What is the relative frequency of Product B with respect to the frequency of Product A?
   (a) 1 (b) 2 (c) 3 (d) 4
   Answer: b.

6. An Italian restaurant is well known for its Tuscan bread, which is served with olive oil to every customer before he/she orders his/her meal. Since the restaurant is famed for this bread, many new customers come to taste the bread. Repeat customers (who came before) come back to enjoy the bread. According to the chef of the restaurant, running out of the Tuscan bread will be disastrous as customers expect to have this bread before and during their meals. Luckily, the bread is not expensive when it is bought from a bakery that supplies other baked goods to the restaurant. It can also be purchased from other bakeries because the recipe for the Tuscan bread is known to many bakeries. The chef took a short procurement course lately and learned about the classification of items as *Critical, Strategical, General, Bulk Purchase* items. Which of these groups is most appropriate for the Tuscan bread?

   (a) Critical items
   (b) Strategical items
   (c) General items
   (d) Bulk purchase items

   Answer: a. The bread is a must to have so it is critical. It is inexpensive, so it cannot be a strategical item. Criticality, low cost and availability of the bread make it a Critical item.

7. Which one of the following is achieved with the objective of a standard newsvendor model?

   (a) Cost is minimized
   (b) Profit is maximized
   (c) Both cost is minimized and profit is maximized
   (d) Both revenue and cost are maximized

   Answer: c.

8. In a strategic partnership, a supplier and a retailer commit to work together to improve supply chain efficiency. Which of the following requires the least commitment from a retailer? In other words, which provides the retailer with most flexibility by restraining the retailer the least?

   (a) Exchange of POS (Point of Sales) data
   (b) Vendor Managed Inventory (VMI)
   (c) Reverse Purchase Order
   (d) Continuous replenishment

   Answer: a.

9. Timberland is selling a boot that features a rubber sole (shoe bottom) that can be snapped off from the leather top. When this sole wears out, consumers will easily take it off and replace it with a new sole. Which one of the following is not exemplified by this boot example?

   (a) Recycling the sole of a shoe
   (b) Environmentally friendly product design
   (c) Product design for an ease of disassembly
   (d) Recycling the leather top of a shoe

   Answer: a. For more information, read WSJ Dec 18, 2009 article "Spendthrift to Penny Pincher: A Vision of the New Consumer".

10. During official holidays, UTD reduces the cooling or heating (depending on the season) of its buildings. Which one of the following is exemplified by this UTD policy?

    (a) Environmentally responsible internal operations
    (b) Environmentally friendly product design
    (c) Environmentally friendly sourcing
    (d) All of the above

    Answer: a.

3. [**Comparison of overstock and understock**] Let D be the nonnegative demand over a single period (season) and let Q be the single order quantity. By the definitions of understock and overstock, recall that expected understock and overstock are

$$\mathrm{E}(understock) = \mathrm{E}(D-Q)^+ \quad \text{and} \quad \mathrm{E}(overstock) = \mathrm{E}(Q-D)^+.$$

[2P] a) Last season the demand was 12 and order quantity was 8. What were the understock and overstock?
ANSWER: Understock was $\max\{0, 12-8\} = 4$ and overstock was $\max\{0, 8-12\} = 0$.

[2P] b) Two seasons ago, the demand was 8 and order quantity was 10. What were the understock and overstock?
ANSWER: Understock was $\max\{0, 8-10\} = 0$ and overstock was $\max\{0, 10-8\} = 2$.

[4P] c) Suppose that the demand is known to be $D = 10$ in the next season and consider the function $y_1(Q) = (10-Q)^+$. Note that this is a function of one variable (i.e. order quantity Q) and it is almost a line. Note that $y_1(Q)$ can also be written as $y_1(Q) = \max\{10-Q, 0\}$. Express $y_1(Q)$ in your words. Draw $y_1(Q)$ as Q varies (x-axis is Q, y-axis is $y_1(Q)$).
ANSWER: $y_1(Q)$ is the understock if the demand turns out to be 10. Over $0 \le Q \le 10$, $y_1(Q)$ decreases from 10 down to 0. For $Q \ge 10$, it remains at 0.

[6P] d) Keep $D = 10$ and define $y_2(Q) = (Q - 10)^+$ and $y_3(Q) = 10 - Q$. Express $y_2(Q)$ and $y_3(Q)$ in your words. Draw $y_2(Q)$ and $y_3(Q)$ below.
ANSWER: $y_2(Q)$ is the overstock if the demand turns out to be 10. $y_3(Q)$ is the difference between demand and order quantity, this difference does not have a specific name/term. Over $0 \leq Q \leq 10$, $y_2(Q)$ is zero. Starting at 0 for $Q = 10$, it increases at 45 degree angle as Q grows. $y_3(Q)$ is a simple line that decreases and goes through (0,10) and (10,0).

[3P] e) Now looking at your drawings determine if

$$i.\ \ (10 - Q)^+ - (Q - 10)^+ = (10 - Q) \quad \text{or} \quad ii.\ \ (10 - Q)^+ + (Q - 10)^+ = (10 - Q).$$

Express in your words the correct equality.
ANSWER: i. is correct. The difference between understock and overstock is the difference between the demand and order quantity.

[2P] f) Judging from the last two seasons where the demands were 12 and 8, we set the demand random variable as

$$D = \left\{ \begin{array}{lll} 8 & \text{with probability} & x \\ 12 & \text{with probability} & 1 - x \end{array} \right\}$$

What should x be?
ANSWER: $x = 1/2$. We have two demand observations, once demand was 8 the other time it was 12. Demand history indicates that 8 and 12 are equally likely.

[3P] g) What is the expected understock if $Q = 14$ and

$$D = \left\{ \begin{array}{lll} 8 & \text{with probability} & 2/3 \\ 12 & \text{with probability} & 1/3 \end{array} \right\} \ ?$$

ANSWER: Order quantity is larger than the demand in each demand scenario so there is no understocking.

4. **[Indian retail liberalization]** Regulations on retail joint ventures in India have changed after the Indian cabinet meeting on Nov 24, 2011: foreign (non-Indian) ownership of multibrand (e.g., WalMart) retailers can now be up to 51% while the same number for single-brand (e.g., Adidas) retailers can be up to 100%. That is foreign-owned retailers will have more power in these joint ventures. Some argue that these liberalization attempts will increase foreign direct investment in India and hence they were long overdue. Others disagree by saying that these attempts put smaller mom-and-pop stores at a severe disadvantage against large international retailers. India has a big/growing retail market with annual sales of $470 B — generated mostly ($\approx 95\%$) through mom-and-pop stores.
[4P] a) With the new regulations, WalMart is expected to open retail stores in India sooner than later. What is WalMart's competitive advantage against mom-and-pop Indian stores?
ANSWER: 1. WalMart knows how to run an efficient supply chain. WalMart has a team of (supply chain) experts whose job is to improve the supply chain. It also has tremendous experience in running efficient and extensive supply chains.

2. WalMart exploits its size (economies of scale) advantage to procure supplies at a low cost, to transport and to store efficiently. To start with, WalMart can bring in its cooled trucks and build large climate controlled storage centers. These will also cut the waste in the supply chain. The large size of operations that WalMart runs reduces portion of the overhead costs that go in to each sold product. On the other hand, mom-and-pop shops sell less and hence must mark up products significantly to recover their own costs.

3. WalMart has global presence and reach. For example, if the rice prices increase in India, it has connections and know-how to bring rice from Vietnam.

4. WalMart has deep pockets (cash reserves). It can afford several mishaps along the way. That is not so mom-and-pop shops that operate with limited cash.

There are four items mentioned above (there can be others not mentioned). You get min{1+number of items mentioned,4} points from this part. For example, if you mention 2 items, you get 3/4. For example, if you mention 4 items, you get 4/4.

[4P] b) When a company moves to new overseas markets for the first time, it faces supply chain problems. WalMart has been operating in India's wholesale market as a joint venture called Bharti WalMart —quite similar to Sam's Club[1]. Raj Jain, CEO of Bharti WalMart, recently said: "WalMart has been in India for over three years now, and we can use the same supply chain that we have set up to expand our business here". Do you completely agree with his assessment? If not, what are the new supply chain functions that retail operations must introduce on top of the existing wholesale functions?
ANSWER: The wholesale supply chain cannot be used in retail operations without adding some functions. The question is basically asking for the difference between wholesale and retail distribution.

1. In retail distribution products are handled in smaller quantities (packages as opposed to boxes or pallets), so the "bulk shipments" must be broken down into smaller pieces.

2. These smaller pieces must be pushed to downstream supply chain closer to the consumer. This requires extending the supply chain: more and smaller stores.

3. The retailer stores are smaller so they require micro-management: keep detailed information about sales/trends and react quickly (as in the case of 7 Eleven Japan). On the other hand, wholesale stores are aggregate the demand, so information does not have to be as detailed.

There are three items mentioned above (there can be others not mentioned). You get min{1+number of items mentioned,4} points from this part. For example, if you mention 1 item, you get 2/4.

[1] Watch the opening of WalMart's first wholesaler in Amritsar (www.youtube.com/watch?v=40ovnOByRbk)

[4P] c) WalMart is not the only retailer which has its eye on the Indian market, Tesco (of United Kingdom) has agreements with Tata group's Star Bazaar stores in India. Carrefour (of France) opened a wholesale store in Seelampur Metro Station Complex on Dec 30, 2010. Tesco and Carrefour are familiar with the market similar to WalMart's familiarity through Bharti WalMart. Metro Group (of Germany) has no involvement yet in the market but welcomed the liberalization efforts. When these large retailers open stores in India, mom-and-pop shops will suffer. To proactively avoid this, the Indian government is considering to impose conditions on large retailers: i) A foreign retailer must invest at least \$100 M and half of this amount must be spent on supply chain facilities (processing and cooled storage), ii) A foreign retailer cannot open stores in cities whose population is less than a million, iii) A foreign retailer can open stores only in suburban areas, but not in city centers or around densely populated residential neighborhoods. Among these restrictions, which are going to be more effective and why?
ANSWER: Investing \$100 M is not a big deal for a market whose annual sales are in the order of \$500 B — 5000 times larger than the required investment. Hence, i) does not really restrict international retail giants such as WalMart, Tesco, Carrefour, or Metro.

India has a population of 1.2 B according to 2011 census. The country has more than 50 cities each of which has population more than a million. The smallest among them, with population slightly over a million, is Kota in Rajasthan. A big portion of the country leaves in these cities. This portion will increase with migration from rural areas to big cities. There are quite a few million-plus cities to open retail stores and many cities can support multiple stores. Restriction ii) saves mom-and-pop shops in small cities but it does not many others in large cities. This restriction is more effective than i).

Restriction iii) applies to all cities, basically it is a zoning restriction. It will be relatively more effective in protecting mom-and-pop shops that generally concentrate in high-density population areas in city centers rather than recently growing suburbs outside cities.

Some of you may not know how large Indian population is and as a result may argue that restriction ii) is as affective as restriction iii). Such arguments may receive full credit.

Restriction iii) is a fictitious one invented by your instructor. The Indian government is actually considering only restrictions i) and ii).

When this exam started at 7pm, it was morning hours on Thursday, Dec 1 in India. Simultaneously with this exam, a nationwide store shutdown started in India to protest the government. The day-long strike is arranged by Confederation of All India Traders. According to one of its senior officials, Praveen Khandelwa, who was at a historically significant protest site in New Delhi on Dec 1: "The foreign retailers can open in big cities, but they will source from markets across rural India and small towns. With their money and power, over time they can corner the supply of produce ..." [2]. These remarks lead to the next part of this question.

[4P] d) When large foreign retailers open many retail stores in India and start negotiating with farmers to reduce food prices (say for fruits and milk), the farmers can be worse off than they are today. This is because large retailers have more negotiation power than smaller mom-and-pop retailers. Can you suggest/describe a structure where Indian farmers can cooperate to negotiate with large retailers?
ANSWER: You can suggest a farmer cooperative (co-op). One of the reasons why farmers make up cooperatives is to pool their negotiation power against large retailers. It is sufficient to describe the cooperative structure loosely by saying something to the effect that "farmers can cooperate during the negotiation process by coming together and acting together". You do not have to use the keyword farmer cooperative.

A cooperative is not a case of a merger/acquisition among farmers, it is a looser structure that allows cooperation among farmers when the prices are determined. Farmers have option to take part in a cooperative or not. After the prices are determined the farmers do not have to cooperate with their daily operational decisions.

Some cooperatives are more rigid than others. In the rigid form, the cooperative not only negotiates with retailers but also collects the sales revenue. This sales revenue is distributed to farmers — not necessarily in proportion to amounts they supplied. In order to obtain the participation of smaller farmers in the cooperative, smaller farmers may actually get slightly more revenue-per-amount-contributed than larger farmers. However, we should not call this revenue arrangement a revenue sharing contract — a term reserved for contracts between a supplier and a retailer, which are at different echelons of the supply chain. A cooperative is among the farmers (all suppliers) that are in the same echelon of the supply chain.

A good example of existing cooperative in India is Amul that operates in the dairy industry. Another recent one is e-Choupal that started with Soya beans and branched into other crops. Amul is older, more integrated and extensive than e-Choupal[3] which works more like an information provider.

[2] WSJ Dec 1, 2011 article titled *Rage Grows Against Retail FDI* by V. Agarwal
[3] See www.amul.com and www.echoupal.com

5. [**Texas Instruments**] TI is one of the largest semiconductor manufacturers in the world. TI is present in over 30 countries; sells about 60,000 products; introduces approximately 900 new products per year; manages 138 sales offices; employs a global team of 2,000 applications and sales engineers and about 30,000 employees; coordinates over 50 design centers worldwide[4]. TI offers four categories of products: *analog*, *wireless*, *other* and *embedded processing*. These respectively brought 6/14, 3/14, 3/14 and 2/14 of the total revenue \$14 B in 2010[5]. All of these products require latest technologies and the lifetime of certain generation of a semiconductor tend to be short, such as 12-18 months.

Analog products accept real-world signals such as moving pictures, sound, vibration and often convert these to digital signals made up of 0s and 1s. Sometimes output can be an analog signal as well. For example, regular cameras (not sold by TI) are analog-input and analog-output devices whereas digital cameras are analog-input and digital-output devices. Analog products have three categories high-volume analog & logic products, high-performance analog products and power management products. Power management products control/optimize the power consumption in cell phones and laptops.

Wireless products are mainly used for two purposes: *applications processor* that runs the operating system of a cell phone/tablet and *connectivity processor* that maintains the connection of a cell phone/tablet through a Bluetooth device, WiFi network, etc. A cell phone/tablet needs both the applications processor and the connectivity processor. These processors can be physically integrated to improve performance and reduce power consumption. An integrated chip performs the functions of both an *application processor* and a *connectivity processor*. However, some cell phone/tablet manufacturers prefer the flexibility of two separate processors. Betting on this, TI is focusing on OMAP (open multimedia *application* platform) mobile *processors* for growth in the wireless segment and giving up on baseband chips (*connectivity processors*).

Analog and Wireless products along with embedded processing and other products are sold in four major end-product markets: Communications (42% of the revenue), computing (22%), industrial (14%), consumer electronics & automotive & education (22%). Industrial markets include applications such as power and motor controls, and smart metering. Products sold to industrial markets are either analog products or embedded processors. Virtually no TI wireless product is sold in the industrial market.

[4P] a) Amazon's Kindle Fire, RIM's Playbook device and Samsung's Galaxy Nexus smartphone include TI's OMAP processors. Samsung's choice is significant because Samsung produces alternative processor chips for smartphones. Samsung uses an Intel baseband in Galaxy Nexus[6]. Explain what would Samsung buy for Galaxy Nexus if TI were selling only a single integrated chip for application and connectivity processing?

ANSWER: Without the flexibility of buying a processor chip from TI and a connectivity chip from Intel, Samsung will be forced to buy either both from TI or from nothing from TI. Obviously TI prefers to sell both as an integrated chip but this requires TI to be the leading company for processor chips, connectivity chips and their integration. This is quite unlikely and TI has made a conscious decision to focus on processor chip segment where it can use its OMAP chips.

You cannot conclude that Samsung will buy the integrated chip from TI, there are other chips available. You should mention the possibility that Samsung may buy nothing from TI. That is TI sells either an integrated chip or nothing. But this is a risky proposition as it is likely that Samsung will buy nothing from TI.

[4] This question is inspired by OPRE 6366 guest lecture on Nov 23, 2011, delivered by Jan De Meulder, TI's Global Trade Compliance and Logistics. However, the information given here does not necessarily represent TI's business practices.

[5] TI's 10-K SEC annual report filed on Feb 25, 2011.

[6] Components of Galaxy Nexus is available at www.ifixit.com/Teardown/Samsung-Galaxy-Nexus-Teardown.

[3P] b) Earlier in 2011, TI acquired National Semiconductor which is headquartered in Santa Clara, Ca and owns fabs (fabrication facility) in Maine and Scotland. 2010 revenue of National Semiconductor was $1.6 B, more than half of which was obtained by selling power control products to industrial markets. A parent company sometimes acquires a similar company (similar products/markets) to consolidate its position in a market. In other times, a parent company buys a slightly different company (slightly different products/markets) to expand its product portfolio. What could be TI's purpose in buying National Semiconductor?
ANSWER: Judging from product portfolios and markets served, TI must have bought National Semiconductor expand its product portfolio, to focus more on the industrial market.

When you combine this with the fact that TI is giving up on baseband chips, it appears that TI is moving away from wireless products and focusing more on power control products that are sold to industrial customers.

[4P] c) TI buys blank wafers (thin, circle shaped silicon crystal of 300 millimeter in diameter) and chemicals from suppliers. TI slowly sprays liquid chemicals on each wafer to achieve desirable conductivity properties. Often a wafer has multiple layers of chemicals. Some layers are later removed by physical or chemical etching to obtain different conductivity properties. From spraying to etching, the processes are done at fabs. A wafer can contain hundreds of chips. Wafers are then shipped from fabs to test and assembly sites where wafers are cut into individual chips. Chips are covered with a plastic package that leaves only necessary electric connections exposed. TI then ships standard chips to distribution centers, from where they are sold to customers such as Samsung. If a chip is customized (either in terms of hardware or for the software the customer intends to use), it is shipped directly to customers. With this description, draw the TI supply chain from suppliers to customers.
ANSWER: The drawing must identify 5 entities: wafer supplier, fab, test & assembly facility, distribution centers and customers. It should also treat standard and customized product shipments differently. A reasonable drawing gets full credit here.

[3P] d) Semiconductor manufacturing is equipment intensive. The equipments are high-tech and costly machines that are used to spray/draw/etch miniscule conductivity patterns on wafers. These specialized equipments are designed with equipment manufacturers and must be ordered 12-18 months in advance of delivery. On the demand side, there are business cycles that can span 2-3 years. At the peak of the cycle, demand is high and equipment capacity falls short of meeting it. At the bottom of the cycle, demand is low and fabs are underutilized. Can TI use chase strategy to match its demand and capacity, explain? Would it be more appropriate for TI to use strategies of building inventory or subcontracting?
ANSWER: Chase cannot be used because capacity is rigid and has very long lead times to adjust. Building inventory is possible but not very effective because semiconductor lifetimes are short 12-18 months. If TI wants to build inventory at the bottom of a cycle to use it at the peak of a cycle, the inventory must be kept about 12-18 months as the cycle lengths are 24-36 months. These 12-18 months of keeping inventory in the stock matches the lifetime of semiconductor chips so chips in the inventory can be easily obsolete by the time demand peaks in a cycle. It is more appropriate to subcontract some capacity to build these chips during peak demand periods.

TI actually subcontracts production to many fabs all over the world. You can find global supply chain along with the locations of subcontractors in the guest lecture slides posted on the OPRE 6366 eLearning site. These slides contain extra information and are not necessary to answer this part.

[3P] e) TI sells standard products that can be bought from many other semiconductor manufacturers as well as other products (such as DLP chips). DLP (Digital Light Processing) chip is developed by TI and it is used in projectors and high definition TVs. DLP chip has about 2 million microscopic mirrors that can be independently controlled to reflect the incoming light in different directions[7]. Explain if it will be easier to subcontract the production of the DLP chip or a standard product.

ANSWER: Standard chips are easier to subcontract to wafer foundries because foundries are already familiar with standard products. If customized chip production is subcontracted, the foundry may have to buy special fixtures and mask sets (often used in laser etching to block the laser from harming certain areas on the wafer), and may have to set up machines in a different configuration. After the set up machines must be certified by running test wafers and checking the quality. All these add to costs of subcontracting a customized products.

Another issue is potential information leakage with customized products. TI or its partner would like to minimize the exposure of customized designs to third parties.

A reasonable answer will get full credit.

[3P] f) Many of the TI's suppliers and customers are in far east. They include Chinese, Japanese, Indonesian and Thai companies. TI products constantly flow between facilities in these countries as well as those in USA and Europe. Since products are entering into many countries, managing customs processes becomes a big hurdle that should be minimized. One option is to seek a carnet for each product; another one is using bonded production facilities and warehouses [8]. Should TI use carnets or bonded facilities?

ANSWER: TI has thousand of products. Obtaining thousands of carnets, one for each product, is a very tedious job. It would be better to use bonded facilities. A bonded facility in China is treated as if it is outside China, so TI does not need to deal with Chinese customs when shipping to this facility.

Carnets are more useful when the products are few and are unique, such as historical artifacts or products that are being developed but not mass-produced yet.

[4P] g) Some of TI chips have export restrictions. Restrictions can be in two forms: i) a chip cannot be sold to a particular country, ii) a chip cannot be used in a military application in a foreign country. First, suppose that you are an official in a the fictitious country of Forbidden-land where TI cannot export. Explain how you can use other countries to indirectly buy TI chips. Second, suppose that you are manufacturing light sensors for the military of Ok-land where TI can only export chips for civilian uses. Explain how you can use other companies in Ok-land to indirectly buy TI chips. This question aims to illustrate the difficulty of enforcing export restrictions.

ANSWER: First you can use a company in Ok-land or another country as an intermediary.

Second you can use an intermediary company engaged in non-military products in Ok-land. A chip used in light sensors can be used for many civilian applications such as medical cameras, security cameras, traffic monitors. Hence, it may not be difficult to find an intermediary company.

[7] www.ti.com/lsds/ti/analog/mems/mems.page

[8] Recall that carnet is a passport for an item that will temporarily remain in a country and bonded facilities in a country are treated as if they are outside the country for customs purposes.