OPRE 6366. SCM : 1. Introduction

1. Supply Chain Management

Supply Chain Mangement is primarily concerned with the efficient *integration* of suppliers, factories, distribution centers, warehouses and stores so that merchandise is produced and distributed in the right quantities, to the right locations and at the right time to minimize total system cost subject to satisfying some service requirements. Suppliers, factories, distribution centers (DCs), warehouses are the physical entities of a Supply Chain (SC). These entities relate to each other through the flow of merchandise; Raw materials are bought from suppliers, they are processed into products at factories, products are sent to DCs/warehouses for storage until delivered to customers. It is generally understood that factories/plants process the materials whereas warehouses/distribution centers can only store the materials.

1.1 Material, Information and Money Flows

The part of the supply chain that is close to the customer is called *downstream supply chain*. Downstream supply chain includes retailers and stores. The other part that is close to the suppliers is called the *upstream supply chain*. Downstream and upstream are relative terms; A DC is downstream with respcet to a plant but it is upstream with respect to a retailer. Materials in a SC, like water, often flow from upstream to downstream. Since the *material flow* is visible, most of us are already familiar with the concept of interaction among facilities via material flow.

What many people are not familiar with is the *information flow* in SCs. Efficient SCM requires access to accurate information, for information is the input for all managerial decisions. Our concept of information is very broad to the extent that it includes indicators (e.g. on-off machines and stock out situation), quantities (e.g. inventory levels, production capacities and all cost figures), it includes expectation about the future events such as demand forecasts, and it also includes mechanisms governing future events such as commitments to suppliers, sales contracts and promotions. The information can flow both from upstream to downstream and vice versa. For eaxmaple, consider Texas Instruments (supplier), Nokia (Manufacturer) and Wal-Mart (retailer) supply chain, and

- Upstream to downstream infromation flow: Nokia informs Wal-Mart about the wholesale price of a cell phone.
- Downstream to upstream information flow: Nokia informs Texas Instruments about its telecommunication chip purchase plans.

Finally, there also is the *money flow* in SCs. Since typically downmstream partner buys materails from the upstream partner, the money flow is the reverse of the material flow. In SCs, money flow is usually from downstream to upstream.

Clearly the amount of information needed to run SCs is ”enormous”. By enormous we do not mean to say that it is impossible to store or retrieve the information. Rather we want to emphasize that the information is so enormous that we do not know how to utilize it efficiently. For example, a warehouse manager does not need to know that a particular machine at a given plant is off at a particular time because that information does not impact his decisions. Thus it may be helpful to check if a given piece of information is relevant, i.e. whether it makes a substantial impact on a particular decision. It is conceivable that information about broken down machines would be kept local at plants and warehouses would not be bothered with it. We will revisit the issue of the relevance of the information, but for now it is sufficient to realize that information flow among the physical entities of SCs is a very important issue in SCM.

1.2 IDI: Intelligent Decomposition for Integration (IDI)

Businesses spend billions of dollars for procurement, transportation, manufacturing, distribution and finally meeting customers' product/service needs. These supply chain processes are extensive for taking place in chains/networks that span several companies and/or continents. A supply chain manager not only plans and executes logistics activities but also seeks and exploits synergies among these activities. Searching for synergies requires integrating activities via a holistic approach (a system-wide thinking). Supply chain management emphasizes this integration more than logistics. Integration, despite potentially revealing synergies, further complicates the supply chain manager's job.

The most challenging aspect of supply chain management is intelligently improving the extensive supply chain processes which are hard to totally capture -especially in real-time. The useful idea in this context is *Intelligent Decomposition for Integration (IDI)*. IDI is simplifying the supply chain system by ignoring information/processes that are inconsequential to decision making. A supply chain manager uses knowledge, experience and common sense to decompose the supply chain system into smaller sub-systems such that synergies are still intact. Then each sub-system can be optimized to take advantage of the synergies. Finally, the optimal decisions of sub-systems are patched together to obtain a sound, implementable plan for the entire supply chain. Such plans form the basis of molding traditional business operations into competitive weapons in today's fierce global economy.

IDI recurs in supply chains while improving operations towards lower costs, faster delivery, higher quality, more sales and mass customization. To achieve this decomposition-integration dichotomy, SC managers need analytical skills, business intuition and acumen. They also need exposure to ideas from business strategy, marketing, risk management, trade-off analysis and economy as well as tools from probability/statistics, optimization, game theory and information systems.

There are numerous activities taking place in SCs. Each of these activities can be managed locally with relative ease but that will not be effective SCM. SCM is managing these numerous activities in an integrated way. We want to highlight two conflicting concepts here: enormity of activities and the need for integration of these activities. In an ideal world, we would like to integrate all — however small or irrelevant — activities in our decision making. However, such a big decision making scheme will be slow and impractical for today's fast paced economy. Therefore, we are bound to decompose decisions; keep some totally local, make some partially global, make some others global.

- Repair activity planning at a plant can be made locally, as suppliers' or warehouses' decisions are not substantially impacted by information regarding these activities.

- Work in process inventory levels at plants are of some interest to warehouses because they limit the future finished good deliveries to warehouses, so work in process levels can be considered as partially global decisions where warehouses give inputs.

- Quality of a product interests every partner in the supply chain, so it more of a global decision than repair plans and work in process inventory levels.

1.3 Conflicts

Integration is one of the core competencies of a SC. This competency does not belong to a single company but to an entire supply chain. Consequently, today's competition for market leadership is among supply chains. For example, Ford's supply chain (including all the parties from suppliers to dealers) competes with Toyota's. Similarly the leading Target's supply chain battles with that of Wal-Mart's. Despite this, the local objectives at a given location can be in disagreement with the objectives of the entire supply chain. Examples of local objectives are:

1. Procurement: Stable purchase order size and mix, large purchase orders, stable vendors, vendors with short lead times, purchase orders with long lead times.

2. Production: High quality raw materials, short delivery lead times for raw materials, stable production order size and mix, large production orders, high utilization, low production costs.

3. Inventory: Low inventory, good customer service, short replenishment lead times, stable demand.

4. Transportation: Low transportation costs achieved by transportation consolidation or by slower modes of transportation.

5. Product development: Fast innovation, frequent product introductions.

6. Marketing: Product proliferation, various production order sizes and mixes, short product delivery lead times, high inventory levels, low prices, stimulating demand with promotions, ability to accept every customer order.

Clearly some of these objectives are diametrically opposing each other. If the local decisions are made with local objectives, such decisions will drive the system away from its global objectives. Then local objectives must be modified to support global objectives of SCs. That is, SCs must be managed with a system approach in an integrated way. This is the biggest challnge in SCM. This also separates SCM from logistics where local optimization is more acceptable.

It is an art as much as a science to conceptualize SCM by integrating necessary activities while decomposing mutually irrelevant activities. However, this is exactly where SCM has the greatest opportunity to create value and competitive advantage. There is not a uniform IDI strategy that works for all companies. Many companies are developing or testing their own strategies. There are strategies that work in certain contexts. Identification of these contexts and matching strategies with contexts are importants aspects of SCM.

1.4 Value generated by SCM

It is true that no controlled real life experiments have been done to illustrate the profit gains due to SCM strategies. No SC manager will allow such an experiment at his company. There are cases where the implementation of supply chain strategies led to profit increases over time. But note that business environment also changes over time in these cases. Basically we cannot ask for controlled experiments to illustrate the consequences of SCM strategies as we would in natural sciences where we have the advantage of experimenting with the real system in a labratory environment. This observation also applies to other business disciplines such as marketing and finance.

On the other hand, there are computer simulation results and sound arguments for the benefits of SCM. SCM can directly support strategic management goals of a company: low price, high quality, product customization, fast delivery, fast technology introduction. One of the aims of SCM is lowering SC inventories. Low inventories cuts down on inventory holding costs so that cost of goods sold goes down. Then keeping the profit margin constant a company can lower its price. Low inventories means that products will spend less time in storage so that they will deteriorate less and will have better quality when delivered to customers. SCM aims to increase the efficiency of distribution process. This without a doubt will lead to faster deliveries to customers. Keeping less inventory and delivering fast, companies can switch from old technology to a new one rapidly without scrapping a lot of old technology products. One can give more examples along these lines to illustrate the benefits of SCM:

- US companies spent $898 B for SC activities in 1998. This number corresponds to 10.6% of GDP. 58% of SC costs were incurred for transportation and 38% for inventory. These numbers became $1397 B, 10.1% of GDP, 48% for transportation and 35% for inventory in 2007.

- According to some estimations, the grocery industry can save \$30 B by using SCM out of its \$300 B operating expenses. Note that it takes more than three months for a typical cereal box to reach supermarkets after leaving the factory floor.
- Compaq claims a loss of \$500 M to \$1 B in 1995, for not having enough computers in their SC.
- IBM claims that it lost a major market share for desktops in 1993, for not being able to purchase enough of a display chip.
- P&G claims that it saved customers \$65 M using effective SCM in 18 months.
- National Semiconductor used air transportation for its microchips and closed 6 warehouses resulting in 34% increase in sales, 47% decrease in delivery lead time and 2.5% decrease in delivery costs.
- Laura Ashley, using a new IT system and a centralized warehouse, has increased its inventory turnover 5 times in 3 years.

We can understand the magnitude of SC related costs by looking at a the percentage of the cost of a product that is not related to manufacturing (raw materials, processing, labor) or marketing. For a manufactured product the manufacturing and marketing costs can run up to 70-80% of the cots. The remaining 20% represents supply chain costs. If a company wants to cut down costs, it can reduce one of these three costs. Reducing manufacturing costs can require knowlege on the engineering of the product and hence it is outside the business domain. Marketing costs are in the business domain, but marketing activities are visible to customers and they stimulate the demand. Reducing marketing costs can have the adverse effect of demand reduction. On the other hand, supply chain costs are not visible to customers so they can be reduced without a hesitation. 20% of supply chain costs represent the costs incurred to store-transport the components, assemble these components into final products, store-transport final products, store-retrieve-transfer information, make-receive payments. Higher the percentage, the bigger the savings that can be achieved by improving SCM. Therein lies the value of SCM.

1.5 What comes first SC or SCM?

SCM has physical and conceptual components. The physical component comprises suppliers, plants, inventories, trucks, basically anything tangible in the system. We refer to this physical component as SC. SC decisions are generally related to design of the SC system: supplier selection, location of plants, location of warehouses, modes of transportation (roadways, railways, seaways) from plants to warehouses, capacity of truck fleet, etc. The conceptual component comprises strategies, information-database system, decision support systems, basically anything intangible, especially related to decision making, in the system. We refer to this conceptual component as SCM. SCM decisions are generally about planning and operation of the SC system: which plant ships to which warehouse, production levels, inventory levels at warehouses.

It is a chicken and a egg problem whether one first analyzes SC or SCM. SC and SCM are strongly related and both contribute significantly to an effective SC system. However, we should realize that SC, being physical, is not as easy to modify as SCM. More often than not, modifications to physical systems require long lead times, months or perhaps a year. Thus, SC is not altered frequently. Unlike SC, SCM is conceptual and can be modified frequently. Therefore, while SC decisions are generally long term, SCM decisions are short term. Then, many SCM decisions are made with a given SC configuration. Because of this, we can first analyze SC decisions (referred as SC design), and then analyze SCM decisions. Design decisions deal with facility location, transportation network, capacities. More SCM oriented decisions deal with production/inventory levels, contracts.

2. SCM Cases

We will now briefly examine several recent SCM applications in companies operating in various areas: Chemistry, health care, and car manufacturing and distribution.

2.1 Minnesota Mining and Manufacturing Company

Minnesota Mining and Manufacturing (3M) had revenues of $15 billion in 1998, was 103rd among Fortune 500. It manufactures 60,000 products ranging from post-it-notes to fiber-optic materials. It has innovative-chemical-processing based adhesive and coating products. These products are sold in 50 countries through 40 product divisions. These divisions form company's industrial, consumer and life-sciences businesses.

In the mid-90's, 3M found three problematic trends:

1. Fewer new product introductions.
2. Loss of market share.
3. Poor customer service: late deliveries and stock-outs.

To overcome these negative trends, the company started a "Supply Chain Excellence" initiative. This initiative was supported by upper management, e.g. 3M's CEO said: "the Supply-Chain-Excellence initiative is a challenge to every business unit and support organization to fundamentally understand and improve their business process." The initiative was aimed to improve customer satisfaction, to increase the speed of business processes, and to lower costs.

The SC Excellence was a five step initiative:

1. Analyze the current SC.
2. List future business requirements.
3. Design goals and business processes to meet the future requirements.
4. Implement business processes.
5. Measure successes and report results.

As a result of the first step, it was found out that 3M has a simple SC with 4 processes: 1) Acquire orders. 2) Procure raw materials. 3) Manufacture products. 4) Fill orders. 3M decided that future business would require: Integrated customer-driven processes, quick changeovers, quick response to customer needs, worldwide relationships, accessible SC information, flexible and efficient product customization.

Different business units have come up with various SC process improvements driven by their own business environment. A business unit installed a telephone technology to identify customer's location and to route calls appropriately and rapidly. As a result sales doubled and 3M earned a vendor-of-the year award. Another business unit implemented a demand driven pull system with quick changeovers and short product run cycles. The fill rate increased to 99%, items delivered within 1 day of their promised lead time, new products introduced in less than 30 days a decrease of more than 50 days. Some other business unit installed a forecasting system to capture customer ordering patterns from 12 key products. That lead to reduction of finished goods inventory to two weeks of supply. Yet another business unit managed major customer's inventory through electronic data interchange (EDI) and integrated customer's order creation. Then order lead time reduced from 30 to three days, SC cycle time reduced from 113 to 60 days. All these taken together helped 3M to meet customer demand on time, expedite product flow in the SC and reduce SC costs. We emphasize that business processes used by units to achieve these goals are rather simple tactics; Effective SCM does not have to be complex.

2.2 Hancock Medical Center

Hancock Medical Center (HMC) is located in Bay St.Louis, Mississippi. It has 66-beds and four major departments: nursing, intensive care, obstetrics (birth center), and emergency. It reported profit of $4.8 million in 1996. At HMC the materials management department (MMD) delivers orders of four departments, keeps on-site inventories and handles urgent orders that cannot be met with on-site inventory. HMC had a manager and three workers, one of whom was a supply technician who was exhausted by her work load and had to stay for overtime almost everyday. This triggered a small scale SC study at HMC. Following four categories of problems were identified:

1. Procedural Problems:
   - Inventory records at the departments did not match with on-hand inventory at the departments. The departments ordered items for urgent delivery even when those items were available at the departments.
   - The supply technician checks out too many (more than 200 items) per day.
   - Staff from departments withdrew items from MMD without a record.
2. Material Problem:
   - Majority of items were delivered on Thursday but they could be classified and labeled (with a charge code) only in several days for use at the departments.
3. Equipment Problems:
   - The supply technician did not have a computer to update inventory records.
   - The label gun ran out of labels and the supply technician had to write labels by hand.
4. Personnel Problems:
   - The supply technician's job was not clearly defined. She helped the staff at four departments, brought in daily mail from the post office, and run out to K-Mart and Wal-Mart for urgent orders.
   - The supply technician was not empowered to inquire about the items' use at departments or to request proper recording at the departments.

The SC study group made several suggestions to overcome these difficulties:

1. Divide the MMD stockroom area according to usage quantity and frequency, and color-code these areas. Purchase counting scales for items so that the number of items on-stock can be seen at a glance without requiring a messy count of the inventory.
2. Establish specific guidelines for routine orders; orders for a week must be turned in by the preceding Friday. Prohibit the staff of departments to withdraw material from MMD without the supply technician approval.
3. Reserve Thursday to classify and label all new supplies.
4. Establish an accurate job description for the supply technician so that she does not need to make the daily mail run. Empower her to inquire about the use of high demand items from the staff of departments and to track these items.
5. Purchase an additional computer for the supply technician so that she can update records in a timely manner.

These suggestions are implemented by the management who six months later declared that MMD managed materials and inventory more efficiently. The manager of MMD, Bernard Chevalier, summarized improvements saying: ”I would like to acknowledge that the recommendations presented are useful for our strategic planning and permit us refine some of our inventory management procedures.”

2.3 Volkswagen of America

Volkswagen of America (VoA) is a subsidiary of Volkswagen of Germany, it imports and markets Volkswagen and Audi automobiles in the US. Volkwagen owns plants in Germany and Mexico where vehicles are assembled. In 1995, these vehicles were brought into US via five seaports. Volkswagen has inspection and storage facilities at the ports. Upon approval from inspectors, vehicles are distributed to the local dealers, perhaps after a brief storage/delay at the ports. Railways and trucks are used for these deliveries.

A big portion of car sales in US is made through dealers. The dealership concept started in the early years of the last century, when the cars were almost identical and customer service was not as critical. Although the same dealership concept has been used since then, the automobile industry has become very cost sensitive and competitive especially through product proliferation. Car manufacturers give dealerships as franchises and has limited control over how these dealerships are run. However, manufacturers like dealers to keep large inventories to meet the customer demand immediately. Early in the last century, dealers did not mind this because customer demand was limited to a few models, so the inventory to immediately meet such a demand was low. With the product proliferation, dealers are having difficulty to keep one of each car configuration (according to body size such as L, XL, transmission type, power windows, color, music system, engine specifications, etc.). An average VoA dealer sold about 30 cars per month but stored about 100 in the inventory in 1995. Still dealers could not meet customer demand immediately.

If a customer demands a configuration that is not in the stock, the dealer first tries to sell another configuration from the stock. The dealer may offer discounts to convince the customer. If the customer insists on the first configuration, the dealer calls other dealers in the area to see if they have this configuration. If the configuration is found at another dealer, dealers trade cars and the dealer requesting the trade makes some payment to the other dealer. This is called transshipment. Otherwise the dealer orders the configuration from distribution centers at the seaports to be delivered within target lead time of 48 hours. This rush delivery costs extra as well, cutting into dealers profit margin. Customers sometimes choose not to wait 48 hours or even distribution centers may not have the configuration, in either case the customer, profit opportunity, is lost. Obviously the dealers can often provide the first configuration chosen by customers by holding more inventory and incurring inventory holding costs. However, VoA wanted to cut inventory, transportation costs and the number of customers lost with a SCM study in 1995.

VoA's basic idea was to increase the number of distribution centers (only 5 existed in 1995) and locate them next to metropolitan areas. That way cars could be sent cheaply to distribution centers by the rail. These distribution centers would serve to pooled demand of several dealers. Thus, they would be likely to hold less inventory than the sum of the inventory dealers would have held otherwise. Moreover, since distribution centers would be located closer to demand points, it would be easier to deliver to dealers within 48 hour window.

The SCM study had two steps: first finding the locations of the new distribution centers (SC design), second finding the optimal inventory levels with a given set of distribution centers. Since the locations depend on actual sales which depend on inventory levels, this is a chicken-egg type problem. Thus, an iterative procedure solving the first and the second steps, one after another was used. The first step was modelled as a fixed facility location problem using integer variables. The second step was analyzed with simulation. The number of distribution centers were increased one by one starting at five until the addition of one more distribution center did not decrease total SC costs.

This study suggested that VoA should open up more distribution centers and advise dealers to decrease their inventories. VoA applied this strategy. It was very successful in the Midwest where dealers had been suffering from being away from five original seaports. On the other hand Southeast dealers complained for low customer service and they did not find this strategy helpful. Note that those dealers were already close to seaports. Furthermore, Volkswagen introduced new models in 1997 and 1998, these models were very popular. This increased the demand and the SCM study's (done with lower demand) conclusions were not relevant anymore. Subsequently more dealers started to complain and VoA stopped using this strategy. This is not to say that the SCM strategy was wrong, it was correct for the circumstances it was designed for. Once the circumstances changed, it was abandoned. In practice, one must always keep an eye on the dynamics of the market and must understand what kind of changes may have a big impact on the SCM performance.

3. SCM Ordering Cycle: Push vs. Pull

The material flows in SCs from upstream to downstream. In a pull system, this flow starts with a customer order at a retailer. In turn, retailer orders from a warehouse and warehouse orders from a plant. In a pure pull system, it would take a long while to have a product completed at a plant, shipped to warehouse and then to the retailer to meet the customer demand. Because of this, many supply chains works as a combination of the push and pull systems. In pure pull systems, speed of delivery is critical.

In a push system, production or shipment happens in advance of the customer demand but with the expectation of the demand. These shipments are accumulated as inventory until customer demand happens. In order to keep inventory low, demand estimation is critical in push systems.

As an example, consider Dell computer supply chain extending from display supplier (such as Sharp), to assembler Dell, and then to Dell's webpage (retailer). In this supply chain, assembly takes place after Dell receives an order so Dell operates with a pull system. On the other hand, Dell's suppliers (Sharp) produce displays in expectation of demand so this production is made with a push system.

4. Company Strategy, Policy and Decision

A company's strategy is a direction along which the company moves to achieve its mission. Strategy is a statement of very general guidelines. Strategy is a more general concept than policy. Several different policies can all be a part of the same strategy. Similar to the general to specific relationship between strategy and policy, we have the same relationship between policy and decision.

For example, when Columbus sailed for India (and mistakenly discovered America), his strategy was to go to west as far as he could. In order to achieve this strategy, he might have used several different policies: Using supplies meagerly, moving to northwest or southwest according to the direction of the wind, keeping a strict control of the sailors to avoid mutiny, etc. These policies in turn must have dictated specific decisions. To use food meagerly, Columbus might have occasionally told the cook to decrease rations for the sailors. To use gunpowder meagerly, he might have forbidden shooting in small engagements with the natives.

Another example comes from SCM, inventory policies such as whenever an item's inventory level falls below a preset number (say 10 units), manufacture it until its inventory reaches another preset number (say 50). With this rule decision making becomes trivial; all that is to be done is to check the status of the SC and see if the inventory level should trigger a production run. This policy can result in different decisions, each decision corresponding to a different status of the SC. When inventory level is 5, 45 units are produced; when it is 1, 49 units are produced. These are two different decisions but outcomes of the same policy.

As these examples illustrate, a strategy resembles the root of a tree, policies resemble the several trunks of this tree and finally decisions resemble the brunches and leaves. As a small trunk looks like a big brunch, we do not have clear distinctions between strategies or policies or between policies and decisions.

5. $\Re\epsilon\alpha\delta$ Strategic Fit, Components of SC from the textbook

6. Why SCM is a big challenge?

Clearly SCM is drawing unprecedented attention from the industry and from the academia but there are still many unresolved questions relating to SCM. Effective SCM is far from being trivial for the following reasons:

1. SCs are too big and complex to run efficiently. Furthermore, different parts of SCs are run by different people with different local objectives. These local objectives may be contrary to the overall SC objectives.

2. There is always a piece of SC under transition or there are always some parameters in SC that keep changing. SCs never become stable to allow for experimental learning or for building up the relevant experience and understanding. With the changes, past experiences are becoming obsolete constantly. Thus, many SC problems are new and it takes time to solve this problems. Unfortunately by the time we solve a problem, that problem may not even exist because of the change (as in the case of SCM study at VoA).

3. In addition to instability, SCs have fair amount of randomness. Randomness is worse than instability; Instability means that future will be different but we will exactly know how different it will be; contrary to that in the case of randomness we do not know how the future will be. Randomness shows up itself in customer demand, lead times, machine break downs, raw material quality, production yields, etc. Planning against randomness is very tricky; There is not a universally accepted consensus among SC professionals how to treat randomness.

Recent attention to SCM looks like the gold rush of the 19th century: Everybody knows that SCM principles are valuable but cannot find the correct principles. However, there is a lot of gold in SCs waiting to be extracted out. Beware, nobody says that the digging will be sweat-free!

Having explained why SCM is challenging, let us discuss the common SCM mistakes and problems:

1. Lack of SCM metrics: By a metric we mean a measurable quantity, especially a quantity representing performance. For example the more established disciplines of cost accounting and quality control are dedicated to developing and monitoring meaningful metrics. Without metrics, it is not possible to measure the performance. SCM has inherited some metrics from inventory control, such as fill rate (percent of demand met on time). However, these metrics are designed for a single site and fail to effectively measure the performance of a supply chain. Even we can find global metrics for SCM, we will have to find new local metrics for individual sites. These new local metrics must agree with global ones and must facilitate coordination.

   An important aspect of SCM is customer service. Metrics must be developed for this aspect. Currently many companies use fill rate to measure customer service. Note that fill rate does not take into account the late delivery of orders. Late orders, however late they are, contribute by the same amount to the fill rate metric. The customer retention rate is also an important metric, it indicates the percentage of customers who are happy with the current product so they continue to come back. There are a few companies measuring customer retention.

2. Poor IT design: When databases at different sites of a SC are not linked, data retrieval and storage becomes very time-consuming and prone to manual errors. Such delays and inaccuracy can drastically slow down the decision making process. These delays can lead to longer decision making cycle hence decreasing the responsiveness of a SC.

3. Poor delivery status information: The first interaction with a customer happens when the customer orders a product and asks for when the order will be shipped. At that moment the person in charge (usually a sales or a marketing person) has to quote a due date for delivery. This person needs information regarding the status of the SC and a decision support system to process the information to come up with a due date. The information about the status of SC may not be available immediately or may not be accurate (see Poor IT design). Even when the information is available, many companies lack decision support systems to quote due dates. What they need is a system that will net all the outstanding orders from inventories and schedule production. This schedule cannot alter previously set customer delivery dates for previous orders, but can tweak the starting times of individual operations of those orders.

   Even when companies can quote due dates, many of them have problems tracking the order in the SC. A customer can ask for an update on the delivery date of a late order or demand an expedited delivery by paying more. The first step of meeting such a request is finding the order (its subassemblies and parts) in the SC. Many companies have trouble at this first step. Only after the order is located, a new due date can be quoted as discussed above.

4. Poor inventory status information: In some situations inventory level may not be known exactly to the Inventory Manager (IM) who is in charge of ordering new items. However, the IM would have some indication about inventory levels. In these cases, we say that inventory is *partially observable* to the IM. Below are some examples of partially observable inventory systems arising in practice.

   Theft: The items in the inventory can be stolen by thieves who violently break into the inventory storage, by the warehouse employees who calmly pilfer, or by the customers who shoplift. Since violent break-ins are generally investigated, they are easily observed and therefore not relevant for our study. We focus more on continuous pilferage or shoplifting because they are not always observed without inventory inspections. The employees may pilfer for various reasons including need, anger at the company or a thrill of committing a crime. According to Bolger [2], "employee theft is a much larger problem for furniture retailers than theft by outsiders". The article goes on to say that "Most ... products are easily sold by thieves or are stolen by employees to meet specific requests from their friends or associates, or even to furnish their own houses!". A single warehouse is reported to have lost $30,000 in leather sofa thefts in a month. Another theft example cited in [12] reports that frozen foods (steaks, lobster tails, etc.) are often stolen from food wholesalers. We summarize by quoting from Axsater [1]: "... thefts may be a major problem. Apart from the loss in value, thefts will also lead to inaccurate inventory records. "

   Theft is almost always ignored in inventory planning. Thus, the inventory manager (IM) who uses inventory records ends up overestimating the available inventory, until an inspection or a stockout happens. In the latter case, there are shortage costs in addition to costs of reordering and re-receiving to compensate for the stolen units. Since reordering and re-receiving are expedited to urgently meet the backlogged demands, they cost more than their regular amounts.

   Transaction errors: Unintentional mistakes happen from time to time during inventory transactions. Some of these transactions are inventory counting, receiving, etc. For a receiving example, suppose that the inventory clerks record a transaction as a receipt of 100 A type products while the receipt can be for 97 As, 102 As or 90 As and 10 Bs. In either case, the inventory records will differ from the actual inventory on hand. When stock-keeping units are discrete, it is possible to eliminate counting errors. On the other hand, when they are not discrete, such as oil in a refinery, exact measurements may be difficult to obtain. While measurement errors cause inventory to be not fully observed, it is the mistakes in reporting transactions that lead to partial observation of inventories.

Common use of modern information technology tends to reduce transaction errors. However, as pointed out by Axsater [1], deployment of big-ticket computer technology is not always economically justifiable. He says: "One example can be an inventory control system for items of low value such as office supplies or bolts." He also adds: "In general, it is especially difficult to keep track of the inventory position due to frequent receipts and deliveries of material. All such transactions are possible sources of errors."

Transaction errors cause inventory record inaccuracy. Raman et al. [11] report a retailer who has inaccurate inventory records for 65% of its stock-keeping units. It is roughly estimated that the retailer loses 10% of its current profit due to these inaccuracies. They go on to say: "[this particular retailer] is not an isolated case; this [inaccuracy] problem is common at other retailers." Value of inspection to reduce/eliminate transaction errors is highlighted in [1] and [11].

Information delays: In large organizations, it takes a while to collect and process the data, and pass the resulting information to the IM. This is especially the case when the sales representatives promise deliveries to customers without the IM's permission. As a result, the IM rarely receives information about current events. The duration from the time an event occurs until the time the information of the event reaches the IM can be termed as the amount of information delay. Information delay forces the IM to make decisions based on dated information amounting to partial observation of the current inventory level.

Misplaced inventory: When a part of the inventory in possession is misplaced, it is not available to meet a demand until it is found. Often the misplaced inventories are not immediately found, and thus they remain unobserved to the IM. This causes the total inventory that is available to meet the demand to become partially observed.

Misplaced inventory can have significant magnitude and impact on the profits. It is reported in [11] that customers of a "leading retailer" cannot find 16% of the items in the stores because those items are misplaced. Misplacement of the items reduce the profits roughly by 25% at this leading retailer.

Inventory may be misplaced in a number of ways.

(a) By inventory clerks: When the warehouse does not have fixed locations for products and the information system used to manage the warehouse is not sophisticated enough, products could be misplaced by the inventory clerks and be lost for a while.

(b) By customers: In a retail store, customers have access to inventories. They pick up, move about and may place products in wrong shelves. Re-shelved (misplaced) products cannot be used to meet other customers' demand until they are found. To avoid misplacements by customers, some clothing retailers encourage customers to return clothes to a designated area after customers try them. Retailers' clerks collect the clothes from the designated area and place them in proper shelves.

Misplacement is more likely when the location of items in the storage is altered dynamically. According to [1], "It is easier to keep the records accurate if the items have fixed locations. On the other hand, this can lead to inefficient space utilization. By dynamically locating items, the same item can be stored in more than one location." The recent trends in supply chain management such as crossdocking also cause dynamic locations. In crossdocking, a warehouse keeps collecting receipts for a retailer, until enough of them accumulate to justify a truck delivery to the retailer. Thus, crossdocked items are not placed at fixed locations.

Misplaced inventories are eventually discovered either by inspection or by luck. When the misplaced items are placed in their proper shelves, they become available once again to meet customer demands. Thus, misplacements can cause the actual inventory to be temporarily more or less than the recorded inventory.

Spoilage: Products can naturally lose their properties while they are held in the inventory. This can be due to the decay of active ingredients in the products. Examples are drugs, chemical and food products. If the spoilage is random and not immediately observed, then the actual inventory is less than the recorded inventory and is partially observed. As an example, consider the number of car batteries in a Sears retailer store. Only when these batteries are inspected (say by measuring their voltage, one by one), the inventory level of fully functioning batteries becomes known.

In retail stores, customers can cause damage to products, making them unsuitable for sale. Some examples are tearing of a package to feel the contained product, wearing down a product, erasing software on computers on demonstration, spilling food on clothes, and scratching a car during a test drive. Some of these damages can be intentional and the others can be accidental. Nevertheless, so long as they are not detected by the IM, the actual inventory becomes partially observed.

Product quality and yield: When the product quality is low or a production process has low yield, the actual inventory is not known. Below, the reasons for the partial observability of the inventory is classified and examples are given.

(a) Economic reasons: Receipts at a warehouse can include products that are defective or the ones not conforming to quality standards. It is very often the case that nonconformance of a product is not immediately observed by the IM. Receipts are usually added to the inventory at the warehouse without a full inspection. Acceptance sampling, a subfield of the quality control literature (e.g. [4]), is an economic method of accepting the receipts without full inspection. As a result the inventory on record may consist of both nondefective products (available to meet customer demands) and defective products (not fit for sale). Since the defective products that slip through acceptance sampling are not observed, the actual (nondefective) inventory becomes partially observed.

    It is worth mentioning that while there is a vast literature on acceptance sampling, it does not consider backordering or inventory costs. Our project therefore can build a bridge between the acceptance sampling and the inventory literatures.

(b) Timing reasons: Because of production lead times, an IM may have to place a particular order before observing the yields from previous orders, so that the production of the particular order is completed by a given due date. When the production lead times are short or negligible, the IM can issue the particular order after observing the yield from the previous orders. Thus, partial observability of inventory is caused by due dates and production lead times as well as process yields.

    A simple example occurs in a golf club manufacturing facility in Taiwan where a manufacturer promises to deliver a certain number of golf clubs by a specific due date. The manufacturer has several options for producing golf clubs: regular runs and rush runs. Manufacturing a golf club on a regular run costs less than manufacturing it on a rush run. However, a regular run has a longer production lead time than a rush run. Also, a regular run has a nonperfect process yield, where a rush run goes through a different production process and has a different (possibly perfect) yield. When the yield of a regular run is expected to be low, a rush run is sought. A rush run is typically started a rush-run lead time before the due date. However, the yield from the regular run is not known when the rush run starts. Thus, the IM must determine how many units to produce in the rush run with a partially observed inventory position.

(c) Technological reasons: Besides economic and timing reasons, there may be technological constraints making an inspection impossible. A case in point is the implantation step in semiconductor manufacturing where silicon is doped by chemicals in the active regions of the transistors to create source and drain regions. The implantation process may result in low and variable production yields, which can be tested only after the wiring of the chip is completed. Therefore, the problems during implantation cannot be totally detected before wiring is completed and the chip is ready for electrical testing. Consequently, the number of functional chips in the work-in-process inventory between the implant and the wiring is not fully observed. The IM often decides to run another lot of wafers through the implant without knowing the actual number of non-defective chips fabricated earlier.

Lack of inventory visibility in supply chains: Unlike previous cases, the IM fully observes the inventory of which he is in charge. But the IM's decisions are affected by the inventories of other parties in the supply chain. Most often, the inventories of the others are only partially observable to the IM.

(a) Consider a supply chain composed of a supplier and a retailer, who faces the customer demand. Suppose that the retailer and the supplier belong to different organizations, and the IM is in charge of managing the supplier's inventory. The retailer may or may not share its inventory level information with the IM. For example, if the IM knows that the retailer has a large amount of inventories, he infers that the retailer will not order any time soon and the IM will attempt to keep his inventory level low. However, the retailer prefers that supplier carries ample inventories. Because of this conflict of interest, the retailer may hide its inventory level from the IM. In turn, the IM manages its inventory by making inferences about the retailer's inventory level. The inferences can be based on when and how much the retailer ordered. Then, the IM manages his inventory with only a partial information about the retailer's inventory level.

(b) Consider a supply chain composed of two competing retailers. Each retailer has his own demand and the demand overflowing from the other retailer when the other is out of stock. Suppose that each retailer does not observe but make inferences about the other's inventory. For example, a car dealer can drive by his competitor's car lot to eyeball his inventory. A retailer can place fake orders with a competing retailer to see how quickly they are delivered or if the competitor is stocked out. Also a retailer can survey its own customers to see if they are overflowing from a competitor. When a retailer believes that the competitor's inventory is low, he will keep his inventory high in order to capture overflowing customers. Thus, the retailers manage their inventory with only partial information about the competing retailer's inventory.

One reason, why poor inventory status information is not publicized by retailers as a problem, lies in its ridiculous nature. For example, it is hard for a world class retailer to accept that 16% of the items cannot be located because of misplacement.

5. Ignoring the unceratinties: There are uncertainties in SCs. Finding where they are and measuring them contributes greatly to planning the SC operations. There are many analytical techniques that deal with uncertainties. However, all these techniques require measurement of uncertainties (see Lack of SC metrics). Instead of developing metrics for uncertainties, many companies choose to ignore them (this is no different than a scared ostrich putting its head into the sand). Then some items are overstocked, some are understocked, SC fails to meet the customer demand and managers are at a loss without knowing how to deal with SC.

   The easiest way to measure uncertainties is by putting the uncertain quantity in a range: say, transportation times are 3-5 days, demand is 80-150 per day, etc. A more statistics oriented way is computing the mean and variance of the uncertain quantity: transportation times have mean of 4 days and variance of 1/4 day. A more complicated measurement way is coming up with the distribution of the uncertain quantity: transportation times have a normal distribution over [3,5] days. As more information in the form of accurate metrics is made available to decision support systems, the quality of decisions improve.

Another negative effect of ignoring uncertainties is failing to eliminate them. Some uncertainties are very hard/costly to reduce, but some are not. With an innovative product or SC design uncertainties can be reduced. Of course such innovative designs are not free, but the spending on designs can be compensated by the savings due to less uncertainty. To quantify such a tradeoff, we again need metrics measuring uncertainties.

6. Internal customer discrimination. Until recently, internal customers were thought to be loyal and would buy no matter how poor service they may get. This belief was the source of internal customer discrimination; given the choice, companies chose to prioritize external customer orders over internal customer orders. That led to internal customer's suffering of long uncertain lead times. Thus, for items supplied from within a company, the inventories were higher. Moreover, each internal order is a part of an external order, so delaying internal orders is delaying external orders as well. The system-wise understanding has started to find root in companies so there is less but still significant internal customer discrimination.

7. Poor integration: Integration is the main theme in SCM. SCM strives to cut costs by creating a synergy among plants, warehouses, suppliers and customers. However, the best way to achieve this synergy is not clearly known. Lack of SC metrics is contributing to this problem because without metrics who is to tell one synergy is better than the other. SC metrics are necessary but not sufficient for SCM. SCM requires turning global SC metrics into local metrics so that local metrics also support the overall desired SC goals. Controversially put, SCM advises integration by smart decomposition of global metrics into local metrics.

   For example, lack of integration has led many distribution center managers to deliver products to local warehouses with ground transportation as opposed to air transportation. That means a longer transportation time but lower transportation costs. Distribution center managers especially like this practice when they are responsible for the transportation costs. However, at the receiving end, the local warehouses must keep a large inventory to counterbalance long and generally uncertain delivery lead times. If we can make distribution center managers responsible for warehouse inventories through a local metric that accounts for those inventories, distribution centers may choose air transportation. In this case, although the choice of transportation method is made locally at the distribution centers (hence the term decomposition), the decision takes care of warehouse inventories (hence the term integration).

   Another example of poor integration comes from the mismatch between the metrics of sales and manufacturing departments. Sales departments are praised over how much they sell. It is rare that the conditions of a sale is scrutinized. It is conceivable that a sales department which quotes an unrealistic short delivery lead times will increase its sales. Therefore, sales department increases the sales and looks good on the sales metric. On the other hand, the manufacturing department is burned by the short lead times and falls behind the schedule and it often resorts to overtime to make promised deliveries. With overtime manufacturing costs increase, without overtime manufacturing misses due dates, a loss-loss situation. However, this situation will not occur if marketing is made sensitive to manufacturing metrics, such as fill rate, production costs. Another way to overcome this problem is by supplying marketing with a decision support system that automatically quotes due dates according to the status of the SC (see Poor delivery status information).

8. Elusive inventory costs. The basic question is how much it costs to hold a product, say a laptop or a

cabbage, in the inventory, say for a week? Many people agree that the inventory holding cost must include opportunity cost (generally based on internal rate of returns), warehouse space, lighting, cooling costs. However, there may be other costs. Note that a cabbage is rotten if kept a long time in the inventory. Similarly a laptop can fall behind the state of the art technology while waiting in the inventory. In either case, discounts over the regular price must be made to get rid of the cabbage or the laptop. These discounts are hard to expect in advance but they must be considered as a part of inventory costs.

9. SC-insensitive product design: Many times products are designed by R&D to perform a function without paying attention to how they will be produced. These products face many problems when they are put into production in mass quantities. There must be a smooth transition from product design to its production, which can be achieved by foreseeing potential SC problems that may arise in mass production. Even without any such problems, it makes sense to tweak the design to simplify supply chain operations.

   A good idea that simplifies SC operations is delayed product differentiation. That is, push a generic product as far as possible, and make different products from the generic product as late as possible. The common story that made this concept popular is Hewlett and Packard's SC. HP used to produce printers in US and package them with product manuals in different languages in US. These packages were than sent to distribution centers over the world. Note that HP was making its products different with various type of manuals even before they left US. Then there were instances of HP overstocking in Germany and understocking in France. Since printers in Germany had manuals in German they could not be shipped to France. A SC study at HP concluded that HP should send printers to distribution centers without manuals. According to demand, manuals should be put into packages at distribution centers. Basically printers are kept as generic products until demand occurs for them. HP has implemented this plan without incurring much cost. Now in the case of local demand-supply mismatches, regional distribution centers can transfer printers among each other. HP reported major savings with this simple idea of delayed product differentiation.

7. Exercises

1. Consider the framed nature pictures for decoration sold at Wal-Mart's location on the Coit Road and the associated SC.
   a) Is this a push or a pull SC, why?
   b) Starting from the raw materials (paper, wood frame and glass), briefly explain the stages and the associated operations in the SC.

2. Compare a capitalist and communist economy from the integration vs. decomposition point of view. Which is more integrated and why? If you think that a communist economy is more integrated and you are convinced about the benefits of integration (synnergy), why do you think communist economies could not compete against capitalist economies? Are there lessons to be learned from this comparison, especially for big companies such as too-big-to-fail financial institutions (Citi, Bank of America) or others like GM, GE, IBM?

3. Give an example and briefly discuss (at most 3 sentences) an important decision made in one of the following SC processes: distribution planning and network configuration, transportation, inventory control, partnering with suppliers, and the role of IT in SC coordination.

4. According to Table 2.1 of Chopra, implied demand uncertainty increases with the service level. High service level means a low average stock out rate. In Table 2.2 of Chopra, low average stock out rate

appears to be resulting in low implied uncertainty. Is there a typo here? If not, how do you reconcile these seemingly conflicting observations?

5. Explain why the cost-responsiveness efficient curve of Figure 2.3 of Chopra should be expected to be concave (downward looking curvature, as already is in the figure) as opposed to be convex (upward looking curvature)?

6. How does the cost-responsiveness efficiency curve changes if there happens to be a drastic technological improvement? Does it turn by 90^o, or does it become its mirror image (the mirror placed at Low cost point), or does it shift to left or right? Qualitatively explain why such a change happens?

7. Consider adding product price as third dimension to Figure 2.6 of Chopra. Suppose that low cost point is put on the book's surface and high cost point is directly above it. Now explain how should we modify the zone of strategic fit?

8. US Postal Service is commissioned to provide service to almost everywhere in the United States. Mail delivery to the native Indian villages in the Grand Canyon constitutes an extreme example where the delivery is made by the mules even today.
a) Place Fed Ex and US Postal service on the zone of strategic fit figure where the axes are the implied demand uncertainty and responsivenss, briefly explain your thought process while placing these.
b) Until recently, US Postal service has been obligated by law to deliver mail on six days of the week, except for Sunday. If the Postal Service stops delivery on Saturdays, does it remain in the zone of strategic fit, how does it move in the figure of a)?
c) Your instructor has petitioned with the US Postal Service to stop the delivery of mail (such as promotional/advertisement material that wastes paper) that is not specifically addressed to him. His petition was rejected. Has the US Postal Service been responsive to its customer by rejecting the petition? Answer first by assuming the sender of a mail is the customer and then answer by assuming the receiver is the customer.

9. MBA students on average spend 5 semesters at UTD. Every semester about 45 students are accepted into the program and that many graduate as well. How many MBA students do you expect to find at UTD now? Which formula is useful to answer this question?

10. In a closed loop supply chain, some of the materials (products, containers, tools) circulate in the supply chain by coming back to the same stage or location many times. Give a real life example of a closed loop supply chain and briefly explain what is circulating in your example.

11. The FED Reserve Bank in Dallas manages the banknote supply/circulation in Texas which we can assume to be isolated from the other states. Suppose that the Dallas FED actually does not print money but cleans existing money. Cleaning of the money refers to heat treating it to get rid of dirt/wrinkles and pressing it afterwards. This cleaning operation also extends the life of each banknote. Many detectors in ATMs and dispensing machines can read and hence accept only the clean money. After FED cleans the money, it is given to the commercial banks which put them in to their ATMs. So the money circulation in Texas as defined above is a good example of a closed loop supply chain. Suppose that the Dallas FED on the average finishes the cleaning of \$1.2 million every working day and gives this amount to the commercial banks in Texas. Furthermore, suppose that the average banknote remains in circulation for about 700 working days after each cleaning.
a) Estimate the amount of money in circulation in Texas. Explain which formula you use and what the variables in your formula are.
b) It is said above that each banknote remains in circulation about 700 working days between two cleaning operations. How does Dallas FED actually figures this out operationally? Without referring

to additional resources, guess/list what is the relevant data to arrive at the statistic of 700 days and how can this data be collected?

12. When OPEC cuts oil production or increases it, the effects in the US markets are felt 4 months later. This is because of the oil already in the pipelines or tankers making their way to the US markets. Since the oil spends 4 months in transportation, the owners of the oil must tie up a lot of capital for oil and incur a lot of opportunity costs. This opportunity cost can constitute a base for the inventory holding costs for the oil in transportation. Discuss if we can consider the oil in transportation as inventory. If yes, is this cycle, safety, seasonal or another kind of inventory? If no, should we account for the opportunity cost of the oil in transportation?

13. After reading the obstacles to achieving strategic fit, discuss whether Internet helps to overcome the obstacles or makes the obstacles bigger.

14. Pull or Push: Let us consider the simplest supply chain possible, infinite and instantaneous raw material supply, single production stage which feeds a single product into a finished goods inventory. Suppose that a single customer has daily demand (D, d) for the single product, where D is the quantity and d is the due date. None of these parameters are known in advance. Let us provide several sensible definitions for a pull system:

    I. A pull system has no finished goods inventory.
    II. In a pull system, customer demand at time t instigates an equal amount of production at time $t - LT$ where LT is the production lead time.
    III. In a pull system, customer demand at time t instigates an equal amount of production at time $t - LT$ and the demand is satisfied with the production it instigated.

    Clearly, definition (II) is more general than definition (III). Any system that does not fit any of these definitions will be called push. Let us consider several job release rules for production:

    (a) For demand (D, d), a job for D units is released exactly LT days before the due date d.
    (b) A single unit is released for production when the work in process reaches a dangerously low level presumably with high demand.
    (c) Jobs are released for production at a rate equal to average daily demand rate.

    Determine which definition of pull system applies to which job release rule, does any of these rules indicate a push system? In this course, definition (II) is accepted as the definition of a pull system.

15. Consider the simple supply chain of the previous question.
    a) Raw material commonality with push or pull. Suppose that there are two products A and B which are produced using raw materials A' and B'. Under $A' = B'$ or $A' \neq B'$, one is more likely to use a pull system, explain?
    b) Tight due dates with push or pull. Under tight or relaxed due dates, one is more likely to use a pull system, explain?
    c) High capacity with push or pull. Under high or low production capacity, one is more likely to use a pull system, explain?

16. **Conflict of Objectives** Some students write the following into midterm course evaluations for a class:
    - "The instructor expects us to work very hard and do well on exams. But he eventually curves the course grades so only the relative performance with respect to the rest of the class matters. We figured that from now on the best thing for all students to do together is to study less to bring down the class average. "

According to Hopp and Spearman (2000) people in organizations act according to the following laws:
a) People's objective are different than their organization's mission.
b) Organizations include many people, who are different.
c) Every program/change requires a champion to lead.
d) People get burned out.
e) Responsibility must be commensurate to authority.
Which one of these laws can be used to explain the students' feelings. Comment.

17. **Operational Flexibility** Using multiple retailers to supply the same raw materials, increasing component commonality among products, designing alternative routings (work flow) for a manufacturing process, employing truck drivers capable of inputting transportation data into palm pilots connected to central databases and launching alternative products are examples of operational flexibility. What does the term "operational flexibility" mean? Give an example of your own for operational flexibility. Would a company need more or less flexible strategy with increasing levels of uncertainty, explain. Would more flexibility generally lead to more efficiency, explain?

18. **Sears+Kmart** Sears stores sell hardware, appliances and home products. Where would you place the demand faced by Sears on the implied demand uncertainty spectrum, explain. Before Sears and K-Mart merger do you think that the Sears supply chain was responsive to the customers? How is Sears aiming to be more responsive after the K-Mart merger?

19. How can Sears expand the scope of strategic fit to its appliance suppliers Kenmore, General Electrics and Maytag? What intercompany functions may need attention or improvement?

20. **Humanitarian SCM** On August 28, 2005, the tropical storm Katrina went over the city of New Orleans and destroyed many buildings and the infrastructure supplying electricity and water to the city. Despite a mandatory evacuation order, about 100,000 residents remained in New Orleans on August 28, 2005. Suppose now these residents must receive drinking water to survive.
a) Identify the sources/suppliers for drinking water. Discuss how the water can be transported to New Orleans and how should it be distributed within the city.
b) Elaborate on the challenges involved in providing supplies to the New Orleans residents. What are the extra challenges, faced in emergency operations, which do not exist in regular operations of commercial supply chains? Hint: Read van Wassenhove [15].

21. **7Eleven Japan in USA** On November 28, 2005, Joseph M. DePinto was named the President and Chief Executive Officer (CEO) of 7eleven in the USA. Couple weeks before Nov. 28, 7eleven Japan and its affiliates gained the control of 7eleven USA. The new CEO is considering to duplicate the SCM strategies used in Japan in the USA. What are the pros and cons of his approach?

22. **Tohoku Earthquake** On March 11, 2011, Eastern Japan experienced a strong earthquake and a tsunami. Most of Japanese industrial facilities are in the South. However, Texas Instruments (TI), Toshiba, and Fujitsu are among the companies that operate facilities in Eastern Japan.
TI's Miho Fab had substantial damages (in pipes for gasses and water and in equipment) and had a slightly damaged building. This fab produced DLP (digital light processing for projectors for home or IMAX theaters and TVs). Fujitsu's Iwate Fab produces logic chips and its operation was suspended after the earthquake. Toshiba's Yokkaichi Fab in Southern Japan was adversely affected. This plant produced critical nand (short for no-and logic operation) chips that went into iphones and ipads.
a) There are many logic chip manufacturers in the world. On the other hand, Toshiba has 35% share of the global nand market (slightly trailing behind the largest manufacturer Samsung). Discuss whether the logic or nand chip supply is affected more by the earthquake. [1]

[1] A good source to learn about electronic parts supply is IHS iSuppli http://www.isuppli.com.

b) Consumers are more loyal to car brands than to nand chip brands. Toyota, Honda, Suziki, Nissan all suffered from the earthquake. But they have plants overseas. Toyota has plants in Cambridge, Canada; Tijuana, Mexico; La Fayette, Princeton, Georgetown, Blue Springs, San Antonio, Long Beach in the USA. Unlike chip manufacturing, shifting of manufacturing of car parts does not require strict calibration/certification. Discuss whether the chip or car parts supply is affected more by the earthquake.
c) On March 17, General Motor's Shreveport, LA plant announced that it would close for at least a week. This plant produced compact pickup trucks (Chevrolet Colorado and the GMC Canyon) but not the full-size pickups (Chevrolet Silverado and GMC Sierra). Both compact and full-size pickups have Japanese manufactured parts. From GM's decision, we can speculate about the following:

i) Demand rate for full-size trucks is higher than the rate for compact trucks,

ii) Inventory for full-size trucks is lower than the inventory for compact trucks?

Explain, if we can certainly infer i), ii), or both of these statements or either one.

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