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Supply Chain Management
Case Analysis

A Detailed Analysis of the Hewlett-Packard Company Deskjet Printer Supply Chain (A)

INTRODUCTION

Discussions about the supply chain process generally revolve around the optimization of processes between players along the chain as well as the logistics of individual players within it. These processes include manufacturing, assembly, packaging, transportation, inventory control, stocking, and even sales. However, the gap between design and manufacturing based on customization for region and locale, and its subsequent impact on inventory levels, distribution and delivery to multiple market segments, has been ignored until recent years. These market segments may differ in language, hardware specifications, power and even governmental regulations. Therefore, it is worth our while to explore the impact of product differentiation and associated factors on the overall surplus of the supply chain. Case GS-3A of the Hewlett Packard Deskjet Printer Supply Chain (A) serves as a good example of the problems associated with stocking inventory and distribution of products that differ in terms of customization of specifications according to the regional and local markets. Consequently, it also points out the advantages of inventory pooling using physical centralization, and mass customization using delayed differentiation, and postponement.

THE DESKJET MARKET AND HP's POSITION IN THE MARKET

In 1990, worldwide sales of personal printers were 17 million units, amounting to $10 billion, with inkjet printers forming 20% of the printer market.

Sales increased dramatically as customers discovered the superior quality of the ink jet printers, and more and more sales were going through superstores such as Kmart and Price Club. By 1990, HP had sold over 600,000 units of its DeskJet printer, amounting to sales of $400 million.

THE HP DESKJET SUPPLY CHAIN

The system of suppliers, the manufacturing site, distribution centers (DCs) in North American, Europe, and the Asia Pacific, retailers and the end consumer in the regional markets made up the HP Deskjet supply chain. Manufacturing was done at the Vancouver plant. The manufacturing process consists of two separate and consecutive processes. The first, called the Printed Circuit and Assembly Test (PCAT) involved the "assembly and testing of electronic components like ASIC's (application specific integrated circuits), ROM (read-only-memory), and raw printed circuit boards to make logic boards and printer head drivers for the printers". The second phase of manufacturing is the Final Assembly and Test (FAT) in which smaller components such as motors, cables, chassis, plastic buttons, as well as those produced from the PCAT process are integrated together to create and test a final working printer. The individual components needed for both stages were sourced in-house as well as from external suppliers around the world.

The customization of the printer to meet regional language and power specifications is called localization. This process involves the integration of appropriate power modules, plugs, as well as packaging it with the product manual in the correct language. Since this has to be done prior to the testing of the finished product, it was inherently done as part of the FAT process. Therefore, localization of the printers was done at the Vancouver factory while the DCs did not have a system for assembly operations that would allow for localization.

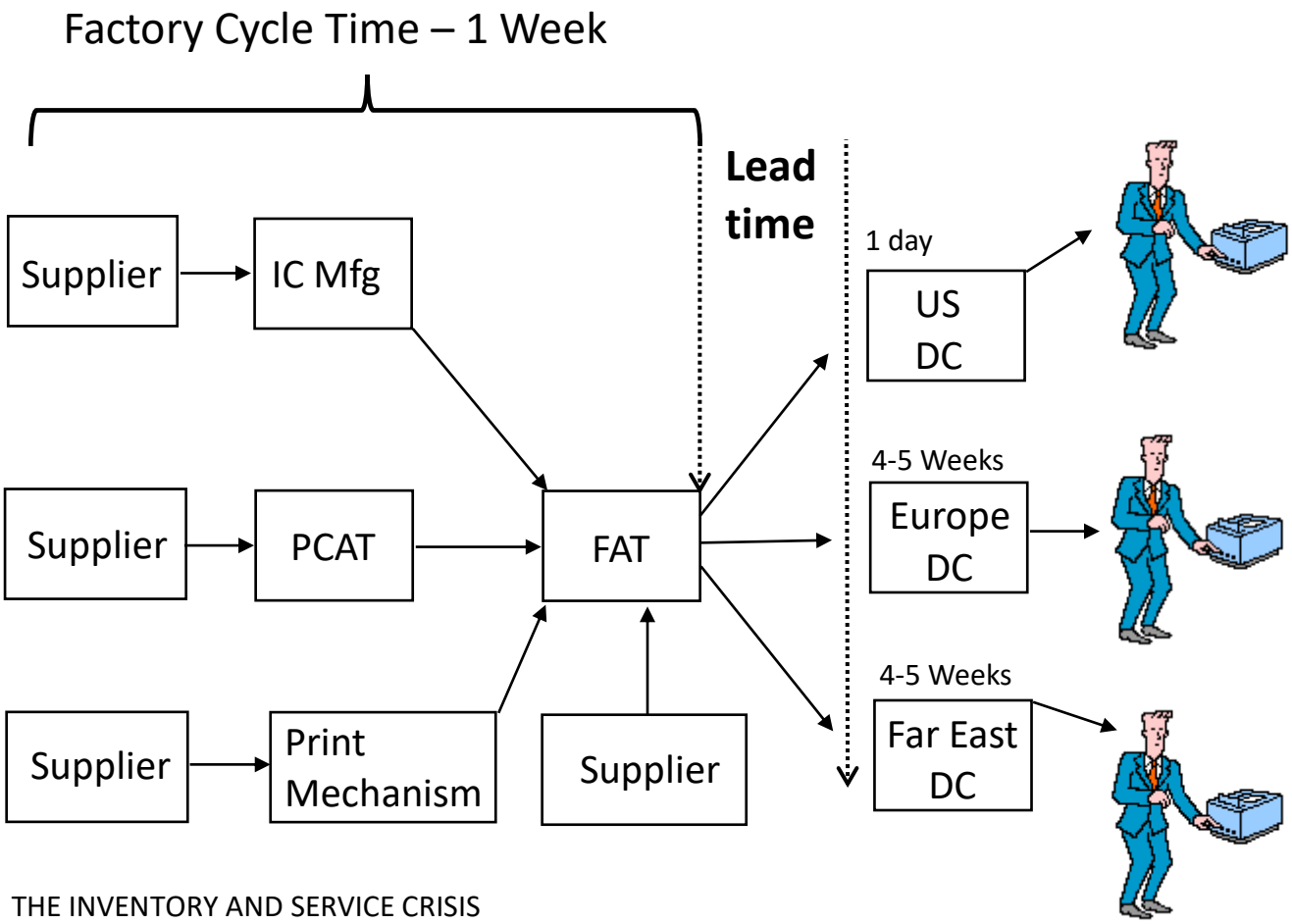
After passing the FAT, the finished printers are packaged, and sorted according to any one of their destinations from North America, Europe, and the Asia-Pacific. The factory-cycle time for this process was one week. Packaged products were then shipped to the distribution centres by ocean frieght. Transport to the North America DC located in San Jose, California took about a day, while it took about 4-5 weeks to ship to Europe and the Asia-Pacific.

The DCs functioned using a linear and standardized operating model which involved four basic functions:

1. Receive finished, previously localized, goods and stock them
2. Select the products required to fill a customer order
3. Shrink-wrap an order and bundle it
4. Ship the order out via appropriate carrier

The DCs performed a minimal integration function with other products such as monitors and keyboards only to include and package the correct make and model for the respective country with the order. While this required minimal effort, it did disrupt the standardized process flow of the DC. Considering this, it would be reasonable to deduce that the DCs were most definitely not equipped to perform any localization functions that involved final assembly of market-specific components and therefore completing the manufacturing process.

An overview of the Deskjet supply chain is given below.



THE INVENTORY AND SERVICE CRISIS

The supply chain function was based on a “stockless” factory model for Vancouver, producing printers with a “Just In Time” replenishment strategy for its DCs, thereby subscribing to a ‘pull’ mode of operation. On the other hand, pressures to provide maximum availability of stock to resellers meant the DCs were operated in made-to-stock mode. The inventory levels at the DCs were based on forecasted demand plus some level of safety stock. In addition, long lead times made it difficult for HP to respond to fluctuations in

demand. This mode of overall operation combined with the use of forecasted demand to determine levels of inventory poses several problems:

1. High levels of inventory at European and Asian DCs:

HP's inability to respond to fluctuations in demand promptly meant that in order to meet uncertain demand in a timely manner, DCs had to maintain high levels of safety stock of each printer model. However, despite the high levels of inventory, some managers suggested a further increase in inventory safety stock in order to better meet the target line item fill rate of 98% given by the marketing department of HP.

The DCs, however, were quickly running out of physical space required to store new shipments of stock, and wanted to be able to meet customer demand while holding minimum levels of inventory.

Since HP is the manufacturer of a technology product, which is also produced in competition with other manufacturers of inkjet printers, it carries with it an increased risk of an obsolescence cost due to rapid developments in technological innovation.

Increased levels of inventory will lead to high carrying costs (holding, breakage, obsolescence, etc). This variability in carrying costs can range from 12%-60% of costs of production.

This apparent imbalance between customer demand and inventory levels was partly due uncertainty factors in the manufacturing and shipping processes, but largely attributed to the limited accuracy of demand forecasts use to determine the levels of safety stock for each model of printer sold in the regional market.

2. Uncertainty Factors:

Basing safety stock levels primarily on demand forecasts gives ground to inaccuracies in the levels of safety stock that forms part of inventory. Consumer demands may change due to several factors, and may even change unexpectedly. Therefore, a large standard deviation within the forecasted demand for an individual product, will lead to larger levels of safety stock required of each localized product type. In addition, longer forecasting horizons further increase the variability in forecasted demand, and therefore the corresponding levels of safety stock. On the other hand, incorrect

forecasts may also lead to a shortage of available stock, and subsequent backordering retailers or lost sales from end consumers, thereby causing HP to incur costs of understocking.

Other uncertainty factors that contribute to the imbalance between demand and inventory are related to the manufacturing and shipping processes. Since the localization process is done during the FAT at the manufacturing site in Vancouver, changes in the efficiency of assembly and equipment involved in the manufacturing of printers due to maintenance or breakdowns will lead to longer downtimes at the manufacturing site. These downtimes contribute to the factory cycle time and therefore the lead time required for replenishment. In addition, delays in ocean freight transit, customs clearance and payment of duties at the respective ports of entry may also contribute to overall lead times.

3. Inventory Policies

There had been no specific policy in place to determine how much or when the replenishment inventory was required for individual models. Instead, "target inventory levels at the DCs were based on safety stocks that were a result of some judgmental rule of thumb." The absence of a review policy based on empirical data and analysis contributed largely to the mismatch between the demand and inventory levels of various models. As a result, the European resellers indicated a decrease in product availability even though large consignments of Deskjet printers had been shipped to the European DC in the past months. The European DC often finds that it has too much inventory of customized printers for certain markets, and not enough inventory of customized printers for others.

HP's SOLUTION TO INVENTORY IMBALANCE AND MISMATCH IN DEMAND

The answer for Brent Cartier, Manager for Special Projects in the Materials Department of HP's Vancouver division, is a multi-tiered approach that encompasses the product design, manufacturing, shipment, and distribution processes. According to this approach, the Deskjet printer would be redesigned so that a generic version of the printer is manufactured and packaged at the Vancouver facility without any of the customization for, for example, power supply units, power cords, instruction manuals, and other localization variables. This

generic model would then be shipped out to the DC's where it would be localized for different specifications according to its destination within the region. The revision in design is known as 'Design for Localization' while the delayed product localization is known as 'Postponement'. As a consequence of this, HP's DC's would maintain safety stocks of generic build printers which could then be localized as demand is realized, thus allowing the DC's to respond to fluctuations in consumer demand in a significantly faster way. One could then infer that the DC's would now be able to maintain levels of inventory of finished goods for each model supplied to the region, given by its mean demand, as well as lower safety stock of generic printers since shortages in any regional market segment can be met quickly by localization of the generic printers instead of relying on the Vancouver facility to manufacture and then ship them. This pooling of inventory has significant advantages both in terms of shortened response time to fluctuating demand, as well as of lower inventory holding costs, as demonstrated below.

Let us consider the information provided by the 'Monthly Demand Data by Region and Option Type' for Europe as given in Exhibit 4 of the case. The average demand, **μ,** for each model and its corresponding standard deviation, **σ,** are given to us as follows.

f= 0.98

$ESC=\mu(1-f)$ $L(Z)=ESC/\sigma_{(T+L)}$ $ESC/(\sqrt{2}*\sigma_{(T+L)})$

$\sigma_{(T+L)} = \sqrt{(\sigma^2 + \sigma^2)} = \sqrt{2}\sigma^2$

$S=\mu_{(T+L)} + Z\sigma_{(T+L)}$

Base Stock

Safety Stock

Europe	Average, μ	Std Dev, σ	Expected Stock Out	L(Z)	Z	S	$\mu_{(T+L)}$	Zσ(T+L)
A	42.33	32.41	0.8466	0.018470737	0.54	109.4107172	84.66	24.75072
AA	420.17	203.9	8.4034	0.029142232	1.5	1272.877218	840.34	432.5372
AB	15830.08	5624.58	316.6016	0.039802285	1.36	42478.08595	31660.16	10817.93
AQ	2301.17	1168.49	46.0234	0.027850866	1.52	7114.131496	4602.34	2511.791
AU	4208	2204.58	84.16	0.026993852	1.54	13217.33028	8416	4801.33
AY	306.83	103.12	6.1366	0.042079436	1.34	809.0771614	613.66	195.4172
Europe Total	23108.58	6244	462.1716	0.074018514	1.06	55577.33045	46217.16	9360.17

Assuming a line item fill rate, **f**, of 98% for each printer model, we can then calculate the level of Expected Stock Out, **ESC**, for each model by using the equation

$$\mathbf{ESC=\mu(1-f)}$$

From ESC, we can now obtain a value for the standard loss function, **L(Z)**, which is the expected number of lost sales as a fraction of the standard deviation. The L(Z) value for each model can be calculated as follows:

$$\mathbf{L(Z)=ESC/\sigma_{(T+L)}}$$

$$\mathbf{\sigma_{(T+L)} = \sqrt{(\sigma^2 + \sigma^2)} = \sqrt{2}\sigma}$$

$$\mathbf{L(Z)=ESC/(\sqrt{2}*\sigma_{(T+L)})}$$

where $\mathbf{\sigma_{(T+L)}}$ is the sum of the standard deviations of demand during the average lead time for replenishment and the review interval while using a periodic review policy.
The corresponding **Z** values can be looked up from the values of the standard loss function L(Z). The Z values can then be used to calculate our levels of inventory, **S**, where

$$\mathbf{S = \mu_{(T+L)} + Z\sigma_{(T+L)}}$$

where $\mu_{(T+L)}$ is the sum of the mean demands for the same period as $\sigma_{(T+L)}$

$\mathbf{\mu_{(T+L)}}$ represents the base stock level of inventory for each printer model while $\mathbf{\sigma_{(T+L)}}$ represents the level of safety stock for each model. This approach of determining safety stock levels at the DCs assumes that only finished goods, localized for destination at source are kept in inventory. Therefore, the total safety stock of finished printers of all models required in inventory at the Europe DC as per available demand data is 18784 printers.

Now let us consider the postponement of localization processes at the DCs instead of at the Vancouver facility, and therefore take into account pooling of generic printers as our safety stock that are to be customized when demand is realized. We can then determine inventory levels as an aggregate quantity for the entire region. While the mean demands of the finished printer models remain the same, the difference in overall level of inventory arises from differences between the safety stock levels of individual finished printer models and those of generic printers to be customized later. Assuming the same line item fill rate of 98%, according to this pooling strategy of inventory, the total number of generic printers

required in safety stock for delayed customization is 9360, a staggering difference of approximately 50% in safety stock levels.

OTHER CONSIDERATIONS

1. Implementation Costs

The strategic advantage gained by shifting the localization process from the manufacturing facility in Vancouver to the European and Asian DCs comes at a price. The DCs will need to be equipped with equipment, machinery, and an assembly system for mass customization and high volume processing in order to perhaps emulate the efficiency of the Vancouver facility built around the Kanban process. Staff will require training to move into new jobs created by the introduction of the localization process at the DCs or trained professionals will need to be hired from outside the company. As with any new system, HP will need to allow time to work out any bugs in the process. Therefore, costs of physical capital, training, hiring new employees, added operational costs, and other opportunity and implicit costs will be incurred by HP. However, the added efficiency in process, the ability to better match supply with demand, savings in manufacturing and inventory holding costs, etc will outweigh the costs of implementation in the long run.

2. Transportation

HP may consider changing their choice of carriage from ocean freight to air freight entirely, or a combination thereof. However, air shipment may prove to be prohibitively expensive in this competitive, low-margin business.

3. Building a European Factory

European sales volumes may not justify the costs of setting up and operating a new production facility in Europe. In addition to capital costs, the costs of labour, material sourcing, and governmental regulations on tax in Europe, as well as offshore taxation by the U.S. government are only a few of the many considerations needed to be made.

4. Direct Sales

HP already has direct sales for other product lines such as its PC's and laptops, and could integrate a related good such as its printers into the same channel. Direct online sales could offer several advantages:

- quicker sales
- no physical space required for inventory
- higher product availability
- no waiting period

Such a drastic revision in HP's channel management strategy could bring about possible positive and negative responses:

- existing channel members may turn towards HP competitors
- HP could face legal action from channel members
- Existing or new channel members may integrate themselves into this revised distribution strategy and further increase surplus

CONCLUSION

It is clear that inventory pooling using physical centralization, and mass customization using delayed differentiation, and postponement offers a clear strategic advantage as well as greatly reducing shipping and holding costs while allowing HP to respond promptly to fluctuations in customer demand within the region. Being able to do so may also reduce duplicity in stock carried at the DCs and resellers. The postponement of localization may also allow the sourcing of some components to be made locally possibly leading to a decrease in freight cost as well as lead times.

While this strategy has its advantages, it is possible to include other considerations to further optimize existing supply chain processes, or introduce new, more efficient ones, a few of which have already been discussed above. DELL may prove to be an example of a technology product manufacturing firm that shifted its longstanding direct sales business model to that of made-to-stock. In the end, constantly changing business landscapes require firms to adapt and revise strategies accordingly to maintain their strategic and competitive edges.

Hewlett-Packard: DeskJet Printer Supply Chain

COORDINATED PRODUCT AND SUPPLY CHAIN DESIGN

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ITM 310

The HP DeskJet Printer

- Introduced in 1988
- In 1990, sold 600,000 units, $400 million
- Mission statment:
  - To become the recognized world leader in low cost premium quality printers for offices and homes
- Main division is located Vancouver
  - Consolidating four divisions
    - Colorado, Idaho, California, Oregon

Manufacturing Printer

- In 1979, Manufacturing Cycle is 8 to 12 weeks
- 3.5 months of inventory
- In 1981, Just-in-Time strategy had been introduced
  - Reduced inventory from 3.5 months to 0.9 months
- However, this strategy and production system were not used efficiently.

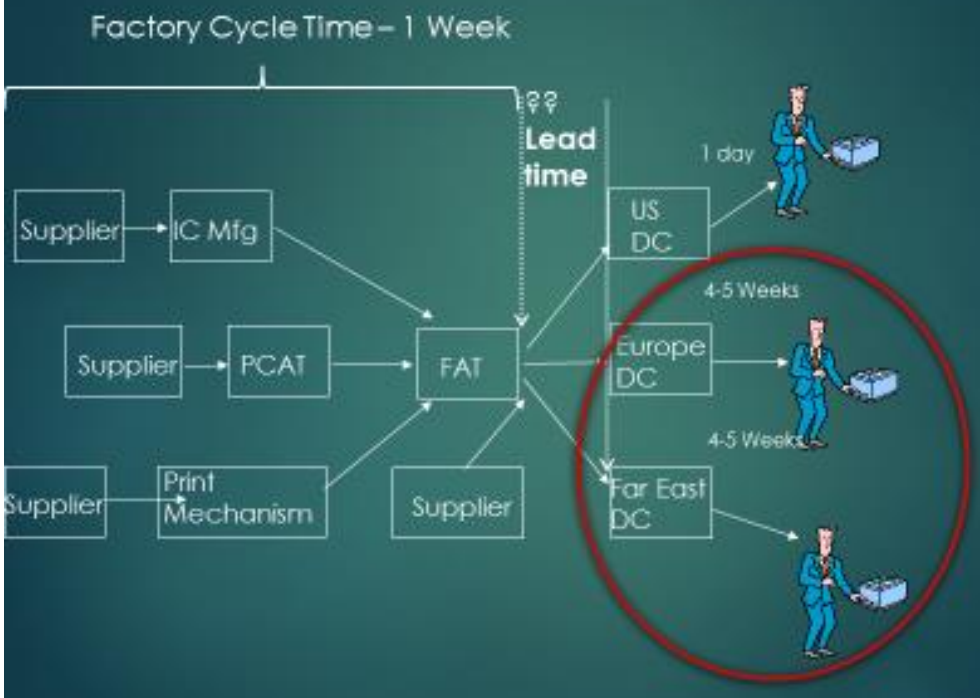
Problems and Issues

- Satisfy customer requirements by holding minimum inventory
- Bring a consensus among various divisions about inventory levels
  - Marketing: 98% product availability (page 8)
  - Distribution wants minimum inventory
- Reduce the uncertainty caused by
  - delivery of incoming materials ->lead times
  - Internal processes: manufacturing and equipment efficiency, reduce downtimes -> lead times
  - Demand; affects inventory levels -> forecast accuracy

Vancouver Plant

- Printer production at Fort Collins, CO, Boise, ID, Sunnyvale, CA and Corvallis, OR is consolidated to the Vancouver site
- Vancouver plant uses a **push** system
  - » JIT, Stockless production
- Vancouver had the proper production system
- DeskJet printer became its flagship product

Printer Supply Chain



Brent Cartier's Problem

- Too much inventory in the Desktop supply chain
- Some managers suggested increasing inventory levels
- European and Asian DC's cannot meet demand because of

Brent Cartier's Problem

- Demand and inventory level mismatch

inventory levels

overstocking of DC's
higher inventory costs (holding, obsolescence, breakage, etc)

inventory levels

Low product availability
Lost sales = high cost of understocking

What changes should HP make?

Another part of the Supply Chain

- The Distribution Process
  - Perfomance Measures:
    - Inventory Level, Distribution Cost
    - Major Costs: Outbound Frieght and Salaries
  - Distribution Center's Process
    - Receive
    - Retrieve
    - Arrange and pack the order
    - Ship

The BIG question: Should DC serve a warehousing or integration function?

Do DCs operate as a Push or Pull System?

PULL…sort of

What is localization?

- Customization of a printer to meet the language and power supply requirements of the **local** countries
  - Product manuals
  - Several power cords
- Where is localization done?
  - In Vancouver

Can a DC localize?

- DCs do not have a system for assembly operations
- US DC manager To Beal says:
  - [At a DC] We have to decide what our core competency is …. If we want to take on manufacturing processes here, we have to put processes in place to support them
- In conclusion, DC managers are for/against (??) localizing at DCs.

Lets See If DC's Should Now
Serve A Localization Function?

Inventory imbalance

- Start with an example:
  - There are 1000 DeskJet configured/packaged for **France**
  - Another 1000 for **England**
  - What is the shortage if the demand in France and England are both 1000 printers?
  - What is the shortage if the demand in France is 1500 while the demand in England is 500?
  - Inventory imbalance is having the correct amount of total inventory but the incorrect mixture

Can localization at a DC avoid inventory imbalance?

- Continuing with the same example:
  - There are 2000 DeskJet ready for

EUROPE

  - What is the shortage if the demand in France and England are both 1000 printers?
    - Shortage is ??
  - What is the shortage if the demand in France is 1500 while the demand in England is 500?
    - Shortage is ??

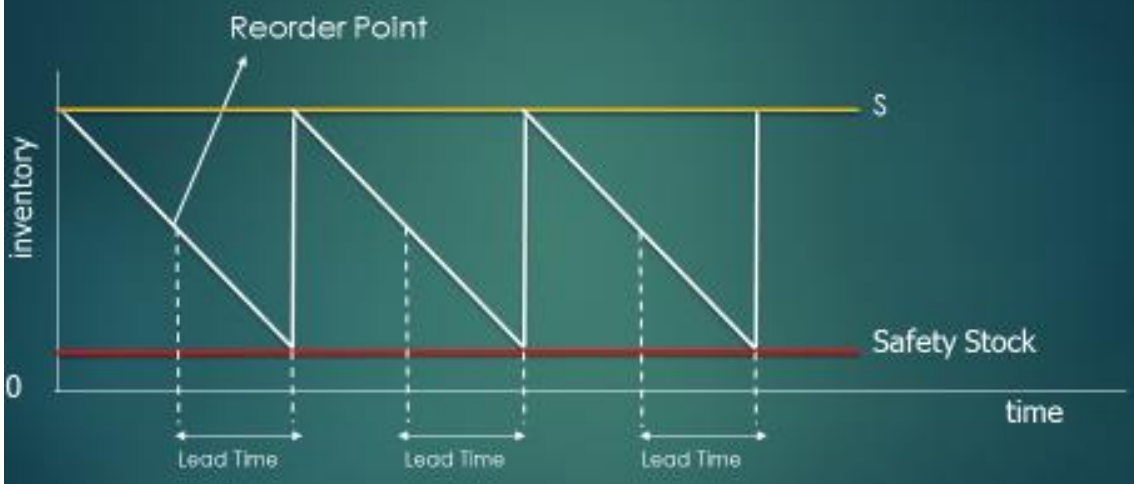
Postponing localization to the DCs

- Is the US DC manager right?
- What problems are possible with localization at DCs?
  - Capital cost to set up assembly
  - Hiring of skilled workers
- Benefits of localization of DC's?
  - Better ability to match inventory with demand
  - Reduced holding costs
  - Improved response to variations in demand

Bad Solution - Forecasting

- Reliability
- Longer forecasting horizon
- Aggregate forecasts are much more accurate
- In case of HP deskjet, the problem is more serious because
  - Higher inventory carrying costs in case of HP can vary from 12% to 60% (page 8)
  - With technology products, the chances of obsolescence are higher

Periodic Review Policy



Considering varying demands, should this strategy be adopted for each individual product line or at an aggregate level?

Revise Inventory Levels

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