Designing the Distribution Network in a Supply Chain

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Abstract

This paper describes a framework for designing the distribution network in a supply chain. Various factors influencing the choice of distribution network are described. We then discuss different choices of distribution networks and their relative strengths and weaknesses. The paper concludes by identifying distribution networks that are best suited for a variety of customer and product characteristics.

0. Introduction

Distribution refers to the steps taken to move and store a product from the supplier stage to a customer stage in the supply chain. Distribution is a key driver of the overall profitability of a firm because it directly impacts both the supply chain cost and the customer experience. Good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness. As a result, companies in the same industry often select very different distribution networks.

Dell distributes its PCs directly to end consumers, while companies like Hewlett Packard and Compaq distribute through resellers [3]. Dell customers wait several days to get a PC while customers can walk away with an HP or Compaq PC from a reseller. Gateway opened Gateway Country stores where customers could check out the products and have sales people help them configure a PC that suited their needs. Gateway, however, chose to sell no products at the stores, with all PCs shipped directly

from the factory to the customer. In 2001, Gateway closed several of these stores given their poor financial performance. Apple Computers is planning to open retail stores where computers will be sold [4]. These PC companies have chosen three different distribution models. How can we evaluate this wide range of distribution choices? Which ones serve the companies and their customers better?

W.W. Grainger, an MRO distributor, stocks about 100,000 skus that can be sent to customers within a day of the order being placed. The remaining slower moving products are not stocked but shipped directly from the manufacturer when a customer places an order. It takes several days for the customer to receive the product in this case. Are these distribution choices appropriate? How can they be justified? When should a distribution network include an additional stage such as a distributor? Proponents of e-business had predicted the death of intermediaries like distributors. Why were they proved wrong in many industries?

In this paper we provide a framework and identify key dimensions along which to evaluate the performance of any distribution network.

1. Factors Influencing Distribution Network Design

At the highest level, performance of a distribution network should be evaluated along two dimensions:

1. Customer needs that are met
2. Cost of meeting customer needs

The customer needs that are met influence the company's revenues, which along with cost decide the profitability of the delivery network.

While customer service consists of many components, we will focus on those measures that are influenced by the structure of the distribution network. These include:

- Response time
- Product variety
- Product availability
- Customer experience
- Order visibility
- Returnability

Response time is the time between when a customer places an order and receives delivery. Product variety is the number of different products / configurations that a customer desires from the distribution network. Availability is the probability of having a product in stock when a customer order arrives. Customer experience includes the ease with which the customer can place and receive their order. Order visibility is the ability of the customer to track their order from placement to delivery. Returnability is the ease with which a customer can return unsatisfactory merchandise and the ability of the network to handle such returns.

It may seem at first that a customer always wants the highest level of performance along all these dimensions. In practice, however, this is not always the case. Customers ordering a book at Amazon.com are willing to wait longer than those that drive to a nearby Borders store to get the same book. On the other hand, customers can find a far larger variety of books at Amazon compared to the Borders store.

Firms that target customers who can tolerate a large response time require few locations that may be far from the customer and can focus on increasing the capacity of each location. On the other hand, firms that target customers who value short response times need to locate close to them. These firms must have many facilities, with each location having a low capacity. Thus, a decrease in the response time customers desire increases the number of facilities required in the network, as shown in Figure 4.1. For example, Borders provides its customers with books on the same day but requires about 400 stores to achieve this goal for most of the United States. Amazon, on the other hand, takes about a week to deliver a book to its customers, but only uses about 5 locations to store its books.

Insert Figure 4.1 Here

Changing the distribution network design affects the following supply chain costs:

- Inventories
- Transportation
- Facilities and handling
- Information

As the number of facilities in a supply chain increases, the inventory and resulting inventory costs also increase as shown in Figure 4.2. For example, Amazon with fewer facilities is able to turn its inventory about twelve times a year, while Borders with about 400 facilities achieves only about two turns per year. As long as inbound transportation economies of scale are maintained, increasing the number of facilities decreases total transportation cost, as shown in Figure 4.2. If the number of facilities is increased to a point where there is a significant loss of economies of scale in inbound transportation, increasing the number of facilities increases total transportation cost. A distribution

network with more than one warehouse allows Amazon.com to reduce transportation cost relative to a network with a single warehouse. Facility costs decrease as the number of facilities is reduced as shown in Figure 4.2, because a consolidation of facilities allows a firm to exploit economies of scale.

Insert Figure 4.2 Here

Total logistics costs are the sum of inventory, transportation, and facility costs for a supply chain network. As the number of facilities is increased, total logistics costs first decrease and then increase as shown in Figure 4.3. Each firm should have at least the number of facilities that minimize total logistics costs. As a firm wants to further reduce the response time to its customers, it may have to increase the number of facilities beyond the point that minimizes logistics costs. A firm should add facilities beyond the cost- minimizing point only if managers are confident that the increase in revenues because of better responsiveness is greater than the increase in costs because of the additional facilities.

Insert Figure 4.3 Here
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2. Design Options for a Distribution Network

We will discuss distribution network choices in the context of distribution from the manufacturer to the end consumer. When considering distribution between any other pair of stages, such as supplier to

manufacturer, many of the same options still apply. There are two key decisions when designing a distribution network:

1. Will product be delivered to the customer location or picked up from a preordained site?
2. Will product flow through an intermediary (or intermediate location)?

Based on the choices for the two decisions, there are six distinct distribution network designs that are classified as follows:

1. Manufacturer storage with direct shipping
2. Manufacturer storage with direct shipping and in-transit merge
3. Distributor storage with package carrier delivery
4. Distributor storage with last mile delivery
5. Manufacturer / distributor storage with costumer pickup
6. Retail storage with customer pickup

We now describe each distribution option and discuss its strengths and weaknesses.

2.1 Manufacturer Storage with Direct Shipping

In this option, product is shipped directly from the manufacturer to the end customer, bypassing the retailer (who takes the order and initiates the delivery request). This option is also referred to as drop shipping. All inventories are stored at the manufacturer. Information flows from the customer, via the retailer, to the manufacturer, while product is shipped directly from the manufacturer to customers as shown in Figure 4.4. In some instances like Dell, the manufacturer sells directly to the customer. Online retailers such as eBags and Nordstrom.com use drop shipping to deliver goods to the end consumer. eBags does not hold any inventory of bags and has them drop shipped directly from the manufacturer to the customer. Nordstrom carries some products in inventory while using the drop-ship

model for slow moving footwear. W.W. Grainger also uses drop shipping to deliver slow moving items that are not carried in inventory.

Insert Figure 4.4 Here

The biggest advantage of drop shipping is the ability to centralize inventories at the manufacturer. A manufacturer can aggregate demand and provide a high level of product availability with lower levels of inventory than individual retailers. The benefits from centralization are highest for high value, low volume items with unpredictable demand. The decision of Nordstrom to drop-ship low volume shoes satisfies these criteria. Similarly, bags sold by eBags tend to have high value and low relatively volume per sku. The inventory benefits of aggregation are small for items with predictable demand and low value [1]. Thus, drop shipping would not offer a significant inventory advantage to an online grocer selling a staple item like detergent.

Drop shipping also offers the manufacturer the opportunity to further lower inventories by postponing customization until after the customer order has been placed. Build-to-order companies such as Dell hold inventories as common components and postpone product customization, thus lowering the level of inventories carried.

Transportation costs are high with drop shipping because the average outbound distance to the end consumer is large and package carriers must be used to ship the product. Package carriers have high shipping costs per unit compared to truckload(TL) or less-than-truckload (LTL) carriers. With drop shipping, a customer order with items from several manufacturers will involve multiple shipments to the customer. This loss in aggregation in outbound transportation further increases cost.

Supply chains save on the fixed cost of storage facilities when using drop shipping because all inventories are centralized at the manufacturer. There can be some savings of handling costs as well because the transfer from manufacturer to retailer no longer occurs. Handling costs can be significantly reduced if the manufacturer has the capability to ship orders directly from the production line.

A good information infrastructure is needed so that the retailer can provide product availability information to the customer even though the inventory is located at the manufacturer. The customer should also have visibility into order processing at the manufacturer even though the order is placed with the retailer. Drop shipping will generally require significant investment in the information infrastructure. The information infrastructure requirement is somewhat simpler for direct sellers like Dell because two stages (retailer and manufacturer) do not need to be integrated.

Response times tend to be large when drop shipping is used because the order has to be transmitted from the retailer to the manufacturer and shipping distances are on average longer from the manufacturer's centralized site. eBags, for example, states that order processing may take from 1-5 days and ground transportation after that may take from 3-11 business days. This implies that customer response time at eBags is 4-16 days using ground transportation and drop shipping. Another issue is that the response time need not be identical for every manufacturer that is part of a customer order. Given an order containing products from several sources, the customer will receive multiple partial shipments over time making receiving more complicated for the customer.

Manufacturer storage with drop shipping allows a high level of product variety to be made available to the customer. W.W. Grainger is able to offer hundreds of thousands of slow moving items from

thousands of manufacturers using drop shipping. This would be impossible if each product had to be stored by Grainger.

Drop shipping provides a good customer experience in the form of delivery to the customer location. The experience, however, suffers when a single order containing products from several manufacturers is delivered in partial shipments.

Order visibility is very important in the context of manufacturer storage because two stages in the supply chain are involved in every customer order. Order tracking, however, becomes harder to implement in a situation of drop shipping because it requires complete integration of information systems at both the retailer as well as the manufacturer. For direct sellers such as Dell, order visibility is simpler to provide.

A manufacturer storage network is likely to have difficulty handling returns, hurting customer satisfaction. The handling of returns is more expensive under drop shipping because each order may involve shipments from more than one manufacturer. There are two ways that returns can be handled. One is for the customer to return the product directly to the manufacturer. The second approach is for the retailer to set up a separate facility (across all manufacturers) to handle returns. The first approach incurs high transportation and coordination cost while the second approach requires investment in a facility to handle returns.

The performance characteristics of drop shipping along various dimensions are summarized in Table 4.1.

Insert Table 4.1 Here

Given its performance characteristics, manufacturer storage with direct shipping is best suited for a large variety of low demand, high value items where customers are willing to wait for delivery and accept several partial shipments. Manufacturer storage is also suitable if it allows the manufacturer to postpone customization, thus reducing inventories. For drop-shipping to be effective, there should be few sourcing locations per order. It is thus ideal for direct sellers that are able to build-to-order. Drop shipping is hard to implement if there are more than 20-30 sourcing locations that have to ship directly to customers on a regular basis. For products with very low demand, however, drop shipping may be the only option.

2.2 Manufacturer Storage With Direct Shipping and In-Transit Merge

Unlike pure drop shipping where each product in the order is sent directly from each manufacturer to the end customer, in-transit merge combines pieces of the order coming from different locations so that the customer gets a single delivery. Information and product flows for the in-transit merge network are as shown in Figure 4.5. When a customer orders a PC from Dell along with a Sony monitor, the package carrier picks up the PC at the Dell factory, the monitor at the Sony factory and merges the two together at a hub before making a single delivery to the customer.

Insert Figure 4.5 Here

As with drop shipping, the ability to aggregate inventories and postpone product customization is a significant advantage of in-transit merge. In-transit merge allows Dell and Sony to aggregate all their inventories at the factory. This approach will have the greatest benefits for products with high value whose demand is hard to forecast, in particular if product customization can be postponed.

In most cases, transportation costs are lower than drop shipping because of the merge that takes place at the carrier hub prior to delivery to the customer. An order with products from three manufacturers thus requires only one delivery to the customer compared to three that would be required with drop shipping. Fewer deliveries save transportation cost and simplify receiving.

Facility and processing costs for the manufacturer and the retailer are as in drop shipping. The party performing the in-transit merge has higher facility costs because of the merge capability required. Receiving costs at the customer are lower because a single delivery is received. Overall supply chain facility and handling costs are somewhat higher than drop shipping.

A very sophisticated information infrastructure is needed to allow the in-transit merge. Besides information, operations at the retailer, manufacturers, and the carrier must be coordinated. The investment in information infrastructure will be higher than for drop shipping.

Response times, product variety, and availability are similar to drop shipping. Response times may be marginally higher because of the need to perform the merge. Customer experience is likely to be better than drop shipping because the customer receives only one delivery for their order instead of many partial shipments. Order visibility is a very important requirement. While the initial setup is difficult because it requires integration of manufacturer, carrier, and retailer, tracking itself becomes easier given the merge that occurs at the carrier hub. Up to the point of merge, the order from each

manufacturer is tracked separately. After that the order can be tracked as a single unit. Returnability is similar to drop shipping. Problems in handling returns are very likely and the reverse supply chain will continue to be expensive and difficult to implement as with drop shipping.

The performance of factory storage with in-transit merge is compared with drop shipping in Table 4.2.

Insert Table 4.2 Here

The main advantage of in-transit merge over drop shipping is the somewhat lower transportation cost and improved customer experience. The major disadvantage is the additional effort during the merge itself. Given its performance characteristics, manufacturer storage with in-transit merge is best suited for low to medium demand, high value items where the retailer is sourcing from a limited number of manufacturers. Compared to drop shipping, in-transit merge requires a higher volume from each manufacturer to be effective. If there are too many sources, in-transit merge can be very difficult to coordinate and implement. In-transit merge is best implemented if there are no more than four or five sourcing locations and each customer order has products from multiple locations. The in-transit merge of a Dell PC with a Sony monitor is appropriate because product variety is high but there are few sourcing locations with relatively large total volume from each sourcing location.

2.3 Distributor Storage with Carrier Delivery

Under this option, inventory is not held by manufacturers at the factories but is held by distributors / retailers in intermediate warehouses and package carriers are used to transport products from the

intermediate location to the final customer. Amazon.com as well as industrial distributors like W.W. Grainger use this approach combined with drop shipping from a manufacturer. Information and product flows when using distributor storage with delivery by a package carrier are shown in Figure 4.6.

Insert Figure 4.6 Here

Relative to manufacturer storage, distributor storage will require a higher level of inventory because the distributor / retailer warehouse aggregates demand uncertainty to a lower level than the manufacturer. From an inventory perspective, distributor storage makes sense for products with somewhat higher demand. Both Amazon and Grainger only stock the medium to fast moving items at their warehouse with slower moving items stocked further upstream. In some instances, postponement can be implemented with distributor storage but it does require that the warehouse develop some assembly capability. Distributor storage, however, requires much less inventory than a retail network. Amazon achieves about 12 turns of inventory using warehouse storage while Borders achieves about 2 turns using retail stores.

Transportation costs are somewhat lower for distributor storage compared to manufacturer storage because an economic mode of transportation (e.g. truckload) can be employed for inbound shipments to the warehouse, which is closer to the customer. Unlike manufacturer storage where multiple shipments may need to go out for a single customer order with multiple items, distributor storage allows outbound orders to the customer to be bundled into a single shipment further reducing transportation cost. Transportation savings from distributor storage relative to manufacturer storage increase for faster moving items.

Compared to manufacturer storage, facility costs are somewhat higher with distributor storage because of a loss of aggregation. Processing and handling costs are comparable to manufacturer storage unless the factory is able to ship to the end customer directly from the production line. In that case, distributor storage will have higher processing costs. From a facility cost perspective, distributor storage is not appropriate for extremely slow moving items.

The information infrastructure needed with distributor storage is significantly less complex than that needed with manufacturer storage. The distributor warehouse serves as a buffer between the customer and the manufacturer, decreasing the need to coordinate the two completely. Real time visibility between customers and the warehouse is needed, whereas real time visibility between the customer and the manufacturer is not. Visibility between the distributor warehouse and manufacturer can be achieved at a much lower cost than real time visibility between the customer and manufacturer.

Response time with distributor storage is better than with manufacturer storage because distributor warehouses are, on average, closer to customers and the entire order is aggregated at the warehouse when shipped. Amazon, for example, processes all warehouse-stored items within a day and it then takes 3-7 business days using ground transportation for the order to reach the customer. Grainger processes customer orders on the same day and has enough warehouses to deliver most orders next day using ground transport. Warehouse storage will limit to some extent the variety of products that can be offered. Grainger does not store very low volume items at its warehouse, relying on manufacturers to drop ship those products to the customer. Customer convenience is high with distributor storage because a single shipment reaches the customer in response to an order. Order visibility becomes easier than with manufacturer storage because there is a single shipment from the warehouse to the customer and only one stage of the supply chain is directly involved in filling the

customer order. Returnability is better than with manufacturer storage because all returns can be processed at the warehouse itself. The customer also has to return only one package even if the items are from several manufacturers.

The performance of distributor storage with carrier delivery is summarized in Table 4.3.

Insert Table 4.3 Here

Distributor storage with carrier delivery is well suited for medium to fast moving items. Distributor storage also makes sense when customers want delivery faster than offered by manufacturer storage but do not need it immediately. Distributor storage can handle somewhat lower variety than manufacturer storage but can handle a much higher level of variety than a chain of retail stores.

2.4 Distributor Storage with Last Mile Delivery

Last mile delivery refers to the distributor / retailer delivering the product to the customer's home instead of using a package carrier. Webvan, Peapod, and Alberston's have used last mile delivery in the grocery industry. Unlike package carrier delivery, last mile delivery requires the distributor warehouse to be much closer to the customer, increasing the number of warehouses required. The warehouse storage with last mile delivery network is as shown in Figure 4.7.

Insert Figure 4.7 Here

Distributor storage with last mile delivery requires higher levels of inventory than all options other than retail stores, because it has a lower level of aggregation. From an inventory perspective, warehouse storage with last mile delivery is suitable for relatively fast moving items where disaggregation does not lead to a significant increase of inventory. Staple items in the grocery industry fit this description.

Transportation costs are highest using last mile delivery. This is because package carriers aggregate delivery across many retailers and are able to obtain better economies of scale than available to a distributor / retailer attempting last mile delivery. Delivery costs (including picking and transportation) can be as high as $30-$40 per home delivery in the grocery industry. Last mile delivery may be somewhat cheaper in dense cities. Transportation costs may also be justifiable for bulky products where the customer is willing to pay for home delivery. Home delivery for water and large bags of rice has proved quite successful in China, where the high population density has helped decrease delivery costs.

Facility and processing costs are very high using this option given the large number of facilities required. Facility costs are somewhat lower than a network with retail stores but much higher than either manufacturer storage or distributor storage with package carrier delivery. Processing costs, however, are much higher than a network of retail stores because all customer participation is eliminated. A grocery store doing last mile delivery, performs all the processing until the product is delivered to the customer's home unlike a supermarket where there is much more customer participation.

The information infrastructure with last mile delivery is similar to distributor storage with package carrier delivery. It requires, however, the additional capability of scheduling deliveries.

Response times are faster than the use of package carriers. Product variety is generally lower than distributor storage with carrier delivery. The cost of providing product availability is higher than every option other than retail stores. The customer experience is very good using this option, particularly for bulky, hard to carry items. Order visibility is less of an issue given that deliveries are made within 24 hours. The order-tracking feature does become important to handle exceptions in case of incomplete or undelivered orders. Of all the options discussed, returnability is best with last mile delivery because trucks making deliveries can also pick up returns from customers. Returns are more expensive to handle than at a retail store where a customer can bring the product back.

The performance characteristics of distributor storage with last mile delivery are summarized in Table 4.4.

Insert Table 4.4 Here

In areas with high labor cost, it is very hard to justify distributor storage with last mile delivery on the basis of efficiency or improved margin. It can only be justified if there is a large enough customer segment willing to pay for this convenience. In that case, an effort should be made to couple last mile delivery with an existing network to exploit economies of scale and improve utilization. An example is Albertson's use of existing grocery store facilities and labor to provide home delivery. A portion of the grocery store serves as a fulfillment center for online orders as well as a replenishment center for the grocery store itself. This helps improve utilization and lower the cost of providing this service. Last mile delivery may be justifiable if customer orders are large enough and customers are willing to pay

for this service. All home delivery companies like Peapod now charge for this service even for very large order sizes.

2.5 Manufacturer or Distributor Storage with Consumer Pickup

In this approach, inventory is stored at the manufacturer or distributor warehouse but customers place their orders online or on the phone and then come to designate pickup points to collect their orders. Orders are shipped from the storage site to the pickup points as needed. Examples include 7dream.com operated by 7 Eleven Japan, which allows customers to pick up online orders at a designated store [2]. A B2B example is W. W. Grainger where customers can pick up their order at one of the Grainger retail outlets [1]. In the case of 7dream.com, the order is delivered from a manufacturer or distributor warehouse to the pickup location. In the case of Grainger, some items are stored at the pickup location while others may come from a central location. The information and product flows in the network for 7 Eleven Japan is as shown in Figure 4.8.

Insert Figure 4.8 Here
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7 Eleven has distribution centers (DC) where product from manufacturers is cross-docked and sent to retail outlets on a daily basis. A retailer delivering an online order can be treated as one of the manufacturers with deliveries cross-docked and sent to the appropriate 7 Eleven outlet. Serving as an outlet for online orders allows 7 Eleven to improve utilization of its existing logistical assets.

Inventory costs using this approach can be kept low with either manufacturer or distributor storage to exploit aggregation. Grainger keeps its inventory of fast moving items at pickup locations, while slow moving items are stocked at a central or warehouse, or in some cases the manufacturer.

Transportation cost is lower than any solution using package carriers because significant aggregation is possible when delivering orders to a pickup site. This allows the use of truckload or less-than-truckload carriers to transport orders to the pickup site. In a case like 7 Eleven Japan, the marginal increase in transportation cost is small because trucks are already making deliveries to the stores and their utilization can be improved by including online orders.

Facility costs are high if new pickup sites have to be built. A solution using existing sites will lower the additional facility costs. This, for example, is the case with 7dream.com and W.W. Grainger where the stores already exist. Processing costs at the manufacturer or the warehouse are comparable to other solutions. Processing costs at the pick up site are high because each order must be matched with a specific customer when they arrive. Creating this capability can increase processing costs significantly if appropriate storage and information systems are not provided. Increased processing cost at the pickup site is the biggest hurdle to the success of this approach.

A significant information infrastructure is needed to provide visibility of the order until the customer picks it up. Very good coordination is needed between the retailer, the storage location, and the pickup location.

A response time comparable to the use of package carriers can be achieved in this case. Variety and availability comparable to any manufacturer or distributor storage option can be provided. There is some loss of customer experience because unlike the other options discussed, customers must come

and pick up their orders. On the other hand, customers who do not want to pay online can pay by cash using this option. In countries like Japan where 7 Eleven has over 8,000 outlets, it can be argued that the loss of customer convenience is small because most customers are close to a pickup site and can collect their order at their own convenience. In some cases, this option can be considered more convenient because it does not require the customer to be at home at the time of delivery.

Order visibility is extremely important for customer pickups. The customer must be informed when the order has arrived and the order should be easily identified once the customer arrives to pick it up. Such a system will be hard to implement because it requires integration of several stages in the supply chain. Returns can potentially be handled at the pickup site. The problem with some existing sites such as 7 Eleven stores is that they are not equipped to accept and process returns for products not sold at the stores. From a transportation perspective, however, return flows can be handled using the delivery trucks. For customers, returning a product will be easy because they have a physical location to bring it to. Overall, returnability is fairly good using this option.

The performance characteristics of manufacturer or distributor storage with consumer pickup sites are summarized in Table 4.5.

Insert Table 4.5 Here

The main advantage of a network with consumer pickup sites is that it can lower delivery cost, thus expanding the set of products sold as well as customers served online. The major hurdle is the increased handling cost at the pickup site. Such a network is likely to be most effective if existing locations such as convenience or grocery stores are used as pickup sites because such a network

improves the economies from existing infrastructure. Unfortunately, such sites are typically designed to allow the customer to do the picking and will need to develop the capability of picking a customer specific order.

2.6 Retail Storage with Customer Pickup

In this option, inventory is stored locally at retail stores. Customers either walk into the retail store or place an order online or on the phone, and pick it up at the retail store. Examples of companies that offer multiple options of order placement include Albertsons.com. Albertsons uses part of the facility as a grocery store and part of the facility as an online fulfillment center. Customers can walk into the store or order online. A B2B example is W. W. Grainger where customers can order online, by phone, or in person and pick up their order at one of the Grainger retail outlets. Alberston's stores its inventory at the pickup location itself. In the case of Grainger, some items are stored at the pickup location while others may come from a central location.

Local storage increases inventory costs because of lack of aggregation. For very fast moving items, however, there is marginal increase in inventory even with local storage. Albertson's uses local storage given that most of its products are relatively fast moving and are being stocked at the supermarket in any case. Similarly, Grainger keeps its inventory of fast moving items at pickup locations, while slow moving items are stocked at a central warehouse.

Transportation cost is much lower than other solutions because inexpensive modes of transport can be used to replenish product at the retail store. Facility costs are high because many local facilities are required. A minimal information infrastructure is needed if customers walk into the store and place

their order. For online orders, however, a significant information infrastructure is needed to provide visibility of the order until the customer picks it up.

Very good response times can be achieved in this case because of local storage. For example, both Alberston's and Grainger offer same day pickup from their retail locations. Product variety stored locally will be lower than other options. It is more expensive than all other options to provide a high level of product availability. Order visibility is extremely important for customer pickups where orders are placed online or on the phone. Returns can be handled at the pickup site. Overall, returnability is fairly good using this option.

The performance characteristics of a network with customer pickup sites and local storage (such as retail stores) are summarized in Table 4.6.

Insert Table 4.6 Here

The main advantage of a network with local storage is that it can lower the delivery cost and provide a faster response than other networks. The major disadvantage is the increased inventory and facility costs. Such a network is best suited for fast moving items or items where customers value the rapid response.

3. Selecting a Distribution Network Design

A network designer needs to consider product characteristics as well as network requirements when deciding on the appropriate delivery network. The various networks considered earlier have different strengths and weaknesses. In Table 4.7, the various delivery networks are ranked relative to each other along different performance dimensions. A ranking of 1 indicates the best performance along a given dimension and the relative performance worsens, as the ranking gets higher.

Insert Table 4.7 Here

Only niche companies will end up using a single distribution network. Most companies are best served by a combination of delivery networks. The combination used will depend upon product characteristics as well as the strategic position that the firm is targeting. The suitability of different delivery designs (from a supply chain perspective) in various situations is shown in Table 4.8.

Insert Table 4.8 Here

An excellent example of a hybrid network is W.W. Grainger that combines all the above options into its distribution network. The network, however, is tailored to match the characteristics of the product or the needs of the customer. Fast moving and emergency items are stocked locally and customers can either pick them up directly or have them shipped depending upon the urgency. Slower moving items

are stocked at a national distribution center from where they are shipped to the customer within a day or two. Very slow moving items are typically drop shipped from the manufacturer and involve a longer lead time. Another hybrid network is Amazon where some items are stocked at their warehouse while other slow moving items may be drop shipped from distributors or publishers.

4. Conclusion

We now revisit the questions raised at the beginning of the chapter. In the computer industry today, customization and high product variety seem to be valued by the customer. PCs are assembled at few sources by a company but with high variety of end product. Demand for any one configuration tends to be low and variable. This is also a purchase for which customers are willing to wait a few days for delivery. Product value is reasonably high. Product postponement can play an important role in reducing inventories. From Table 4.8 it would thus seem to be a product better suited for drop shipping or factory storage with pickup from a local site. Thus, at present IBM's decision to stop selling many slow moving configurations at retail stores would appear better than that of Gateway to open retail stores. Gateway has created a network of retail stores but is not exploiting any of the supply chain advantages such a network offers because no products are sold there. To fully exploit the benefits of the retail network it would make sense for Gateway to sell their standard configurations (likely to have high demand) at the retail stores with all other configurations drop shipped from the factory (perhaps with local pickup at the retail stores if it is economical). Apple has decided to open some retail stores (fewer than Gateway) and actually carry product for sale at these stores. If Apple uses these retail stores to sell the fast moving items and display the configurable items (which can be drop shipped), it will be a good use of their retail network.

Finally, intermediaries such as distributors add value to a supply chain between a supply stage and a customer stage if there are many small players at the customer stage, each requiring a small amount of the product at a time. The value added increases if distributors carry products from many manufacturers. Improvement in supply chain performance occurs for the following reasons:

- Reduction in inbound transportation cost because of truckload shipments from manufacturers to distributor
- Reduction in outbound transportation cost because the distributor combines products from many manufacturers into a single outbound shipment
- Reduction in inventory costs because distributor aggregates safety inventory rather than disaggregating at each retailer
- A more stable order stream from distributor to manufacturer (compared to erratic orders from each retailer) allows manufacturers to lower cost by planning production more effectively
- By carrying inventory closer to the point of sale, distributors are able to provide a better response time than manufacturers can
- Distributors are able to offer one stop shopping with products from several manufacturers

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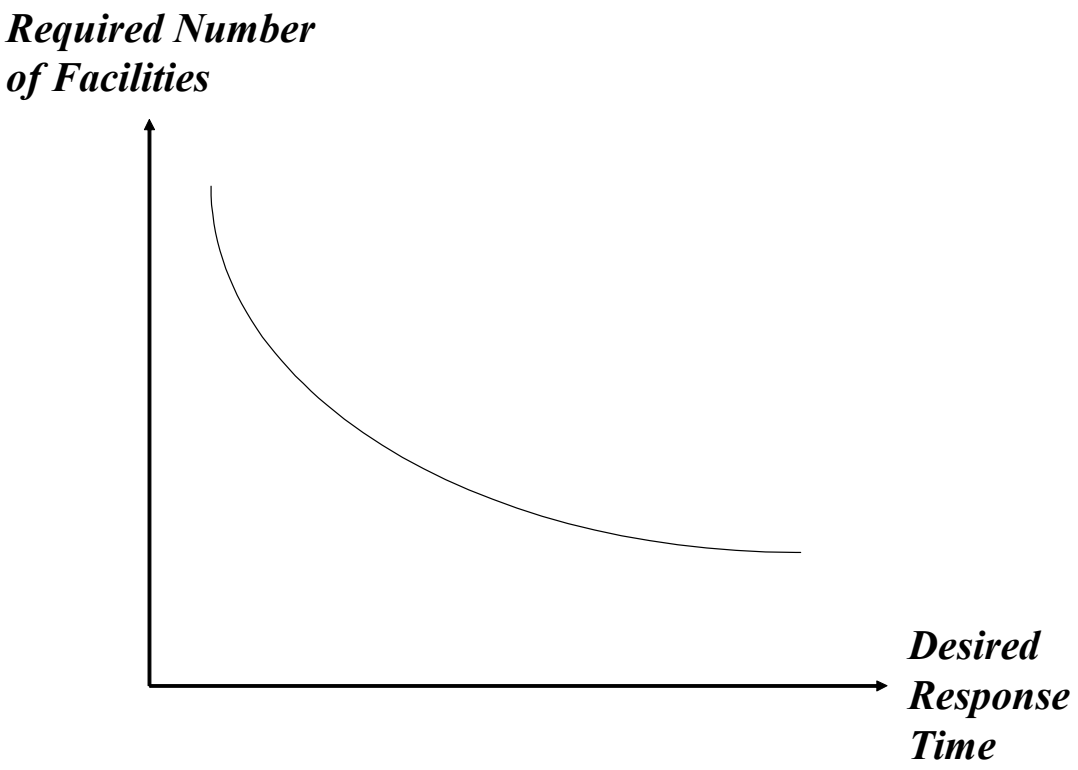

Figure 4.1: Relationship between desired response time

and number of facilities

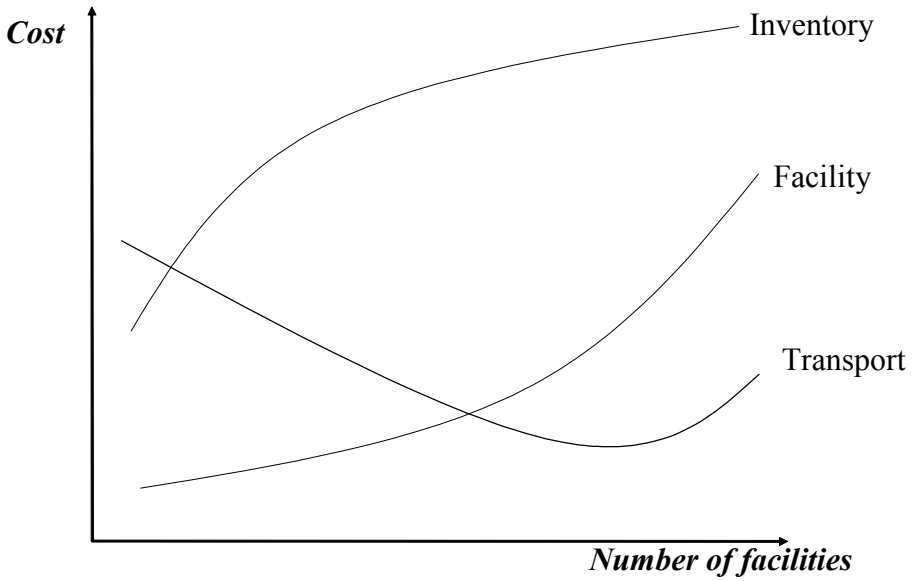

Figure 4.2: Relationship between number of facilities and logistics cost

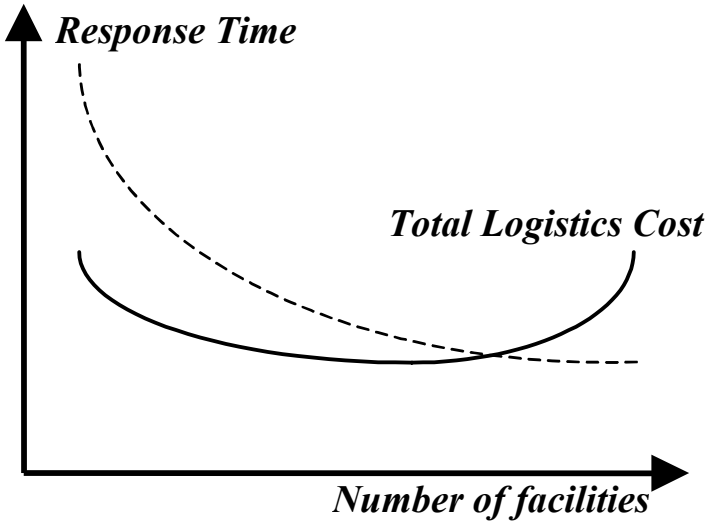

Figure 4.3: Variation in Logistics Cost and Response Time

with Number of Facilities

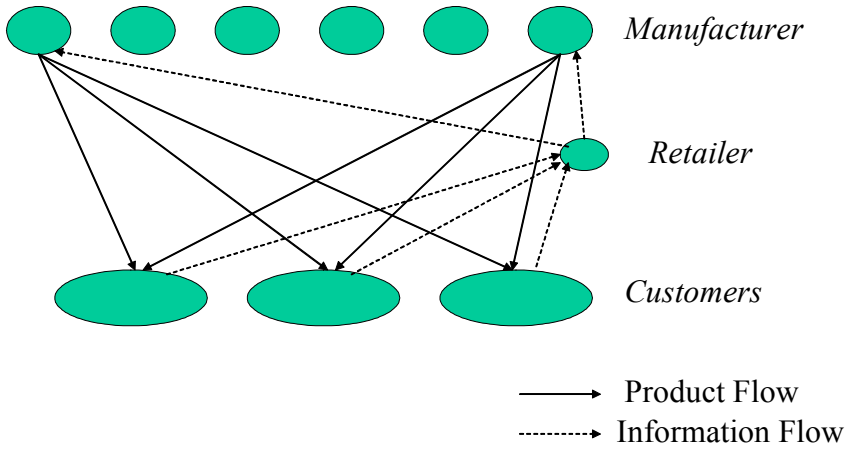

Figure 4.4: Manufacturer Storage with Direct Shipping

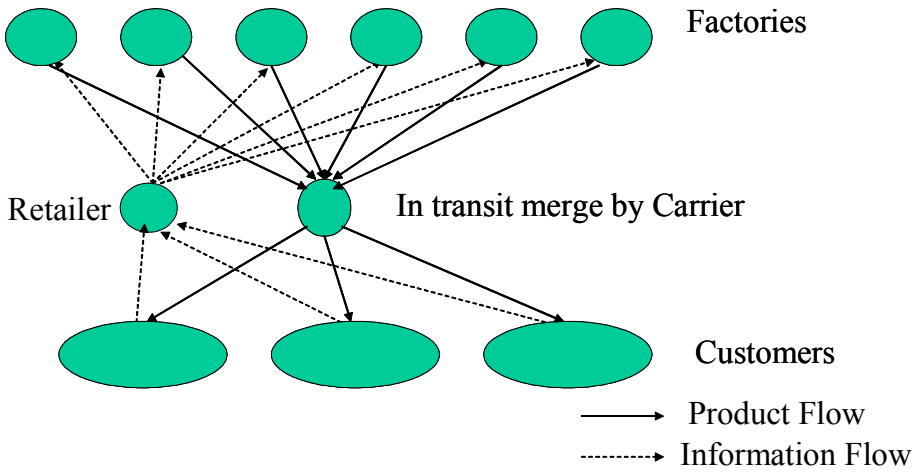

Figure 4.5: In-Transit Merge Network

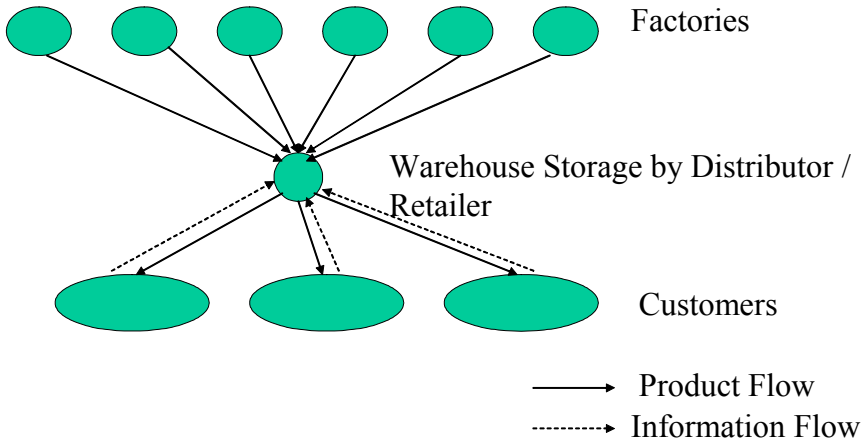

Figure 4.6: Distributor Storage with Carrier Delivery

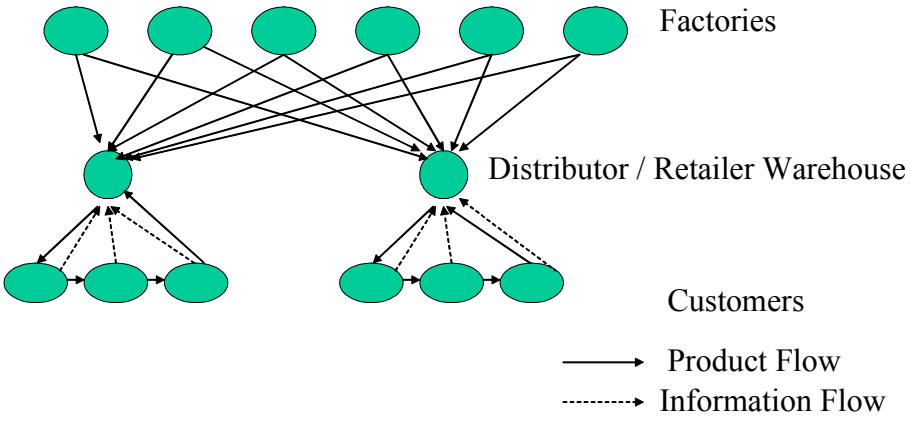

Figure 4.7: Distributor Storage With Last Mile Delivery

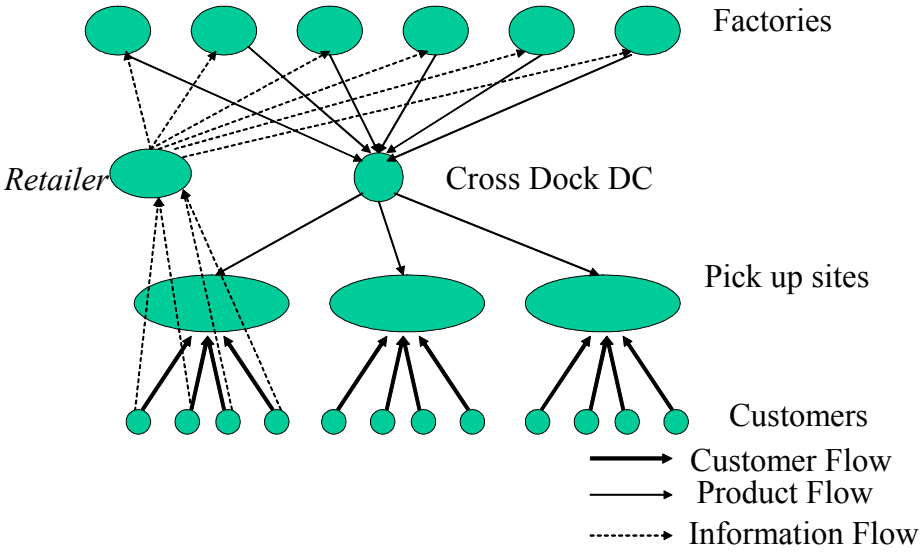

Figure 4.8: Manufacturer or Distributor Warehouse Storage with Consumer Pickup

Cost Factor	**Performance**
Inventory	Lower costs because of aggregation. Benefits of aggregation are highest for low volume, high value items. Benefits are very large if product customization can be postponed at the manufacturer
Transportation	Higher transportation costs because of increased distance and disaggregate shipping
Facilities and handling	Lower facility costs because of aggregation. Some saving on handling costs if manufacturer can manage small shipments or ship from production line
Information	Significant investment in information infrastructure to integrate manufacturer and retailer
Service Factor	**Performance**
Response time	High response time of between 1-2 weeks because of increased distance and two stages for order processing. Response time may vary by product, thus complicating receiving
Product variety	Easy to provide a very high level of variety
Product availability	Easy to provide a high level of product availability because of aggregation at manufacturer
Customer experience	Good in terms of home delivery but can suffer if order from several manufacturers is sent as partial shipments
Order visibility	More difficult but also more important from a customer service perspective
Returnability	Expensive and difficult to implement

Table 4.1: Performance Characteristics of Manufacturer Storage with Direct Shipping Network

Cost Factor	**Performance**
Inventory	Similar to drop shipping
Transportation	Somewhat lower transportation costs than drop-shipping
Facilities and handling	Handling costs higher than drop shipping at carrier, receiving costs lower at customer
Information	Investment is somewhat higher than for drop-shipping
Service Factor	**Performance**
Response time	Similar to drop shipping, may be marginally higher
Product variety	Similar to drop shipping
Product availability	Similar to drop shipping
Customer experience	Better than drop shipping because a single delivery has to be received
Order visibility	Similar to drop shipping
Returnability	Similar to drop shipping

Table 4.2: Performance characteristics of in-transit merge

Cost Factor	**Performance**
Inventory	Higher than manufacturer storage. Difference is not large for faster moving items
Transportation	Lower than manufacturer storage. Reduction is highest for faster moving items
Facilities and handling	Somewhat higher than manufacturer storage. The difference can be large for slow moving items
Information	Simpler infrastructure compared to manufacturer storage
Service Factor	**Performance**
Response time	Faster than manufacturer storage
Product variety	Lower than manufacturer storage
Product availability	Higher cost to provide the same level of availability as manufacturer storage
Customer experience	Better than manufacturer storage with drop shipping
Order visibility	Easier than manufacturer storage
Returnability	Easier than manufacturer storage

Table 4.3: Performance Characteristics of Distributor Storage with Carrier Delivery

Cost Factor	**Performance**
Inventory	Higher than distributor storage with package carrier delivery
Transportation	Very high cost given minimal scale economies. Higher than any other distribution option
Facilities and handling	Facility costs higher than manufacturer storage or distributor storage with package carrier delivery, but lower than a chain of retail stores
Information	Similar to distributor storage with package carrier delivery
Service Factor	**Performance**
Response time	Very quick. Same day to next day delivery
Product variety	Somewhat less than distributor storage with package carrier delivery but larger than retail stores
Product availability	More expensive to provide availability than any other option except retail stores
Customer experience	Very good, particularly for bulky items
Order traceability	Less of an issue and easier to implement than manufacturer storage or distributor storage with package carrier delivery
Returnability	Easier to implement than other options. Harder and more expensive than a retail network

Table 4.4: Performance Characteristics of Distributor Storage with Last Mile Delivery

Cost Factor	**Performance**
Inventory	Can match any other option depending on the location of inventory
Transportation	Lower than the use of package carriers, especially if using an existing delivery network
Facilities and handling	Facility costs can be very high if new facilities have to be built. Costs are lower if existing facilities are used. The increase in handling cost at the pickup site can be significant
Information	Significant investment in infrastructure required
Service Factor	**Performance**
Response time	Similar to package carrier delivery with manufacturer or distributor storage. Same day delivery possible for items stored locally at pickup site
Product variety	Similar to other manufacturer or distributor storage options
Product availability	Similar to other manufacturer or distributor storage options
Customer Experience	Lower than other options because of the lack of home delivery. In areas with high density of population loss of convenience may be small
Order visibility	Difficult but essential
Returnability	Somewhat easier given that pickup location can handle returns

Table 4.5: Performance Characteristics of network with consumer pickup sites

Cost Factor	**Performance**
Inventory	Higher than all other options
Transportation	Lower than all other options
Facilities and handling	Higher than other options. The increase in handling cost at the pickup site can be significant for online and phone orders
Information	Some investment in infrastructure required for online and phone orders
Service Factor	**Performance**
Response time	Same day (immediate) pickup possible for items stored locally at pickup site
Product variety	Lower than all other options
Product availability	More expensive to provide than all other options
Customer experience	Related to whether shopping is viewed as a positive or negative experience by customer
Order visibility	Trivial for in store orders. Difficult, but essential, for online and phone orders
Returnability	Easier than other options given that pickup location can handle returns

Table 4.6: Performance Characteristics of local storage at consumer pickup sites

	Retail Storage with Customer Pickup	**Manufacturer Storage with Direct Shipping**	**Manufacturer Storage with In-Transit Merge**	**Distributor Storage with Package Carrier Delivery**	**Distributor storage with last mile delivery**	**Manufacturer storage with pickup**
Response Time	1	4	4	3	2	4
Product Variety	4	1	1	2	3	1
Product Availability	4	1	1	2	3	1
Customer Experience	5	4	3	2	1	5
Order Visibility	1	5	4	3	2	6
Returnability	1	5	5	4	3	2
Inventory	4	1	1	2	3	1
Transportation	1	4	3	2	5	1
Facility & Handling	6	1	2	3	4	5
Information	1	4	4	3	2	5

Table 4.7: Comparative Performance of Delivery Network Designs

++: Very suitable; +: Somewhat suitable; +-: Neutral; -: Somewhat unsuitable; --: Very unsuitable.

	Retail Storage with Customer Pickup	**Manufacturer Storage with Direct Shipping**	**Manufacturer Storage with In-Transit Merge**	**Distributor Storage with Package Carrier Delivery**	**Distributor storage with last mile delivery**	**Manufacturer storage with pickup**
High demand product	++	--	-	+-	+	-
Medium demand product	+	-	+-	+	+-	+-
Low demand product	-	+	+-	+	-	+
Very low demand product	--	++	+	+-	--	+
Many product sources	+	-	-	++	+	+-
High product value	-	++	+	+	+-	++
Quick desired response	++	--	--	-	+	--
High product variety	-	++	+-	+	+-	++
Low customer effort	--	+	++	++	++	-

Table 4.8: Performance of Delivery Networks for Different Product/Customer Characteristics