# Framework for Selection of Distribution Strategies

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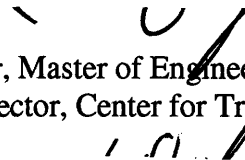at the

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## Abstract

When a company grows rapidly, the existing infrastructure of the supply chain system set up long ago, faces an increasing pressure to meet new challenges and needs to be restructured. A seasonal seed manufacturing company, such as Seed Corp, has only five months of manufacturing time in the Fall each year. Customers usually do not want the seed delivery until Spring. Such companies face a tremendous pressure to find space to store their products during the manufacturing peak season. Companies must search for good strategies to meet these challenges.

This thesis assesses the framework for selection of distribution strategies, reviews the these strategies, and analyzes the benefits and challenges among them. This research analyzes trade-offs between centralized and decentralized distribution systems, as well as between service level and cost. The analysis focuses on the response time and total cost for four distribution options. We have chosen Seed Corp as a case study. As the result of the research, the thesis suggests distribution strategies to meet the company's supply chain challenges. Finally, we recommend the further areas that need to be explored.

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# 1 Introduction

This thesis reviews distribution strategies and frameworks for selecting these strategies. It compares the benefits, costs and challenges of using a traditional Distribution Center (DC) Model against the other approaches. This thesis analyzes trade-offs between the Centralized (DC model) and decentralized distribution systems, and provides a guideline for selecting different distribution strategies. We will also discuss demand shaping as a way to improve distribution system.

## 1.1 Motivation

Each year, a seed manufacturing firm, referred to as Seed Corp, has six months manufacturing time (including three months harvest time at the beginning) from August to January year, while the inventory level in the warehouse changes from close to zero to full. The challenges are that most of the customers (dealers or end users) do not want to receive the seed until the next year in February and often change the order of the product types and quantity after they placed an order, because the customers do not want to store seeds for several months before planting. When a company grows rapidly, the existing supply chain system is usually based on an older situation. The company's existing supply chain system faces an increasing pressure to meet the new challenge. The company must find enough space to store the raw materials and seeds during this peak manufacturing time. Therefore, the company starts to search and study different distribution strategies to try to find the best strategies to meet the new challenge. This leads to a need to redesign the entire supply chain as the conditions change.

There are several different of ways a company can distribution or flow their product from manufacturing to point of consumption. A traditional approach, like Seed Corp's existing system, is to produce and store products at manufacturing locations and then ship them directly to customers. This is a manufacturing centric approach.

## 1.2 Outline

There are four major distribution strategies: Direct shipment from manufacturing plant to customer, Shipment from manufacturing via dealer's DC, to customers, Cross-Docking, and Transshipment.

This thesis consists of four parts. First, we discuss potential distribution strategies for manufacturing firms and how to select strategies. Second, we present a case on Seed Corp. Third, based on Seed Corp's data, we conduct the analysis. Finally, make the recommendation and further fields to need to be research.

Chapter 2 reviews and studies the distribution strategies and metrics. The industry metrics were provided by the United States Department of Agriculture (http://www.usda.gov), Economics Research Service, National Agricultural Statistics Service, and the Food and Drug Administration (FDA), and published related papers and books. In Chapter 2, we also describe framework for selection of distribution strategies

In Chapter 3, we focus on understanding Seed Corp's existing distribution system. Information and understanding is through interviews with the company's marketing and sales, product management, logistics, distribution, and manufacturing groups, and

collected the company's information and data, such as manufacturing capability, production delivery, and customer database.

Chapter 4 analyzes the information collected from Seed Corp. The main question for the thesis need to answer is applicability of a large DC (Distribution Center). Chapter 4 uses several methods of analysis to include: Data mining, center of gravity location model and K-means clustering.

Finally, Chapter 5 suggests several recommendations and the possible new fields needed to be study which may lead to innovation solutions.

# 2 Literature Review

The thesis needs to answer questions about what distribution strategies are available for a company and how to select an appropriate distribution strategy for a company. The literature review includes two sections: a framework for the selection of distribution strategies and a review of distribution strategies.

## 2.1 Framework for Selecting a Distribution Strategy

A successful distribution strategy is one that for a particular company, allows it to reduce its channel inventory and streamlines of its operations.

Chopra and Meindl (2007) define the goal for a great distribution strategy to maximize the company's profits while satisfying customer needs in terms of demand and responsiveness.

Simchi-Levi and Kaminsky (2003) emphasize risk pooling in selecting the distribution strategy for a company. Risk pooling suggests that demand variability is reduced if one aggregates demand across locations. They also summarize three important points about risk pooling:

a) Risk pooling reduces both safety store and average inventory in the system.

b) The higher the coefficient of variation, the greater the benefit obtained from using centralized distribution system.

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c) The benefits from risk pooling depend on the behavior of demand from one market relative to demand from another.

To select the right distribution strategy to fit a company's circumstances and competitive strategies, Chopra and Meindl (2007) suggest three steps:

a) Understanding the customer and supply chain uncertainty. A company must understand the customer needs for each targeted segment and the uncertainty the supply chain faces in satisfying these needs. These needs help the company define the desired cost and service requirements. The supply chain uncertainty helps the company identify the extent of the unpredictability of demand, disruption, and delay that the supply chain must be prepared for.

b) Understanding the supply chain capabilities. There are many types of supply chains, each of which is designed to perform different tasks well. A company must understand what its supply chain is designed to do well.

c) Achieving strategic fit. If mismatch exists between what the supply chain does particularly well and the desired customers needs, the company will either need to restructure the supply chain to support the competitive strategy or alter its competitive strategy.

There is no single magic distribution strategy to solve every company's problems. When selecting which strategies are fit for the company, often we need to utilize a combination of strategies in different sections based on the company's situations, especially for a large company. It does not matter which strategy we select, we need to

consider the company's distribution system as a whole to optimize the overall

performance based on the customer's needs and costs to meet those needs.

## 2.1.1 Selection of Distribution Strategies

The distribution system should be evaluated by two aspects- meeting the customer's

requirements (Service factors) and costs of meeting the customer requirements (Cost

factors). The service factors include response time, product variety, product availability,

customer experience, time to market, order visibility, and returnability. The costs factors

include transportation, holding (inventory and facility), handling, and information costs.

The service and cost factors are described in more detail in Chapter 4.

Table 1 shows a variety of distribution strategies, these distribution strategies all have

different strengths and weaknesses in terms of cost and service factors. A score ranking

of 1 corresponds to the strongest performance while 6 is the weakest. Table 1 lists costs

and service factors of six different distribution strategies performances. While selecting a

strategy, for example, if the response time is important, we find the best one should be

the one score 1, which is retail storage with customer pickup. So this strategy is the best

for have the shortest response time. If we think the product availability is important, from

the table 1 we can find there are three strategies scored 1. We can base on the situation

selecting fit distribution strategy among these three options scored 1.

|  | Retail Storage with Customer Pickup | Manufacturer Storage with Direct Shipping | Manufacturer Storage with In-Transit Merge | Distribution Storage with Carrier Delivery | Distribution storage with last mile delivery | Cross-Docking |
|---|---|---|---|---|---|---|
| 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 1 Comparative Performance of Distribution Storage (Chopra& Meindl, 2007)**

Selecting a distribution strategy also needs to consider product and customer

characteristics. The different distribution strategies fitting for the various situations are

shown in Table 2 : +2=very suitable;+1=somewhat suitable; 0=neutral; -1=somewhat

unsuitable;-2=very unsuitable.  First company needs to identify the product

characteristics, such as, high or low (fast or low) demand, high or low value of the

product, and find which factor matter the most. Then find in Table 2, which strategy

score at least 1, then select the one score more than 1. For example, if the product is a

high demand product, we can see the "Retail storage with customer pickup" score +2, and

is the best strategy for this type of product. The retail storage is very close the customer

location. Only a few companies use a single distribution strategy, most companies use a

combination of distribution strategies based on the product characteristics and strategies.

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| | Retail Storage with Customer Pickup | Manufacturer Storage with Direct Shipping | Manufacturer Storage with In-Transit Merge | Distribution Storage with Package Carrier Delivery | Distribution storage with last mile delivery | Cross-Docking |
|---|---|---|---|---|---|---|
| High demand product | +2 | -2 | -1 | 0 | +1 | -1 |
| Medium demand product | +1 | -1 | 0 | +1 | 0 | 0 |
| Low demand product | -1 | +1 | 0 | +1 | -1 | +1 |
| Very low demand product | -2 | +2 | +1 | 0 | -2 | +1 |
| Many product sources | +1 | -1 | -1 | +2 | +1 | 0 |
| High product value | -1 | +2 | +1 | +1 | 0 | -2 |
| Quick desired response | +2 | -2 | -2 | -1 | +1 | -2 |
| High product variety | -1 | +2 | 0 | +1 | 0 | +2 |
| Low customer effort | -2 | +1 | +2 | +2 | +2 | -1 |

**Table 2 Product and Customer to Distribution Strategies (Chopra& Meindl, 2007)**

# 2.1.2 Risk Pooling

Risk pooling is an important factor to establish framework for selection of distribution strategies (Simchi-Levi and Kaminsky 2003). Risk pooling suggests that demand variability is reduced if one aggregates demand across locations because, as we aggregate demand across different locations, it becomes more likely that high demand from one customer will be offset by low demand from another. This reduction in variability allows a decrease in safety stock and therefore reduces average inventory. In the centralized distribution system described above, the warehouse serves all customers, which leads to a reduction system in variability measured by either the standard deviation or the coefficient of variation. The centralized inventory saves safety stock and average inventory in the system. The benefits from risk pooling depend directly on the relative market behavior: If we compare two markets and when demands from both markets are

more or less than the average demand, we say that the demands from the market are positively correlated. Thus the benefits derived from risk pooling decreases as the correlation between demands from the two markets becomes more positive.

A common metric to capture variability is the coefficient of variation (CV). It is defined as the ratio of the standard deviation $\sigma$ to the mean $\mu$:

$$c_v = \frac{\sigma}{\mu}$$

## 2.1.3 Trade-offs between Service Level and Costs

When selecting a distribution strategy, a company has to find a balance point between service level and costs. Strategic supply chain design and redesign have become a major challenge for firms as they simultaneously try to improve customer service (response time) and reduce operating costs. Although, building a decision-support system that integrates these cost elements with customer service goals is a considerable undertaking for most businesses, doing so can provide a company with a tremendous competitive advantage in the marketplace.

Shen (2005) proposed a more realistic model by adding a service consideration into the supply chain design model. As a result, Shen (2005) designed a multi-objective optimization model that includes the fixed order costs, the fixed transportation costs from a plant to the DCs, and the nonlinear working inventory cost and the nonlinear safety stock inventory cost, resulting from a *(Q, r)* inventory policy with a specified cycle service level requirement. Furthermore, two solution approaches (Shen et al. 2005), one based on the weighting method and the other based on genetic algorithms, are proposed

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to solve this multi-objective model. The genetic algorithm performs very well compared to the weighting method, and it is the only feasible approach for large-sized problem instances, because the weighting method requires excessive computational time in these cases.

## 2.2 Distribution Strategies

Chopra and Meindl (2007) define distribution as the steps taken to move and store a product from supplier to customer. Distribution is a key driver of the overall profitability of a firm because it affects both supply chain costs and the customer experience directly.

Simchi-Levi and Kaminsky (2003) describe various distribution strategies including direct shipment, warehousing, cross-docking, and transshipment. The direct shipment refers to products shipped from the supplier or manufacturer to the retailer or customer without going through distribution centers. Warehousing strategy is a conventional strategy that product moves from plant to warehouse where they are stored. Customers are replenished from the warehouse. Cross-docking strategy is where the products are distributed from the suppliers through a distribution center (DC) by full load truck to customers. The DC in cross-docking strategy keeps products less than 15 hours (Simchi-levi and Kaminsky 2003). Transshipment is defined as that the shipment of products between different facilities at the same level in the supply chain to meet certain immediate needs. We explain the details about each of these strategies next.

## 2.2.1 Direct shipment

Direct shipment bypasses warehouse and distribution centers, and manufacturers directly delivery products to customers. The direct shipment avoids the cost of running a distribution center, and lead time will be reduced.

There are several drawbacks for using the direct shipment, the first is risk-pooling (See 2.1.2) effects are negative because direct shipment is a decentralized system and needs to have higher inventory. The second is the manufacturing and distributor transportation cost increase because it must send LTL trucks to more locations. When the lead times are critical for the company and customer, the direct shipment may dominate. There are two types of direct shipments which are described as the following sections:

### 2.2.1.1    Manufacturer Storage With Direct Shipping

The structure of manufacturer storage with direct shipping (Pure direct shipping) is shown in Figure 1.

In this option, the order information flows from the customers, via dealers, to the manufacturer. For dealer, the biggest advantage is the ability of centralizing inventories at the manufacturer's site. A manufacturer can aggregate demand for all dealers that it supplies. The system can offer a high level of product availability with low level of inventory for dealers. This strategy also offers the manufacturer the chance to postpone customization until after a customer has placed an order. Thus further lowers inventory level and cost.
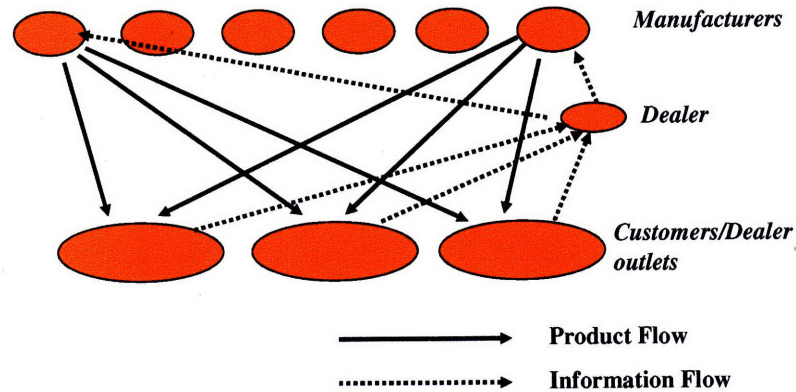
**Figure 1 Manufacturer Storage with Direct Shipping (Chopra& Meindl, 2007)**

The issue for this configuration is the ownership structure of the inventory at the manufacturer. When the inventory is stored at a manufacturer's site, when and who (dealer or manufacturer) owns the inventory is difficult to decide. The benefits of this strategy are achieved only if the manufacturer can allocate the inventory to the individual dealers.

Fixed costs of facilities are saved in dealers, because all inventories are stored at the manufacturer. This removes the need for other warehousing space and transfers of product from manufacturer to dealer's warehouse. When the customer demand increased dramatically, and the manufacturer has tremendous pressure to find enough space to store the products.

A good information infrastructure is required between manufacturer and dealers, so it needs significant investment in information infrastructure. The response time is long, if

the customer orders products from multiple plants, the receiving is more complicated for the customer. This strategy can have a difficulty when handling returns, thus hurting customer satisfaction. Direct shipping is best suited for a large variety of low-demand, high-value items for which customers are willing to wait for delivery and accept several partial shipments. This strategy also fits postponement customization strategies. There should be few sourcing locations per order.

## 2.2.1.2    Direct Shipping and In-Transit Merge

As show in Figure 2, this strategy ships multiple products in a single order from different locations and merges them into a single delivery. This approach has the significant benefits for products with high value whose demand is difficult to forecast, because it can use the postponed strategy to match the uncertainty demand.
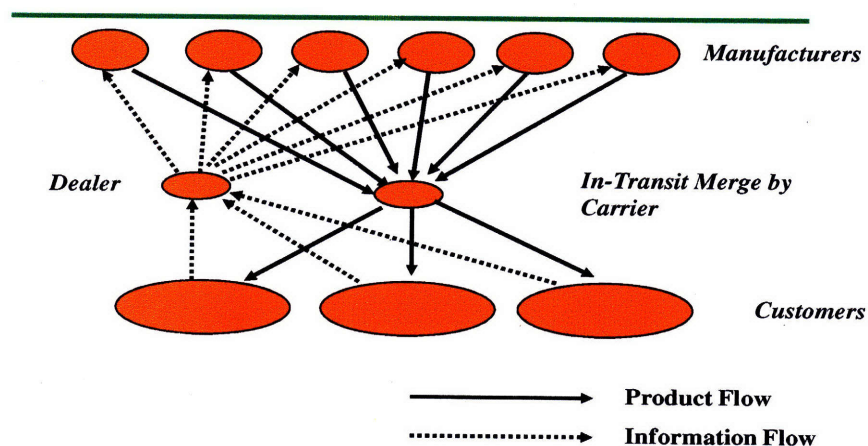
**Figure 2 Direct Shipping In-Transit Merge (Chopra& Meindl, 2007)**

A very sophisticated information infrastructure is needed to allow in-transit merge, therefore costs higher than pure direct shipping. Receiving costs are lower due to a single delivery is received, customer experience is better than pure direct shipping.

The major advantages of in-transit merge over pure direct shipping are lower transportation cost and improved customer experience and satisfaction. The main disadvantage is the additional effort needed to manage for the in-transit merge system. The system is suit for low-to medium-demand, high-value items. Customer can receive a single delivery of multiple high-value and low demand items, and willing to wait a longer response time.

## 2.2.2 Warehousing

This strategy is the traditional strategy where the dealer's warehouse stores products and ships the product when customers (end users) order. This strategy includes the centralized (a few Distribution Center) and decentralized systems (many DCs close to customer's locations).

### 2.2.2.1    Distribution Storage with Carrier Delivery

In this strategy, inventory is held at the warehouse, and the package carriers are used to move products from warehouse, as shown in Figure 3. From an inventory perspective, distribution storage is suited for products with higher demand. Transportation costs are lower for distribution storage compared to manufacturer storage, especially on fast moving items.

This strategy has higher processing costs than manufacturer storage, and facility costs are high. This strategy is not fit for slow-moving products.

The information system is much less complex than that needed for manufacturer storage. The response time of this strategy is better than that of manufacturer storage. This strategy fits well for medium to fast moving products.



Manufacturers

Warehouse Storage

Customers

→ Product Flow
····▶ Information Flow
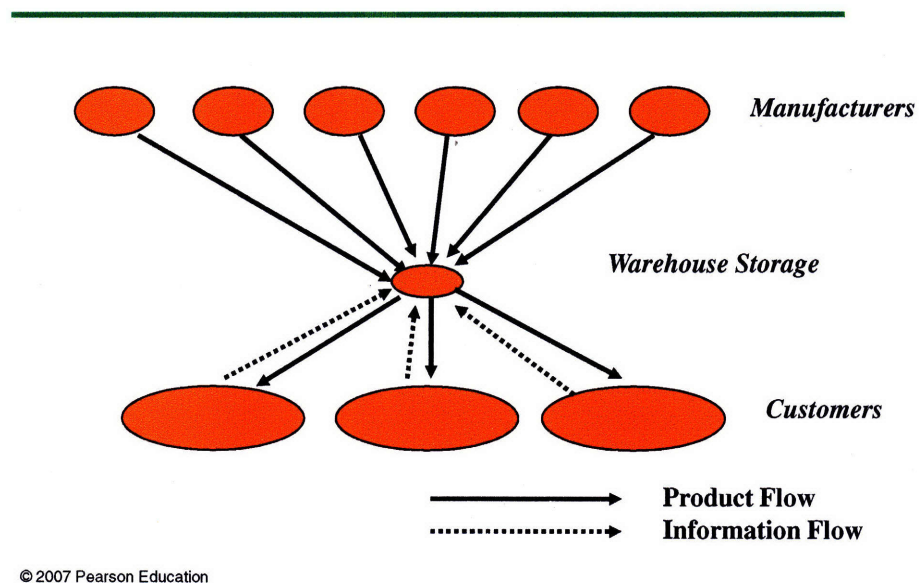
**Figure 3 Distribution Storage with Carrier Delivery (Chopra& Meindl, 2007)**

## 2.2.2.2     Distribution Storage with Last-Mile Delivery

This strategy is where a dealer delivers to the customer's home instead of using a package carrier, as shown in Figure 4. The main benefit for this strategy is to bring the customer the convenience and flexibility. In order to make profit, the customer orders need to be large enough to provide economies of scale.
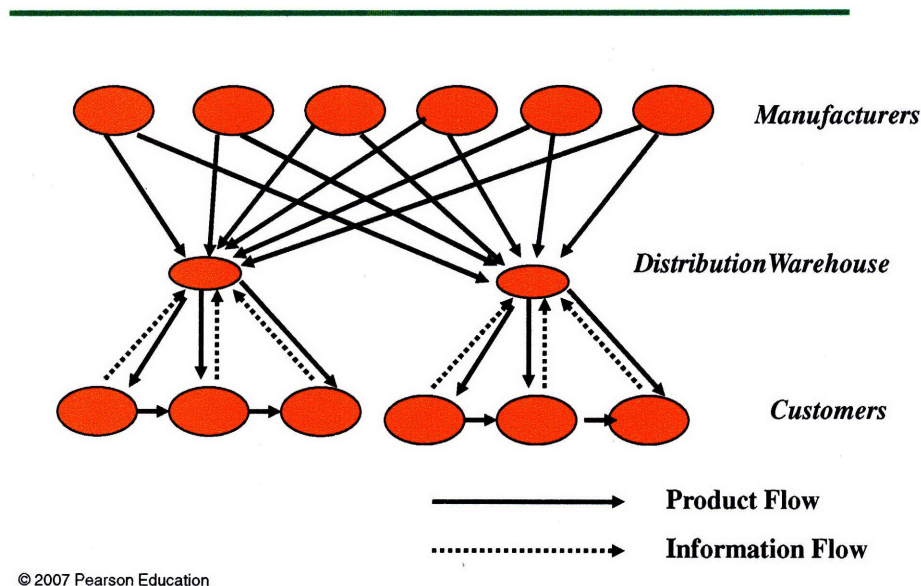
**Figure 4 Distribution Storage with Last Mile Delivery (Chopra& Meindl, 2007)**

## 2.2.3 Cross-Docking

Cross-Docking is a strategy that is used by many retailers, such as Wal-Mart and 7/Eleven. In this system, warehouses function as inventory coordination points rather than as inventory storage points. In cross-docking systems, products arrive at warehouses from the manufacturer, are transferred to vehicles servicing the customers, and are delivered to the retailers as rapidly as possible. Goods spend very little time in storage at the warehouse-often less than 15 hours. This system limits inventory costs and decreases lead times by decreasing storage time. Cross-docking systems require a large investment and are difficult to manage. For Cross-docking, distribution centers, retailers, and suppliers must be linked with an advanced information system to share the required information. Cross-docking also requires a fast and responsive transportation system.

Cross–docking is effective only for large distribution systems, which have a large number of vehicles for delivery.
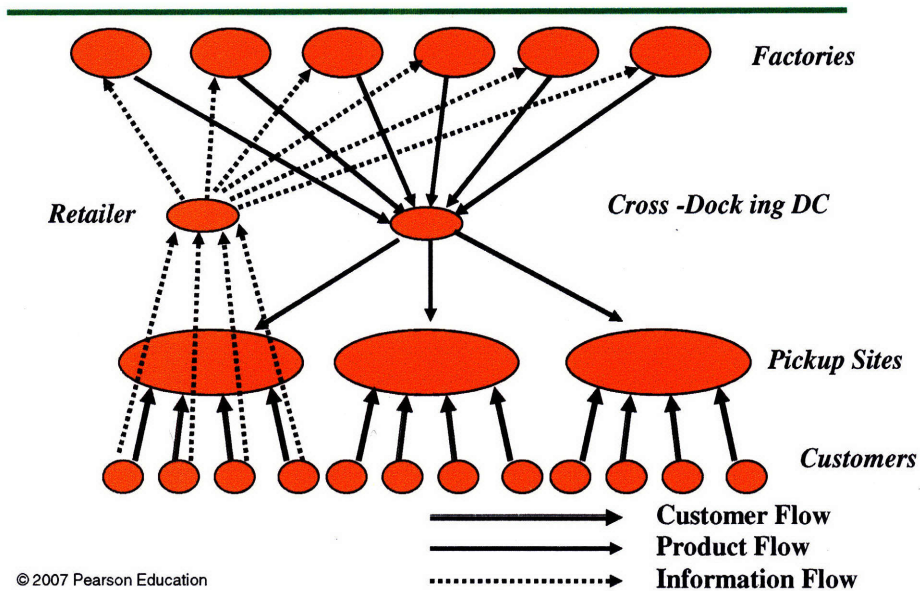


**Figure 5 Cross-Docking (Chopra& Meindl, 2007)**

## 2.2.4 Transshipment

The progress of prompt transportation alternatives and advanced information system has made transshipment an possible important distribution strategy. Transshipment denotes the shipment of items between different facilities at the same level in the supply chain to meet customer immediate need.

Normally, transshipment is considered at the retail level, and it allows the retailer to meet the customer demand from the inventory of other retailers. In order to do this, the other retailer must have the product in hand and have a quick way to ship the product to the customer. Only through an advanced information system, the retailer can see the other

retailer's inventory information and track the shipment of the other retailers. The advanced information system links the whole retailer locations together as a single system.

Transshipment is effectively taking advantage of risk-pooling, though without centralized large warehouse, because we can view inventory in the other different retail facilities as part of one large, single pool link all together by an advanced information system.

Transshipment distribution strategy only fits well when all retail facilities are owned by the same company. If retail facilities are separately owned, transshipment is not a good selection because they will be helping their competitors.

# 3 Seed Corp's Background

Seed Corp provides agricultural products for farmers primarily in the United States. It operates in two sections: Seeds and Genomics, and Agricultural Productivity. The Seeds and Genomics section manufactures corn, soybeans, canola, and cotton seeds, as well as vegetable and fruit seeds, including tomato, pepper, eggplant, melon, cucumber, pumpkin, squash, beans, broccoli, onions, and lettuce. This section also develops biotechnology traits that assist farmers in controlling insects and weeds, as well as supply genetic material and biotechnology traits to other seed companies for their seed brands. The company sells its products through distributors, independent retailers, dealers, agricultural co-operatives, plant raisers, and agents to farmers, agricultural chemical producers, and dairy farmers.

This case only focuses on corn operation at Seed Corp in North American. Seed Corp manufactures seed at their plants and distributes them through dealers located across the US. During the peak season, the company arranges trucks to ship harvested seeds from farm suppliers to manufacturing plants. The raw seeds are processed, packed, and stored in warehouses. Each manufacturing plant has its own warehouse acting as a Distribution center. Some of these bags are shipped to the other plant's warehouses or offsite warehouses where close to the customer's locations. At the same time, the manufacturing plant's warehouse also receives other breed of corn seeds from the other offsite warehouses or manufacturing plant locations where the different types of corn seeds were processed. As orders come in from the dealers, the seeds are shipped directly from plants or offsite warehouses to the dealer's outlet locations.

The entire timeline, shown in Figure 6, for harvest and manufacturing of seeds is compressed within six months. Harvesting occurs from August to October while manufacturing and packing occurs from August to January.
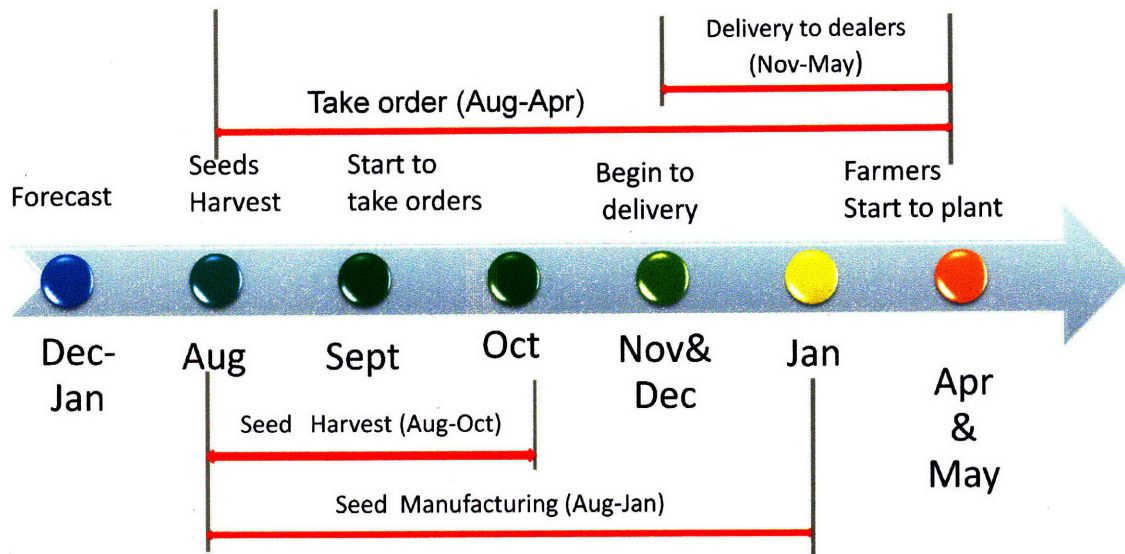


**Figure 6 Timeline of the Company's Operation**

Unfortunately while all seeds are started produced in August, dealers do not want to receive the seeds until next Spring.

During delivery peak time (Jan and Feb), almost all shipments are full truckloads. There are 113 trucks per day, average of 215 miles per shipment based on the distance to 8-10 The company plants. Each year, September to October is the seed harvest period at the company, the manufacturing period is from September to the next year January.

After having the order, the company checks the inventory and the dock space, goes to customer service confirms customer demand and ships to customer (The same day or the next day delivery). Payment is often due on June 25th each year.

The monthly percentage of total tasks complete for harvest, manufacturing, and delivery.
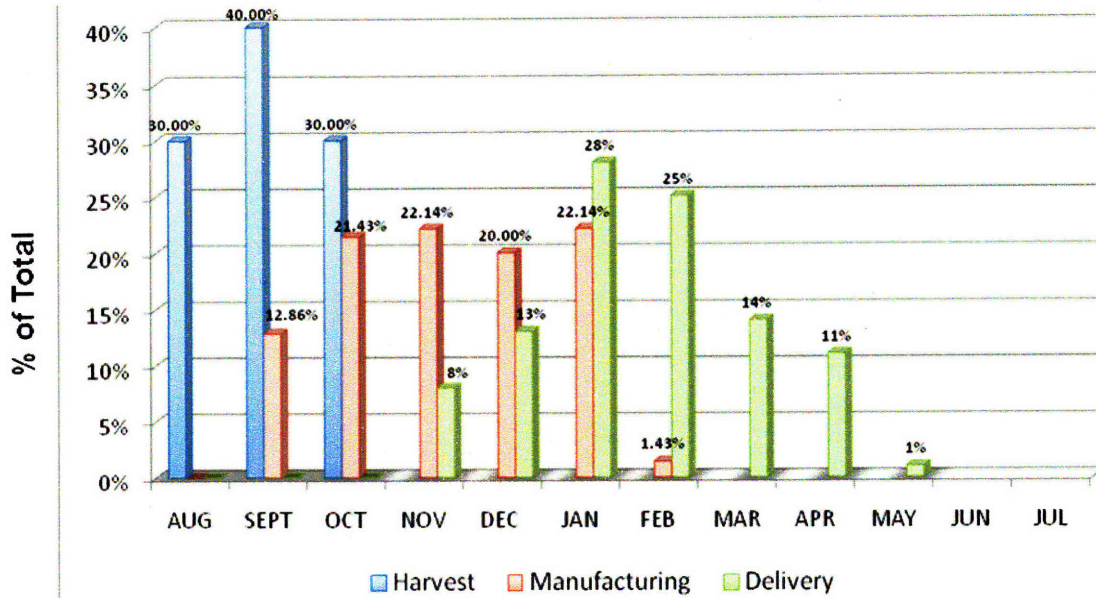


**Figure 7 Units Monthly Shipment (% of Total)**

As it shows on the Figure 7, the manufacturing keeps a similar productivity rate for four months from October to January. Though the delivery time starts in November, the shipment peak time is January and February (Total shipped 57%). After May, the customer does not want any delivery because it's past the planting season.

For the past several years, the corn seed demand has been extremely strong due to increasing demand of ethanol. Due to the dealer shelf space limitation, the company has to use the offsite warehouse (Rent or contract). Total shelf space of dealers is still unknown for the company. Seed Corp's existing distribution system was designed based on the situation 10 years ago, and now the company has a much higher demand than

expected each year. As it shown in Table 3, the demand increased by 50% in 2006

compares that in 2005.

**Table 3 Customer Demand History and Forecast of Seed demand**

| Year | 2004 | 2005 | 2006 | 2007 ... | 2012 |
|------|------|------|------|----------|------|
| Seed | 5 | 6.1 | 9.2 | 11 | 16 |

(Unit: million bags)

Each manufacturing plant has an onsite warehouse, but many onsite warehouses store

seeds shipped from the other plant and do not store most of the seeds which

manufactured by that local plant. The onsite warehouse of the plant functions as a DC

(distribution center). The limited warehouse spaces and locations became a challenge in

delivering the right seeds to the right customers in correct quantity in the right time

during peak season, while the demand is increasing the recent years.

The main distribution channel is the seeds are shipped from manufacturing plant to

dealers, then the dealers shipped the seed to the farmers, and counts for 62.8% of total

OB (outbound) shipment.4,000 dealers support around 40,000 farmers.

There are two main types of transportation movements of products for Seed Corp:

inter-plant (IP) moves and outbound (OB) moves as show in Figure 8. The IP movements

include movements from plants to plants, from plants to offsite warehouses, and from

offsite warehouses to plants. Seed Corp's manufacturing locations were selected based on

the optimal production output of the field. Each manufacturing plant has its own onsite

warehouses, large numbers of Seed Corp's customers are not close the manufacturing

plant in which these types of seeds are not manufactured. In order to close to customer's locations, there are many transfers between plant and plant, and plants and offsite warehouses.

a) 39.3% of total IP movements are transported between plant to plant;

b) 38.7% of the total IP movements are transferred from plant to offsite warehouse;

c) 22% of the total IP movements are moved from offsite warehouse to plant;

The top outbound movements at the company are:

a) 62.8% of total outbound shipments are shipped from plant to dealer;

b) 37.2% of total outbound shipments are transported from offsite warehouse to dealer.
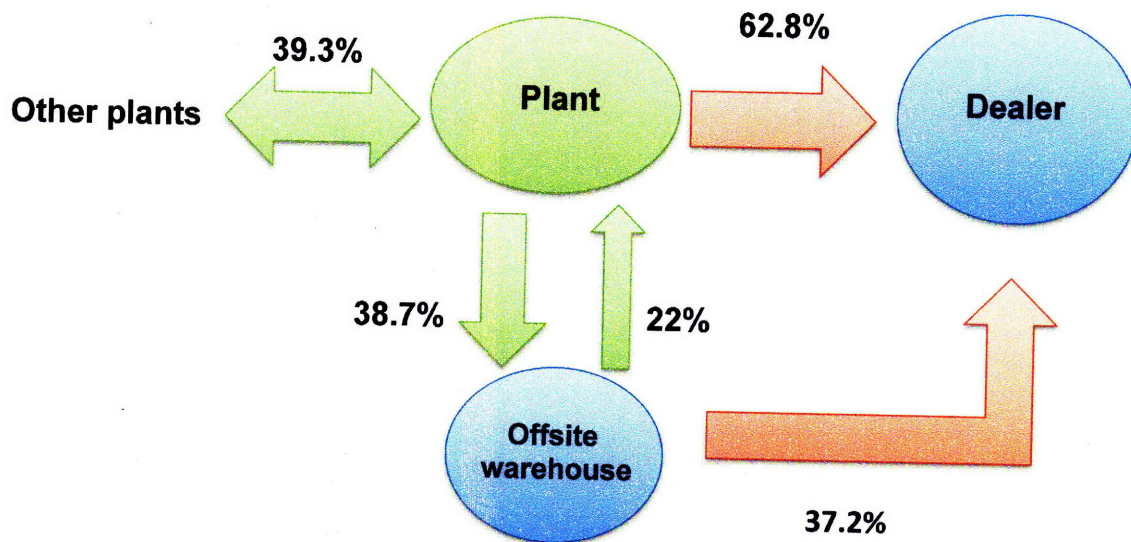


**Figure 8 Products Transportation Movement**

**(Red=OB, Green= IP)**

In Figure 9 shows Seed Corp's customer location distribution map. Most of Seed Corp's customers are located in east and mid-north in the US. The most density zone is the area around Chicago. Each year, Seed Corp ships products to close to 3,000 customer locations with average small shipment quantity: 3 truck loads /year /dealer.



**Figure 9 Dealer Location Distribution Map**

Seed Corp's transportation activities principally focus on the outbound transportations-dock to dock, point to point, DC to plant, and delivery to customer. Most vehicles are dry van standard 53 feet units carrying 750-900 bags (80,000 seeds per bag).

After packaging, some of the final seeds store in the temperature controlled warehouses onsite. Some of them directly ship to customers and the other plants' warehouses and offsite warehouses. Also the company has offsite warehouses to handle the storage and delivery.

The manufacturing capability is 150-140 FTL (Full Truckload) to deliver to dealer per day. The plant will only ship full truckloads, in order to avoid the LTL (Less Than Full Truckload).

# 4 Distribution Case Analysis

We examine three different scenarios:

a) As-is: This is the manufacturing centric approach (Manufacturing Focused) and Seed Corp's existing system. Each manufacturing plant has its onsite warehouse. The onsite warehouse also receives large partial of the products from the other warehouses and plants; most of the products are shipped from onsite warehouse to dealer's outlet locations.

b) Centralized DC: Ignoring product characteristics, we examine the benefits and cost for setting up a single DC; Regional DC: establishing a number of DC's, based on cluster locations. In this case we describe three clusters and five clusters models

c) Hybrid Distribution Network: Considering the different product characteristics we create a fast and slow moving net work

This case analysis first evaluates the DC models and answers the questions about whether having the large Distribution Center is a good fit the company's current situations- demand dramatically grow each year and does not have enough warehouse spaces to store the product during the peak time. The manufacturing plant has a great challenge to face not only increasing production but also large workload to handle the shipment to dealers during the peak time. The analysis only roughly compares the costs of the four main distribution strategies. The case analysis does not confirm the existing supply chain model, as well as not developing a new supply chain model. This analysis

does also not discuss details about the where to locate or how many DCs are required. The case analysis need to answer the question about whether using the large DCs model a good fit for the company's situation.

To answer this critical question, we mainly compare the key cost and service factors which include transportation costs, handling costs, and response time.

One of the traditional strategies is centralized warehousing distribution. If the company selects this strategy, they must decide whether to use centralized distribution system or decentralized distribution system: numbers and locations of DCs .The warehousing distribution strategies include two main parts-the centralized system with large DCs and decentralized system has warehouses close to manufacturing sites. We collected one year of data for Seed Corp. The data we collected include the shipment quantity, ship from location, ship to location, and date, etc.

In order to compare the costs between centralized to decentralized distribution systems (Seed Corp's current system), we estimated the transportation and handling costs. Due to the characteristics of Seed Corp's products and industry, the holding and information costs for different distribution strategies are nearly the same. To calculate the transportation costs, we need to get the distance, shipment quantity, and transportation rate.

To select appropriate strategies to fit Seed Corp's circumstances, the company needs to consider cost factors and service factors. In this case, the most important factors are total logistics cost (TC), and Response time (service factors). We set a response time and minimize the total cost. In this case, we assume existing system's response time is the set

time. The cost factors include transportation, holding, handling, and information cost. This case analysis does not consider risk pooling; because Seed Corp has harvested, packed, and stored all the seed in the warehouses in six months before the peak customer demand in spring season, as the result, the inventory level is always high and has little risk pooling effects. Because the holding and information costs are similar for both decentralized and centralized system, this thesis does not compare the holding and information costs of system. The service factors consist of response time, product availability, and product returnability, etc. For Seed Corp's situation, we mainly focus on the response time analysis mainly in the term of distance to customer's location. The following sections discuss details about trade-offs between centralized and decentralized systems, the cost factors, and service factors.

# 4.1 Trade-offs between Centralized and Decentralized Systems

In this section, we discuss the trade-offs between the centralized and decentralized systems based on general situations not from this specific case. A centralized system has fewer warehouses than a decentralized system; Also centralized systems have larger warehouses. In general, as the following figure 11 shows:
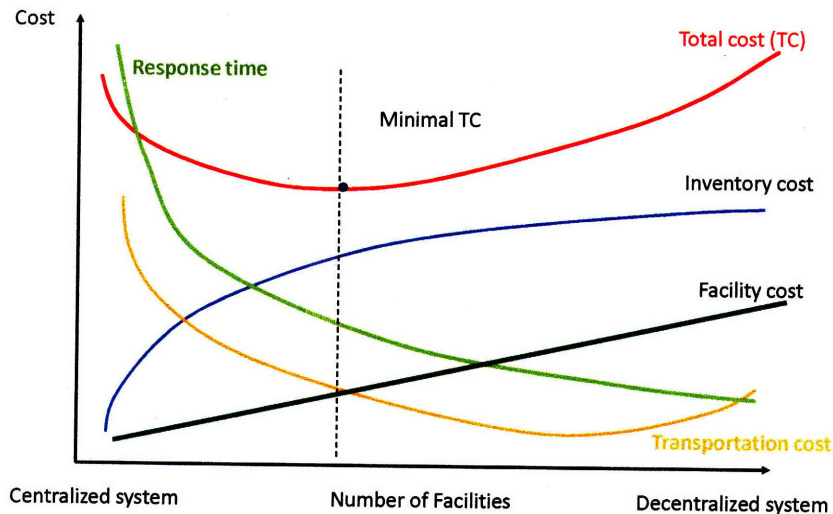
**Figure 10 Trade-offs between Centralized and Decentralized Systems (Chopra& Meindl, 2007)**

For the centralized system, while the total cost decrease while the number of facilities increased, due to the transportation cost decrease dominates the total cost. When the number of facilities continuously increase, the increase costs of inventory and facility cost starts to be dominating the total cost, soon the total cost reaches to the minimal point; increasing number of the facilities is not longer decreasing the total cost.

Both facilities and inventory costs increase in the decentralized system

Transportation costs depend on the circumstances. On one side, due to the decentralized system having more warehouse locations close to customers, the outbound transportation costs of decentralized system are lower than these of the centralized system. On the other side, for the inbound transportation(ship the products from the supply and manufacturing plants to the warehouses, there are two types of the situations in the

decentralized system: one case is the warehouses still have some distances to the manufacturing plants, the other case is the warehouses are located in the same location with manufacturing sites. For the warehouses not close to the manufacturing plants, the inbound transportation costs in the decentralized system are higher than these in the centralized system. If the warehouses are close to or within manufacturing building, the inbound costs decrease, the actual costs need to be based on the actual data to compare costs of the decentralized system to these of the centralized system.

Safety stock will decreased when the company changes from the decentralized to centralized distribution system. Lower safety stock means lower holding costs because they are holding smaller number of products in the warehouse.

Overhead and inventory costs are less in a centralized system due to the economies of scale and risk pooling.

For the same response time, a decentralized system costs less since the warehouses are much closer to the customers than a centralized system.

## 4.2   Costs Factors

In order to move product from production to customer, the operation incurs costs related to "motion" and "holding". Motion costs are classified as either handling costs or transportation costs. Handling costs include packaging and loading costs. Holding costs include storage costs and inventory costs. A total cost (TC) function is a mathematical expression of the sum of the related costs which are classified in categories. TC is defined

in relation to time periods or product quantity. The time periods can be week, month, or year. The thesis studies on the costs per year.

The TC formula as the following:

$$TC = C_t + C_h + C_{ho} \qquad (1)$$

Where:

TC=Total Cost per period ($ /year)

$C_t$ = Transportation Cost per period ($/year)

$C_h$ =Handling Cost per period ($/year)

$C_{ho}$ =Holding Cost per period ($/year)

The handling cost is related to upload and unload the products. The holding costs include facility, storage and inventory costs.

Typically, the costs include two main parts: fixed costs and variable costs. Fixed costs are related to the system configuration and are un-changed in time while the variable costs depend on the level of resources required to operate the system.

To simplify Seed Corp's costs calculation, for all the distribution strategies, we assume holding costs are the same because Seed Corp manufactures all the products in six months, the inventory level per month for all the distribution strategies is the same. Therefore, for comparison of the TC of different distribution strategies, we primarily compare the $C_t$ and $C_h$.

## 4.2.1 Transportation Costs

When we transfer products from one location to another location, expenses occur by using the vehicles, gasoline, and drivers to ship the products. These costs are transportation costs.

In order to compute transportation costs, we need to have the number of full load track from one point to another point and the distance between these two points. Depending on the strategy, normally the transportation costs include the costs related to move products from manufacturing plants to customers (Dealers). Fixed costs are surcharge per trip. Variable costs are the company transportation pay rate to have other companies to offer the service.

$$C_t = \sum_{ij} C_{ij} N_{ij} \qquad (2)$$

$$C_{ij} = Max[250, D_{ij}C_v + C_f] \qquad (3)$$

Where

$C_{ij}$ = Transportation cost per period between point i and j ($/year)

$C_f$ = Fixed transportation cost per FTL ($/FTL)

$C_v$ = Variable transportation cost ($/mile/truck)

$D_{ij}$ = Travel distance from point i to j (mile)

$N_{ij}$ = Number of full truck load between point i to j

In Seed Corp's Case, we assume $C_f$: \$50, $C_t$'s minimum charge: \$250,

$C_v$ :\$1.5/mile/Truck. For different strategies, the travelled distance is the key metric for

compute the transportation costs.

## 4.2.2 Handling Costs

Each time where there is a shipment, there are handling costs while we have the

charge to load and unload the products.

Handling costs include the handling equipment and labor cost. The equipment costs

are considered fixed costs, and labor costs are variable costs.

Fixed handling costs are determined by the number of handling equipment cost and

the depreciation cost. Variable costs are determined by labor and overhead costs required

to load and unload the products.

$$C_h = C_{fh} + C_{vh}D\ Q_h \qquad (4)$$

Where

$C_h$ = Handling cost per period (\$/Year)

$C_{fh}$ = Fixed costs per handling unit per period (\$/Year)

$C_{vh}$ = Variable handling costs per bag per time (\$/Bag/time)

$D$ = Demand per period (bag/Year)

$Q_h$= Total times of handling per bag (times/bag).

In this research of Seed Corp case, we focus on the decentralized and centralized system. We assume Seed Corp sold all corn seed each year, for all the possible distribution strategies use the same handling equipment. So the fixed cost of handling for both of the systems are similar, same labor pay rate, similar handling equipment, and the same total quantity of products need to be handled. Therefore, for comparison, we compare the times of the product had been handled. When use the DCs models: one DC, three DCs, and five DCs configurations, the product movements are the same: moving from plant to DC, then from DC to dealer. Thus the handling costs for all the DC models are the same. For existing system, the movement more complicated, so the handling costs of existing system are higher than these of DC models. The hybrid system only moves slow moving items are handled by four times, the fast moving items are only handled two times, directly shipped from plants to dealer locations. So the hybrid system has the lowest handling costs among all the other strategies. In order to compare the handling costs, we assume the total fixed costs( $C_f R$) for all the distribution configurations are the same $C_{vh}$= \$25/hour, each person can load or unload 400 bags/hour.

## 4.2.3 Holding Costs

For the Manufacturing based, DC based, and Hybrid distribution strategies the holding costs are the same. For the demand shaping strategy, the holding costs are various due to the gap changes by offering price discount. The first part of holding costs includes the rent, equipment depreciation, maintenance and overhead for the warehouses facilities. The second part of the holding costs is inventory costs, which include the opportunity cost of capital invested in cycle inventory and safety stock in the warehouses and in-transit inventory. In order to simplify the calculation of holding costs, we assumed

the holding cost is around 25% of the value of the products. The product price range $200-250/bag, assumed cost for the company is 50% of the sale price, the unit variable cost per bag is $100-125/bag. We further assume the value of one bag is the average is $112.5/bag.

$$C_{ho} = \bar{I}vr \qquad (5)$$

Where

$\bar{I}$=Average Inventory in units per period

v=Unit Variable Cost $/Unit

r=Carrying Charge $/$/Unit

Because Seed Corp manufactured all its products in six months and the monthly shipment is the same for all decentralized and centralized system, the holding costs are the same.

In order to obtain the holding costs, we assume the company sold all the products it made and carry charge r is 0.25 of the total value of the product. The manufacturing time is August to January each year, and the delivery starts in October and ends in May. We compute the monthly quantity of shipment, then, we aggregate monthly production quantity to calculate the monthly inventory. Based on these assumptions and data, using the number from Seed Corp and the formula (6), r=0.25, v=$112.5.We can compute the average inventory/month based on the table data, and calculate the holding costs for all the distribution strategies, use the formula (5), the monthly inventory

Monthly inventory= QTY (quantity) of accumulate production- QTY of shipped

Then we can get the average inventory: 1,702,386, so $C_{ho}=\bar{I}vr=1,702,386*112*0.25$, the total holding costs are $47,879,616.

## 4.3 Service Factors

The service factors include response time, product variety, product availability, returnability, customer experience, time to market, and order visibility. Our key metric will be the response time, which is the amount of time the company takes for a customer to get an order. Product variety is the number of product configurations that are offer by the distribution system. Product availability is the probability of having a product in stock when a customer places an order. Returnability is the ease with which a customer can return unsatisfactory product and the ability of the supply chain system to handle such returns. Customer experience is the ease with a customer can place and receive an orders as well as the extent to which this experience is customized. Time to market is the time company takes to introduce a new product to the market. Order visibility is the ability of customers to track their orders.

Service level is the measurement to quantify a firm's market conformance. In reality, service level can vary from firm by firm, it is generally related to the capability of satisfaction a customer's delivery date, such as response time. A certain level of service directly relate to the supply chain cost and performance.

For example, Seed Corp situations, a customer wants to have many choices of the seed; when the time close to plant season, a customer wants to the product available right

away; Time to market is important to customer. The order visibility is not important to customer.

## 4.4 Analysis of Seed Corp's Existing System

Seed Corp's existing system (As is) is a manufacturing focused distribution system. To compare the costs of this distribution system to those of the other systems, we will compare transportation costs and handling costs.

First we calculate the transportation costs. Based on the data collected from Seed Corp, from the zip code we found the latitude and longitude of each location including dealers, manufacturing plants, and warehouses (DCs). In order to calculate the transportation costs, we need to know the distance. We have Zip Codes of Seed Corp's dealer locations, use Zip Code as input, we can locate the latitude and longitude of each dealer location. If we know the latitudes and longitudes of two points, use the following formula we can obtain the distance –D (Mile):

$$D=3959(ACOS(SIN(Lat1/57.3)SIN(Lat2/57.3)+COS(Lat1/57.3)COS(lat2/57.3)COS($$

$$ABS(Long1-Long2)/57.3))) \qquad (6)$$

Where:

Lat1=latitude of point1

Lat2 =latitude of point 2

Long1=longitude of point1

Long2=longitude of point2

Using formula (6), we can get individual distance from plants to dealers, offsite

warehouses to dealers, plants to plants, plant to offsite warehouses, offsite warehouses to

plants. Then transportation costs are computed based on the above shipping movements.

We have the total quantity of shipment for each of the movement and transportation rate

and surcharge of the fixed cost mentioned in 4.2.1, By using the formula (2) and (3) in

4.2.1, the detailed transportation breakdown show as the table 4, then we obtain the total

transportation costs for shipment: **$ 6,905815/year.**

In this case, we do not calculate the inbound transportation costs from suppliers (raw

seed supply farmers) to manufacturing plants. It does not matter whether there is

centralized or decentralized distribution system, because manufacturing plant locations

are fixed, costs from suppliers to the manufacturing plants are the same for each of the

distribution strategy.

| | Plant to Plant(IP) | Plant to DC(IP) | DC to Plant(IP) | DC to Dealer(OB) | Plant to Dealer(OB) | Total |
|---|---|---|---|---|---|---|
| Transportation Costs | $ 1,852,126 | $ 1,184,597 | $ 537,850 | $ 1,127,165 | $ 2,204,077 | $6,905,815 |

Table 4 Transportation Costs for "As is"

Next, we calculate the handling cost. For each movement, each bag is handled two

times: load and unload seed bags. Some bags were handled by four times: such as

shipping from plant to DC, then from DC to dealer. Based on the assumptions in 4.2.2

and the formula (4) we only compute the variable handling costs: $C_{vh}D \ Q_h = \$1,863,546$.

# 4.5  Analysis the Centralized Distribution System

Centralized Distribution Systems generally includes several numbers of the DCs, most of the distribution activities happen in the DCs. In this section, based on the Seed Corp's data analyze three DC models: One large DC, Three DCs, and Five DCs.

## 4.5.1 Single Location Using the Center of Gravity Method

First, applying current collected data, we design an extreme model using centralized distribution system, the whole distribution system only have one large DC, all plants ship the finished products to this single DC, and then all the products are shipped from this single DC to dealers (customers). Use the gravity location model approach to define the total cost.

The location of this central DC is based on customer locations and we use a single gravity model to find this location by minimizing the transportation costs. Gravity models are used to find locations, that minimize the cost of transport. Gravity models assume that both the markets and the supply sources can be located as grid points on a plane. All distances are calculated as the geometric distance between two points on the plane. The models also assume that the transportation cost grows linearly with quantity shipped. Use the customer location's zip code, to find latitude and longitude (http://www.batchgeocode.com/), then we use formula (7) and (8) to calculate the latitude and longitude of gravity center.

The formula as the following:

$$\bar{X} = \frac{\sum_i ViXi}{\sum_i Vi} \tag{7}$$

and

$$\bar{Y} = \frac{\sum_i ViYi}{\sum_i Vi} \tag{8}$$

Where

$\bar{X}$ = the Latitude of the gravity center

$\bar{Y}$ = the Longitude of gravity center,

$X_i$ = the latitude at point i

$Y_i$ = the Longitude at point i

$V_i$ = shipment quantity at point i

We used 3 digit zip code regions for this analysis. There are 398 of them. We first determined the center for each region, the most customer centric location is found to be at Latitude=$\bar{X}$ =41.41411, Longitude=$\bar{Y}$=-92.1558, the place located at Webster, IA 52355, where located 270 miles west of Chicago in Figure 11

**Figure 11 Single DC Location Map**

Because there are close to 3000 different dealer locations, we group areas by having the same first three digits zip code zone. The number of areas reduced to close to 400, and add the total quantity shipped together for each 3- Zip-Code Zone.

We use the formula (6) in 3.2.3 to compute the distance between the DCs to each 3zipcode zone. Then we apply the formula (2) and (3) in 4.2.1 to get the transportation costs from the plant to DC : $3,121,879, and from DC to dealer: $4,661,895.Then we calculate the total transport costs: $7,783,774.

For computing handling costs, we employ formula (4) and assumptions in 4.2.2, all the seed bags are handled two times from plants to DC and then two times from DC to dealers. The total handling costs for DC model =Labor rate *Handling times*total bags handled/ bags handled per person per hour=25*4*8,258,011/400= **$2,064,503/year.**

The total transportation and handling costs for a single DC are

**$7,783,774+$2,064,503=$9,848,277/year.**

## 4.5.2 Multiple Locations using K-Means Cluster Analysis

In order to roughly estimate the total costs, we tested three to five DCs, we use K-mean cluster analysis to identify the locations. We analyze two options: three DCs and five DCs, there two options is between the one single DC and existing decentralized system. By estimating three DCs and Five DCs, we can find costs change trend from Centralized system (One DC) to Decentralized system (the existing system several plants with own warehouses and small local DCs)

Clustering algorithms include both hierarchical and partitional algorithms. K-means cluster is a partitional cluster. The $K$-means algorithm assigns each point to the cluster whose center (also called the centroid) is nearest. The center is the average of all the points in the cluster — that is, its coordinates are the arithmetic mean for each dimension separately over all the points in the cluster.

The algorithm steps are (J. MacQueen, 1967):

a) Choose the number of clusters, $k$.

b) Randomly generate $k$ clusters and determine the cluster centers, or directly generate $k$ random points as cluster centers.

c) Assign each point to the nearest cluster center.

d) Re-compute the new cluster centers.

e) Repeat the two previous steps until some convergence criterion is met (usually that the assignment hasn't changed).

The main advantages of this algorithm are its simplicity and speed which allows it to run on large datasets. Its disadvantage is that it does not yield the same result with each run, since the resulting clusters depend on the initial random assignments. It minimizes intra-cluster variance, but does not ensure that the result has a global minimum of variance.

This K-Means Cluster Analysis attempts to identify relatively homogeneous groups of cases based on selected characteristics, using an algorithm that can handle large numbers of cases ( SPSS K-means analysis 2007). The algorithm requires to specify the number of clusters. In this case initial number of cluster centers is 3 and 5. The K-Means Cluster has two methods for classifying cases, either updating cluster centers iteratively or classifying only. We can save cluster membership, distance information, and final cluster centers. Optionally, we may specify a variable whose values are used to label case wise output. (SPSS K-means analysis 2007)

There are several main assumptions: distances are computed using simple Euclidean distance. If we want to use another distance or similarity measure, we can use the Hierarchical Cluster Analysis procedure. Scaling of variables is an important consideration--if variables are measured on different scales, the results may be misleading. In such cases, we should consider standardizing your variables before you perform the k-means cluster analysis (this can be done in the Descriptive procedure). The procedure assumes that we have selected the appropriate number of clusters and that we have included all relevant variables. If we have chosen an inappropriate number of

clusters or omitted important variables, the results may be misleading (SPSS K-means analysis 2007).

## 4.5.3 Three DC Analysis

We used the SPSS software and select K-means cluster method to located the three cluster DC locations, then calculate each DC transportation costs to dealers. At the same time, we also calculated the transportation costs from plant to the three DCs. DC1 counts for 39.45% total number of products sold, DC2 count for 12.21%, and DC3 count for 48.35%. We assume each manufacturing plant ships the same percentage of its total number of products to each DC. Then using the formula (2) and (3) in 4.2.1, we calculate the transportation costs from three DCs to Dealers and from plants to three DCs, the total transportation costs from plant to DC: $8,246,621. The following table 5 shows the specific transportation costs break down of three DCs', figure 12. The activities located in the DC #3 counted for almost half of the overall activities.

| Centers | 1 | 2 | 3 | |
|---|---|---|---|---|
| Lat | 42.48 | 38.44 | 40.05 | |
| Long | -98.19 | -81.43 | -90.8 | Total Costs |
| Costs from plant to DC | $ 2,271,184 | $ 989,816 | $ 1,591,883 | $4,852,883 |
| From DC to dealer | $ 1,226,755 | $ 568,971 | $ 1,598,011 | $3,393,737 |
| % total customers | 31.34% | 23.54% | 45.12% | $8,246,621 |

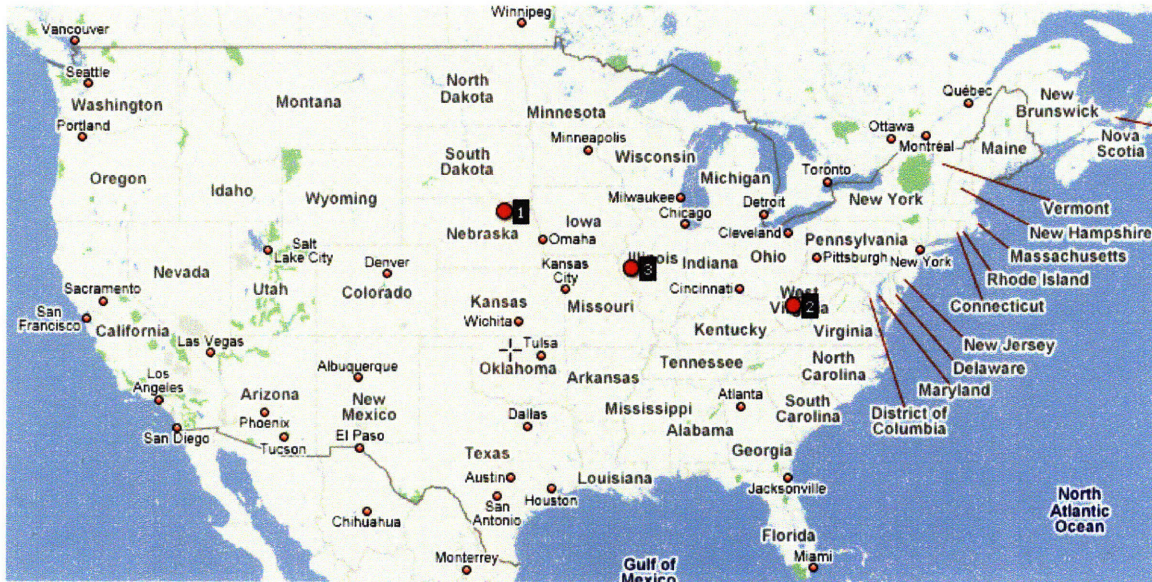**Table 5 Three DCs Transportation Costs**

**Figure 12 Three DCs Locations Map**

## 4.5.4 Five DC Analysis

Five clusters analysis is very similar as the three clusters process: Use the SPSS software select K-means cluster method to located the five cluster DC locations, then calculate each DC transportation costs to dealers. At the same time, also calculate the transportation costs from plant to three DCs. DC1 count for 8.63% total number of products sold, DC2 counts for 4.63%, DC3 count for 0.4%, DC4 counts for 10.16%, DC5 count for 76.18%. We assume each manufacturing plant ship the same percentage of its total number of products to each DC. Using the formula (2) and (3) in 4.2.1, we calculate the transportation costs from five DCs to Dealers and from plants to five DCs, the total transportation costs from plant to DC: $8,995,625. The following table 6 shows the latitudes and Longitudes of three DCs'. We can see more the ¾ of the total volumes were heavily handled by DC #5.

If we view the Figure 9 dealer locations distribution map, several dealers located in west of the US, the DC center #3 is for those dealer locations. Please see the table 6 and Figure 13. From Figure 9 and Figure 13, we can see that DC #3 is for several dealer locations in West in the US.

| Center | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Lat | 35.36820684 | 37.16564971 | 40.9246715 | 40.14341211 | 43.1069366 | |
| Long | -96.2253634 | -78.8230153 | -115.85189 | -87.9865121 | -95.97165049 | Total Costs |
| Costs from Plant to DC | $ 631,442 | $ 422,645 | $ 83,861 | $ 561,483 | $ 3,090,555 | $ 4,789,986 |
| From DC to dealer | $ 369,238 | $ 156,148 | $ 20,208 | $ 404,887 | $ 2,324,157 | $ 3,274,638 |
| % of Customers | 12.96% | 7.90% | 0.64% | 19.10% | 59.40% | $ 8,064,623 |

**Table 6 Five DCs Transportation Costs**



**Figure 13 Five DCs Locations Map**

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# 4.6 Hybrid Distribution System

Fast (High sale volume) moving items are stocked locally in the manufacturing plant's warehouses where close to the customers and then directly shipped to customers. To minimize the transportation costs, the shipment is always a full Truckload.

Slow moving items are stocked at regional DCs from where they are shipped to the customer within a short distance. For the slow moving system, build or rent DCs, use the part of direct shipping with in −Transit Merge method, mix the multiple orders into a single truckload to a single dealer location.

First, we need to establish the definition of slow and fast moving items (SKU). A full load truck can carry 880 bags of the seed; Seed Corp's shipping operation normally lasts for six months; if an item is shipped by a full load truck each month, this item will be shipped total 5280 bags for six months. We assume fast moving items ship at least one full truckload to dealers per month, and the delivery time lasts for six months each year. Therefore the fast moving item is defined as a single item shipped more than 5280 bags per year. The slow moving item is defined as a single item shipped less than 5280 bags per year. There are more than 5000 items for Seed Corp's operation; Seed Corp has 69.16% of total annual quantity shipped less than 5280 bags per year and 30.84% of total annual quantity shipped more than 5280 bags per year.
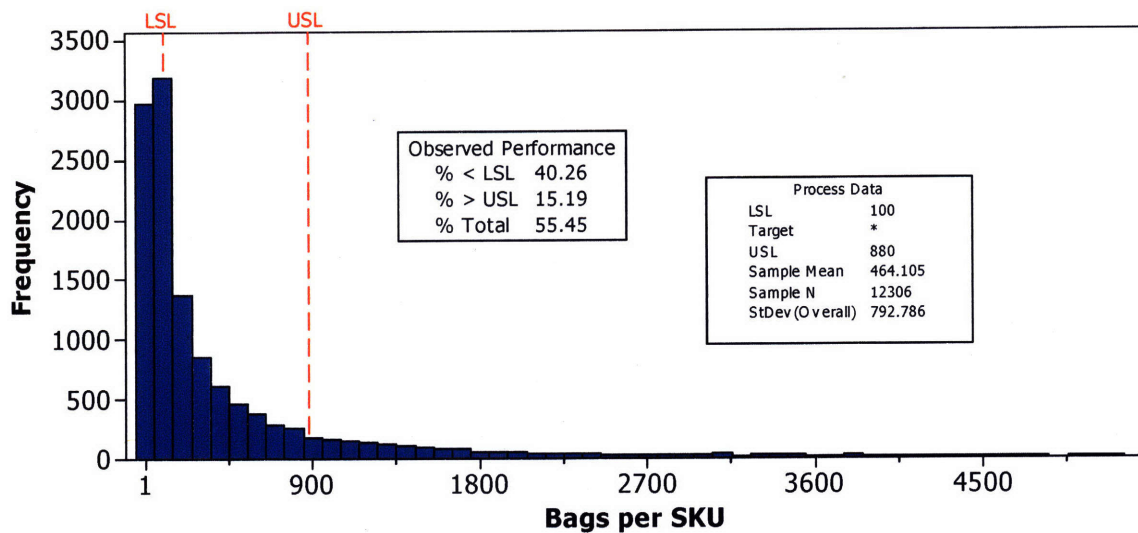
## Shipment QTY <=5280 bags



**Figure 14 SKU Shipment Distribution <=5280**

Figure 14 is the distribution of the SKUs shipped to a dealer with less than 5280 bags.

We collected 12,306 sample data. The average bags shipped per SKU is 464 bags. Most

of shipment is less than 880 bags for each SKU, this count for 85% of the total SKU less

than 5280 bags per year. There are 40.3% SKU shipped less than 100 bags.
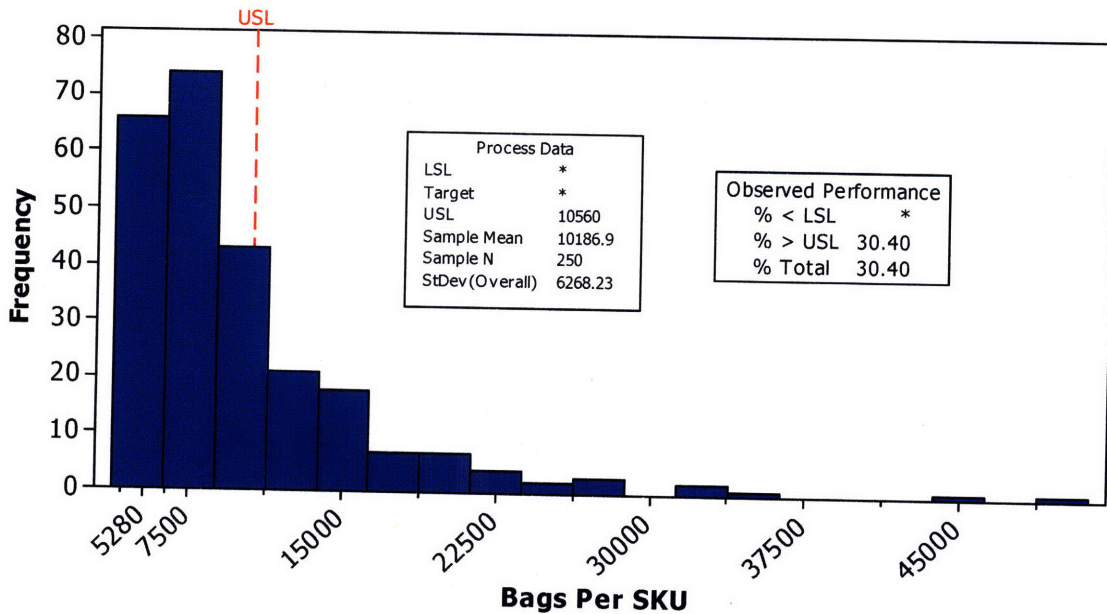
## Shipment QTY >5280



Figure 15 SKU Shipment Distribution >5280

As it shown in the Figure 16, there are only 250 SKU shipments are more than 5280 bags per year. Around 70% of the total shipments are less than 10,560 bags per year.

In this case, all the slow moving items ship from plant to the DC. The location of the DC , we unitize the same method formula (2) and (3) in 4.2.1, then calculate the transportation cost of shipping the slow moving items to the DCs using the formula in Chapter 4.2.1, as well as compute transportation costs from DCs to dealers, then add all the transportation costs. For this option, when ship products from DC to dealers use the FTL delivery the product to dealers around the DC.  In Seed Corp's case, we use hybrid distribution strategies: the distribution configuration for fast moving items is similar as 2.2.1.1 Manufacturer Storage with Direct Shipping; For slow moving items in DC, use the similar strategy as 2.2.1.2 Direct Shipping and in-Transit Merge distribution strategy

to combine different items into one full load truck and ship to the same dealer; The only different is the In-Transit Merge by Seed Corp instead of by Carrier.

In order to compute the costs, we consider One DC for the slow moving item. If there are only one DC for the slow moving items, the fast moving items still stay at the manufacturing plant warehouses. We assume the one DC location is the same as the place defined by 4.5.1 at Latitude=$\overline{X}$ =41.41411, Longitude=$\overline{Y}$=-92.1558. The average distance from plant to DC is the same as the average distance computed in 4.5.1 about 201 miles. The total quantity of bags for slow moving items (<5280bags) are 5,711,278 bags. The transportation rate is $1.5/mile/truck. The average full load truck carries 880 bags. So the rate per bag is $1.5/880= $0.001704545/mile/bag. Therefore the costs for transporting slow moving items from plant to DC are 5,711,278*201*0.001704545= $1,956,240, similar, the costs from DC to dealer are 5,711,278*562*0.001704545= $5,475,046. There are 2,546,733 fast moving units stay in the plant's warehouses, the average distance to the dealer is 296 mile, so the costs ship the fast moving items from the plant to the dealer are 2,546,733*296*0.01794545= $1,283,847. We can get the total costs are $8,715,133.

The holding and handling costs between Hybrid and "As is" system are the same, so we do not compare these costs.

The main advantages for this fast and slow moving items strategy are saving the IP transportation costs for Seed Corp due to FTL shipment, as well as less handling costs, and taking less time to receive the products for the customer due to FTL shipment, and the customer can conveniently receive multiple orders from a single FTL.

# 4.7 Comparison of Distribution Strategies

Based on the above calculation, Figure 16 is the result diagram of comparison of the transportation and handling costs, and response time for four strategies and existing system. IP is the Inter-Plant transportation costs. The "As is" is Seed Corp's existing system, which is a manufacturing focused system. The IP costs include transportation costs from plant to plant, plant to offsite warehouse, and offsite warehouses to plant. OB is the outbound transportation costs include the costs ship products from plant to dealer and from offsite warehouses to dealer. All four DC strategies, the IP costs include transportation costs from plant to DC, and OB costs contain transportation costs from DC to dealers.

For the "As is" strategy, though there are large volume movements inside the company, but the due to the short movement distances, the total transportation costs are lower than most of the other strategies except hybrid. For comparing the " Hybrid" and "As is" strategies, though OB costs of "Hybrid" are $1.2 million higher than these of " As is", the IP costs of "Hybrid" are $1.3 million lower than these of " As is". So the total transportation costs of "Hybrid" are lower than these of "As is". In addition, "Hybrid" has a lower handling cost than "As is" does. Therefore, Hybrid strategy has the lowest total costs among the five strategies.
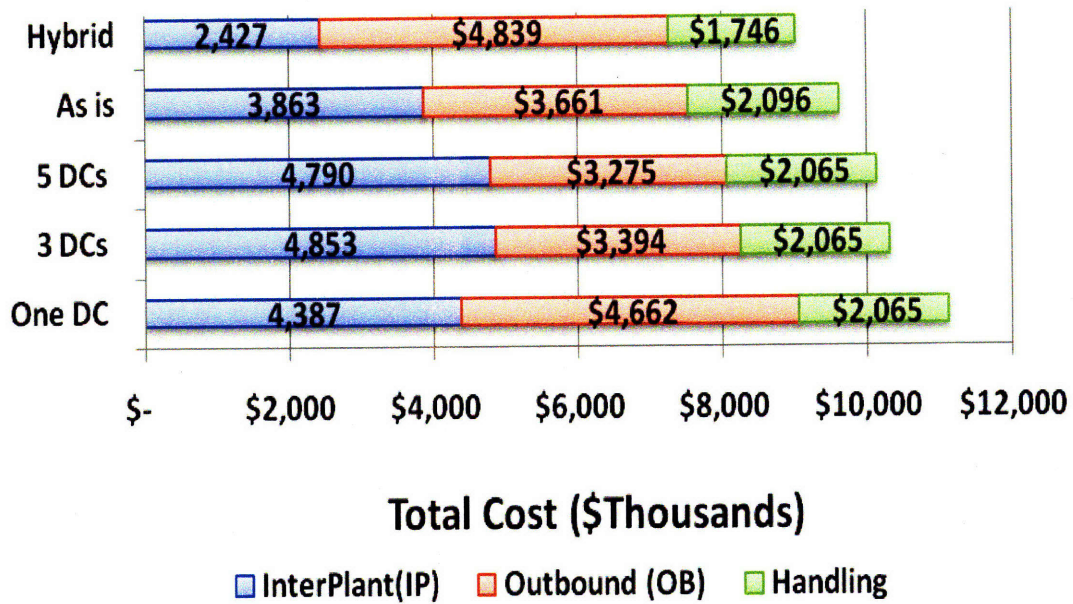
**Figure 16 Costs Comparison**

For the service factor, we compare the response time, which is meaured by the shipping quantity Weighted Average Distance (WAD) for different distribution strategies. Longer distance means longer response time. We mainly compute two kinds of WAD: IP and OB. WAD uses the following formula (9) :

$$D_{wa} = \frac{\sum_{ij} D_{ij}Q_{ij}}{\sum_{ij} Q_{ij}} \qquad (9)$$

Where:

$D_{wa}$ = Weighted Average Distance(WAD) (mile)

$D_{ij}$ = Distance between point i to j (mile)

$Q_{ij}$ = Quantity shipped from point i to j

As shown in table 7, the IP WAD on existing system(As is) is 233 miles, and the OB WAD is 200 miles. We use the existing system as the baseline, longer distance costs more to achieve the same response time or has a longer response time. For the existing system, though the manufacturing locations are not optimal sites for customer, each plant's warehouse is considered a DC function, in addition with other offsite warehouses which also function as DCs. Seed Corp's exsiting system fuctions in 20 DCs of the distribution system. The IP WAD of existing system is not the shortest one, but the OB WAD is the shortest one among all the options due to have the largest number of facilities close to customer locations. For "one DC" option, the IP WAD is 216 miles, and the OB WAD is 317 miles. The OB WAD of "One DC" option is much higher than that of "As is" option. So the "one DC" option has much higher OB costs than that of "As is". For the three and five DCs distribution configurations, the IP WADs are more than 100 miles than the other strategies due the DC locations have the longer distance to the manufacturing loations than these of the others. The existing system (As is/ MFG focused) has the lowest average WAD of IP and OB, therefore fastest response time.

| Average Distance (Mile) | IP | OB | Average of IP&OB | Ratio to As is (IP) | Ratio to As is (OB) |
|---|---|---|---|---|---|
| Hybrid | 216 | 310 | 263 | 0.93 | 1.55 |
| As is | 233 | 200 | 216 | 1.00 | 1.00 |
| 5 DCs | 331 | 216 | 273 | 1.42 | 1.08 |
| 3 DCs | 335 | 224 | 280 | 1.44 | 1.12 |
| 1 DCs | 216 | 317 | 266 | 0.93 | 1.58 |

**Table 7 Comparison for Response Time (By distance)**

Changing from existing system to large DC model does not save the total cost. When selecting and designing supply chains, firms are often faced with the competing demands of improved customer service, such as responses time, and reduced cost.

In this case, we assume in order to offer the same response time, the longer the distance, the more costs have to spend on to keep the same response time.

Due to the seasonality of industry, if Seed Corp builds large DCs itself, each year the DC will be utilized only for six months and almost empty for another six months, and costing money too. At the same time, Seed Corp only hires most of people working at the large DC for six month every year. It's difficult to keep good employees only work for half year every year. For Seed Corp's industry, the large DC is also required to control the temperature and humidity, the ideal DC location normally can't be easy to find by renting the existing warehouses. If Seed Corp wants large DCs, it has to build new large DCs, and adding large fixed costs and construction time.

If Seed Corp builds large DCs, the response time will be much longer and costly; at the same time, the transportation costs will be much higher than company's existing system. In Seed Corp's case, delivering product on time is very critical for the customer, especially when it's close to the planting season. For Seed Corp's Case, the main advantage for building large DCs is reducing number of people to operate the distribution system during the peak season and make the system operation more efficiency. But the money it saved cannot offset the costs increased in order to maintain the same delivery response time, as well as increased transportation costs.

# 4.8   Framework of Recommendation

A good distribution strategy is a hybrid strategy based on the company's product

characteristics and business strategies. At the highest level, distribution strategy should

be evaluated by whether it meets the customer's requirements and costs of meeting these

requirements.

For selecting different distribution strategies, a company must assess the impact on

costs and customer service. Meeting the customer's needs effects the company's revenues,

as well the costs. The customer service consists of many parts, in this case we mainly

include response time and product availability. The costs parts mainly include the

handling, holding, and transportation costs. Depend on which factors are important for

the company, the table 8 creates a framework for selecting a strategy, score 1 is the

strongest performance and 6 is the weakest performance.

For example, if the product availability is very important for customers, MFG focused

( As is) scored 1, so MFG focused strategy is good for this case.  If we think

transportation costs are high and need to reduce the transportation costs, the Hybrid

strategy score the best, it will be the first choice. But we also need to compare the other

factors, this may lead to select a combination of strategies for different situation of in the

various sections of the company.

| | MFG Focused | DC Based | Hybrid Fast/Slow |
|---|---|---|---|
| Response Time | 4 | 3 | 3 |
| Handling | 1 | 3 | 1 |
| Holding | 3 | 3 | 3 |
| Transportation | 2 | 3 | 1.5 |
| Product Availability | 1 | 2 | 1.5 |

**Table 8 Framework of Recommendation**

# 5 Conclusions and further research

Based on existing system, expand current onsite warehouse at the manufacturing plant. If the manufacturing plant's warehouse is far away from the customers, use hybrid strategy: build or rent limited number of regional DCs where close to the customers to store the slow moving items, at the same time use similar strategy described in 2.2.1.2 ( direct shipping in-transit merge strategy). For the fast moving item still store at the local plants.

Further research about the Demand shaping (Demand lags production schedule): as it illustrates in figure 17, starting at August each year, Seed Corp manufactures the product in a constant rate until January next year. The demand curve is delay about two months with the similar shape with production (supply) curve. There is a gap between supply and demand. The largest gap happens in December, and is a 55% gap.

The demand shaping is study the relationship shapes gaps between production and demand and to offer the customer (dealer). We assume Seed Corp sells all the seed they manufacturing each year. In Figure 17, if Seed Corp offers the price discount covering the cost more than dealer maintain the shelf spaces, then the dealers are willing to take the order earlier. Therefore the whole blue curve shifted from right to left to reduce Seep Corp inventory holding costs.
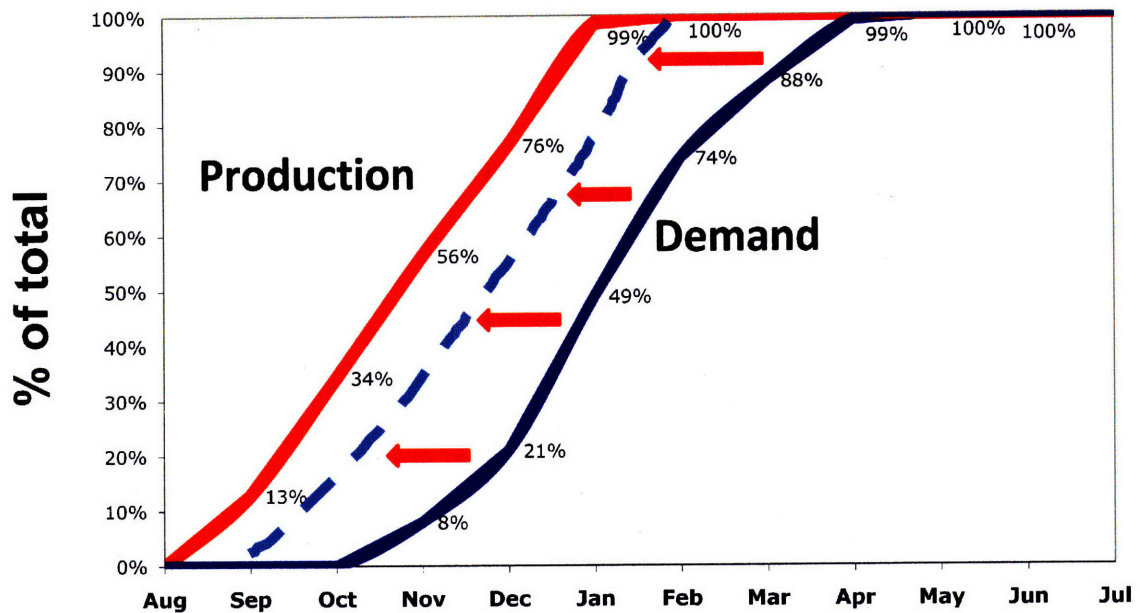
**Figure 17 Demand Shaping**

We need find quantity relationship between discount price of Seed Corp giving to dealers and shelf spaces of dealer willing to offer, this will benefit for Seed Corp to find the optimal point to minimize the total costs without changing existing physical structure of the distribution system. This is also a good way for the company to releasing the pressure of the limitation of warehouse space during manufacturing peak season.

Finally, search and study the innovation distribution strategy, for example, company can build limited number of the large DCs which are close its' major dealer locations, outsourcing the large DCs to third party or dealers. The DCs hold not only Seed Corp's products but also the other products from the other companies. In the case, the customers can take the ownership of the product earlier by offering the price discount by Seed Corp, and the products still stay in the same warehouses. It's not only fully taking advantage

consolidation effects to reduce the costs, but also utilizing DC facilities for a whole year.

Further research needed to be explored for this new type of distribution strategy.

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