INVENTORY CENTRALIZATION IN AN ELECTRONIC RETAIL BUSINESS

By

SAKAYONG PATTANAVEKIN

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

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Martin de Tours School of Management
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Bangkok, Thailand

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Assumption University

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Master of Science in Supply Chain Management

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I, Sakayong Pattanavekin

declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

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ABSTRACT

Inventory centralization is a distribution system that centralizes inventory in one place and distribution to other locations, well known as a distribution center (DC) system. Conceptually, inventory centralization allows each store to keep inventory only at safety stock level, most inventory being kept at a DC. By implementing a DC distribution system, the researcher expects a reduction in total distribution cost, which is composed of average aggregated inventory level, transportation cost, and inventory administration cost.

This research examines the impact of changing a distribution system from a direct distribution system (from supplier direct to each store) to a DC distribution system, in the Paisarn Group Co. Ltd., which is a multi location electronic retail company. The aim is to reduce the total distribution cost by implementing a real case. The research statistically compares a three-month period of implementing DC distribution with the same period of the previous year in order to eliminate the seasonal nature of the product sales volume.

By observing the total distribution cost, which consists of the average aggregated stock level, transportation cost, and inventory management and administration cost after the company has implemented a DC distribution system, the results comparing with and without DC show that a DC system can reduce the total distribution cost, as expected. However, the results of the impact on transportation cost are surprising as weighted sales volume transportation cost is reduced by a DC distribution system which is opposite to what was expected when the research began.

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SAKAYONG PATTANAVEKIN
Assumption University
November 2009

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GENERALITIES OF THE STUDY

1.1 Background and Problem review

In response to an increasingly shorter products life cycle, higher customer expectation, fierce global competition between retailer chains such as discount stores, modern trade, or department stores, all these retailers have to realize how to supply products to meet customer demand.

In order to supply various products to fulfill customer demand, the simplest way is to keep stock to serve customer requirements. If the level of inventory is high, it means that the retailer can serve customer demand and achieve a high service level. But the inventory is an investment that retailers have to be concerned about, because high level of inventory means that cash flow management has to invest in inventory more than operations in other activities which can generate more profit. Thus, the retailers have to create a strategy to fulfill customer requirements with a high service level by reducing shortages.

A warehouse is one of the answers to this issue; a warehouse is an important part of a supply chain to support customer service at minimum cost. A warehouse is used for storage and distribution of inventory and is a link between supplier, wholesaler, retailer, and the consumer.

Paisarn Group Co., Ltd

Paisarn Group is a multi location electronic goods Retail Company, which has seven branches around southern Thailand: Suratthani (headquarter), Nakorn Sritumarad, Had Yai, Trung, Vieng Sa, Phung Nga. The company has 25 product categories on shelf that cover ten electronic brands: Samsung, Toshiba, Hitachi, LG, JVC, Philip, Pioneer, Electrolux, Sanyo, and Haier. The products sold by the company are about 2,200 SKUs.

The long-term competitiveness of any retail company depends ultimately on the success of its logistic management system capabilities. An efficient logistic system holds hope for improving the market position and financial performance, creating new industry standards and new niche markets, and even renewing the organization.

Beyond this fact, Paisarn Group, an electronic goods retailer, has a vision to develop its logistic system in order to enhance its competitive advantage to be outstanding in the industry. Moreover, improving its logistic system would help Paisarn Group with its three current problems, which are:

1. Low inventory turnover ratio

Inventory turnover ratio is defined as:

$$Inventory\ Turnover = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventories}$$

Denote: average inventories = (Beginning inventories + Ending Inventories)/2

Paisarn Group has an inventory turnover ratio of 1.8, but the industry benchmark is 2.2.[1] This ratio shows that the company has an inventory turnover ratio below the industry average.

2. High level of sunken inventories

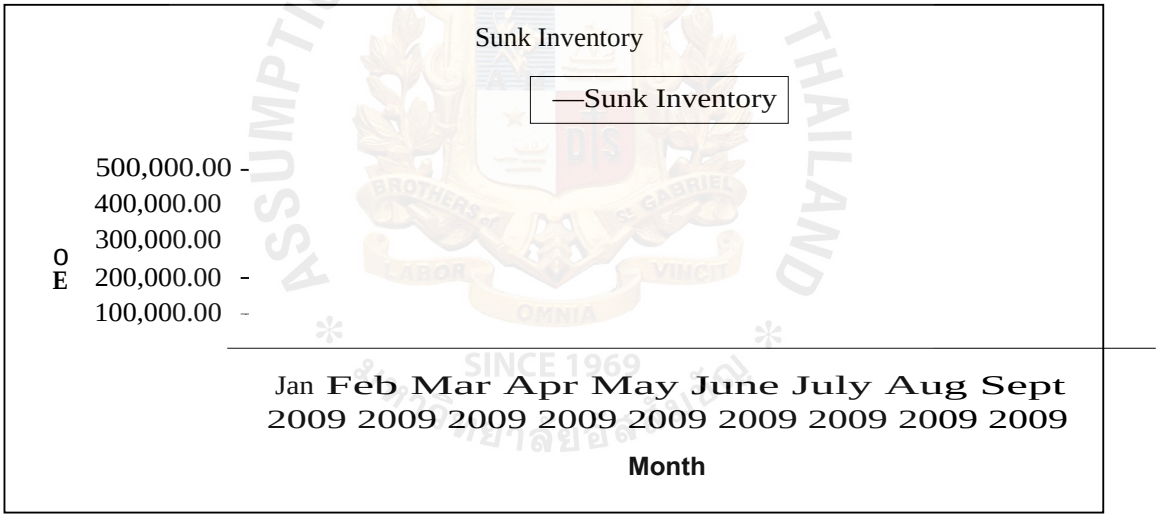

Figure 1.1: sunk inventory of Paisarn Group. Jan 2009 – June 2009; the company was using a direct distribution system, but changed to a DC distribution system in July 2009.

High level of sunken inventories shows the waste in inventory investment and inefficient inventory management as well as the inventory turnover ratio.

3. Low level of customer service – the firm does not have the inventory to meet customers' instant demands, and also have a long lead-time of ordering that product.

[1] GFK Retail and Technology (Thailand) – market research 2008

The research began with an informal survey of the company salesclerks. Mostly, salesclerks observe that about 15% of customers who come to the store cannot find the product that they want at the store instantly. 7% of those customers will wait for the order if it takes no longer than three days, otherwise they will not wait. But the company can serve only 40% of customers who are waiting for the product by transferring it from another branch. The company loses the other 60% of waiting customers due to a long lead-time of ordering from suppliers.

These indicators show that the company has a poor inventory management. The company should work on these problems to maintain a robust company competitive advantage in sales and service.

Consequently, these problems cause poor financial performance and continuous loss of market share. To prevent Paisarn Group from these unwanted conclusions, the Board of Directors had meeting to agree a solution plan. A distribution center (DC) or warehouse distribution system may be a possible way to solve the problem. Using a warehouse system instead of the current system where each vendor transfers their products directly to each branch may solve the company problem, and is urgently considered by the company.

By utilizing the distribution warehouse system, Paisarn Group expects to solve the current situation and bring effectiveness and efficiency to inventory management.

This study provides the strategic managerial analysis of whether distribution warehouse utilization can reduce the total distribution cost of Paisarn Group. To provide an appropriate answer, this study includes Paisarn Group's profitability, average aggregated inventory level, customer service level, logistic cost (i.e. transportation cost, inventory carrying cost, order cost), and inventory management performance comparing with and without a distribution warehouse.

1.2 Statement of the Problem

Inventory management is one of the key success factors of a retail business in order to deal with the uncertainties and variability of demand. A phenomenon called the "bullwhip effect" is the demand fluctuation caused by rapid changes in consumer demand (Russell & Taylor, 2002). Distorted information, or lack of information, from one end of the supply chain is one of the main causes of uncertainty, and it can lead to

excessive inventory, poor customer service level, lost revenues, ineffective transportation, and high costs. It causes retailers to maintain and keep a high inventory level to serve customer demand (Lee, et al., 1997).

Nowadays, retailers have targeted service level performance and inventory level as their preference, for preventing their sale volume rather than inventory management and other logistics reasons. Shortage does not bring only lost sales opportunity but also a bad image of the store. But keeping as much inventory as retailers can do, is not a smart choice for them; it costs a lot of money.

One possible strategy that may be able to solve this issue is to utilize a distribution center (DC). DC can reduce inventory cost, inefficient inventory management problems, excessive inventory problem, and increase inventory turnover. However, DC brings an operation cost, and may increase the transportation cost.

The alternative solution is to improve the demand forecasting. Accurate demand forecasting can help a company save cost in inventory stock investment, and also carrying cost. But in order to get accurate demand forecasting, it needs specialists, a high level of computer software, a long historical data, and a good collaboration with suppliers. It requires money and time to get accurate demand forecasting. It is hard to make it occur in a short time. This should be a long-term development.

As well as other retailers, Paisarn Group is trying to improve operating efficiency in order to build its own competitive advantage by implementing a DC distribution system to reduce total distribution cost while still retaining the same customer service level. However, a major constraint of Paisarn Group is that the warehouse locations can only be at the headquarter location (Suratthani) because of area constraint, budget constraint, and operational human resource constraint.

Accepting these constraints, the following research problem can be stated as:

"Does the distribution center distribution system reduce total distribution cost of Paisarn Group?"

1.3 Objectives of the research

The general objective of this research is to study the distribution center distribution system in the way that it can improve inventory management.

The main objectives of this research are:

To determine whether a distribution center distribution system can reduce the total distribution cost of Paisarn Group, compared with a direct distribution system.

1.4 Scope of the Research

The research is intended to determine whether a distribution center is a solution for Paisarn Group in order to minimize inventory cost, and improve inventory management efficiency. Therefore the scope of this research includes:

1. A case study of Paisarn Group Co., Ltd. (an electronic goods retailer)
2. Selecting the data, for a three-month period of study.
3. Determining whether a distribution center can improve inventory management at Paisarn Group Co., Ltd.
4. The sample population cannot cover all product SKUs (Stock keep unit) in Paisarn Group because of time constraints and the limitations of data sources. Therefore, two AA products have been chosen, which are refrigerator and washing machine.
5. According to the constraints in the warehouse location in Paisarn Group, headquarter is the only location that can be set up to be a warehouse.
6. The life cycle of electronic products is very short; new products are launched every quarter. This research needs to eliminate new products from the data sample in order to investigate how exactly a distribution center can improve inventory management efficiency.
7. The findings of this research can be used primarily by electronic retailers. However, it can be generalized with marginal modification

1.5 Limitation of the Research

The only one limitation of this research is time to do the research. To complete the research question with solid answers, this research needed at least one year to collect data

of ordering, sales, stock-out data, transportation cost, and overhead cost. Thus, the results of this research are based on a three-month period of collecting data, which might not be representative. This research really needs more time to establish solid research answers.

1.6 Significance of the Study

This study is useful for the inventory management of Paisarn Group and other electronic retailers, as follows:

1. To improve the inventory management of the company in an efficient way.
2. To help the company to identify the best location to be a distribution center.

1.7 Definition of Terms

To clarify this research, the following teams are defined to prepare readers for the rest of the research.

Demand – Rate of product flow out of the Distribution Center (Lee, 2003).

Demand Variation – Fluctuation of the product outflow from period to period (Lee, 2003).

Inventory Centralization – Distribution center inventory management model.

Inventory control – consists of all the activities and procedures used to ensure the right amount of each item held in stock (Waller, 1999).

Key Performance Indicators (KPIs) – are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organization. They will differ depending on the organization. A business may have as one of its Key Performance Indicators the percentage of its income that comes from return customers (Reh, 2004).

Lead Time – Expected time delay between ordering and having a new product available to fulfill demand (Lee, 2003).

Service level – is the measure of stock availability when needed by the customer A higher service level performance is better; however it should be balanced with inventory investment (Waller, 1999).

Stock – consists of all the goods and material stored by an organization. It is a supply item, which is kept for future use (Waller, 1999).

Stock Keep Unit (SKUs) – The primary or basic unit of measure assigned to an item. The SKU is the smallest unit of an item that may be dispensed from inventory or returned to a vendor (Johnson, 1999).

Supply Chain – The facilities, functions, and activities involved in producing and delivering a product or service from suppliers to customers (Russell and Taylor III, 2002).

Supply Chain Management – Supply chain management means managing the flow of information through the supply chain in order to attain the level of synchronization that will make it more responsive to customer needs while lowering costs (Russell & Taylor, 2002).

Total distribution cost – the total cost of distribution to serve customer at the target service level, which includes safety stock level, transportation cost, and inventory management cost.

The Bull Whip Effect (inventory boom blast cycle) – This lack of coordination or information transferred in the form of "orders" tends to be distorted and can misguide upstream members in their inventory and production decisions. In particular the variance of orders may be larger than that of sales, and distortion tends to increase as one moves upstream, which will affect each party holding high inventory (Lee, et al., 1997).

The Bull Whip effect can be defined as a logistic phenomenon revealed by an amplification of demand variation as demand is transmitted from retailers to suppliers through a stock management system (Brun & Giovanni, 2004).

Chapter II

REVIEW OF RELATED LITERATURE AND RESEARCH FRAMEWORKS

In this chapter, we go through various previous literature in attempting to understand and create theoretical links to be the research framework. This chapter will explain details of inventory management and related factors in order to find the best distribution system for Paisarn Group. Also, the objective of this chapter is to explain the concepts related to inventory management through a distribution center as one of the key factors in the supply chain and supply chain management, which will define the importance of each one, the attributes involved, and some useful knowledge regarding the formulation of inventory management.

2.1 Definition and Aims of Inventory management

Inventory is an American accounting term for the value or quantity of raw materials, components, assemblies, consumables, work-in-progress and finished stock that are kept or stored for use as the need arises (Leenders, 2002).

An immediate problem is that Americans use "inventory" to mean both the list of items in stock, and the stock itself. In recent years this convention has become more common and the terms are becoming increasingly interchangeable. The given definition above will stick to the formal definitions. Therefore "inventory control" and "stock control" have been used to describe the means of controlling stock (Waters, 1999).

Inventory control refers to the techniques used to ensure those stocks of raw material or other supplies; work-in-progress and finished goods, are kept at levels that provide maximum service level at minimum costs (Leeders, 2002).

Inventory control consists of all the activities and procedures used to ensure the right amount of each item is held in stock (Waters, 1999).

Lambert (2002) postulated the five aims of inventory as follows:

1) To enable the firm to achieve economies of scale
2) To balance supply and demand
3) To enable specialization in manufacturing
4) To provide protection from uncertainties in demand and order cycles
5) To act as a buffer between critical interfaces within the supply chain

In order to explain more about economy of scale, inventory is required if a firm is to realize economies of scale in purchasing, transportation and manufacturing. For example,

a raw materials inventory is necessary if the manufacturer is to take advantage of the unit price reductions associated with volume purchases. However, increasingly when purchased volumes are sufficiently large, purchase contracts are being negotiated based on annual volumes, not the amount purchased in an individual order. The reason for the lower per unit cost is that a full truckload represents lower transportation rates than smaller shipments of less than full truckload. When suppliers are located in the same geographic area, it may be possible to consolidate small volumes into one large shipment.

Finished goods inventory can be used as a means of improving customer service level by reducing the likelihood of a stock-out due to unanticipated demand or variability in lead-time. If the inventory is balanced, increased inventory investment will enable the manufacturer to offer higher levels of product availability and less chance of a stock-out. A balanced inventory is one that contains items in proportion to expected demand.

Formulation of an inventory policy requires an understanding of the role of inventory in manufacturing and marketing (Leenders, 2002). Inventory serves the purposes within the firm as follows:

1) To provide both internal and external customers with the required service levels in terms of quantity and order fill rate.

2) To have certain present and future requirements for all types of inventory to avoid overstocking while avoiding "bottlenecks" in production.

3) To keep costs to a minimum by variety reduction, economical lot sizes and analysis of costs incurred in obtaining and carrying inventories.

Waters (1999) explains more about the objective of inventory management, that inventory is a major use of capital and the objectives of inventory management are to increase corporate profitability, to predict the impact of corporate policies on inventory levels, and to minimize the total cost of logistics activities.

Corporate profitability can be improved by increasing sales volume or cutting inventory costs. Increased sales are often possible if high levels of inventory lead to better in-stock availability and more consistent service levels. Low inventory levels can reduce fill rates on customer orders and result in lost sales. However, the costs associated with high levels of inventory usually exceed the benefits derived. Methods of decreasing inventory

related costs include such measures as reducing the number of back orders or expedited shipments, purging obsolete or dead stock from the system, or improving the accuracy of forecasts (Leenders, 2002).

Finally, total cost integration should be the goal of inventory planning. That is management must determine the inventory level required to achieve least total cost logistic, given the required customer service objectives (Waller, 1999).

2.2 Inventory Control System

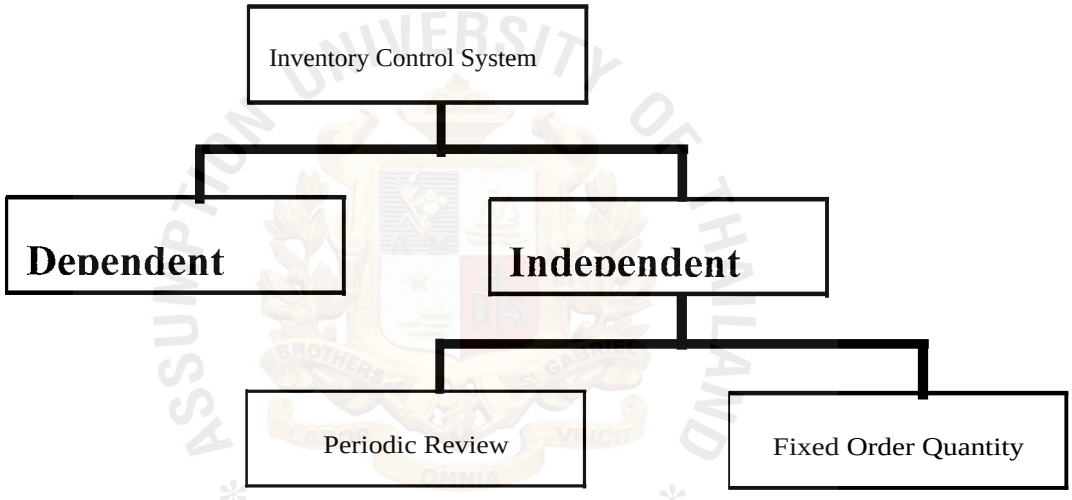

Figure 2.1: Inventory control system

1) Independent demand inventory is influenced by market conditions and not related to production decisions for any other item held in stock. In manufacturing, only end items (Waters, 1999), the finished products, are sold to customers. Demand for them depends solely on the requirements and demand of the consumer. Managing these inventory items requires forecast information on consumer needs.

Independent demand models can use either fixed order quantities or periodic reviews.

a. Fixed order quantity systems place an order of fixed size whenever stock falls to a certain level. The system needs continuous monitoring of stock

levels and is better suited to low, irregular demand for relatively expensive items.

b. Periodic review systems place orders of varying size at regular intervals to raise the stock level to a specified value. For example, supermarket shelves may be refilled every evening to replace whatever was sold during the day. The operating of this system is lower and it is better suited to high regular demand of low value items.

2) Dependent demand inventory is derived from the product decisions for its "parent"; it is an item manufactured from one or more component items, usually assemblies or parts used in the manufacture of the final consumer product.

In this research, we focus on "independent demand inventory" according to retail businesses that sell the finished goods. To control independent demand inventory efficiently with a limited budget, we have to use the right model of distribution system for the business.

2.3 Reasons for holding inventory

Inventory has a value, so keeping a store of goods costs money. However, there are many valid reasons why a firm keeps in storage a certain amount of inventory and often more than is required in the next immediate period. In term of a retailer, finished goods held by a distributor or even wholesale distributors for retail outlets always have a certain amount of inventory on hand for reasons such as those given in the following sections.

Stock and Lambert (2002) state the reasons for carrying inventory, as follows:

a) Variation in customer demand

Customer's demand varies from period to period, and as it is not always easy to forecast these needs, extra supplies are kept in order always to be able to satisfy the customer and provide the best service level. In addition, it is often more economical to hold inventory rather than place emergency order for clients.

b) Display of products

Holding inventory allows display of products to aid the sale. In some cases, it may not be possible to sell products after they have been used for display purposes. Alternatively, they will be sold at a marked-down price.

c) Price discounts

If finished products are purchased in bulk, discounts are often available. Thus, it is more economical to take advantage of lower unit prices and store what is not immediately required.

d) Anticipated price increases

Finished goods may be held in anticipation of price increases. For example, an increase in value added taxes announced by the government or tax increase on petrol, cause consumers or retailers to stock up on the finished product.

Inventory is also held as protection from uncertainties demand In terms of retailers who hold onto finished goods, they can be used as a means of improving customer service level by reducing likelihood of a stock-out due to unanticipated demand or variability in lead-time.

But the inventories should be held at the optimal level. If they are held in high inventory, the firm cannot generate cash flow to create other activities. It means the firms have to reduce inventory to the optimal level, which has benefits, such as reduction of stock holding costs, release of money tied up in stocks, easier specification when ordering, narrower range of inventory and a reduced supplier base.

Thus, stocks give a buffer between variable and uncertain supply and variable and uncertain demand.

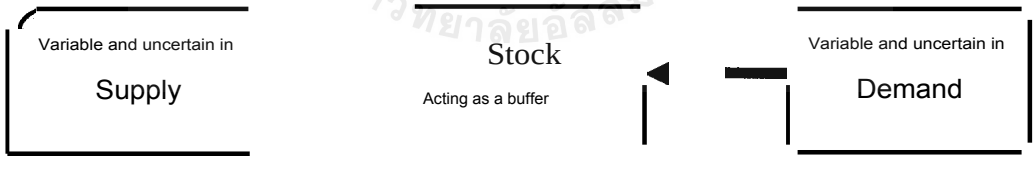

Figure 2.2: Stock as a buffer between uncertain and variable supply and demand

Source: Waters (1999)

Figure 2.2 explains the main purpose of stock, which is related to the nature and purpose of keeping inventory by many retailers. The main purpose of holding stock is to act as a buffer between supply and demand in order to allow operations to continue smoothly: when the supply rate does not exactly match the demand rate, the buffer must bring timely support to demand. In addition, a supply site is composed of many suppliers with

differences in both lead-time and capacity. Then the buffer stock allows a buffer between uncertainty in supply and uncertainty in demand. Thus, stocks give a buffer between variable and uncertain supply and demand (Waters, 1999).

However, holding inventory in order to service customer is a high level costs involving a huge amount of money. A number of inventories are required beyond the number of stocking locations, at least at the safety stock level. Thus, the retailer, which has a lot of branches or locations, would require a lot of aggregate inventory in order to retain the safety stock of each location. This will bring high unnecessary investment in inventory. This research works on this issue to offer the best solution.

2.4 Independent Variables

In addition to knowing how much inventory to order, it is also necessary to know the order point, or the date at which to place the purchase order for a new quantity of inventory. This quantity would normally be when the level of inventory currently being used has fallen to a certain minimum level. An order point is based on the lead-time (the time between placing the order and receiving shipment) and the estimated amount of inventory that is going to be consumed or demanded during this lead-time period. The value of demand is critical. If it were higher than expected, there would be the risk of stock-outs. If demand were low, inventory levels would be high with the associated high stocking costs (Waller, 1999).

I. Lead-time – is derived from two components; 1) supplier's production lead-time, 2) customer demand.

Supplier – suppliers may be extremely reliable and always deliver as promised. hi this case, the lead-time will not be a variable or a factor that we have to be concerned about. However, generally, there are cases such as delivery delays, raw materials are short, or a machine has broken down. For these cases, the lead-time is longer than planned and so consideration should be given to having a safety stock on hand to cover unexpected situations.

Customer demand- the demand cannot be predicted, the daily demand for each product varies and fluctuates. Alternatively to deal with these fluctuations, the safety stock is issued. However, determining safety stock levels may not be straightforward.

Service level

II. Service level in inventory situations is for clients whose proportion of orders can be completed by using existing inventories of finished goods. Service levels are given as a percentage. Thus, a 95% service level means that on average 95% of customers' orders are fulfilled from current inventory. The other 5% will not be filled because a stock-out is experienced. This 5% of orders will have to be filled at a later date (Waller, 1999).

A service level is the ability to meet the demands of customers from stock. Leenders (2002" defined the method of calculation service level as the number of times an item is provided on demand, divided by the number of times an item is demanded.

Stock-out Risk

Stock-out is a situation that the store does not have the inventory to serve its customer. The stock-out does not only bring lost sales opportunity but also a bad image to the shop.

III. Safety stock - To attempt to avoid stock-outs resulting from the uncertainties, firms might keep a safety stock. This safety stock is dead inventory; it provides a safeguard, but adds to inventory carrying costs. Since there is a cost associated with holding or carrying inventory, or a safety stock, the risk of a stock-out must be traded off against the cost of carrying inventory. The objective is to carry the optimum level of inventory. The more inventories that are carried, then the lower is the probability or risk of a stock-out; however, the greater is the holding cost. The more the variability in customer demand or supplier lead-time, then the greater the amount of safety stock required to achieve an established service level (Waller, 1999).

Stock-out risk = 100 – percentage service level

2.5 Distribution Center

One of the best solutions is a "Distribution center (DC)". A distribution center is a principal part, the "order processing" element, of the entire "order fulfillment" process. Distribution centers are usually thought of as being "demand driven".

Distribution centers are the foundation of a "supply network" as they allow a single location to stock a vast number of products. Some organizations operate both retail

distribution and direct-to-consumer out of a single facility, sharing space, equipment, labor resources and inventory as applicable.

The way a typical retail distribution network operates is to have centers set up throughout a commercial market. Each center will then serve a number of stores. Large distribution centers for companies such as Wal-Mart serve 50-125 stores. Suppliers will ship truckloads of products to the distribution center. The distribution center will then store the product until needed by the retail location, and ship the proper quantity.

Since a large retailer might sell tens of thousands of products from thousands of vendors, it would be impossibly inefficient to ship each product directly from each vendor to each store. Many retailers own and run their own distribution networks, while smaller retailers may outsource this function to dedicated logistics firms that coordinate the distribution of products for a number of companies. A distribution center can be co-located at a logistics center.

2.6 Distribution center and Inventories management

Discussing the decision support systems (DSS), the distribution requirements planning system is the one module that is very important for DSS. Distribution requirements planning is the planning process in the supply chain to help ensure that finished goods destined for a client reach the right location, on the right date and in the right quantity. The supply chain covering the distribution requirements planning may be from the manufacturer through the various distribution centers to the retailers in a service firm. The distribution requirement plan might be a pull or push system (Simchi & Kaminsky, 2003).

A pull system is the most common type of planning approach and for many it is the only distribution requirements plan. A pull system is when the outlet at the lowest level, or end of the distribution network, usually the retailer, initiates the order. The retailer "pulls" the products through the distribution, or supply chain, network. The retailer has its own ordering policy and the supplier only makes a delivery when a specific order has been made (Simchi and Kaminsky, 2003).

The demand from each retailer imposes a master production schedule (MPS) on the manufacturer, which may not be optimum. The manufacturer loses some control of his planning process and has to be flexible to accommodate customer demands. In some

instances the pull system may impose a MPS on the manufacturer that is not feasible, when, for example, insufficient resources are available. If a just-in-time system is in place the manufacturer will have more flexibility.

Push system. In the push system, the supplier at the beginning of the network, usually the manufacturer, produces the finished products according to the master production schedule (MPS). This MPS would have been established according to estimates of clients' demands and then modified to suit the company's resource available at the manufacturing site. Material is pushed through the distribution channel when the products are ready. The flow of material may not necessarily be in harmony with the needs of the final retail outlet. As a result, the retailer accumulates too much stock or worse.

A hybrid of the push and pull systems in distribution requirements planning is to use a *distribution center* as the inventory buffer to avoid stock-outs.

2.7 Discussion of Previous Studies

Zinn, Levy, and Bowersox (1989) measured the effect of inventory centralization/ decentralization on aggregate safety stock by using the square root law in order to approximate the changes in aggregate safety stock resulting from changes in the number of stocking locations used in the distribution of a product. They collected data from four stores of a department store chain. Unit sales per store were obtained for a typical product – men's white Jockey underwear, size 36. They find the reduction in aggregate safety stock made possible by centralizing inventories.

Their finding guide us to identify how to reduce inventory cost without reducing customer service level in an environment of multiple locations, as in Paisarn Group Co., Ltd. Then, we present the distribution center solution to Paisarn Group in order to centralize inventory and reduce aggregate inventory level but still retaining the customer service level.

Baganha and Cohen (1998) review some empirical results concerning the destabilizing effect of inventories. They find that wholesalers can, in fact, introduce a degree of stabilization into the supply chain by transmitting an order process to manufacturers with variability lower than the variability inherent in the retailer replenishment order process. They also noted that there are no models available for the

study of the impact of inventory policies on the variability of demand throughout the manufacturing/ distribution supply chain that takes the stochastic linkages associated with the multiechelon structure of such systems into account.

Beyond what they find, in order to stabilize effect of inventory or reduce variance amplification throughout the supply chain, they need a distribution center to be transmitting an order process to manufacturers, instead of a retailer replenishment order process, which is like the centralization of order process. But they remind us that each location only has local information, so the sharing of information in the network is necessary for the occurrence of a stabilization effect of inventory.

Moreover, Simchi and Kaminsky (2003) also argue about centralized versus decentralized distribution system as follow:

Safety stock – decreases as a firm moves from a decentralized to a centralized system. The amount of decrease depends on a number of parameters, including the coefficient of variation and the correlation between the demands from the different markets.

Service level - when the centralized and decentralized systems have the same total safety stock, the service level provided by the centralized system is higher. As before, the magnitude of the increase in service level depends on the coefficient of variation and the correlation between the demands from the different markets.

Overhead costs – typically, these costs are much greater in a decentralized system because there are fewer economies of scale.

Customer lead-time – since the warehouses or distribution centers are much closer to the customers in a decentralized system, response time is much shorter.

Transportation cost – the impact on transportation costs depends on the specifics of the situation. On one hand, as we increase the number of warehouses, outbound transportation costs (the costs incurred for delivering the items from the warehouses to the customers) decrease because warehouses are much closer to the market areas. On the other hand, inbound transportation costs (the costs of shipping the products from the supply and manufacturing facilities to the warehouses) increase. Thus, the net impact on total transportation cost is not immediately clear.

Their argument is very useful for us to determine the independent variables that we have to be concerned with when we do research into whether a decentralized or centralized distribution system is suited for Paisarn Group.

Finally, safety stock, service level, overhead costs, customer lead-time, and transportation costs are our independent variables that we have to measure and be concerned with in order to reach our research answer.

2.8 Theoretical Framework

In this section, we construct the conceptual framework using the valid theoretical link that we have discussed above. This section also includes the research hypotheses and operationalization of the variables.

Inventory

One of the most important key success factors in retail business is to manage inventory efficiently in order to obtain profit improvements through efficient techniques for setting individual item inventory. Inventory is used to avoid unpredictable demand spurt during lead-time while the next order has not yet arrived, and "stock-out" may occur. The probability of a stock out occurrence depends on how much inventory is held, with inventory defined as the average amount of inventory still left in hand when the new order arrives. With a large inventory, stock-outs will have less chance to occur (Herron, 1997).

Therefore, inventory is kept to prevent uncertainty in demand and uncertainty in lead-time. Stock and Lambert (2002) state that if a manager wants to protect against the maximum variability in demand and lead-time, the firm would need a large amount of inventory. Thus, inventory level is determined by two factors:

1. Demand uncertainty
2. Lead-time uncertainty

Inventory Centralization

Inventory centralization is the warehouse or DC distribution system that consolidates all inventories at a warehouse and distributes to stores when the stores order. In a DC distribution system, the central warehouse inventory protects the whole system

against demand variations during procurement (or production) lead-time (P), and warehouse safety stock also provides protection during transit lead-time (T).

Hence, the effect of inventory centralization on aggregate inventory is quite clear: inventory centralization can reduce the aggregate inventory at the same given service level (Zinn, Levy, and Bowersox, 1989).

The logistics concepts to improve profitability is involved with cost effective actions to reduce and standardize replenishment lead time, get rid of excess stock, reduce order quantities and manufacturing lot sizes, take maximum discounts, and push the cost of carrying inventory back to the supplier if possible. In order to implement these actions and improve inventory management, the system has to utilize a distribution center (Simchi and Kaminsky, 2003).

2.9 Interpretation of the conceptual framework model

For a given service level goal, the change in total distribution cost by a centralized distribution system depends on the change in averaged aggregated stock level, transportation cost and inventory administration cost, as discussed above. Basically, if we utilize the distribution center to stock inventories and distribute to each store, and we can determine absolutely the length of the lead-time for each store, then we can reduce the aggregated stock level of each product in each store. But we have to compare the benefit of utilizing DC against transportation cost and inventory administration cost. The conceptual framework for this research is illustrated by the equation below:

A Total distribution cost DC = A Averaged Aggregated stock level + A Transportation cost + A Inventory administration cost

As discussed above, DC utilization allows us to reduce the lead-time from supplier to each store by keeping most stock at a warehouse and deliver it when a store makes a reorder. A DC distribution system can determine a reliable delivery schedule from warehouse to store rather than a direct distribution system where a supplier makes a delivery to stores individually and independently, and long lead-times might occur. When a DC distribution system could eliminate the lead-time from warehouse to store',

[2] Our only assumption, "service level of DC to each store is nearly 100%".

the averaged aggregated stock level would be less. Then inventory capital of the company would be less, but the company still has the same service level.

The concept of eliminating lead-time from DC to each store is the key factor. Eliminating lead-time from DC to each store, the company can make each store keep inventory only at safety stock level. It means that DC can serve each store at nearly 100% service level, which leads to our only assumption:

Assumption: service level of DC to each store is 99%

However, the DC utilization and 99% service level to each store bring an increase in transportation cost to the company. The company has to bear the transportation expense rather than push the transportation cost to suppliers.

The other variable is inventory administration cost; the conclusion about overhead cost is mixed. A DC distribution system changes the operation of the company by centralizing the inventory management at the head-office. The centralization of inventory management also gains the benefit of economies of scale in ordering and saving resources in the management operation in each store rather than decentralization. However, decentralization of inventory management may respond to the local demand better than centralization, which can reduce lost sales opportunities.

The chart below illustrates the *Conceptual Framework* of this research.

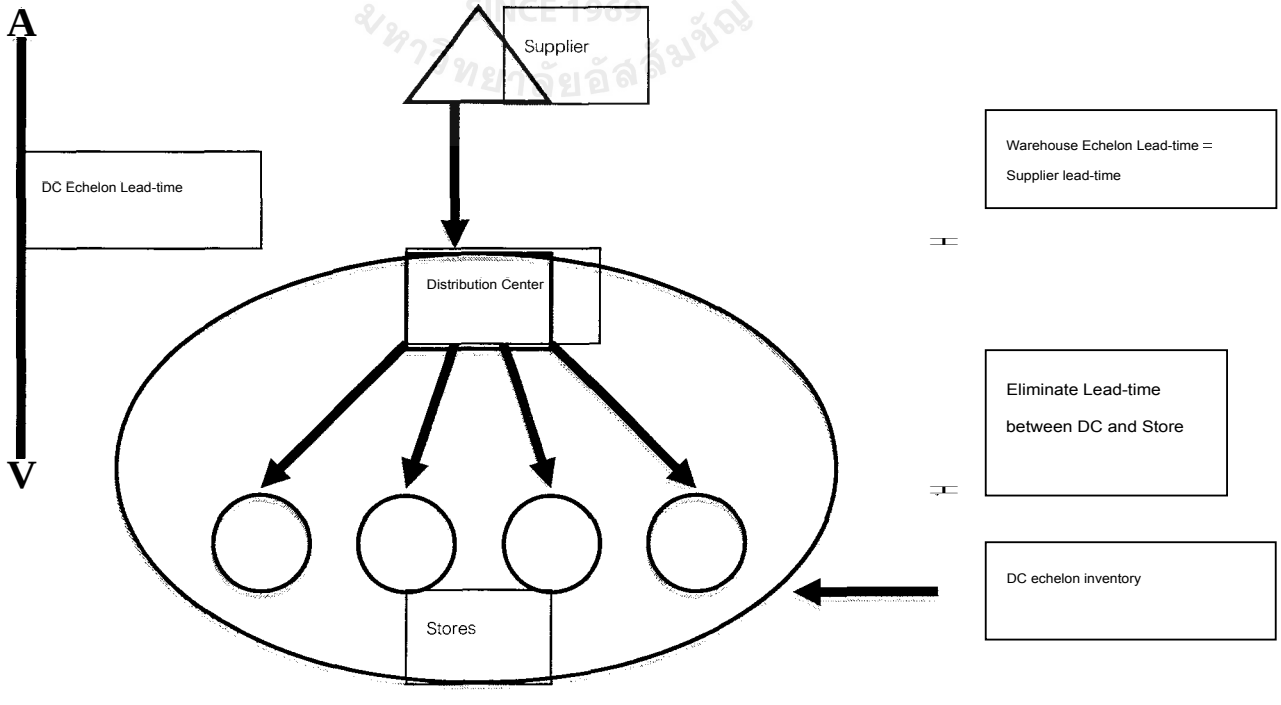

Figure 2.3: How DC system reduces Echelon lead-time

Source: Sichi-Levi & Kaminsky (2003)

With this concept, we can reduce the aggregated stock level by DC. The DC keeps the most stock, each store keeps only safety stock.

Figure 2.4: Direct distribution system – with this system, each store has to carry large amount of stock to deal with uncertain demand and long lead-time from supplier.

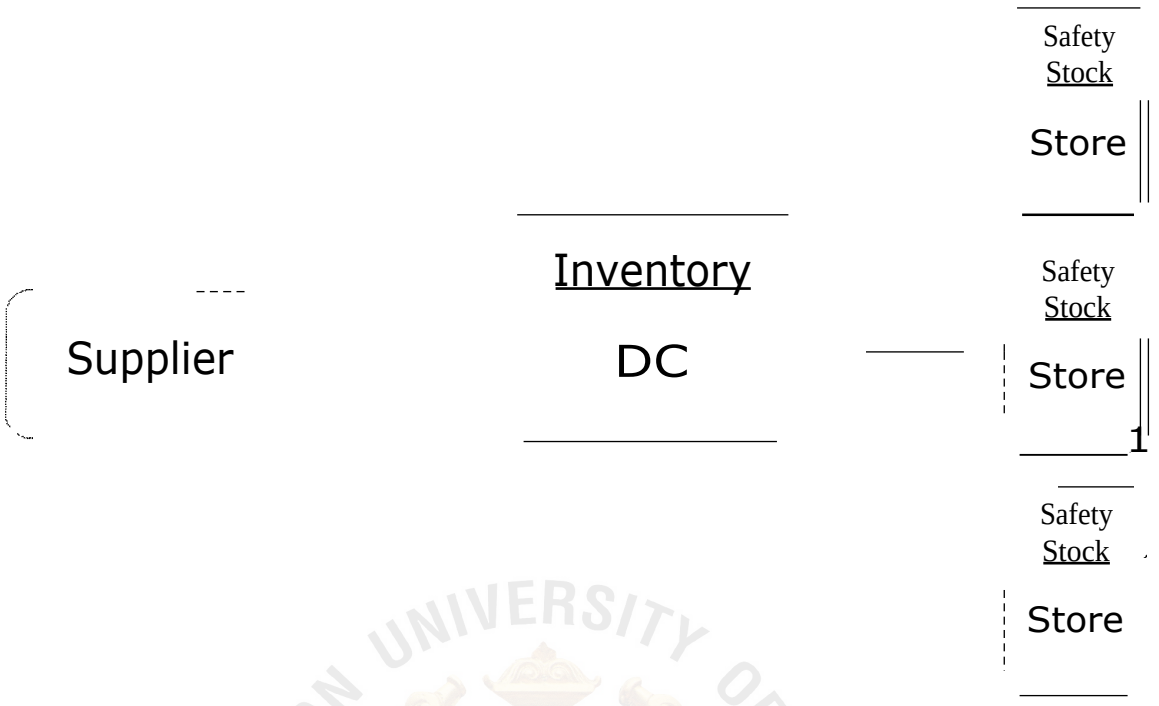

Figure 2.5: DC distribution system – each store keeps only safety stock.

We expect the outcome from this model of a distribution system (distribution center system) to improve inventory management, reduce inventory days on hand and averaged aggregated inventory level, but still retain the same service level. The financial ratio will indicate whether the result of a distribution center system can improve the inventory management efficiency.

2.10 Research Hypotheses

This research proposes a distribution center utilization by comparing the averaged aggregated inventory level and total distribution cost between distribution center utilization and without distribution center, at the same service level.

This research also adds other factors by hypothesis, which is an educated guess about a problem's solution. It can be defined as a logically conjectured relationship between two or more variables expressed in a testable form.

This research provides three main hypotheses of dependent and independent variables as follow:

$H1_0$: There is no significant reduction in averaged aggregated inventory level between with and without a distribution center

$H1_1$: There is a significant reduction in averaged aggregated inventory level between with and without a distribution center

H20: There is no significant change in transportation cost between with and without a DC

H21: There is a significant change in transportation cost between with and without DC

H30: There is no significant change in inventory administration cost between with and without a DC

H31: There is a significant change in inventory administration cost between with and without a DC

2.11 Conclusion

Inventory is an essential part in order to run a retail business. The strategic decision on inventory strategy is important as well. Every retailer must realize the need to balance the inventory cost and shortage cost. The shortages of products brings lost sales opportunity and a bad retailer image, but keeping a lot of inventory is not a smart choice. Paisarn Group is very concerned about inventory investment, and tries to find a way to reduce investment in inventory but still retain its service level.

The discussion in this chapter aims to find the optimum strategy of managing inventory for a retailer. Beyond the centralization of inventory concept, the daily replenishment of retailer in DC is quite a good strategy for the multi-location retailer in order to have a buffer to fulfill customer demand with efficiency. The process, from the production till sending to the end consumer, involves many parties in the supply chain, thus lead-time and a bullwhip effect could occur. Inventory is one of the tools to deal with uncertainty situations in order to retain the service level, however, more inventories mean the more investment in inventory. It would be worse for a multi-location retailer; the retailer has to invest in inventory in each location, which means much more money has to be spent. Distribution center is concerned as the best solution for Paisarn Group inventory management strategy, which hopefully can reduce the aggregated stock level but still retain the same service level.

CHAPTER III

RESEARCH METHODOLOGY

This chapter is about research methodology, which includes the data collection method, the sampling designs, determination of the sample size, and data analysis techniques. Various factors, which are identified as critical factors, are discussed in this chapter.

The research methodology is illustrated in figure 3.1:

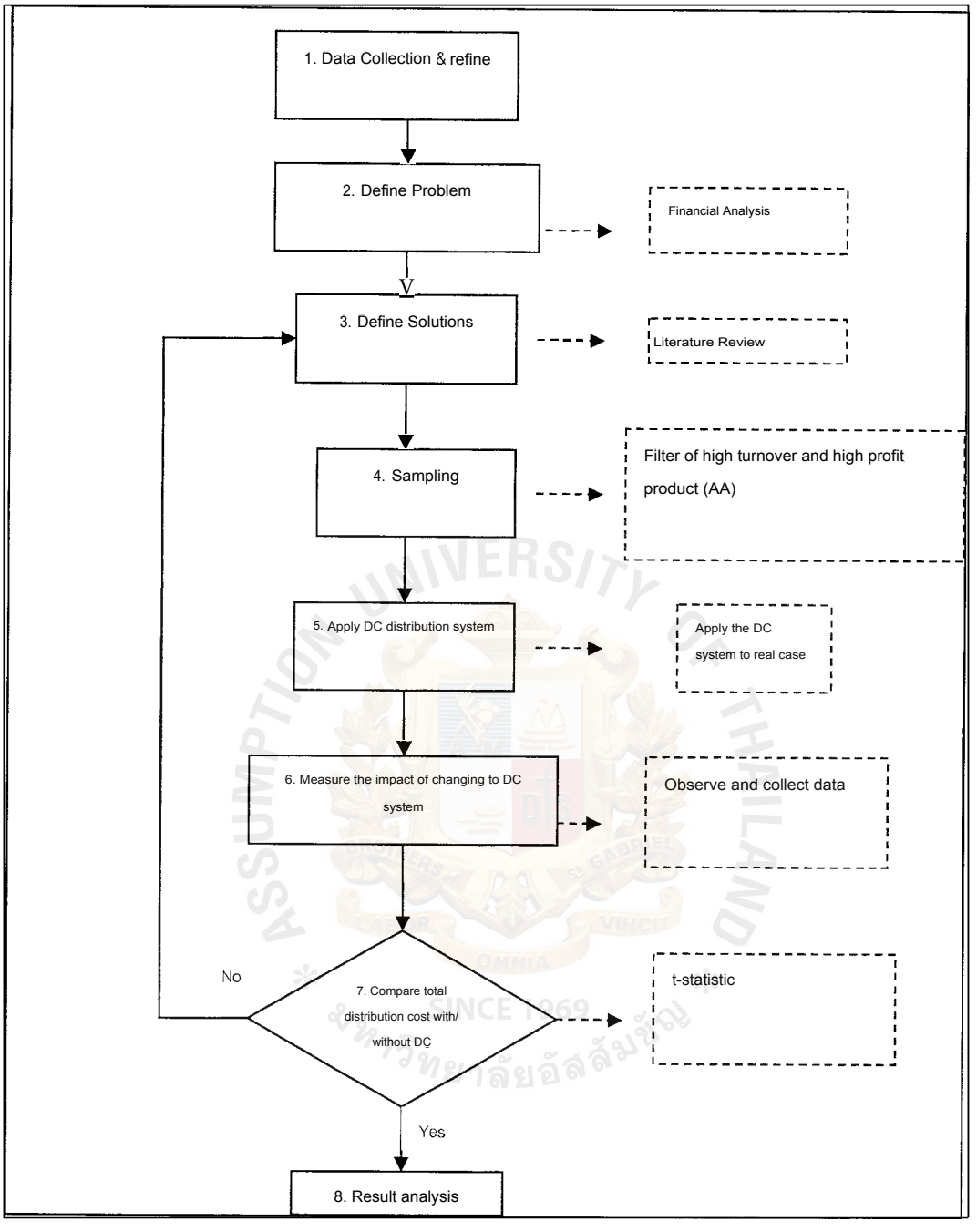

Figure 3.1: The Research Methodology Flowchart

3.1 Methods of Research Used

The research is a quantitative analysis research, which uses the historical data and current data in a case study of Paisarn Group Co.,Ltd. to test the impact of implementing a distribution center system. Secondary data is gathered and analysed to examine statistically how changes of independents variables (which were discussed in Chapter II(affect the total distribution cost.

3.2 Respondents and Sampling Procedures

Our sample is the 3-month data of July-Sept, 2008 and July-Sept, 2009. The 3-month period of July-Sept, 2008 is when Paisarn Group Co.,Ltd. was using the direct distribution model. The July-Sept, 2009 data is the data from implementation of the DC distribution model.

Paisarn Group has 25 product categories in stores, which are 2,200 SKUs, that move incessantly throughout the year. We sample only the AA product (high profit, high turnover) as our sample, which has only two categories:

1) Refrigerator

2) Washing Machine

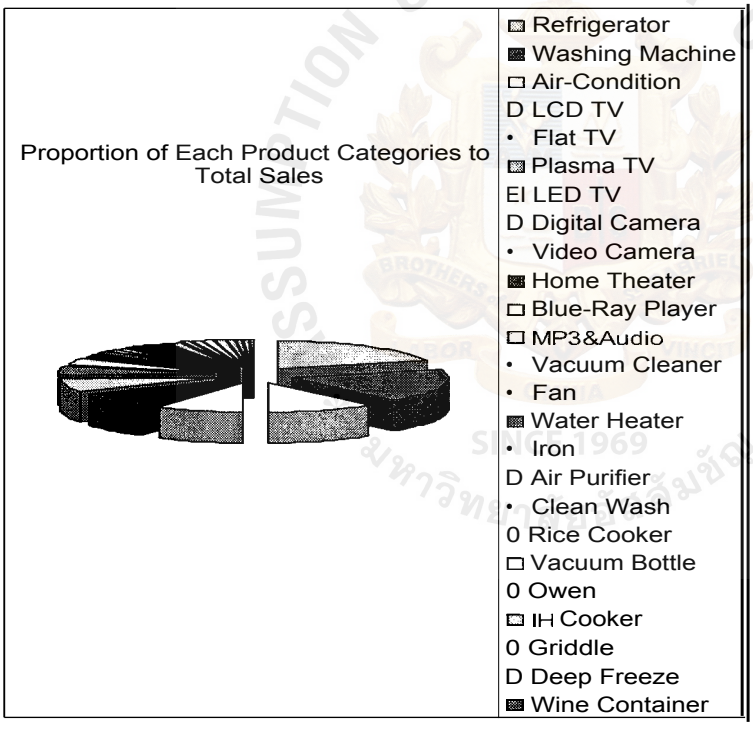

Figure 3.2: Proportion of Each Product Categories to Total Sales

The refrigerator product category contributes a gross profit margin of 20 % with 20% of total sales. The washing machine product category has a proportion of 19% to total sales with 19% of gross profit margin. We classify these two product categories as AA product categories.

We require data from our sample as follow:

a) Sales information by products, overall sales information

b) Gasoline expenses and depreciation in transportation

c) Lead-time of each product from supplier to store

d) Lead-time of each product from supplier to DC

e) Averaged inventory on hand of each product in each store, monthly

0 Administration expense in inventory management

3.3 Research Instruments

To answer the research question, the researcher sought to find out the total change in each factor of the total distribution cost when the company implements a DC distribution system. The historical data reflects the data when the company was using the direct distribution system, as well as the current data which reflects a DC distribution system. By weighting with sales volume, it was hoped to capture the impact of implementing DC distribution compared with the direct distribution system, in order to answer the research question.

3.4 Collection of Data

Our data is the secondary data that can be obtained from Paisarn Group's database. We created a list of our sample, which are all SKUs of refrigerator and washing machine products. Then we obtained all relevant data of our sample such as sales data, inventory on hand in each month, ordering data, and safety stock.

3.5 Operationalization of Independent and Dependent Variables

The research systematically examines the effect of each independent variable on the total distribution cost. The result must provide very strong directionality of each independent variable with respect to inventory management cost savings.

Basically, this research observes the change in the total distribution cost, comparing with and without a distribution center. The independent variables are: 1) change in averaged aggregated inventory level, change in transportation cost, and change in inventory administration cost.

Averaged aggregated inventory level

We define averaged aggregated inventory level as the sum of amounts of each store averaged inventory level necessary to satisfy a given level of demand. We calculate averaged aggregated inventory level as:

$$\textit{Averaged aggregated inventory level} = \frac{\textit{order quantity}}{2}$$

Safety stock can be determined by computer simulation or statistical techniques. In this illustration the statistical techniques will be used in calculating safety stock levels. It is necessary to consider the joint impact of demand and replenishment cycle variability. This can be accomplished by gathering statistically valid samples of data on recent sales volume and replenishment cycles. Once the data are gathered, it is possible to determine safety stock requirement (Stock and Lambert, 2002) that is shown on the model calculation of safety stock in order to optimize the inventory level, by using the following formula:

$$\textit{Safety Stock level} = Z \bullet \sqrt{\textit{Avg Lead Time} * \sigma_D^2 + \textit{Avg. Demand}^2 * \sigma_L^2}$$

Whereas Z is the standard Normal variable corresponds to the service level. We expect the target service level as 99.5% in the DC model to eliminate the lead-time from DC to store.

The average amount of inventory on hand is equal to the safety stock plus the replenishment quantity. There are trade-offs between the replenishment quantities to achieve a specified probability of being able to fill orders from stock (Herron, 1997).

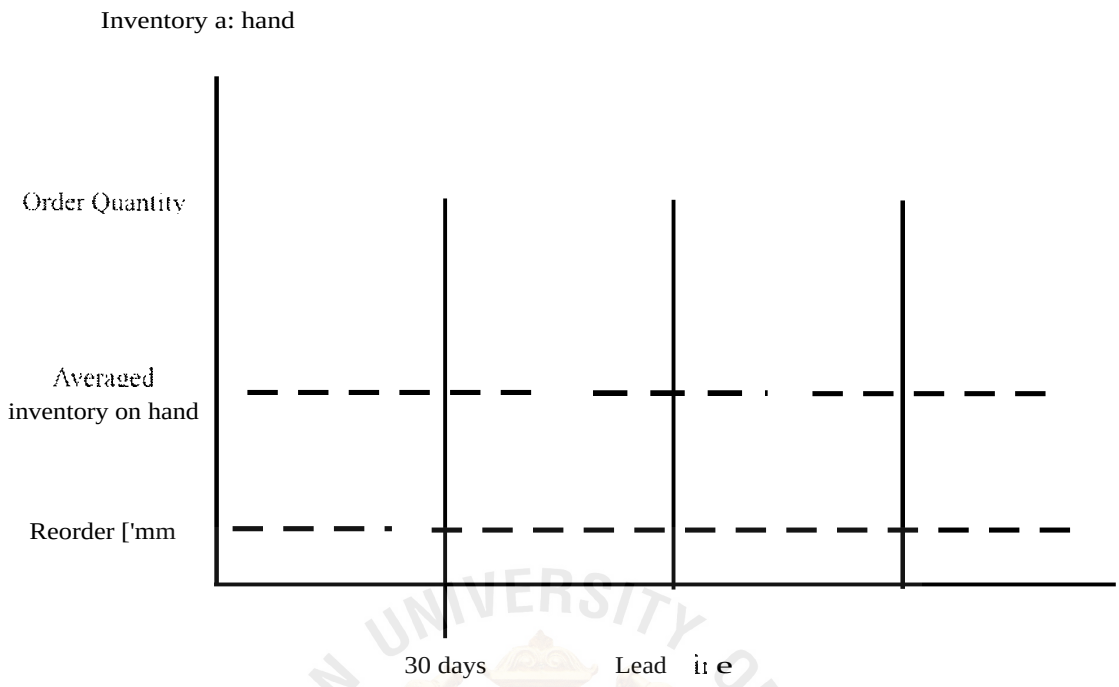

Figure 3.3: Averaged inventory on hand

Service level

Service level measures the performance of an inventory system. Certain goals are defined and the service level gives the percentage which should be achieved.

The a service level is an event-oriented performance criterion. It measures the probability that *all* customer orders arriving within a given time interval will be completely delivered from stock on hand, i.e. without delay.

Two versions are discussed in the literature, differing with respect to the time interval within which the customers arrive. With reference to a *demand period,* a denotes the probability that an arbitrarily arriving customer order will be completely served from stock on hand, i.e. without an inventory-related waiting time (period α_p service level):

$$a_p = P(Period\ demand\ Inventory\ on\ hand\ at\ the\ beginning\ of\ a\ period).$$

In order to determine the safety stock that guarantees a target α_p service level, the stationary probability distribution of the inventory on hand must be known. This version of a is also called *ready rate.'*

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[3] Tempelmeier, Horst, *Inventory Management in Supply Networks*, Norderstet (Books on Demand) 2006

Distribution center utilization or centralized inventory may reduce the aggregate safety stock level by eliminating lead-time, which brings a saving in inventory management cost at the same service level.

Transportation cost

However, with distribution center utilization, we have to bear the transportation cost instead of pushing it onto the supplier, as in the original distribution model that supplier makes shipments directly to each store. We expect that the transportation cost will be definitely increased.

We compute the transportation cost by observing the total expense in gasoline plus the depreciation of book value that is used in transportation and estimate the transportation cost in term of Baht/km. We use the Google map to measure the distance between DC to each store. The transportation cost is computed by transportation cost in Baht/km multiple by distance to each store.

We also weight the transportation cost by sales volume in order to obtain the real transportation cost incurred by sales. The difference in transportation cost is the difference of the previous expense of 2 months before DC implementation compared with 2 months after DC implementation, as follows:

$$\Delta Transportation\ Cost = w_{sales+1}(Gas\ expense + depre) - w_{sales-1}(Gas\ expense + depre)$$

We also compare the average total expense in gasoline of 2 months before DC utilizing with the average total expense in gasoline of 2 months after DC utilizing.

Inventory management costs

Typically, these costs are much greater in an inventory-decentralized system because there are fewer economies of scale. Inventory centralized may gain economies of scale in big lot orders and bargaining power from the supplier. Moreover, the inventory centralized system may gain an extra benefit from the supplier because the supplier just delivers to one place (DC) rather making a shipment to each store, and the company may negotiate for this.

It is hard to observe the change in inventory administration costs because there is no fair measure to measure the inventory administration costs of an inventory centralized

system in an electronic goods retail business. Since the price of electronic goods decreases all the time, it is hard to separate the benefit of economies of scale from the perpetual price reduction.

Thus, we measure the inventory administration costs by using only the extra benefit that the company can gain from the supplier; it would be a fit amount:

$$\Delta Ad\ ministration\ costs = extra\ benefit$$

We define total distribution cost as:

$$Total\ distribution\ \cos t = aggregated\ inventory\ level + transportation\ \text{cost} + \text{ad min cost}$$

3.6 Statistical Treatment of data

First, we calculate the different scores that are the impact of using a DC distribution system. The different scores are computed by subtracting each variable of a direct distribution system (pre-implementing DC distribution system) from each own variable of a DC distribution system.

We also add together the changes of each variable to find out the impact of the distribution system change to total distribution cost when the company changes from a direct distribution system to a DC distribution system.

Then, we employ t-statistics and z-statistics to determine if changes in measured attributes are significantly different from zero in order to test our hypotheses. The t-statistic is computed to test whether the mean data changes are significantly different from zero, and the Wilcoxon signed-rank test is used to test whether the median changes are significantly different from zero.

CHAPTER IV

PRESENTATION OF DATA AND CRITICAL DISCUSSION OF RESULTS

This chapter presents the research finding of independent variables and dependent variable. As discussed in chapter III, the main impact of changing the distribution system will be reflected by total distribution cost, which is composed of aggregated stock level, transportation cost, and administration cost that is the cost of inventory management.

After the company implements the DC distribution system, we observed and collected data to analyze the impact of changing. The results are as follow:

4.1 Overview

First, we begin with an overview of Paisarn Group in July – Sept 2008, and July – Sept 2009. The total sales are shown below:

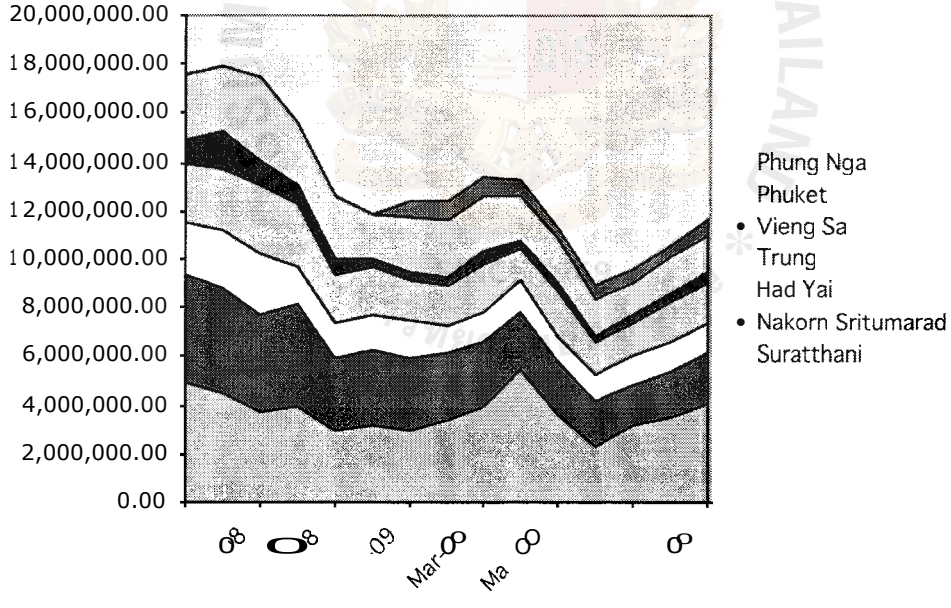

Figure 4.1: Total sales of the company from July 2008 to September 2009, monthly

The main effects on the company sales are classified into two categories:

External Environment

1. Political and Economic situation – the political situation in Thailand has affected the whole country's economic system since the middle of 2008.

The worst situation occurred in the end of last year when an anti-government mob took over the international airport of Thailand, and the other worst point was the red-shirt mob in the middle of this year that really damaged the Thai economy. Especially in the tourism sector, foreigners and travelers were panicked by the political situation. A huge number of hotel reservations were cancelled. The tourism sector is the main economic sector of southern of Thailand, and the crises made a large number of small and medium businesses close down because of liquidity problems. Paisarn Group sales volume were affected by the political situation. Naturally, electronic goods are high elasticity to income goods; loss in customer confidence and liquidity problems in other businesses had a direct impact on electronic goods sales volume. The sales volume of Paisarn Group are in Figure 4.1.

2. Swine flu – a new spreading virus in the middle of 2009.

The tourism economic sector became worse in the middle of 2009 not only because of the political situation but also by a new spreading virus, called “H5N1” or "Swine flu". This virus spread had a direct effect on the tourism sector, and also on Paisarn Group sales volume. However, this was just a short-term effect, as we can see the recovery signs since July 2009 in Figure 4.1.

Internal Environment

1. Phung Nga branch was set up at the beginning of January 2009. Thus, there is no comparable data for this branch of with and without DC distribution system. This branch had to be eliminated from the study sample.

2. The company changed its distribution system from a direct distribution system to a DC distribution system in July 2009.

Because of these effects, sales volume in each month is subject to fluctuations. We decide to weight our data by sales volume to observe the real impacts of implementing a DC distribution system.

4.2 Averaged Aggregated Inventory Level

Weighted by sales volume, the observed aggregated stock level will be unaffected by the external environment. By changing to a DC distribution system, the company's aggregated stock levels of washing machine and refrigerator are as follow:

Averaged inventory (Washing Machine)

Month	Surattani			Trang		Phuket	Averaged Aggregated Inventory Level
Direct distribution							
July 2008	418,220.00	394,238.28	202,850.46	325,468.45	138,015.00	263,740.00	1,742,532.19
Aug 2008	528,035.00	354,490.61	213,429.86	278,901.58	171,480.00	200,110.00	1,746,447.05
Sept 2008	391,325.00	467,756.97	314,901.89	320,606.49	111,560.00	220,420.00	1,826,570.34
DC distribution							
July 2009	545,027.49						
Aug 2009	737,935.36						
Sept 2009	1,090,198.24						

Averaged inventory (Refrigerator)

Month	Sur..		Bad Yai	Trang		Philo	Averaged Aggregated Inventory Level
Direct distribution							
July 2008	341,742.10	454,299.13	94,386.00	263,406.50	66,685.99	93,387.83	1,313,907.54
Aug 2008	558,227.50	263,496.28	302,942.75	338,217.50	31,991.73	209,832.27	1,704,708.02
Sept 2008	254,307.55	251,682.68	253,667.00	181,045.00	95,226.30	389,148.49	1,425,077.02
DC distribution							
July 2009	442,629.70						
Aug 2009	995,526.47						
Sept 2009	863,146.05						

Table 4.1: Averaged inventory of each branch, monthly

We eliminated Phung Nga branch because it was set up only this year, and there is no data from last year.

Obviously, the stock level in July 2009 had dramatically decreased compared with the stock level in July 2009. This is because when the company centralized inventory, there was a large amount of inventory at the warehouse, classed as sunken inventories of each branch, but that does not mean that these sunken inventories cannot be sold in the other branches.

Then, we weight the aggregated stock level by sales volume as follows:

Weighted by Sales Volume

	Washing Machine			Refrigerator		
	Direct distribution	*DC distribution*	*Duff*	*Direct distribution*	*DC distribution*	*Diff*
July	345,622.54	110,585.84	-235,036.71	273,052.11	51,690.84	-221,361.27
Aug	341,011.28	110,547.68	-230,463.60	319,026.40	123,559.11	-195,467.29
Sep	382,523.89	230,189.65	-152,334.24	308,975.35	104,277.81	-204,697.54

Table 4.2: Sales weighted averaged aggregated inventory level comparison

Figure 4.2 shows the sales weighted averaged aggregated inventory level comparison graphically of each product.

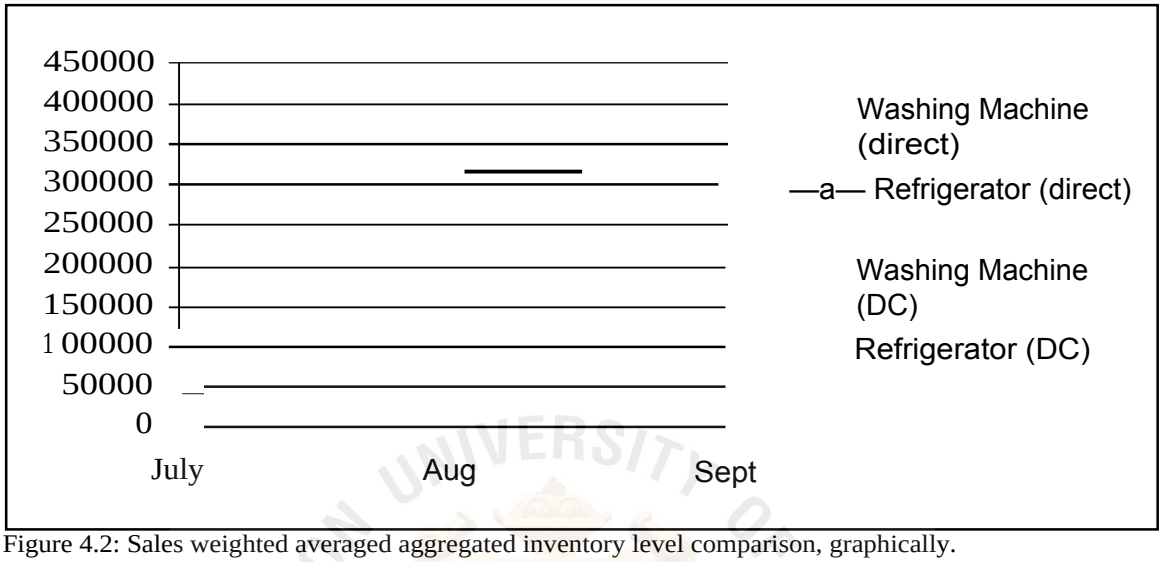

Figure 4.2: Sales weighted averaged aggregated inventory level comparison, graphically.

We calculate inventory turnover ratio and inventory turnover ratio days in order to observe the impacts of changing to a DC system. These ratios are also weighted by sales volume to eliminate the sales volume effects, as shown:

Washing Machine	Turnover ratio		Turnover days	
	Direct distribution	*DC distribution*	*Direct distribution*	*DC distribution*
July	1.8133	3.5862	16.5442	8.3654
Aug	1.8955	2.2357	15.8349	13.4187
Sept	1.8799	2.9240	15.9585	10.2599
Refrigerator	Turnover ratio		Turnover days	
	Direct distribution	*DC distribution*	*Direct distribution*	*DC distribution*
July	2.5012	4.6358	11.9943	6.4714
Aug	1.7674	2.2302	16.9738	13.4518
Sept	2.3885	2.4416	12.5599	12.2872

Table 4.3: Inventory turnover ratios and inventory turnover days

Obviously, a DC distribution system can increase inventory turnover ratios and reduce inventory turnover days.

We also perform the t-test to be confident with the results that they were significantly improved, the two-sample assuming unequal variances, a comparison between two variables, is used in testing the results of the monthly inventory costs totaling six observations. The hypothesis test and decision rules are that:

<u>Hypothesis test:</u>

Ho: There is no significant reduction in averaged aggregated inventory level between with and without distribution center

H_1: There is a significant reduction in averaged aggregated inventory level between with and without distribution center

<u>Decision rules:</u>

- Reject Ho, if P (probability of hypothesis) is less than significance or □ at 95 percent confidence lima
- Accept Ho, if P (probability of hypothesis) is greater than significance or ⌐ at 95 percent confidence lima

The output of the test is demonstrated in Table 4.4

t-Test: Two-Sample Assuming Unequal Variances

	alpha = 0.05		alpha = 0.01	
	Direct distribution	*DC distirbution*	*Direct distribution*	*DC distirbution*
Mean	322399.9289	113010.7892	322399.9289	113010.7892
Variance	996339825	1621206336	996339825	1621206336
Observations	6	6	6	6
Hypothesized Mean Difference	0		0	
Df	9		9	
t Stat	10.02495895		10.02495895	
P(T<=t) one-tail	1.75237E-06		1.75237E-06	
t Critical one-tail	1.833112923		2.821437921	
P(T<=t) two-tail	3.50474E-06		3.50474E-06	
t Critical two-tail	2.262157158		3.249835541	

Table 4.4: Two-Sample assuming unequal variances t-test of averaged aggregated inventory level comparison

From the results of the Two-Sample assuming unequal variances, t-test aggregated stock level between direct distribution and a DC distribution system, P (sig. 1-tailed) values of all items are less than 0.05: then Ho is rejected and H_1 is accepted. In conclusion, there are significant differences between direct distribution and a DC distribution system at 95% confidence level for all items, which confirms the better performance of inventory management in a DC distribution system. Moreover, at 99% confidence level, we also see a significant reduction of averaged aggregated inventory levels from a DC distribution system, compared with a direct distribution system.

4.3 Transportation cost

After the company implemented a DC distribution system, we observed gasoline expense as our independent variable, and expected to see increases in gasoline expense due to a DC distribution system. However, the observed data is surprising: when weighted with sales volume the sales weighted gasoline expense of the DC distribution system is less than the direct distribution system, as below:

	Gasoline Expense (Monthly amount)			Sales weighted Gasoline Expense		
	Direct distribution	*DC distribution*	*Diff*	*Direct distribution*	*DC distribution*	*Dill*
July	107,020.00	116,735.00	9,715.00	70741.32364	39571.96118	-31,169.36
Aug	84,355.00	110,385.00	26,030.00	53905.92489	39844.95472	-14,060.97
Sep	105,864.00	112,385.00	6,521.00	64859.25318	43530.55308	-21,328.70

Table 4.5: gasoline expense

The results show that the DC distribution system can save gasoline expense (weighted by sales volume). We also performed the t-Test two-sample assuming unequal variances to test our second hypothesis, and the results are as follow:

t-Test: Two-Sample Assuming Unequal Variances

	Alpha = 0.05		Alpha = 0.01	
	Direct distribution	*DC distribution*	*Direct distribution*	*DC distribution*
Mean	63168.8339	40982.48966	63168.8339	40982.48966
Variance	73000800.73	4888101.771	73000800.73	4888101.771
Observations	3	3	3	3
Hypothesized Mean Difference	0		0	
Df	2		2	
t Stat	4.354202094		4.354202094	
P(T<=t) one-tail	0.024454012		0.024454012	
t Critical one-tail	2.91998558		6.964556734	
P(T<=t) two-tail	0.048908025		0.048908025	
t Critical two-tail	4.30265273		9.9248432	

Table 4.6: Two-Sample assuming unequal variances t-test of gasoline expense comparison

<u>Hypothesis test:</u>

H20: There is no significant change in transportation cost between with and without DC

H21: There is a significant change in transportation cost between with and without DC

From the results of the Two-Sample assuming unequal variances t-test of gasoline expense between direct distribution and DC distribution systems, P (sig. 1-tailed) values of all items are less than 0.05: then H_o is rejected and H_1 is accepted. In conclusion, there are significant differences between direct distribution and DC distribution systems at 95% confidence level. But the significant difference is opposite to that expected, as the DC distribution system reduces gasoline expense significantly compared with the direct distribution system. An explanation of this result may be the clear daily schedule of transportation. Since the company implemented the DC distribution system, the company has set up a master transportation schedule to make an efficient daily transportation schedule. The warehouse and stores know the exact time of delivery. However, at 99% confidence, there is no significant reduction of gasoline expense (0.024>0.01). Hence, at 99% confidence, we accept $H_{0.}$ and reject H1.

4.4 Administration cost

At first, it was expected that there would be extra benefits from suppliers, because the company can save transportation of suppliers by delivery to only one place

(warehouse) instead of delivery to each store location, or economies of scale in inventory management and administration. However, it turns that there is no change in either extra benefit from suppliers, or inventory management and administration cost or expense. The company still uses the same number of employees at the same positions, and in the same jobs. Therefore, we have to accept our third null hypothesis that:

H30: There is no significant change in inventory administration cost between with and without DC

H31: There is a significant change in inventory administration cost between with and without DC

And we reject the hypothesis that there is a change in inventory administration cost between with and without DC. Hence, we conclude that there is no change in inventory management and administration cost.

4.5 Total Distribution Cost

Finally, we reach our dependent variable by combining all impacts of changing the distribution system from direct to DC, aggregated stock level, transportation cost, and inventory administration cost. The results are as follow:

	Sales weighted total distribution cost		
	Direct distribution	*DC distribution*	*Duff*
July	686,876.99	201,848.64	-485,028.35
Aug	696,924.93	273,951.74	-422,973.19
Sep	740,104.15	325,211.82	-414,892.33

Table 4.7: Sales weighted total distribution cost comparison

The results of changing to a DC distribution system show the dramatic decreases in the total distribution cost.

t-Test: Two-Sample Assuming Unequal Variances

	alpha = 0.05		alpha = 0.01	
	Direct distribution	*DC distirbution*	*Direct distribution*	*DC distirbution*
Mean	719906.0272	284599.4654	719906.0272	284599.4654
Variance	1146988042	7842181383	1146988042	7842181383
Observations	3	3	3	3
Hypothesized Mean Difference	0		0	
Df	3		3	
t Stat	7.952360476		7.952360476	
P(T<=t) one-tail	0.002073798		0.002073798	
t Critical one-tail	2.353363435		4.540702858	
P(T<=t) two-tail	0.004147596		0.004147596	
t Critical two-tail	3.182446305		5.840909309	

Table 4.8: Two-Sample assuming unequal variances t-test of total distribution cost comparison

Two-Sample assuming unequal variances t-test of total distribution cost, also confirms the significant reduction in the total distribution cost of changing to a DC distribution system, compared with a direct distribution system, even at the 99% confidence level.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the findings of this research, which lead to the conclusions and recommendations. This chapter also covers further research in this field.

5.1 Summary of the Findings

The main objective of this paper was to examine whether the DC distribution system can reduce the total distribution cost of Paisarn Group, a multi-location electronic retailer. The findings of this research support the company's strategic decision about changing the company distribution system from a direct distribution system (from supplier to each store) to a DC distribution system. A DC distribution system can significantly reduce the total distribution cost of the company.

5.2 Discussion / Conclusions

In discussing this research, the first topic is that there was a surprising result, in that there was a reduction in transportation cost by using a DC distribution system. That is opposite to what was expected at the beginning The new clear master transportation schedule may be a reason for this result. However, an overview of changing to a DC distribution system in this short 3-momth period sheds light on how the company reduced the total distribution cost. By changing to a DC system, the company can save about 859,742 Baht in each month, or 63.55% of the total distribution cost of last year. These results also support the company's strategic decision of changing to a DC distribution system.

5.3 Recommendations

1. The company is on the right track about a distribution system that changes from direct to DC system. However, the transportation cost is quite high compared with a direct system. The company should improve the transportation system more efficiently, such as using a bigger truck,

identifying the optimum truck route, or specifying the optimum transportation schedule from the DC to each store and from each store back to the DC.

2. The company should not ignore the development of demand forecasting. An accurate demand forecast can smooth operations, and maintain service levels and competitiveness, particularly in retailers. An accurate demand forecast can also reduce the inventory carrying cost and ordering cost.

5.4 Further Research

In further research, a researcher could expect to find the optimum location for a distribution center in order to reduce the logistic cost but still maintain the same customer service level. This further research would include optimum truck size capacity, optimum route, and optimum schedule.

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APPENDICES

Appendix A:

Total product categories of Paisarn Group on Shelf

Rank	Categories	% of Total Sales
1	Refrigerator	20.0%
2	Washing Machine	19.0%
3	Air-Condition	11.0%
4	LCD TV	9.0%
5	Flat TV	8.0%
6	Plasma TV	7.6%
7	LED TV	5.0%
8	Digital Camera	3.9%
9	Video Camera	1.8%
10	Home Theater	1.5%
11	Blue-Ray Player	1.0%
12	MP3 &Audi o	1.0%
13	Vacuum Cleaner	1.0%
14	Fan	1.0%
15	Water Heater	1.0%
16	Iron	1.0%
17	Air Purifier	1.0%
18	Clean Wash	1.0%
19	Rice Cooker	1.0%
20	Vacuum Bottle	1.0%
21	Owen	0.9%
22	IH Cooker	0.8%
23	Griddle	0.7%
24	Deep Freeze	0.5%
25	Wine Container	0.3%

Ranking by Sales Volume (January 2009 – September 2009)

Appendix B:

Total sales volume, monthly:

	Suratthani	Nakorn Sritumarad	H Ya	T g	\lingSa	'h '	Pl n ga
on h	o, ɪ'	4n.	' ount	A	An un	ot	' ut
Ju 2008	,892,95 8	4. 8199.00	2,247 35 0	, 8 7.00	101 90.00	61	
' 2008	1549,70 8	;, 1 570.00	2.11;, 80. 0	4: 3 885	51 1 00	5 30.	
2008	3,1 1,79 4	3. 16 850.00	2,587, 85. 0	78 6.30	8 80.00	, 2',875.	
u 200	8 215 628	1 2 550.00	1,145 °9.00	1, 4' 5.00	353,4K00	1 1 80.	51 5 ..00
Aug 2009	35 1 011	1 0,2ɔu.00	1,17 29.00	1 9 0.00	35 940.00	5 ;, 50.	5 0.00
Sept 2009	4,0 5 716.	2, 2,380. 0	1, 6', 70.00	1 25, 9.00	8 21	,5, , 0.	749 u.00

Washing Machine Sales Volume, monthly:

	Suratthani		Nakorn Sritumarad		Ha ai		g		, e g Sa		nu' e		Phung ga	
r:		a t		Ba it	L	a		a	n	Ba	n	B^a t	1	B
Ju 2008	16	836 8 0.	12	7 88 476.56	2	40 00 91	1	5 , 36 90	2	87' 030.00	18	5°7 80.00		
Aug 2008	138	056,070	1	708,981,22	8	12 659 71		557, 03 16	6	34' ,9 0.00	55	400 20.00		
Se 2008	131	782 '50		935 513.93	117	629 803.77		641, 2.99	7	22 ,120.00	62	44 84' 00		
Ju 200	60	442.100	54	419,299 05	5	80,859.81		375 47 22	2	8 ,160.00	26	427,240.00	1°	1 2 0.00
A: 2809	62	48 570	7	360 149 53	0	103,112 5		352, 62.51	-	3 ,150.00	31	178 180.00	18	1 0 0.00
Se 2008	7	54 050	88	626394,59	4	63,1 8 6		358, 83	18	11 0 0.00	67	483 290.00	19	1 0.00

Refrigerator Sales Volume, monthly:

0 1		8	akorn Sritumarad		Had-Yai		8		Veng Sa		P		h ng a	
		hu		B l		Ba		Ba t				B ht	1	Ba
July 2008	2 5	1 8 -02.00	142	880 588 73	7	399 266.35	74	463,054.37	28	60 00	48	27 8 0 00		
Aug 2008	1 2	5 810 00	1 3	820. 20.80	6	373, 02.75	00	570 883.30	3	60 00	71	42 740. 0		
Sept 2008	1 1	9 2 4.80	8	81 149.48	12	643, 91 56	85	534,250 62	26	50 00	178	92 235.00		
200	285	45,731.00	31	2 2,214	2	1 1 21 51	35	247 802.7		80 00		27 ,780 00	16	13, 00
00	265	1 36,867.00	34	768 962.61	1	120, 73.81	39	310.878.55	4	80 00	48	34, 150 00	18	08 67 00
00	158	17 050.40	82	469,020 8	17	112,223.64	43	319.8 ,8 7	7	10 00	32	2 780 00	10	12,840 00

Appendix :C

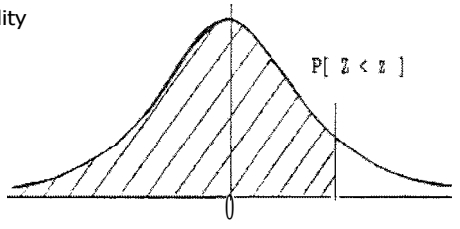
Z-Score

STANDARD STATISTICAL TABLES

1. Areas under the Normal Distribution

The table gives the cumulative probability up to the standardised normal value i.e.

$$P[Z < z] = \int \frac{1}{\sqrt{2\pi}} \exp(-\tfrac{1}{2}Z^2)\, dz$$



	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5159	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0,7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7854
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1:0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.6708	0.8729	0.8749	0.8770	0.8790	0'3804	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9773	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0,9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9865	0.9868	0.9871	0.9874	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0,9922	0.9924	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0,9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9980	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
z	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90
P	0.9986	0.9990	0,9993	0.9995	0.9997	0.9998	0.9998	0.9999	0.9999	1.0000