

**INVESTIGATION FOR NEW POSSIBLE WAREHOUSE LOCATION TO  
MINIMIZE LEAD TIME**



**AN INDEPENDENT STUDY REPORT SUBMITTED IN PARTIAL  
FULFILLMENT  
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MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN  
MANAGEMENT  
INTERNATIONAL COLLEGE  
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG  
2018  
KMITL-2018-IC-M-002-005**

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**BRYAN FOOK SHIN LEE LAN CHONG**



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**INDEPENDENT STUDY TITLE** Investigation for new possible warehouse location to minimize lead time  
**STUDENT NAME** Mr. Bryan Fook Shin Lee Lan Chong  
**STUDENT ID** 59610008  
**DEGREE** Master of Science  
**PROGRAMME** Logistics and Supply Chain Management  
**ADVISOR** Asst. Prof. Dr. Wichitsawat Suksawat Na Ayudhya  
**CO-ADVISOR**

### ABSTRACT

With the globalization era, world economies are spiking up and there are more and more consumers in the society, which leads to an increase in transport demand, movement and logistic handling of material goods. New logistics and supply chain systems have to be invented so as to match up with the constant changing world. Following, new logistics facilities are built to provide a wide range of logistics tasks. The aims of these tasks are to be efficient and provide effective transformation of materials in such way to satisfy the requirements of customers, at the same time trying to lower cost. Warehouse location or facility location is considered to be a typical problem in operations research and in the overall supply chain. The main elements that people focus while building a warehouse is to reduce the initial facility cost as well as the final transportation cost. Besides talking about cost, a good warehouse location will help in providing a good service as well as maximizing the coverage of demand. This project is about the investigation of a current warehouse location for a retail company in Thailand as well as finding if a new location could be found to decrease transportation cost. This study makes use of distance calculation estimation and analytic hierarchy process to help in deciding which location provides the best result.

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Without the help and support from many people, this research would not have been possible. The inspirations from a lot of people have been the key to complete this paper.

Without the contribution of many people, this thesis would not have been existed. It owes the existence to the supports and inspirations from a lot of people.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Background

With the globalization era, world economies are spiking up and there are more and more consumers in the society, which leads to an increase in transport demand, movement and logistic handling of material goods. New logistics and supply chain systems have to be invented so as to match up with the constant changing world. Following, new logistics facilities are built to provide a wide range of logistics tasks. The aims of these tasks are to be efficient and provide effective transformation of materials in such way to satisfy the requirements of customers, at the same time trying to lower cost. This in turn can help in determining the necessity of solving numerous decision-making problems concerning the designing of efficient and effectively manage supply chains(Baker & Canessa, 2009). Logistics facilities play a crucial role for all the supply chains because they are responsible for significant contribution in material handling, which are moved from places of production to consumers. In logistics and supply chain, another important factor is the storage facility, also known as warehouse.

Warehousing has played a major role in our civilization. It is not a new concept as thousands of years ago, people built storage facilities to store their products for future consumption. Nowadays warehouse is regarded as an important element in all of the logistics networks. Having any kind of restrictions in accessing warehouses tend to cause problems throughout the network operations(Hamidi,

Gholamian, Shahanaghi, & Yavari, 2017). Therefore choosing the correct location for a warehouse is very important to achieve a good performance in terms of service.

Warehouse location or facility location is considered to be a typical problem in operations research and in the overall supply chain. The main elements that people focus while building a warehouse is to reduce the initial facility cost as well as the final transportation cost. Besides talking about cost, a good warehouse location will help in providing a good service as well as maximizing the coverage of demand. This project is about the investigation of a current warehouse location for a retail company in Thailand.

## **1.2 Problem statement**

The warehouse is located just outside Bangkok, precisely at BangNa Trat km20, but has to serve 9 different stores, whereby 7 are located in and around Bangkok, 1 in Pattaya and 1 in Chiang Mai. Products are received and sent on a daily basis. The strategy of this company is to keep a minimum inventory on the shelves, at the stores rather than keeping a big stock of products. This strategy is developed to use lower space for stores. Whenever products are purchased at the counter, the system will automatically order the same products and same amount sold. This means that if delivery is not made within a short period of time, these products may not be available for purchase in store. This can cause a bad service reputation for the company as well as loss of opportunity. Therefore the case about warehouse location should be investigated in order to fulfill a better delivery service.

### 1.3 Scope of the study

The focus of the study is based primarily on the warehouse facility location and how it can help to decrease lead time by analyzing other possible warehouse location. It should be noted that the study will not focus on logistic costs.

### 1.4 Objectives of the study

The objective of this research is to find a suitable warehouse location by studying:

- New possible warehouse location
- Amount of time that can be saved
- Improve service by decreasing lead time

### 1.5 Timeline

The primary phase of this project started on 1<sup>st</sup> September 2017 and has been completed in April 2018. A gantt chart is illustrated below to show the time planning.

Item	Activities	Date							
		Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18	Apr-18
1	Introduction	■							
2	Literature Review		■	■					
3	Research Methodology				■	■			
4	Results and Discussions						■	■	
5	Conclusion								■

**Figure 1.1** Timeline of study

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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Supply Chain Management

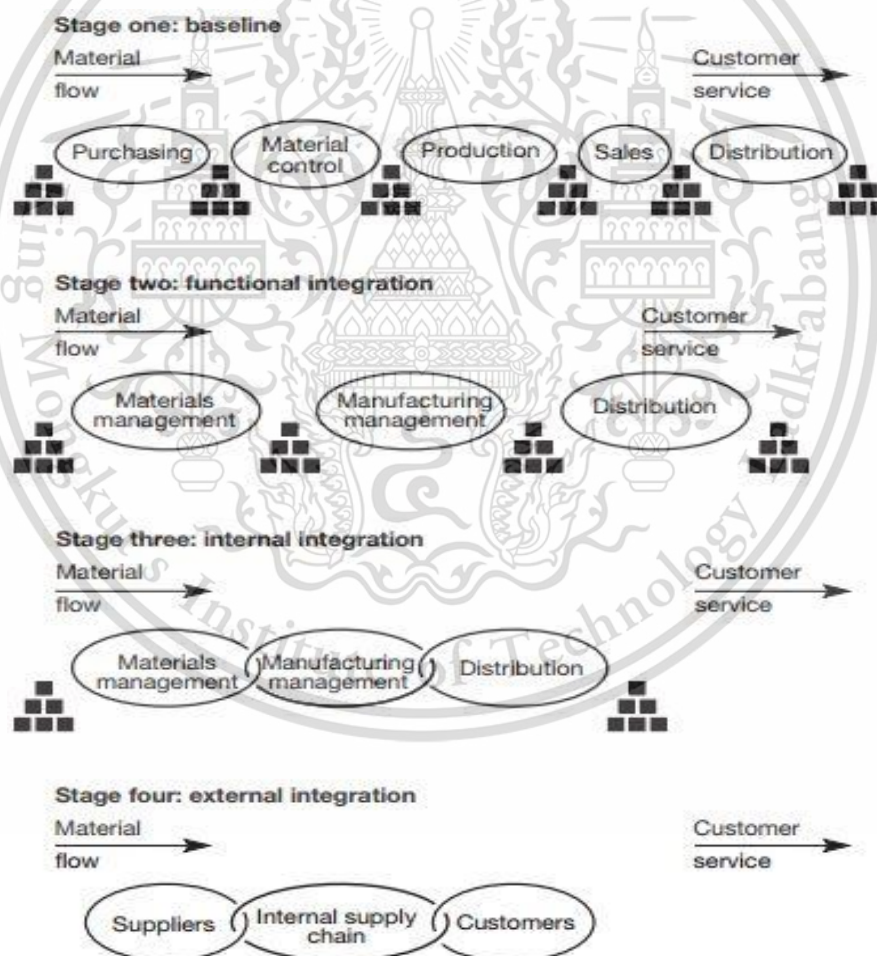
The term known as “supply chain” was first time used in the beginning of 9th decade of XX century, when Oliver and Webber (1982) proposed that this term would be used to describe a new science department which was still in the development period. The sudden change of common strategic business trends led to the creation of supply chain, where the focus was shifted from the satisfaction of inner interests of company to achieving greater good through more efficient structure of organization, which would in turn create better value for clients and shareholders (Masteika & Čepinskis, 2015).

A supply chain is said to be a network of facilities and distribution options that allows several functions such as procurement of materials, then transform these materials into intermediate and finished goods, and the distribution of these finished goods to customers. It is a connection of organizations involved in several processes and activities which involve in the creation of value in the form of products and services for the ultimate consumer. Supply chain management can be defined as a series of methods that bring together suppliers, manufacturers and warehouses in the most efficient way. The advantages of considering supply chain is that it minimizes the whole system costs and meets service level needs. The main objective of the supply chain management is to bring the supply chain surplus at an optimum level. Supply chain management in an industrial point of view includes a variety of management and technical factors, beginning with the good distribution design of

goods and processes, the decentralized but efficiently coordinated production of

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goods through suppliers contracting and outsourcing, the coordination of third-party logistics and multi-locations inventories. Supply chain management keeps on evolving and nowadays new practices are developed and include: supplier partnership, outsourcing, cycle time compression, continuous process flow, and information technology sharing. In general, we can say that supply chain management is a business strategy which aims at improving shareholder and customer value by trying to optimize the flow of products, services, and related information from end to end, that is from source to customer. It surrounds the processes of creating and fulfilling the market's demand for goods and services. (Akdogan & Demirtas, 2014)



**Figure 2.1** An integrated supply chain

Source: Integrating the Supply Chain. (Agarwal, Sahai, Mishra, Bag, & Singh, 2014) *International Journal of Physical Distribution & Materials Management*, 19(8), 3-8.

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Organization business has been considering supply chain as an important focus for competitive advantage in the market. The management of supply chain study focuses on how to bring the overall value of the firm to the maximum by making better use and better deployment of resources across the whole firm. A supply chain is considered to be a set of value adding activities which connect an enterprise's suppliers with its customers.

The way supply chain activity works is to receive input from the firm's supplier, add value then deliver to customers. Any parties that are involved directly or indirectly into fulfilling a customer request are included in the supply chain. When talking about supply chain, this includes manufacturer, suppliers, transporters, warehouses, retailers and even customers themselves. Within each organization, for example a manufacturer, the supply chain takes into account all functions involved from the time a request is made by customer until service is given to the latter. These functions that are included are new product development, marketing, operation, distribution, finance, customer service and other function that are directly related to serving a customer request (Heap, 2007). The effectiveness of supply chain management is important in order to build and sustain competitive advantage in product and services of the firms. Gunasekaran and Ngai,(2004); Sufian (2010) mentioned that the performance of supply chain was impacted by managing and integrating key element of information into their supply chain. According to Sufian (2010) to achieve a competitive advantage and better performance, supply chain management strategy need to support the business strategy.

## 2.2 Logistics

The term “logistics” is derived from the ancient Greek word “lógo2” (logosdratio, word, calculation, reason, speech, oration), and as a result people have been using the term logistics for a much longer period of time as compared to the current business logistics concept. It is believed that the word logistics itself appears from the military discipline. The military divisions which were responsible for the supply of weapons and other materials as and when they were needed were called the logistics divisions. They were also in charge of transportation during the relocation of bases. In the ancient Greek, particularly during the Roman and Byzantine empires, military officers who were responsible for financial, supply and distribution operations were given the title ‘Logistikas’ (Islam, Fabian Meier, Aditjandra, Zunder, & Pace, 2013).

In general, logistics is commonly known as adding “place utility” to a product. This means that, for example, a product needs to be moved from one point to another. The product could be either raw material that needs to be processed in a factory, or it could be finished product from the factory and to be shipped out to the market for sale.

In terms of “place utility” in logistics itself, this is resulted because the customer and the supplier of the product have come to an agreement to sell and buy the product arranged conditions that include delivery price and time. According to the agreed conditions, a transport and/or logistics service provider will be hired either by the customer or the supplier, depending on the agreements, to move cargo from the supplier’s premises to the customer’s premises. Generally, when in transit or under logistics service, the so called “product” will be termed as “cargo” or “goods”. As per the agreement made between the supplier and the customer, the cargo may need to be

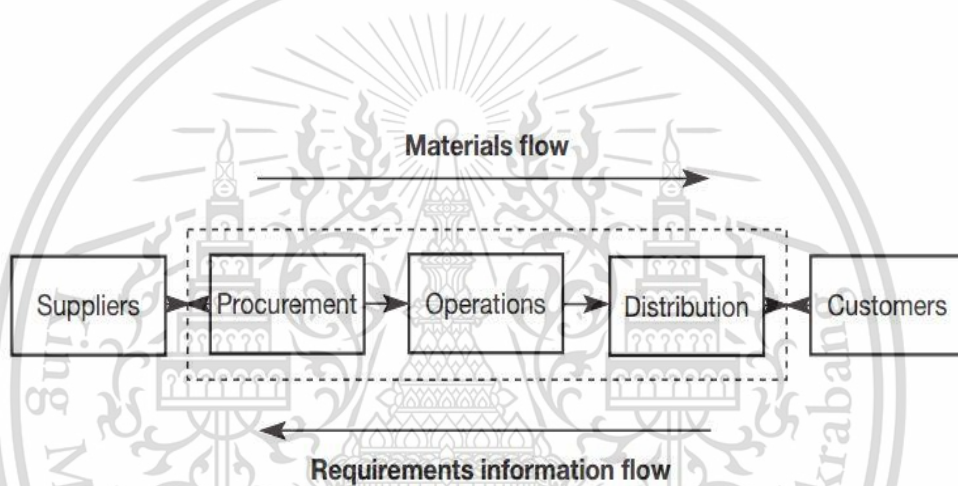
stored somewhere during the transit; this service is known as ‘warehousing’ and the

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warehouse location or size is dependent on the type of cargo. The customer may choose to buy the product in a big lot on a monthly basis or weekly in a smaller lot and this decision influences the level of inventory the customer has to maintain. For the transport and warehousing services, the product will be packed according to its type. In general, logistics is defined as:

Logistics = supply of raw materials  
 + materials management in a factory  
 + distribution to customers



**Figure 2.2** Logistics management process

Source: Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service (Second Edition). (Christopher, 1999). *International Journal of Logistics Research and Applications*, 2(1), 103-104.

Globalization is a term that is simply known as to express the mutually evolving economic, social and cultural relationships between individual world regions whereas The International Monetary Fund defines globalization in several sections. The most general form to define this term is to characterize it as a factor that is constantly affecting the lives of people everywhere in the world. Globalization began as a result of more technological advancement and human innovation. The

International Monetary Fund qualifies it as the growing integration of worldwide economies, especially through the movement of goods, services and capital that cross borders of countries (Goetz, 2010).

Many problems in logistics field have been found due to globalization. One of the examples is that the delivery times have been prolonged, particularly due to uncertainty of transition times. Break-bulk items as well as consignment consolidation requirements have been seen increasing. Direct conflict between globalization and introduction of Just-in-time(JIT) procedures have been caused in some companies. Global companies are changing their policy by trying to prolong delivery times and inventory levels because of the large distances of the markets as well as the complexity of logistics operations. There are still some companies that are doing business based on the JIT philosophy and thus they are aiming at shortening delivery times and stock levels as much as possible. In order for this to happen, many factors including warehouse operations should be accounted for. Thus, the competition is different as they no longer need to compete with rival companies but rather with their own distribution chains. The solution is therefore in solving the warehouse location problem in order to improve the distribution service (Kudláčková & Chocholáč, 2017).

### 2.3 Warehouse

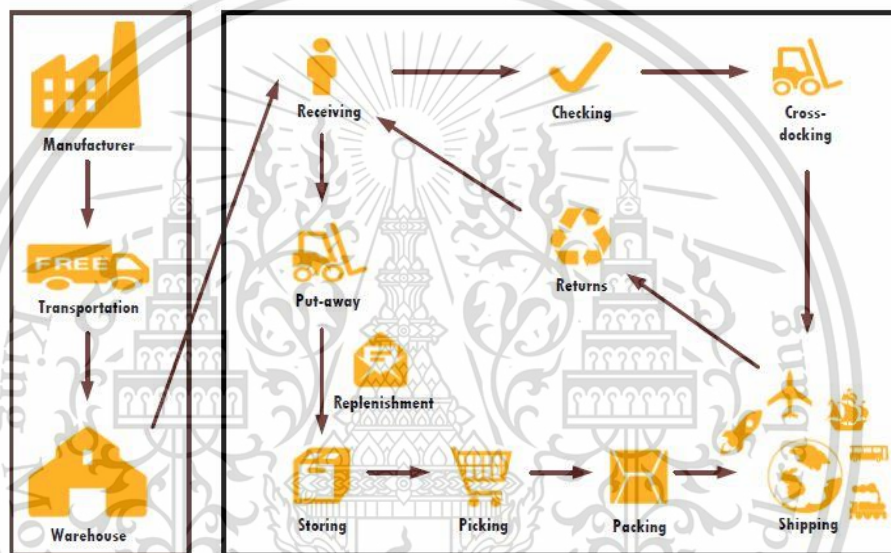
In recent years, supply chains have become quite complicated as compared to decades ago. With globalization, there are a large number of new markets and sourcing options that push business to require more efficient management in the movement of goods between manufacturers, distributors and consumers, which can only be possible by the establishment of large multi-format logistics networks.

Because of this incident, the solution for many companies in this situation has been to

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focus on their core business while outsourcing the logistics and warehousing operations to third party logistics service providers. The success of a company depends largely on its strategic decisions as the result can have a large impact. This is the reason why tools should be carefully chosen while making such decisions. Decision involving location of facilities are strategic in nature(Brunaud, Bassett, Agarwal, Wassick, & Grossmann, 2017).



**Figure 2.3** Logistics flow

Source: *An Overview of Warehouse Optimization* (Vol. 2). (Karasek, 2013)

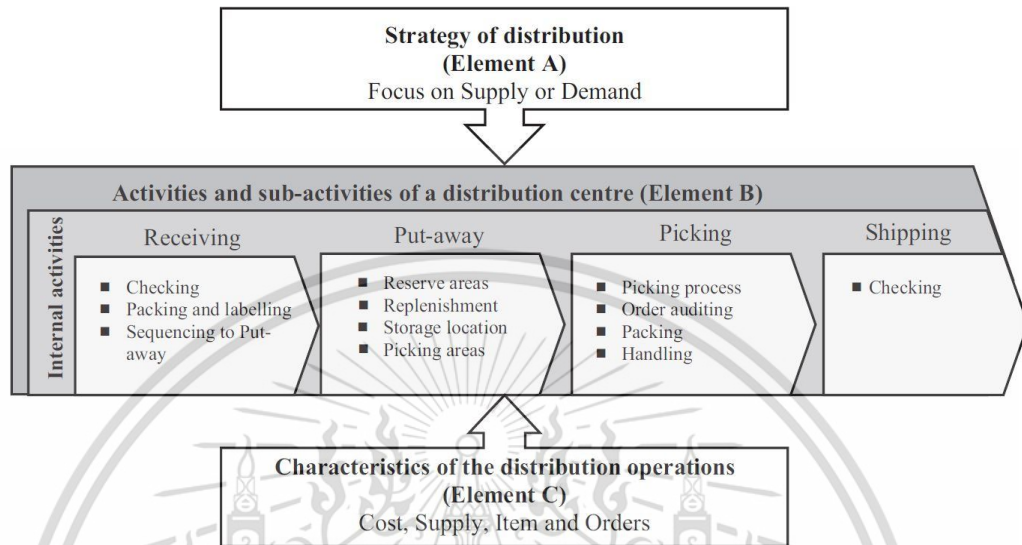
In this current supply chain era, the aim of most companies is to deliver products to customers in the shortest delivery time possible as well as procured with a minimum number of stocks. Small quantity of products must be distributed in a wide variety on a more frequent basis and more rapidly. It is seen that this time constraint directly impacts distribution and warehousing management. Warehousing is considered to be one of the key factors in the supply chain management(Lambert,

Stock, & Ellram, 1998). We consider warehouse to be important because it is the

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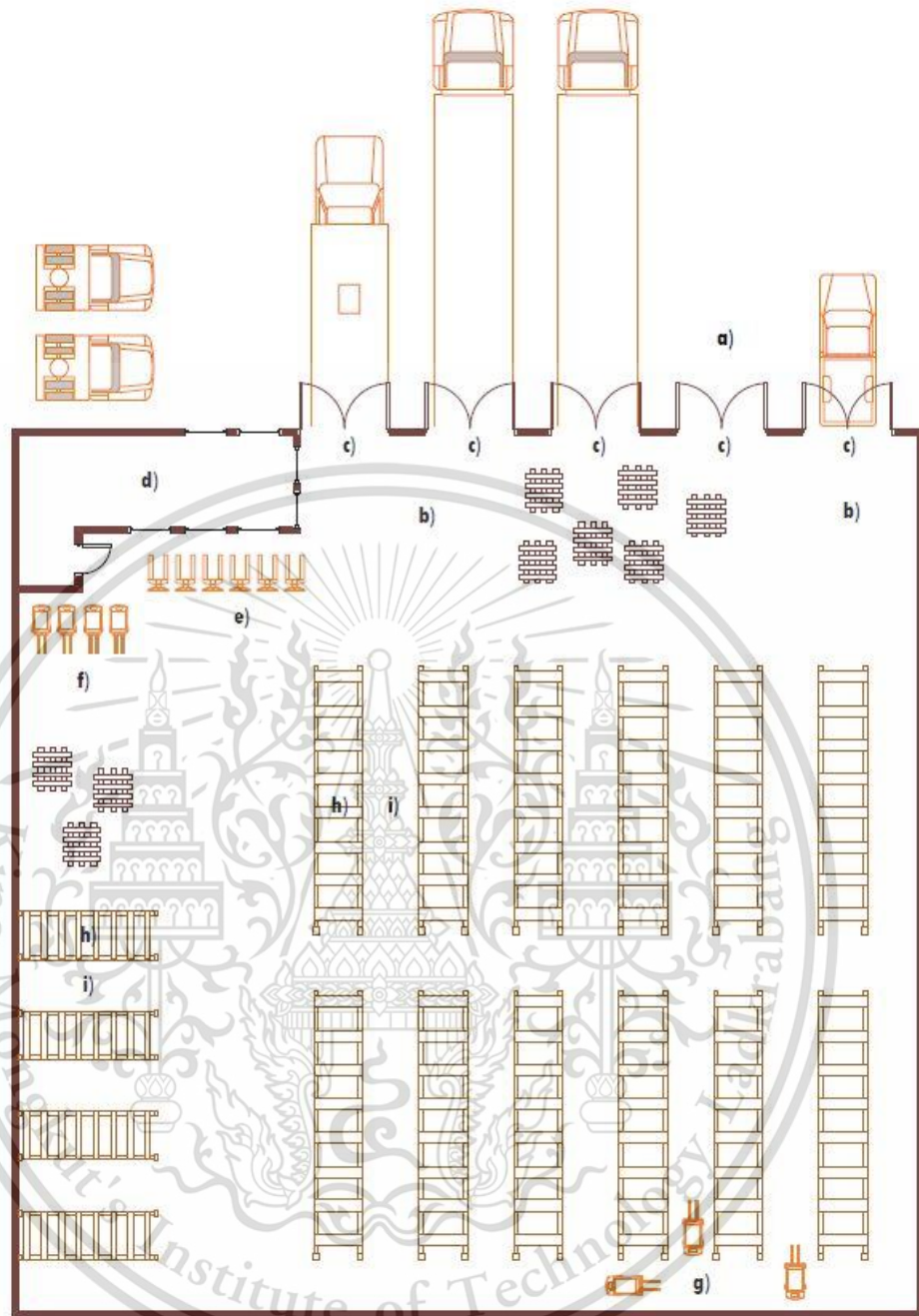
main link that connects producer and customer. A warehouse can be defined as a location from where raw materials, semi-product, and finished goods are received, transferred or put away, picked, sorted and accumulated, cross-docked and shipped in.



**Figure 2.4** Internal warehouse activities

Source: An AHP-based framework for logistics operations in distribution centres. (Vidal Vieira, Ramos Toso, da Silva, & Cabral Ribeiro, 2017). *International Journal of Production Economics*, 187, 246-259.

Most of the time, building a warehouse requires large capital investments as well as labor costs for operations. It is very important to analyze all the costing before deciding to implement a warehouse because great losses can happen in the future. During the recent years, instead of having a big warehouse, some companies opted for the consolidation method to gain a competitive advantage through the economy of scale (Cakmak, Gunay, Aybakan, & Tanyas, 2012).



**Figure 2.5** Example of traditional warehouse layout

Source: *An Overview of Warehouse Optimization* (Vol. 2). (Karasek, 2013)

## 2.4 Analytic Hierarchy Process (AHP)

Because it is simple and easy to use with great flexibility, the analytic hierarchy process (AHP) has been given extensive study and has been in use in nearly all applications that are related to multiple criteria decision- making (MCDM) since it has been developed in 1980(Ho & Ma, 2018).

AHP is a quantification process which makes use of results from pairwise comparisons among criteria, attributes, or alternatives in a hierarchical system, which is constructed by breaking down the decision problem into a hierarchy of interrelated elements. Let's assume that there are  $n$  criteria at a given hierarchy, the pairwise comparison matrix  $A$  is established such that its diagonal elements  $a_{ii}$ 's equal 1 ( $i=1, \dots, n$ ), its elements  $a_{ij}$ 's correspond to pairwise comparisons for which a scale from 1 to 9 is used (Table 2.1) and for judgment consistency  $a_{ij}=k$  implies that  $a_{ji}=1/k$ . Therefore, when  $n$  criteria are being compared,  $n(n-1)/2$  pairwise comparisons are necessary to fill in the matrix  $A$ .

Below is the process for determining the criteria weights:

1. Once the comparison matrix  $A$  is established, it is standardized by dividing the elements of each column by the sum of the elements of the same column. The sum of column elements of the resulting normalized matrix  $N$  is equal to 1.

2. The criteria weights are computed as the row average of the normalized matrix  $N$ .

3. If the decision maker exhibits perfect consistency in specifying the entries of the matrix  $A$ , the columns of the matrix  $N$  are identical. Mathematically, a comparison matrix  $A$  is consistent if  $a_{ij} \times a_{jm} = a_{im}$ , for all  $i, j$ , and  $m$ . The consistency ratio (CR) is used to test consistency. If CR is at most 0.1, the level of inconsistency

in the comparison matrix  $A$  is acceptable. Otherwise, the inconsistency is high and the

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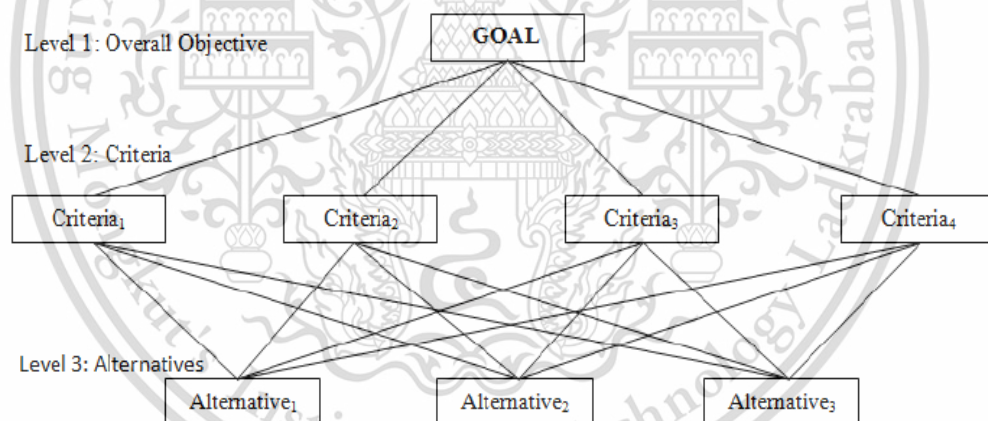
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decision maker is advised to revise the elements of matrix A to realize a better consistency (Sennaroglu & Varlik Celebi, 2018).

**Table 2.1** Scale used for AHP pairwise comparison

Value ( <i>k</i> )	Definition	Explanation
1	Equal importance	<i>i</i> and <i>j</i> are equally important
3	Weak importance	<i>i</i> is slightly more important than <i>j</i>
5	Strong importance	<i>i</i> is strongly more important than <i>j</i>
7	Very strong importance	<i>i</i> is very strongly more important than <i>j</i>
9	Extreme importance	<i>i</i> is absolutely more important than <i>j</i>
2, 4, 6, 8	Intermediate values	used when a compromise is needed

Source: A military airport location selection by AHP integrated PROMETHEE and VIKOR methods. (Sennaroglu & Varlik Celebi, 2018) *Transportation Research Part D: Transport and Environment*, 59, 160-173.



**Figure 2.6** Analytic hierarchy process mapping

Source: *Supplier Selection in Dynamic Environment using Analytic Hierarchy Process* (Vol. 6) (Agarwal et al., 2014).

There are many factors that need to be considered when locating a new facility. The definition of the “correct place” might however not be the same for all types of industries. Some industries need to have unique location requirements whereas others are better at adapting to existing situations. The main question to be considered is

which factors should be prioritized when a Multinational Corporation (MNC) needs to

have a facility location decision. Concepts that are related to different supply chain network configurations should be identified, analyzed, and related to facility location decision models.

When a facility location decision is taken into consideration, it is very important to know the needs and nature of the industry which facilitates the selection and prioritization of the applicable factors by the decision maker. It can be helpful if the process is divided in different stages. Facility location decisions involve factors at global, regional, and local levels. When deciding on a facility location, the organization can start from a global perspective. The first step is to look for the most convenient regions, where regions could be defined by continents or cultures. The second step would be to choose the country where the facility will be located. Afterwards, state, city and eventually the specific site are chosen successively.

Once the factors have been identified, the next step is to decide the way how these factors can help a multinational corporation in deciding for their facility location. There exist several models that have been developed by researchers which present different perspectives on the same problem. Ambrosino and Scutella (2003) defined the integrated distribution network design problem, whereby decisions such as facility location, transportation, and inventories are involved in a complex system. They considered that distribution networks need to be composed of four layers: plants, central transportation network, regional transportation network, and customers or demand points. Their aim was to define the number and location of different location facilities in order to design a completely new distribution network or to improve a current existing one. They based their analysis in the minimization of facility, warehousing, transportation, and inventory costs (MacCarthy & Atthirawong, 2003) .

## CHAPTER 3

### RESEARCH METHODOLOGY

In this chapter, a clear overview about the company's function and how it operates will be described. The key points will be in terms of the company's warehouse since this study is about trying to improve the delivery service and increase customer's satisfaction. A section will be dedicated on the current operations and then based on these operations, different research methods will be employed accordingly. These research methods will be elaborated to give clear steps on how the work will be processed.

#### 3.1 Company Background

This case study is about an international company which sells sport goods and equipment. It opened its first branch in Thailand during the late 2015, but nowadays there are nine stores. Seven stores are located within Bangkok area, one in Pattaya and one in Chiang Mai. This company puts its focus in targeting middle class market as the products offered are at competitive prices as compared to other sport equipment companies. It offers sports equipment and clothing for more than 50 different types of sport and has approximately 5000 exclusive products.

The main strategy that is being used is about having a rather big store whereby all products can be displayed and available on shelf. All the stores do not hold independent storage space in or around the stores, which means that all items are stocked on the display shelf. Whenever purchases are made, the point of sales systems which are linked to the warehouse management system will send a request notifying which items are sold and need to be replaced. Also, custom orders can be

made by customers, and these orders are sent directly to the warehouse management

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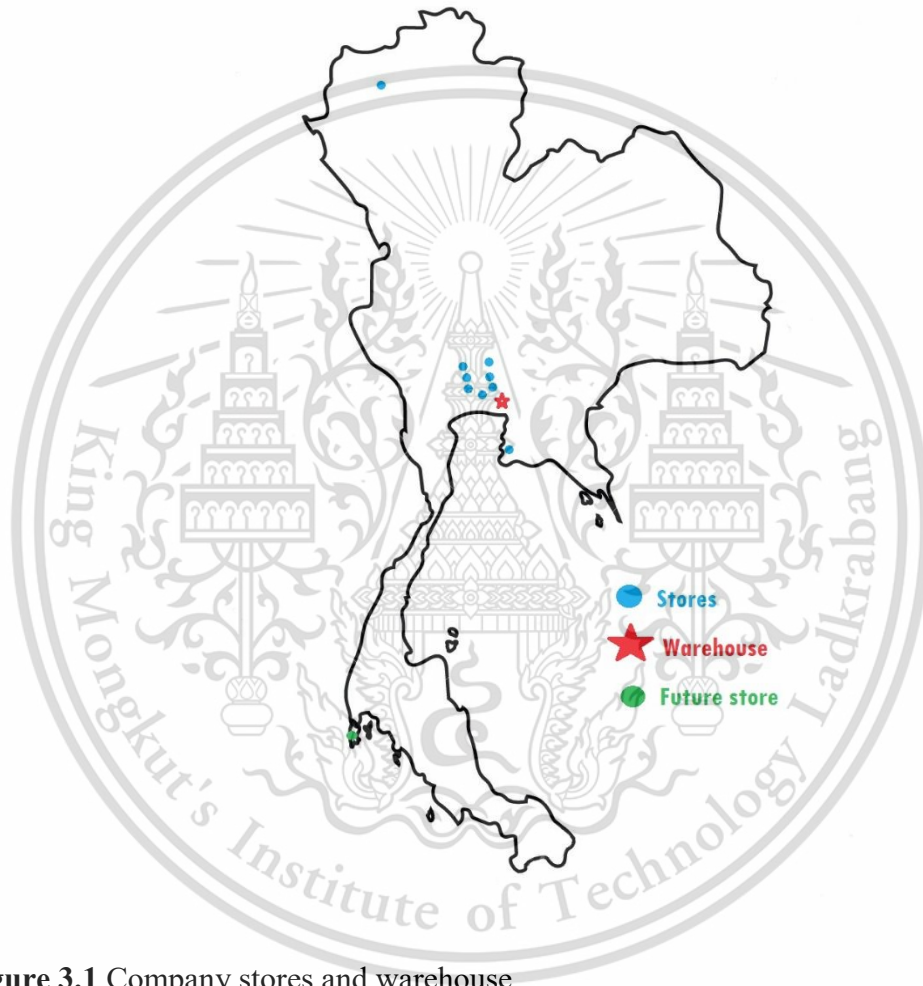
system. Stores have other alternatives mode of ordering products by the use of some parameters that can be set up in the stores' operating system. These parameters can help in automatic reordering for items with high sales volume.

The warehouse is located just outside Bangkok along the road Bangna-Trat and it is the only warehouse that supplies goods to all the stores in Thailand. All goods are received and stored in the warehouse orders are received and sent to each store. The warehouse in Thailand also contains a reception area, which is used specifically for labeling process because all of the products received do not contain Thai instructions label. Sometimes it is expected to have special deliveries, that is a special order has been made by a particular store directly to the supplier. In that case, cross docking is applied and the orders are stored temporarily before shipping in the next delivery truck without being stored in the long term storage area.

During the time frame of this case study, all products received in the warehouse came to Thailand by cargo ships at the Laem Chabang port. Trucks were used to collect the containers from port before sending to ICD Ladkrabang for custom inspection. Third party logistic service provider is used to bring the containers to the warehouse. Upon arrival, boxes are unpacked and assigned staffs are required to stick a Thai instruction label on each item before being scanned and assigned to unique address on the shelves for the ease of picking.

Normally, deliveries are done several times a week for each store with the exception that sometimes one or two stores need to be delivered only once due to distance problem and demand. This is because demand is not predictable and in some cases, there can be high sales in one store. Thus warehouse location is important in the way that deliveries can be made more than once to a store without disrupting the routine delivery operation.

The figure below displays the location of all the stores and warehouse in Thailand. Also, there is a current project to set up a new store in Phuket by next year, and thus, with addition of more store, delivery service will be affected because there will still be one warehouse. That is why this case study is being done in order to see if better possibilities exist.

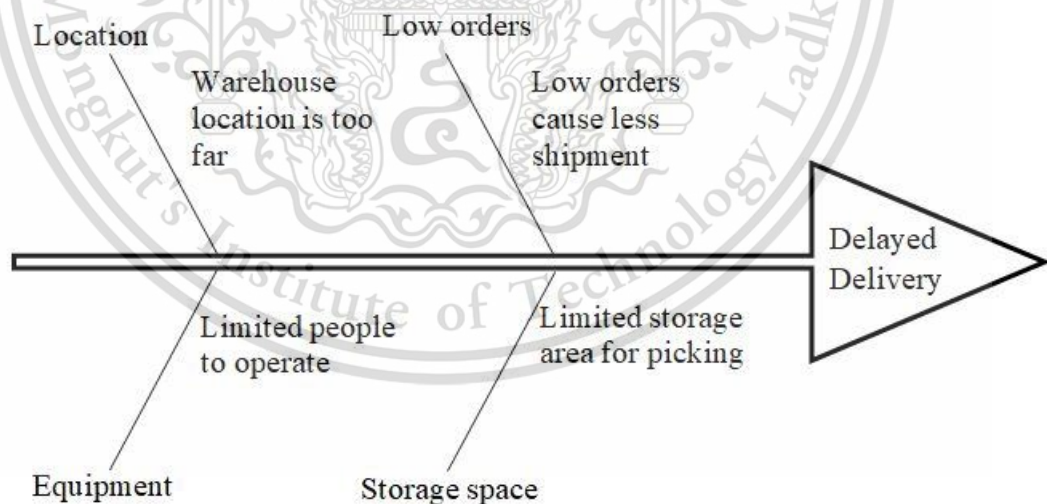


**Figure 3.1** Company stores and warehouse

### 3.2 Current Operation

The current operation is that orders are generated as soon as the stores require items by either manual ordering or by automatic ordering. Then, warehouse operators will print the orders, pick the items then prepare pallets to be shipped to store. Currently the main problem is about the lead time to deliver products to stores. The key performance indicator for the warehouse is to have lead time of 3 days. In some cases, this K.P.I is not met because there are not enough items to fill a truck, so instead of sending a truck half full, the decision to wait for more orders is normally preferred. This case often happens to stores that are located outside Bangkok.

Below is a fishbone diagram showing what leads to delayed delivery and this is the starting point of why this case study is being done as the objective is to see if alternative warehouse location can provide better delivery service than the actual location.



**Figure 3.2** Fishbone Diagram

### 3.3 Root Cause of Problems

As mentioned previously, there are stores located outside Bangkok, more precisely at Chiang Mai and Pattaya. This means that the delivery scheduling should be very well managed in order to prevent lack of items in these stores. Delivering to stores which are located closely to the warehouse may not be a problem as compared to stores located far from the warehouse. The warehouse and delivery service team has provided a policy of 3 days lead time. This means that anytime a store places an order, the latter should reach the store within 3 days to ensure that restocking process is done.

Factors which often affect the delivery service of orders vary from picking time to traffic jam. Since traffic is not a factor that can be controlled, therefore emphasis will be put on how orders are being picked and how deliveries are handled. The picking process is fully manual, which means that no automation system is used. This is one of the main problems that may affect the lead time of an order because order picking is made by human, and the latter cannot work continuously.

As said previously that this company offers sports equipment for more than 50 different sports, it also have several brands for each sport category. For example, all the sports related to ball such as: soccer, basketball, volley and so on, are under the brand of “Kipsta”. Nowadays there are 12 different categories of sports and as a picker in the warehouse, he should not mix 2 different categories in a box while picking products. This can sometimes be confusing and mistakes can happen if attention is not well paid.

The schedules for picking up deliveries and sending to stores are not fixed and

most of the time the schedules are known 1 day in advance. This means that if an

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order has not been prepared and the delivery is scheduled for the next day, the pickers need to rush to clear that order so as not to affect the store's operation. In some cases, orders cannot be picked on time because pickers can only pick orders that are located on the lower rows on the shelves. This means that they need to wait for replenishment process, also known as buffer, whereby products stored on upper shelves are moved to lower shelves for picking to be done. All of the internal activities can also be related to deliveries because if products are not ready to be shipped out, deliveries cannot be done.

### **3.3.1 Steps for delivering orders**

Below are the steps for order processing and order picking.

1. Orders are received from stores in real time,
2. Pickers check orders on AS400 software program,
3. Orders can be printed according to each stores or by sport categories,
4. After orders are printed, pickers will go and pick them,
5. After having picked all products, the pickers will have to return to the computer station to inspect each product and see if the article number matches each products and then a unique barcode is created for each box, which contains the box contents information,
6. The boxes are then placed at the delivery bay according to their corresponding destination,
7. Then, before delivery, boxes are placed on pallets and the pallet's barcode is created.

### 3.4 Data Collection

This study is based on a case study related to a particular company and has not been performed in the past. Therefore all materials required will have to be collected by various methods. In this section, the different methods that will be used to collect data will be explained in detail. The data required for the evaluation of the warehouse performance will be about lead time, which means the time from placing an order to the time the products reach the stores. To assess the lead time, several factors need to be accounted for, such as: printing orders, order picking, packing and pick up for delivery. Collecting data can be an easy task, but interpreting the data may be a problem. Therefore data chosen for this case study will have to be consistent and can be interpreted in a way that is understandable and from which assumption and conclusion can be drawn.

#### 3.4.1 Documentation

The first part of collecting data will be done by documentation method. This kind of method is about studying the collected evidence about anything. It is a traditional way of confirming whether or not a piece information is true. All relevant records concerning this case study will be read in order to gather the required data to proceed with the paper. Normally for the company selected, a log book is kept both electronically and on paper to track down the delivery time of all shipments because this company uses a third party logistic service provider to handle all deliveries. Therefore the record keeping is a way of evaluating their performances, and if not satisfied, the option of changing service provider could be considered.

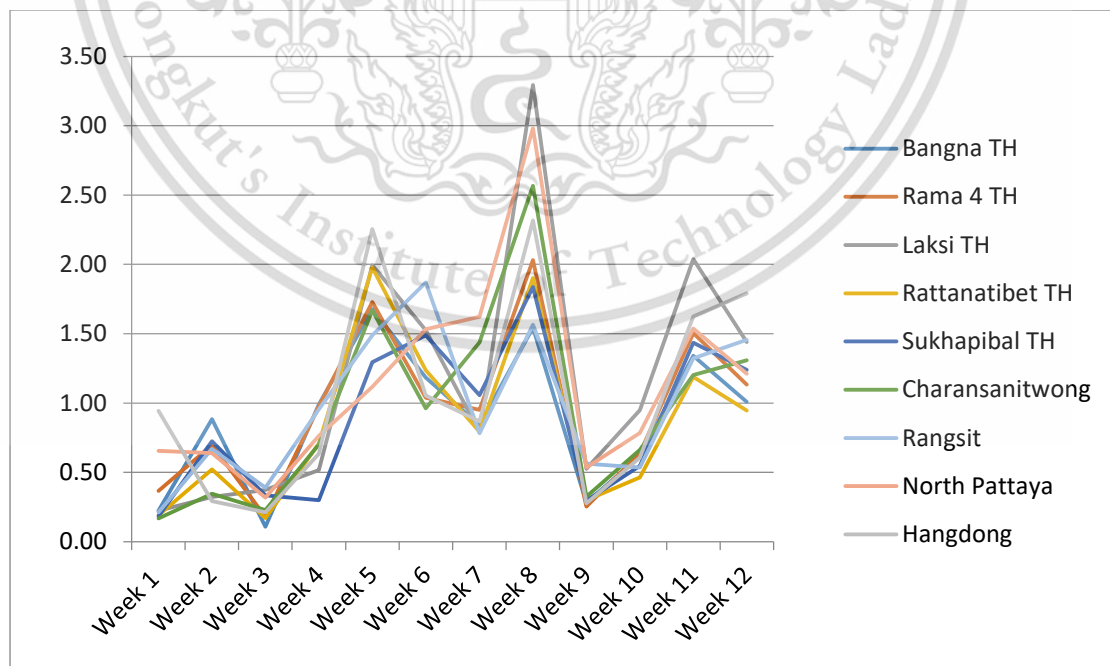
By using this method, an approximate average delivery time to all stores will be known. This can help to evaluate if the delivery schedule need to be modified in

order to optimize the delivery service because if the products do not reach the stores on time, this may lead to a low inventory and possible loss for the company. Sometimes items are picked in the afternoon but the deliveries to stores are done the next morning because stores normally cannot receive products at night due to policy.

### A. Order confirmation lead time

**Table 3.1** Order confirmation lead time

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Bangna TH	0.22	0.88	0.11	0.99	1.68	1.18	0.84	1.54	0.28	0.62	1.34	1.01	0.89
Rama 4 TH	0.37	0.70	0.18	0.98	1.73	1.04	0.95	2.03	0.25	0.64	1.50	1.13	0.96
Laksi TH	0.22	0.32	0.37	0.52	1.99	1.53	0.79	3.29	0.52	0.95	2.04	1.44	1.17
Rattanatibet TH	0.19	0.52	0.17	0.71	1.98	1.24	0.79	1.90	0.30	0.46	1.19	0.94	0.87
Sukhapibal TH	0.18	0.72	0.34	0.30	1.29	1.49	1.06	1.84	0.30	0.55	1.44	1.24	0.89
Charansanitwong	0.17	0.35	0.23	0.70	1.67	0.96	1.44	2.57	0.32	0.66	1.20	1.31	0.96
Rangsit	0.21	0.67	0.39	0.96	1.49	1.87	0.78	1.56	0.56	0.53	1.32	1.46	0.98
North Pattaya	0.65	0.64	0.32	0.76	1.12	1.53	1.62	2.98	0.54	0.78	1.54	1.21	1.14
Hangdong	0.94	0.29	0.21	0.64	2.25	1.05	0.87	2.32	0.28	0.61	1.63	1.79	1.07
Overall Result	0.35	0.57	0.26	0.73	1.69	1.32	1.02	2.23	0.37	0.64	1.47	1.28	0.99



The table above displays the lead time for order confirmation of all 9 stores in Thailand. The numbers represent the time in term of days for each order to reach the warehouse management system. Orders are received in different ways such as auto orders which are generated by the stores' point of sale system, manual order created by employees or allocation orders done by supply team.

Every time an order of any types is generated, it has to go through the SAP system of the company before it reaches the warehouse management system. This means that there is no direct flow from stores to warehouse. Therefore in most cases when orders are generated, they take quite some time to reach the warehouse management system. Thus the lead time is not always the same because before orders are confirmed, the system needs to calculate if warehouse has enough quantity of the products ordered. Also, as everything is linked using internet, this means that the lead time is affected by network connection.

Therefore, the average confirmation lead time for 12 weeks is 0.99 days. Unfortunately as described above that this process is based on internet connectivity, this means that we are not in a position to make any changes to improve this lead time.

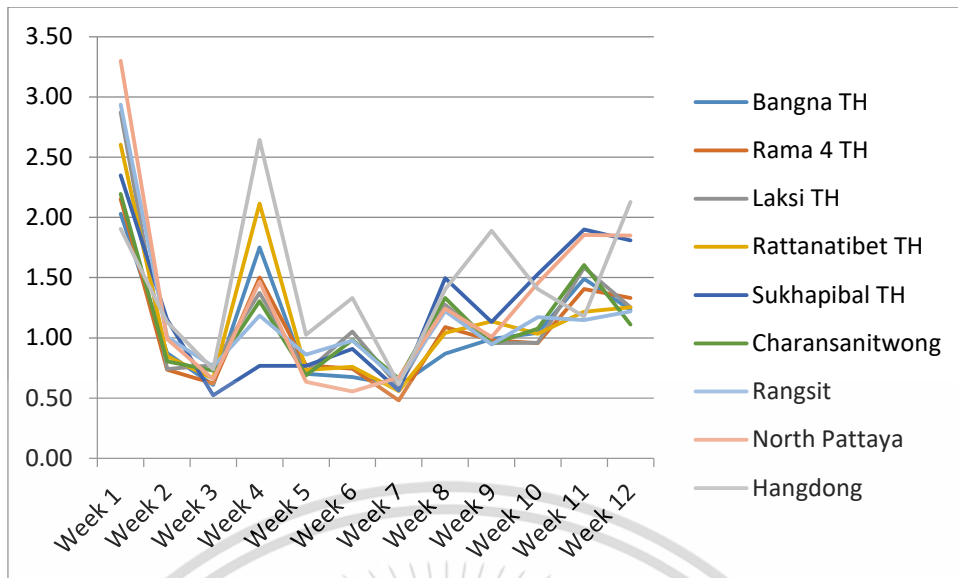
## B. Picking lead time

Table 3.2 Picking lead time

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Bangna TH	2.03	0.88	0.61	1.75	0.70	0.68	0.60	0.87	0.99	1.04	1.49	1.23	1.07
Rama 4 TH	2.15	0.74	0.62	1.50	0.77	0.74	0.48	1.09	0.98	0.96	1.41	1.33	1.06
Laksi TH	2.87	0.74	0.77	1.37	0.71	1.05	0.59	1.28	0.96	0.96	1.58	1.25	1.18
Rattanatibet TH	2.60	0.85	0.66	2.11	0.73	0.76	0.56	1.04	1.14	1.03	1.22	1.25	1.16
Sukhapibal TH	2.35	1.15	0.52	0.77	0.77	0.91	0.56	1.50	1.13	1.53	1.90	1.81	1.24
Charansanitwong	2.19	0.80	0.73	1.30	0.69	0.98	0.66	1.33	0.95	1.08	1.60	1.11	1.12
Rangsit	2.94	1.01	0.76	1.19	0.86	0.98	0.64	1.22	0.95	1.17	1.15	1.22	1.17
North Pattaya	3.30	0.99	0.66	1.47	0.63	0.56	0.67	1.24	1.01	1.45	1.86	1.85	1.31
Hangdong	1.91	1.13	0.74	2.64	1.02	1.33	0.62	1.40	1.89	1.41	1.18	2.13	1.45
Overall Result	2.48	0.92	0.68	1.57	0.77	0.89	0.60	1.22	1.11	1.18	1.49	1.47	1.20

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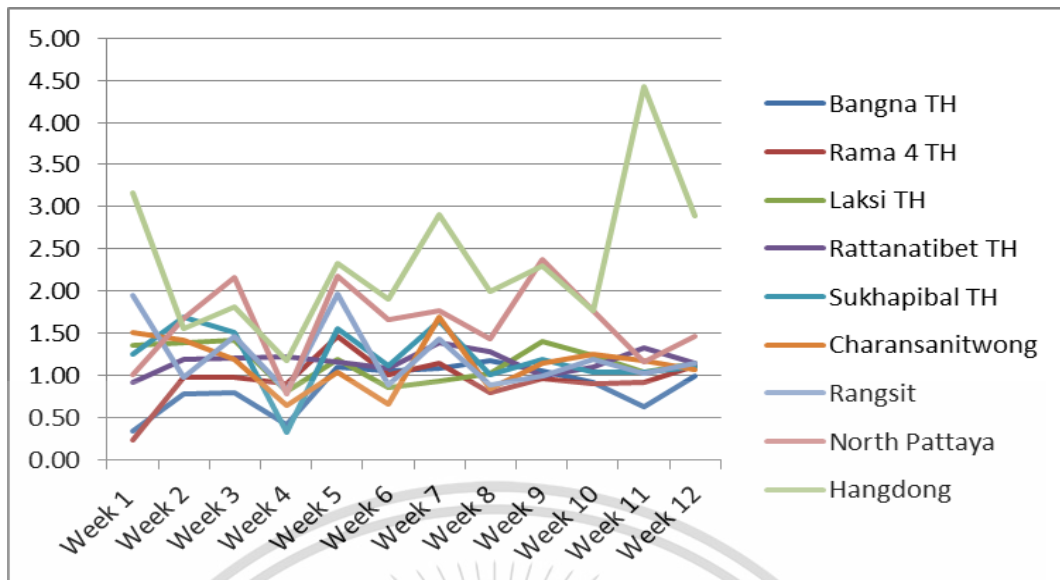


Picking lead time is the time measured once an order is printed out from the warehouse management system, picked and then packed for shipment. This means that the time taken to pick a product is dependent on the picker, who is manual labor.

### C. Loading lead time

**Table 3.3** Loading lead time

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Bangna TH	0.34	0.79	0.80	0.42	1.10	1.05	1.08	1.18	1.06	0.91	0.63	0.99	0.90
Rama 4 TH	0.24	0.98	0.97	0.90	1.46	1.01	1.15	0.80	0.96	0.91	0.91	1.12	0.96
Laksi TH	1.36	1.40	1.42	0.82	1.19	0.86	0.94	1.02	1.41	1.23	1.04	1.15	1.13
Rattanatibet TH	0.91	1.20	1.21	1.23	1.17	1.08	1.40	1.28	0.99	1.10	1.33	1.15	1.18
Sukhapibal TH	1.25	1.70	1.51	0.33	1.56	1.12	1.65	1.01	1.20	1.04	1.04	1.10	1.14
Charansanitwong	1.50	1.41	1.20	0.64	1.05	0.66	1.69	0.84	1.15	1.26	1.18	1.07	1.13
Rangsit	1.95	0.98	1.46	0.81	1.97	0.90	1.44	0.88	1.00	1.19	1.02	1.15	1.21
North Pattaya	1.02	1.67	2.16	0.79	2.18	1.66	1.77	1.43	2.37	1.76	1.17	1.47	1.64
Hangdong	3.17	1.56	1.82	1.17	2.33	1.90	2.91	1.99	2.30	1.76	4.42	2.89	2.38
Overall Result	1.31	1.30	1.39	0.79	1.55	1.14	1.56	1.16	1.38	1.24	1.42	1.34	1.30

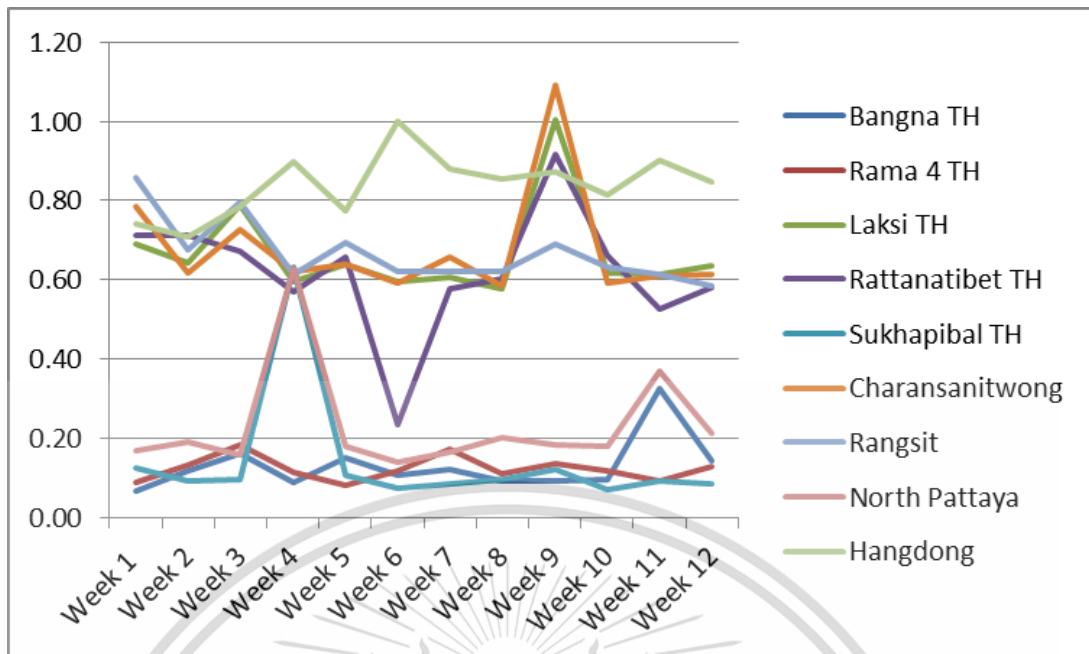


This lead time is based on how long products which are already packed on pallets and ready for shipments stay at the loading bay of the warehouse waiting for delivery truck to pick up. This lead time is dependent on the shipment scheduled which is known several days in advance.

#### D. Transport lead time

Table 3.4 Transport lead time

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Bangna TH	0.07	0.12	0.16	0.09	0.15	0.11	0.12	0.09	0.09	0.10	0.33	0.14	0.13
Rama 4 TH	0.09	0.13	0.18	0.11	0.08	0.12	0.17	0.11	0.14	0.12	0.09	0.13	0.12
Laksi TH	0.69	0.64	0.79	0.60	0.64	0.60	0.61	0.58	1.00	0.62	0.61	0.63	0.67
Rattanatibet TH	0.71	0.71	0.67	0.57	0.66	0.24	0.58	0.60	0.92	0.66	0.53	0.58	0.62
Sukhapibal TH	0.12	0.09	0.10	0.63	0.11	0.07	0.08	0.10	0.12	0.07	0.09	0.09	0.14
Charansanitwong	0.79	0.62	0.73	0.62	0.64	0.59	0.66	0.58	1.09	0.59	0.61	0.62	0.68
Rangsit	0.86	0.67	0.79	0.61	0.69	0.62	0.62	0.62	0.69	0.63	0.61	0.59	0.67
North Pattaya	0.17	0.19	0.16	0.63	0.18	0.14	0.17	0.20	0.19	0.18	0.37	0.21	0.23
Hangdong	0.74	0.71	0.78	0.90	0.77	1.00	0.88	0.86	0.87	0.81	0.90	0.85	0.84
Overall Result	0.47	0.43	0.49	0.53	0.44	0.39	0.43	0.42	0.57	0.42	0.46	0.43	0.46

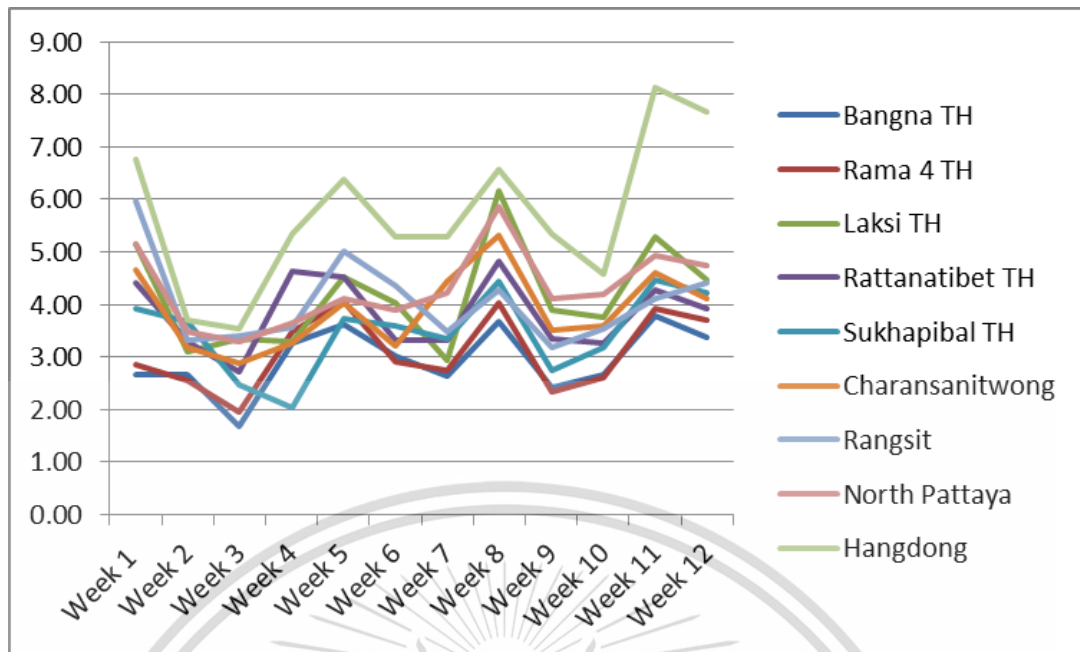


Transport lead time is the time at the point that pallets are placed in the delivery trucks until they reach to their respective destination. Some factors may affect this lead time, such as warehouse location, traffic or even weather.

### E. Total delivery lead time

Table 3.5 Total delivery lead time

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Bangna TH	2.66	2.66	1.68	3.26	3.63	3.02	2.65	3.68	2.42	2.67	3.79	3.38	2.96
Rama 4 TH	2.84	2.55	1.96	3.49	4.05	2.91	2.75	4.03	2.33	2.62	3.92	3.71	3.10
Laksi TH	5.15	3.10	3.35	3.30	4.53	4.03	2.93	6.17	3.90	3.76	5.28	4.48	4.16
Rattanatibet TH	4.42	3.28	2.71	4.62	4.54	3.31	3.32	4.83	3.34	3.26	4.27	3.93	3.82
Sukhapibal TH	3.91	3.67	2.46	2.03	3.72	3.59	3.36	4.43	2.75	3.19	4.47	4.23	3.48
Charansanitwong	4.65	3.18	2.88	3.27	4.04	3.20	4.45	5.32	3.51	3.59	4.60	4.10	3.90
Rangsit	5.96	3.33	3.41	3.57	5.01	4.37	3.48	4.29	3.20	3.53	4.10	4.42	4.05
North Pattaya	5.14	3.49	3.30	3.65	4.11	3.89	4.23	5.86	4.10	4.18	4.93	4.74	4.30
Hangdong	6.76	3.69	3.55	5.35	6.38	5.28	5.27	6.57	5.34	4.59	8.13	7.65	5.71
Overall Result	4.61	3.22	2.81	3.62	4.45	3.73	3.60	5.02	3.43	3.49	4.83	4.52	3.94

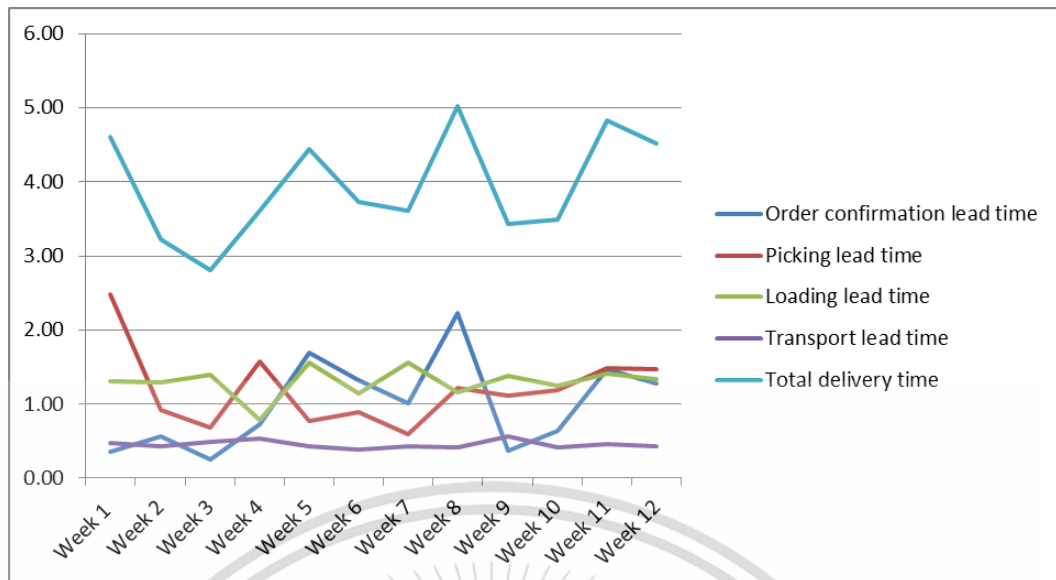


Total delivery lead time is the total amount of time from when orders are confirmed on system to when orders reach the stores. It is the total of all the lead time used by the system.

## F. Lead time summary

**Table 3.6** Lead time summary

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Order confirmation lead time	0.35	0.57	0.26	0.73	1.69	1.32	1.02	2.23	0.37	0.64	1.47	1.28	0.99
Picking lead time	2.48	0.92	0.68	1.57	0.77	0.89	0.60	1.22	1.11	1.18	1.49	1.47	1.20
Loading lead time	1.31	1.30	1.39	0.79	1.55	1.14	1.56	1.16	1.38	1.24	1.42	1.34	1.30
Transport lead time	0.47	0.43	0.49	0.53	0.44	0.39	0.43	0.42	0.57	0.42	0.46	0.43	0.46
Total delivery time	4.61	3.22	2.81	3.62	4.45	3.73	3.60	5.02	3.43	3.49	4.83	4.52	3.94



Based on the table above, we can see that the average lead time for a period of 3 months is about 3.94 days, which is high compared to the target of the warehouse, which is set to be 3 days.

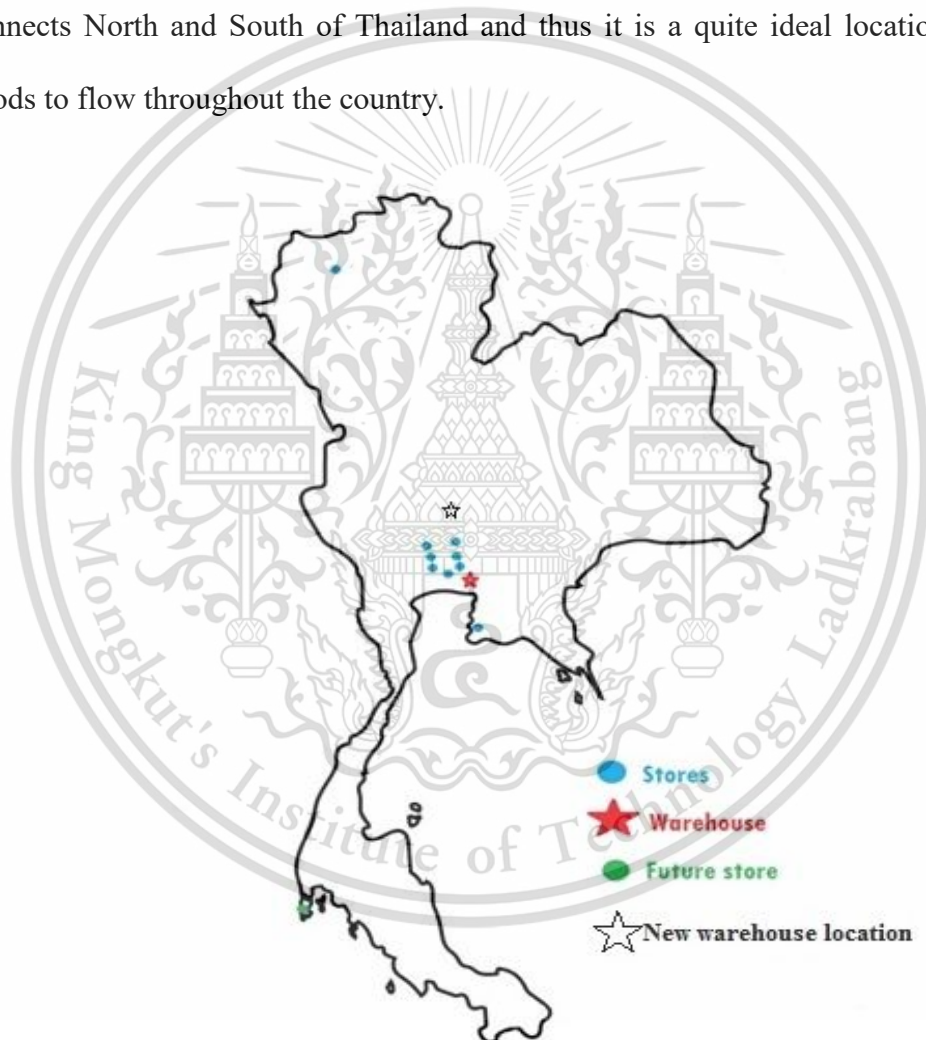
### 3.4.2 Observation

The aim of this method is to analyze how the whole process of preparing an order is done in the warehouse. In contrast with the observation method, some calculations will be used in order to evaluate if the current task distribution among the workers for order picking is efficient or not. In order to evaluate the current performance, data will be collected based on how the order picking work is being done during the period of this case study. One week of observation will be done in order to have an average number orders picked per day. It should be noted that the number of pickers will remain constant on each day but the tasks assigned depend on the number of orders.

### 3.5 Possible warehouse location scenarios

#### 3.5.1 Warehouse in Ayutthaya province

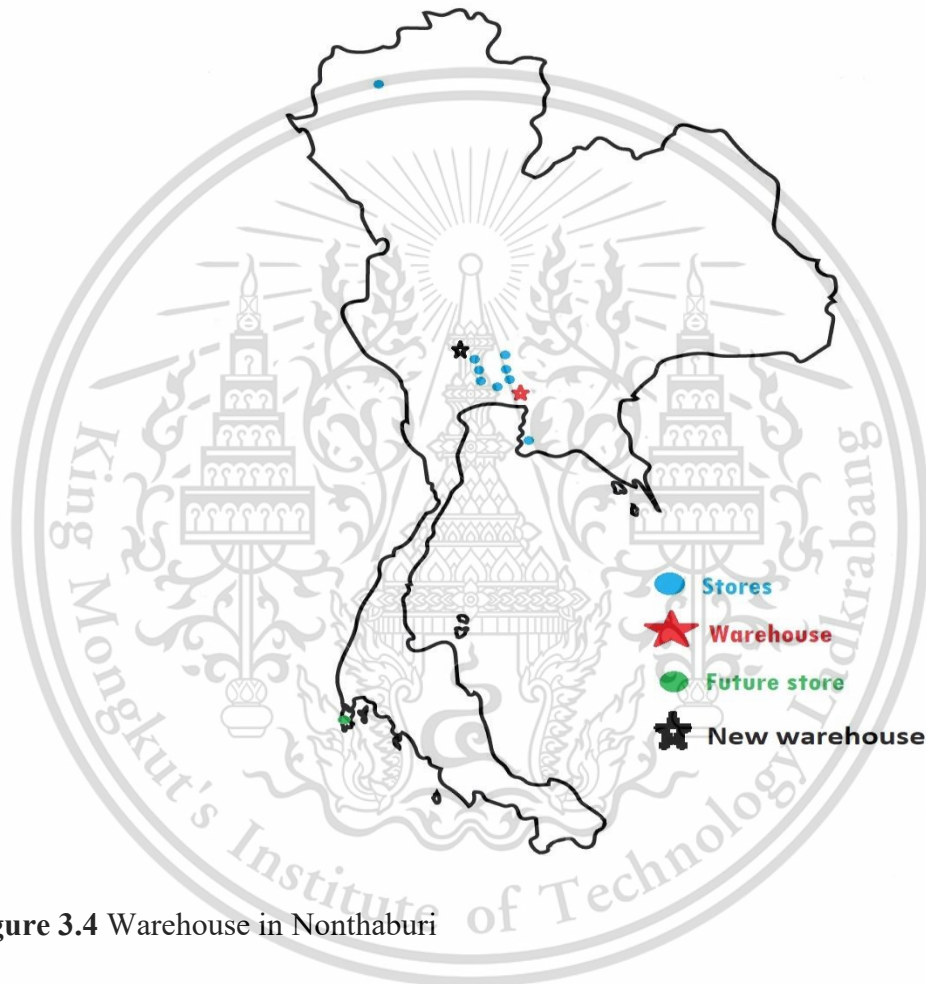
Ayutthaya province is one of the preferred locations to set up a warehouse. In fact, there are many major companies in Thailand that hold their warehouses or distribution centers in this province. One of the main reasons is because the location is not very far from the Bangkok. Also, this province is situated along the way that connects North and South of Thailand and thus it is a quite ideal location to allow goods to flow throughout the country.



**Figure 3.3** Warehouse in Ayutthaya

### 3.5.2 Warehouse in Nonthaburi province

Nonthaburi province is located just north of Bangkok and is also a place whereby people build warehouses closer to the city center. It is believed to be an ideal location for this study because most of the stores will be located closer to this proposed location.



**Figure 3.4** Warehouse in Nonthaburi

## CHAPTER 4

### RESULTS AND DISCUSSIONS

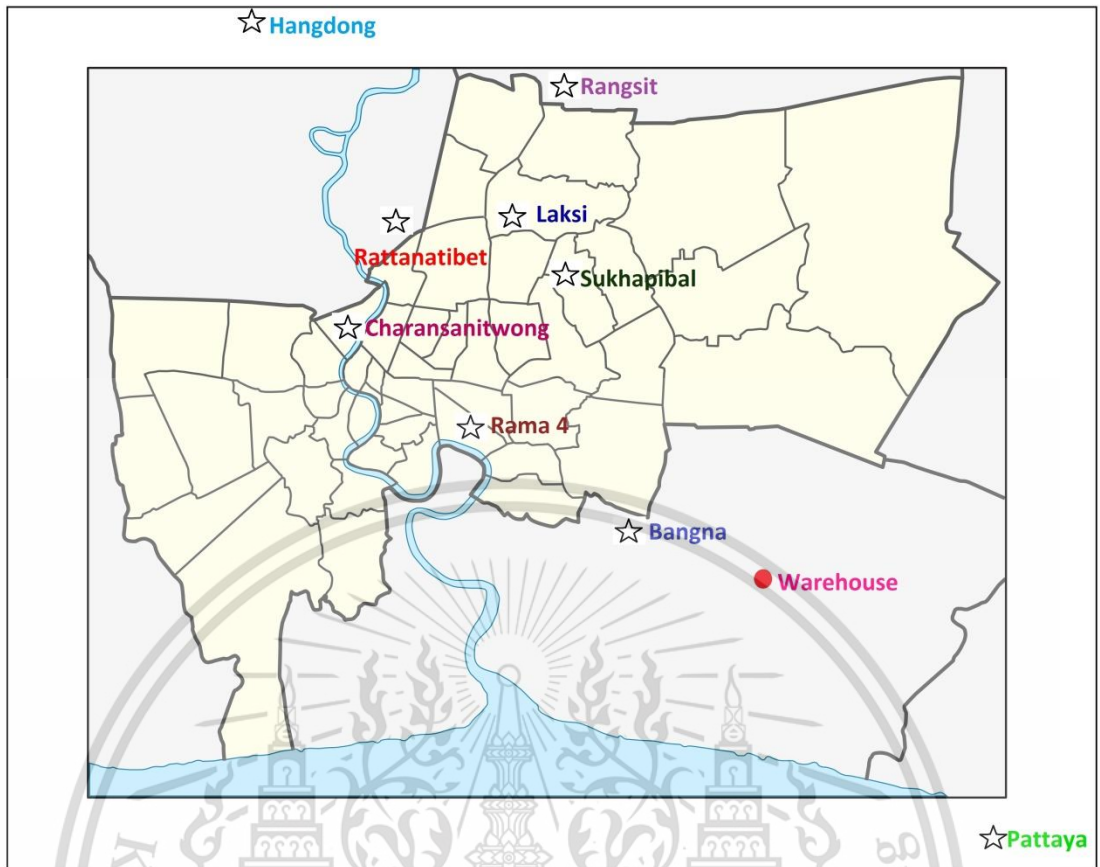
#### 4.1 Lead time calculation related to distance traveled

As this study is based on finding a new possible location of warehouse to decrease delivery lead time, this means that the main factor that we need to focus in on distance of delivery. As seen in the previous chapter, we obtained the data for transport lead time. Now, the first step is to calculate the current total distance that needs to be covered on a weekly basis for store delivery.

The delivery schedule to each stores remained fixed when the analysis has been conducted. Based on the data collected, the delivery pattern is as follows:

**Table 4.1** Weekly delivery schedule

<b>Monday</b>	<b>Bangna, Rama 4, Rattanatibet, Laksi, Charansanitwong, Rangsit</b>
<b>Tuesday</b>	<b>Sukhapibal, Pattaya</b>
<b>Wednesday</b>	<b>Bangna, Rama 4</b>
<b>Thursday</b>	<b>Rattanatibet, Charansanitwong, Rangsit, Laksi</b>
<b>Friday</b>	<b>Pattaya, Sukhapibal, Rama 4, Bangna, Hangdong</b>



**Figure 4.1** Store location map

**Table 4.2** Total current delivery distance per week

Store Location	Total Delivery Distance Per Week in kilometers
Bangna	48
Rama 4	81
Laksi	100
Rattanatibet	100
Sukhapibal	80
Charansanitwong	100
Rangsit	120
Pattaya	240
Hangdong	750

According to the table above, the total distance covered during a full week of operation and for all stores based on the delivery schedule is approximately 1619 km.

**Table 4.3** Lead time table

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Order confirmation lead time	0.35	0.57	0.26	0.73	1.69	1.32	1.02	2.23	0.37	0.64	1.47	1.28	0.99
Picking lead time	2.48	0.92	0.68	1.57	0.77	0.89	0.60	1.22	1.11	1.18	1.49	1.47	1.20
Loading lead time	1.31	1.30	1.39	0.79	1.55	1.14	1.56	1.16	1.38	1.24	1.42	1.34	1.30
Transport lead time	0.47	0.43	0.49	0.53	0.44	0.39	0.43	0.42	0.57	0.42	0.46	0.43	0.46
Total delivery time	4.61	3.22	2.81	3.62	4.45	3.73	3.60	5.02	3.43	3.49	4.83	4.52	3.94

From the above table, data has been collected for 12 weeks so as to be as consistent as possible and the average weekly transport lead time is observed to be 0.46 days.

Total distance per week = 1619 km

Average transport lead time per week = 0.46 days = 11.04 hours

$$\frac{\text{Average transport lead time per week}}{\text{total distance per week}}$$

$$\text{average transport lead time per km} = \frac{11.04}{1619}$$

Therefore, average transport lead time per km = 0.00682 hours

As the approximate transport lead time per km is known, the next step is to calculate the new distance for the proposed warehouse locations.

## 4.2 Warehouse in Ayutthaya

**Table 4.4** Total weekly delivery distance from Ayutthaya

Store Location	Total Delivery Distance Per Week per kilometer
Bangna	300
Rama 4	160
Laksi	120
Rattanatibet	140
Sukhapibal	140
Charansanitwong	150
Rangsit	90
Pattaya	400
Hangdong	610

When adding up all the delivery distances of all the stores, the new total distance traveled is 1865 km. From this, we can calculate the new average weekly lead time.

$$\begin{aligned} \text{Average weekly transport lead time} \\ &= \text{total distance traveled} * \text{average transport lead time per km} \end{aligned}$$

Therefore,

$$\begin{aligned} \text{Average weekly transport lead time} &= 1865 * 0.00682 \\ &= 12.72 \text{ hours} \\ &= 0.53 \text{ days} \end{aligned}$$

As compared to the current warehouse, we can see that with this new proposed location, the lead time is a little higher, and therefore we need to move on with the next proposed location.

### 4.3 Warehouse in Nonthaburi

**Table 4.5** Total weekly delivery distance from Nonthaburi

Store Location	Total Delivery Distance Per Week in Kilometers
Bangna	120
Rama 4	75
Laksi	40
Rattanatibet	24
Sukhapibal	60
Charansanitwong	20
Rangsit	60
Pattaya	320
Hangdong	700

According to the table above, we can calculate the weekly total delivery distance traveled, which is 1419 km. When comparing with the actual weekly total distance traveled, which is 1619 km, we can observe that with the proposed new warehouse location, the distance is relatively lower. This means that the lead time can also be reduced as transport lead time is directly related to distance traveled.

Therefore, the new transport lead time can be calculated as follows:

$$\begin{aligned}\text{Average weekly transport lead time} &= 1419 * 0.0068 \\ &= 9.68 \text{ hours} \\ &= 0.40 \text{ days}\end{aligned}$$

The current transport lead time is 0.46 days and with this new proposed location, the new lead time is lower at 0.40 days. This means that by setting up a warehouse in Nonthaburi, there is a benefit of minimizing transport lead time.

## 4.4 Analytic Hierarchy Process

After having conducted an analysis based on the company information about the total lead time of delivery, the next step is to confirm whether the analysis done yields a valid result.

In this part of analysis, the main goal is to find the best location for the company's warehouse. Therefore we need to compare the current warehouse with the two proposed new warehouse locations as mentioned previously. In order to compare which of these locations is the best, some criteria need to be defined. In this case study, four criteria will be used, namely: traffic, rent cost, distance and labor.

Firstly, we have to analyze the three locations based on the four criteria to see which location has more points per each criterion. Then we need to compare each criterion against each other to see which one is more important and finally calculate the weight of each alternatives and the best location will hold the highest number of points.

### 4.4.1 Traffic

Traffic is an important element to consider while dealing with delivery cases. It is a known fact that Bangkok is the city with highest level of traffic jam in Thailand and thus need to be considered very carefully. This criterion is important for this case study because most of the stores are located in or around Bangkok area and thus it may greatly affect the result.

### 4.4.2 Rent cost

Lands in and around Bangkok area are known to be expensive as compared to other areas, and therefore this is a criterion that should not be omitted in this study.

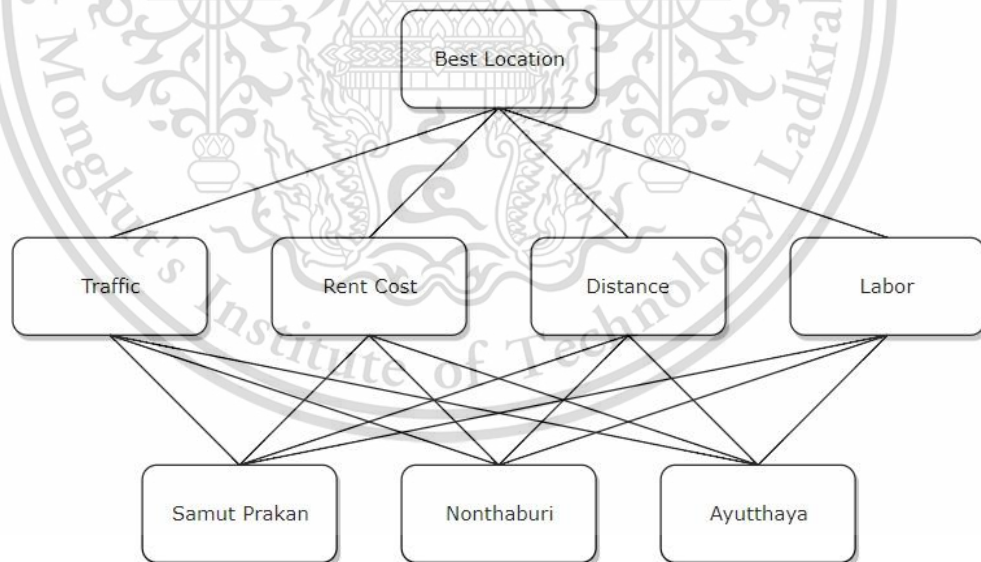
Decisions need to be carefully made about cost because it can result in negative margin for the company and prevent the company from having a future.

#### 4.4.3 Distance

Distance from warehouse to stores is very important for this case study as the main objective of this research is to minimize transportation lead time. This means that distance is the main element to consider when talking about transportation lead time. In general, the shorter the distance, the shorter the lead time will be.

#### 4.4.4 Labor

The reason why labor is one of the criteria to be considered while choosing for a warehouse location is because not in every area that labors can be found easily. It is not very sustainable to have a warehouse in an area where labors cannot be recruited to handle warehouse operations.



**Figure 4.2** Analytic hierarchy processes for best warehouse location

## Criterion 1

This part is to compare each alternative based on traffic.

**Table 4.6** Criterion 1

TRAFFIC	Samut Prakan	Nonthaburi	Ayutthaya			
Samut Prakan	1	1/6	1/3			
Nonthaburi	6	1	3			
Ayutthaya	3	1/3	1			
TOTAL	10	1.500	4.333			
NORMALIZED	Samut Prakan	Nonthaburi	Ayutthaya	TOTAL	PRIORITY	CONSISTENCY MEASUREMENT
Samut Prakan	0.10	0.11	0.08	0.29	0.10	3.005
Nonthaburi	0.60	0.67	0.69	1.96	0.65	3.035
Ayutthaya	0.30	0.22	0.23	0.75	0.25	3.015
					C.I	0.009
					R.I	0.580
					C.R	0.016

## Criterion 2

This section is comparing each alternative with rent cost.

**Table 4.7** Criterion 2

RENT COST	Samut Prakan	Nonthaburi	Ayutthaya			
Samut Prakan	1	1/6	1/7			
Nonthaburi	6	1	1/2			
Ayutthaya	7	2	1			
TOTAL	14	3.167	1.643			
NORMALIZED	Samut Prakan	Nonthaburi	Ayutthaya	TOTAL	PRIORITY	CONSISTENCY MEASUREMENT
Samut Prakan	0.07	0.05	0.09	0.21	0.07	3.006
Nonthaburi	0.43	0.32	0.30	1.05	0.35	3.037
Ayutthaya	0.50	0.63	0.61	1.74	0.58	3.054
					C.I	0.016
					R.I	0.580
					C.R	0.028

### Criterion 3

This part is to compare each alternative according to distance from each location to store.

**Table 4.8** Criterion 3

DISTANCE	Samut Prakan	Nonthaburi	Ayutthaya			
Samut Prakan	1	1/7	1/4			
Nonthaburi	7	1	4			
Ayutthaya	4	1/4	1			
TOTAL	12	1.393	5.25			
NORMALIZED	Samut Prakan	Nonthaburi	Ayutthaya	TOTAL	PRIORITY	CONSISTENCY MEASUREMENT
Samut Prakan	0.08	0.10	0.05	0.23	0.08	3.015
Nonthaburi	0.58	0.72	0.76	2.06	0.69	3.156
Ayutthaya	0.33	0.18	0.19	0.70	0.23	3.062
					C.I	0.039
					R.I	0.580
					C.R	0.067

### Criterion 4

This part is to compare each alternative according to labor availability in each region.

**Table 4.9** Criterion 4

LABOR	Samut Prakan	Nonthaburi	Ayutthaya			
Samut Prakan	1	1/2	1/2			
Nonthaburi	2	1	2			
Ayutthaya	2	1/2	1			
TOTAL	5	2	3.5			
NORMALIZED	Samut Prakan	Nonthaburi	Ayutthaya	TOTAL	PRIORITY	CONSISTENCY MEASUREMENT
Samut Prakan	0.20	0.25	0.14	0.59	0.20	3.030
Nonthaburi	0.40	0.50	0.57	1.47	0.49	3.078
Ayutthaya	0.40	0.25	0.29	0.94	0.31	3.053
					C.I	0.027
					R.I	0.580
					C.R	0.046

## Criterion versus criterion

This part is to compare all criteria with each other in order to get the weight of each of the criterion.

**Table 4.10** Criterion versus criterion

CRITERIA	TRAFFIC	RENT COST	DISTANCE	LABOR			
TRAFFIC	1	2	1/3	1			
RENT COST	1/2	1	1/4	1			
DISTANCE	3	4	1	2			
LABOR	1	1	1/2	1			
TOTAL	5.5	8	2.083	5			
NORMALIZED	TRAFFIC	RENT COST	DISTANCE	LABOR	TOTAL	PRIORITY	CONSISTENCY MEASUREMENT
TRAFFIC	0.18	0.25	0.16	0.20	0.79	0.198	4.107
RENT COST	0.09	0.13	0.12	0.20	0.54	0.134	4.031
DISTANCE	0.55	0.50	0.48	0.40	1.93	0.481	4.123
LABOR	0.18	0.13	0.24	0.20	0.75	0.187	4.067
						C.I	0.027
						R.I	0.900
						C.R	0.030

## Criteria versus Alternatives

Here, the weight for each location is calculated based on each criterion.

**Table 4.11** Criteria versus alternatives

CRITERION	PRIORITY VS GOAL	ALTERNATIVE	A	B	A X B = C
TRAFFIC	0.198	SAMUT PRAKAN	0.10	0.198	0.020
		NONTHABURI	0.65		0.129
		AYUTTHAYA	0.25		0.049
			1		0.198
RENT COST	0.134	SAMUT PRAKAN	0.07	0.134	0.009
		NONTHABURI	0.35		0.047
		AYUTTHAYA	0.58		0.078
			1		0.134
DISTANCE	0.481	SAMUT PRAKAN	0.08	0.481	0.038
		NONTHABURI	0.69		0.332
		AYUTTHAYA	0.23		0.111
			1		0.481
LABOR	0.187	SAMUT PRAKAN	0.2	0.187	0.037
		NONTHABURI	0.49		0.092
		AYUTTHAYA	0.31		0.058
			1		0.187

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## Final result

Finally, when adding up all the points for each criterion, we can obtain the equivalent of point for each alternative and thus the final result is shown.

**Table 4.12** Results of AHP

LOCATION	TRAFFIC	RENT COST	DISTANCE	LABOR	GOAL
SAMUT PRAKAN	0.002	0.009	0.038	0.037	<b>0.086</b>
NONTHABURI	0.129	0.047	0.332	0.092	<b>0.600</b>
AYUTTHAYA	0.049	0.078	0.111	0.058	<b>0.296</b>

According to the above table, location Nonthaburi holds the most points, and therefore can be concluded that it is the best location as compared to the current location and the other proposed location, Ayutthaya.

Since both of the analysis calculation showed the same result, we can conclude that for this study, Nonthaburi can be used to set up the new warehouse to help decreasing delivery lead time.

## CHAPTER 5

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusion

Warehouse facility location is a very important element for retail companies, especially for the ones that the stores do not hold individual storage areas. This means that all products that are received during every shipment are displayed directly into the stores for sale. In this case, replenishments of depleted items depend fully on the warehouse. The longer the replenishment time, the less products retail stores have to sell and thus leading to loss of opportunity.

This case study is based on investigating for a new possible warehouse location in order to minimize the transportation lead time, which will result in faster replenishment of orders. The current warehouse of this company is located in Samut Prakan province, just outside Bangkok. There are seven retail stores located in and around Bangkok vicinity and two other stores are located in Pattaya and Hangdong, Chiang Mai.



**Figure 5.1** Company stores and warehouse

Throughout this study, data about all the lead time concerning delivery have been collected, but finally, since the main purpose of this study is about minimizing transportation lead time, only data on transportation lead time has been taken into account because other lead times contain factors that cannot be investigated at this stage or are out of the scopes of this study.

In order to investigate the possibility of minimizing transportation lead time, two alternative locations have been suggested and they are namely: Ayutthaya and Nonthaburi. These locations have been suggested because of their advantages in terms of geographic position while at the same time bearing in mind that traffic is an important issue in this study.

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In order to conduct a study on whether the two proposed alternative locations would yield a better result as compared to the current location, some methods of analysis have been employed. The first thing was to gather all data concerning lead time and then the total delivery distance per week has been calculated. In this way, an average lead time per kilometer was obtained and used as a baseline to calculate further transportation lead time. The total distance from each new locations were then calculated in order to see if they provided shorter delivery distance, as distance is one main factor that affects transportation lead time.

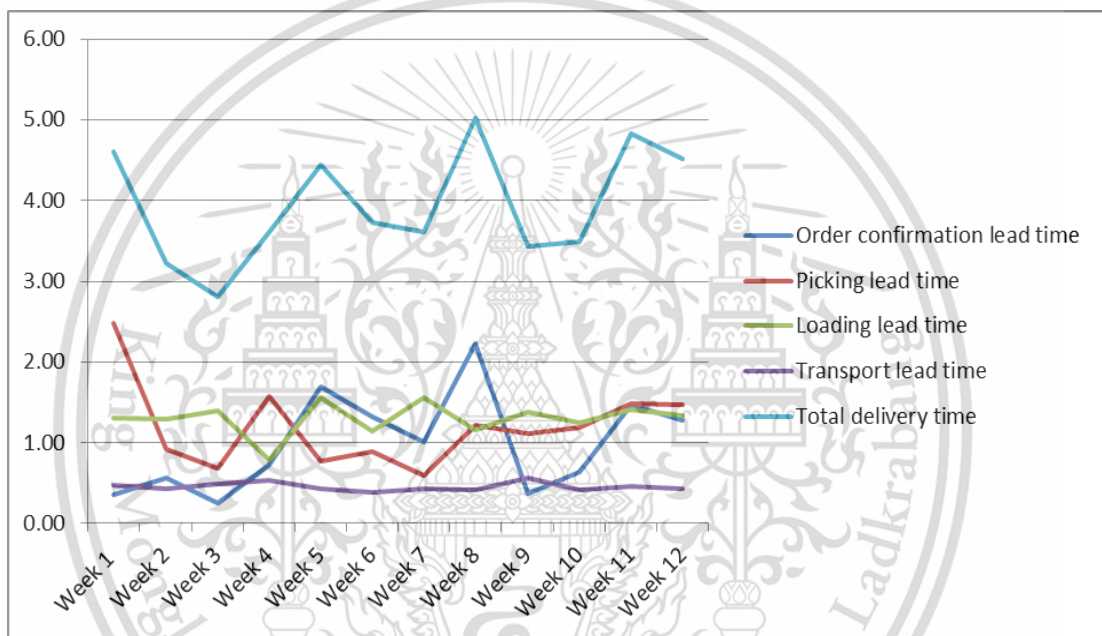
Once the total delivery distance per week for each new locations have been determined, an analytic hierarchy process has been used as a tool to confirm whether the calculation made previously was consistent or not. After this tool has been used, it was concluded that Nonthaburi yielded a better result as compared to the current location and Ayutthaya. Therefore, the new average lead time has been calculated and is 9.67 hours as compared to previously 11.04 hours.

## **5.2 Recommendation**

After the study has been completed, a positive result has been received. Therefore, for future work, the factors that should be studied in order to provide a better delivery lead time could be to study about the picking process. This is because based on the figure below, picking activity plays a major role in delivery lead time and there are several tools that could be used to help in analyzing and suggesting ideas of improvement.

**Table 5.1** Lead time table

Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Order confirmation lead time	0.35	0.57	0.26	0.73	1.69	1.32	1.02	2.23	0.37	0.64	1.47	1.28	0.99
Picking lead time	2.48	0.92	0.68	1.57	0.77	0.89	0.60	1.22	1.11	1.18	1.49	1.47	1.20
Loading lead time	1.31	1.30	1.39	0.79	1.55	1.14	1.56	1.16	1.38	1.24	1.42	1.34	1.30
Transport lead time	0.47	0.43	0.49	0.53	0.44	0.39	0.43	0.42	0.57	0.42	0.46	0.43	0.46
Total delivery time	4.61	3.22	2.81	3.62	4.45	3.73	3.60	5.02	3.43	3.49	4.83	4.52	3.94



From the figure above, the red line displays the picking activity lead time and can be seen that it is not stable and thus could be a good factor to analyze and improve in the future.

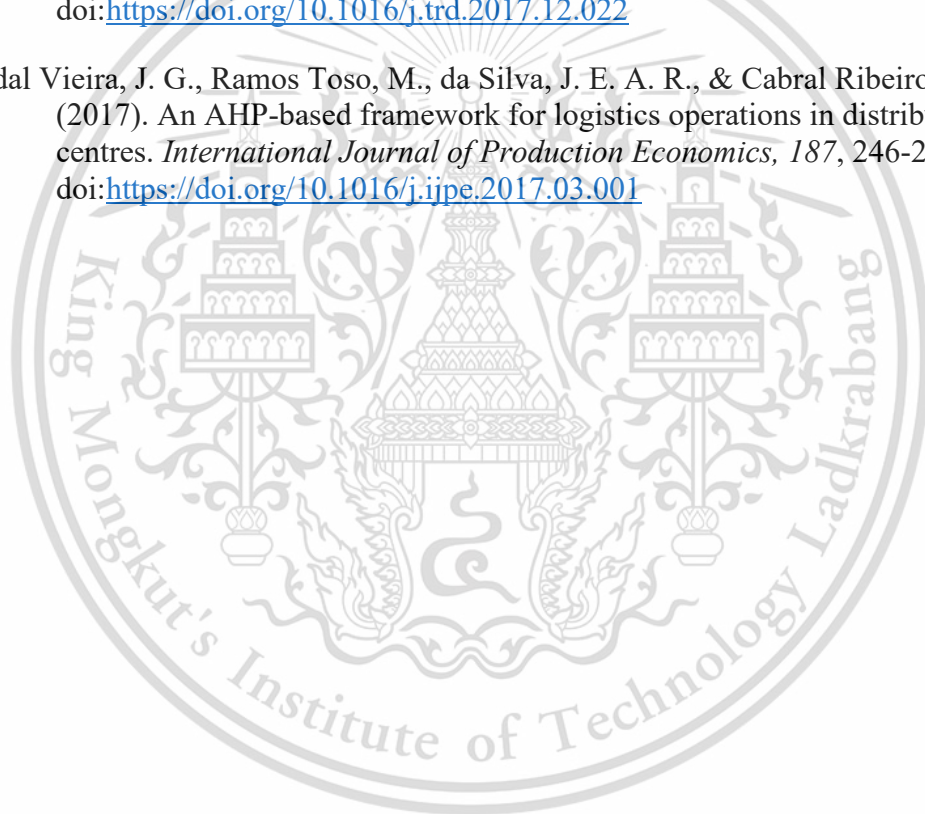
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## APPENDIX

	Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Order confirmation lead time	Bangna TH	0.22	0.88	0.11	0.99	1.68	1.18	0.84	1.54	0.28	0.62	1.34	1.01	0.89
	Rama 4 TH	0.37	0.70	0.18	0.98	1.73	1.04	0.95	2.03	0.25	0.64	1.50	1.13	0.96
	Laksi TH	0.22	0.32	0.37	0.52	1.99	1.53	0.79	3.29	0.52	0.95	2.04	1.44	1.17
	Rattanatibet TH	0.19	0.52	0.17	0.71	1.98	1.24	0.79	1.90	0.30	0.46	1.19	0.94	0.87
	Sukhapibal TH	0.18	0.72	0.34	0.30	1.29	1.49	1.06	1.84	0.30	0.55	1.44	1.24	0.89
	Charansanitwong	0.17	0.35	0.23	0.70	1.67	0.96	1.44	2.57	0.32	0.66	1.20	1.31	0.96
	Rangsit	0.21	0.67	0.39	0.96	1.49	1.87	0.78	1.56	0.56	0.53	1.32	1.46	0.98
	North Pattaya	0.65	0.64	0.32	0.76	1.12	1.53	1.62	2.98	0.54	0.78	1.54	1.21	1.14
	Hangdong	0.94	0.29	0.21	0.64	2.25	1.05	0.87	2.32	0.28	0.61	1.63	1.79	1.07
	Overall Result	0.35	0.57	0.26	0.73	1.69	1.32	1.02	2.23	0.37	0.64	1.47	1.28	0.99

	Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Picking lead time	Bangna TH	2.03	0.88	0.61	1.75	0.70	0.68	0.60	0.87	0.99	1.04	1.49	1.23	1.07
	Rama 4 TH	2.15	0.74	0.62	1.50	0.77	0.74	0.48	1.09	0.98	0.96	1.41	1.33	1.06
	Laksi TH	2.87	0.74	0.77	1.37	0.71	1.05	0.59	1.28	0.96	0.96	1.58	1.25	1.18
	Rattanatibet TH	2.60	0.85	0.66	2.11	0.73	0.76	0.56	1.04	1.14	1.03	1.22	1.25	1.16
	Sukhapibal TH	2.35	1.15	0.52	0.77	0.77	0.91	0.56	1.50	1.13	1.53	1.90	1.81	1.24
	Charansanitwong	2.19	0.80	0.73	1.30	0.69	0.98	0.66	1.33	0.95	1.08	1.60	1.11	1.12
	Rangsit	2.94	1.01	0.76	1.19	0.86	0.98	0.64	1.22	0.95	1.17	1.15	1.22	1.17
	North Pattaya	3.30	0.99	0.66	1.47	0.63	0.56	0.67	1.24	1.01	1.45	1.86	1.85	1.31
	Hangdong	1.91	1.13	0.74	2.64	1.02	1.33	0.62	1.40	1.89	1.41	1.18	2.13	1.45
	Overall Result	2.48	0.92	0.68	1.57	0.77	0.89	0.60	1.22	1.11	1.18	1.49	1.47	1.20

	Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Loading lead time	Bangna TH	0.34	0.79	0.80	0.42	1.10	1.05	1.08	1.18	1.06	0.91	0.63	0.99	0.90
	Rama 4 TH	0.24	0.98	0.97	0.90	1.46	1.01	1.15	0.80	0.96	0.91	0.91	1.12	0.96
	Laksi TH	1.36	1.40	1.42	0.82	1.19	0.86	0.94	1.02	1.41	1.23	1.04	1.15	1.13
	Rattanatibet TH	0.91	1.20	1.21	1.23	1.17	1.08	1.40	1.28	0.99	1.10	1.33	1.15	1.18
	Sukhapibal TH	1.25	1.70	1.51	0.33	1.56	1.12	1.65	1.01	1.20	1.04	1.04	1.10	1.14
	Charansanitwong	1.50	1.41	1.20	0.64	1.05	0.66	1.69	0.84	1.15	1.26	1.18	1.07	1.13
	Rangsit	1.95	0.98	1.46	0.81	1.97	0.90	1.44	0.88	1.00	1.19	1.02	1.15	1.21
	North Pattaya	1.02	1.67	2.16	0.79	2.18	1.66	1.77	1.43	2.37	1.76	1.17	1.47	1.64
	Hangdong	3.17	1.56	1.82	1.17	2.33	1.90	2.91	1.99	2.30	1.76	4.42	2.89	2.38
	Overall Result	1.31	1.30	1.39	0.79	1.55	1.14	1.56	1.16	1.38	1.24	1.42	1.34	1.30

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	Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Transport lead time	Bangna TH	0.07	0.12	0.16	0.09	0.15	0.11	0.12	0.09	0.09	0.10	0.33	0.14	0.13
	Rama 4 TH	0.09	0.13	0.18	0.11	0.08	0.12	0.17	0.11	0.14	0.12	0.09	0.13	0.12
	Laksi TH	0.69	0.64	0.79	0.60	0.64	0.60	0.61	0.58	1.00	0.62	0.61	0.63	0.67
	Rattanaibet TH	0.71	0.71	0.67	0.57	0.66	0.24	0.58	0.60	0.92	0.66	0.53	0.58	0.62
	Sukhapibal TH	0.12	0.09	0.10	0.63	0.11	0.07	0.08	0.10	0.12	0.07	0.09	0.09	0.14
	Charansanitwong	0.79	0.62	0.73	0.62	0.64	0.59	0.66	0.58	1.09	0.59	0.61	0.62	0.68
	Rangsit	0.86	0.67	0.79	0.61	0.69	0.62	0.62	0.62	0.69	0.63	0.61	0.59	0.67
	North Pattaya	0.17	0.19	0.16	0.63	0.18	0.14	0.17	0.20	0.19	0.18	0.37	0.21	0.23
	Hangdong	0.74	0.71	0.78	0.90	0.77	1.00	0.88	0.86	0.87	0.81	0.90	0.85	0.84
	Overall Result	0.47	0.43	0.49	0.53	0.44	0.39	0.43	0.42	0.57	0.42	0.46	0.43	0.46

	Time Period	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Overall Result
Total delivery time	Bangna TH	2.66	2.66	1.68	3.26	3.63	3.02	2.65	3.68	2.42	2.67	3.79	3.38	2.96
	Rama 4 TH	2.84	2.55	1.96	3.49	4.05	2.91	2.75	4.03	2.33	2.62	3.92	3.71	3.10
	Laksi TH	5.15	3.10	3.35	3.30	4.53	4.03	2.93	6.17	3.90	3.76	5.28	4.48	4.16
	Rattanaibet TH	4.42	3.28	2.71	4.62	4.54	3.31	3.32	4.83	3.34	3.26	4.27	3.93	3.82
	Sukhapibal TH	3.91	3.67	2.46	2.03	3.72	3.59	3.36	4.43	2.75	3.19	4.47	4.23	3.48
	Charansanitwong	4.65	3.18	2.88	3.27	4.04	3.20	4.45	5.32	3.51	3.59	4.60	4.10	3.90
	Rangsit	5.96	3.33	3.41	3.57	5.01	4.37	3.48	4.29	3.20	3.53	4.10	4.42	4.05
	North Pattaya	5.14	3.49	3.30	3.65	4.11	3.89	4.23	5.86	4.10	4.18	4.93	4.74	4.30
	Hangdong	6.76	3.69	3.55	5.35	6.38	5.28	5.27	6.57	5.34	4.59	8.13	7.65	5.71
	Overall Result	4.61	3.22	2.81	3.62	4.45	3.73	3.60	5.02	3.43	3.49	4.83	4.52	3.94

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## AUTHOR BIOGRAPHY

**Author:** Mr. Bryan Fook Shin Lee Lan Chong  
**Degree:** Master of Science  
**Date:** 28<sup>h</sup> May 2018  
**Date of Birth:** 02<sup>nd</sup> December 1991  
**Place of Birth:** Pamplemousses, Mauritius

### Undergraduate and Graduate Education:

Master of Science in Logistics and Supply Chain Management,  
King Mongkut's Institute of Technology Ladkrabang, Bangkok, 2018

Bachelor degree in Aeronautical Engineering,  
Nanjing University of Aeronautics and Astronautics, Nanjing, China, 2015

