Feasibility Study of Service Facility Location in the Pallet Industry at CHEP (Thailand) Limited

by

Mr. Supaphat Tabarn

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

Submitted in Partial Fulfillment
Of the Requirement for the Degree of Master of Science
in Supply Chain Management
Assumption University

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Project Title	Feasibility Study of Service Facility Location in the Pallet Industry at CHEP (Thailand) Limited
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ABAC School of Management, Assumption University has approved this 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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November 2007

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and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

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ABSTRACT

The objective of this project is to study the feasibility of establishing sub-service centers so as to improve total transportation costs, travel times, and sales opportunities, and to maximize revenue for the pallet rental provider. This paper applies a heuristic method which is a step by step solution or, trial and error solution as a tool for analyze and solving problems.

Based on an analysis of current environmental data, we found that the present location of the service center is not convenient pallet for customers, and it also allows low competitive opportunity and high transportation costs in its supply chain. We developed an approached towards improving the current situation problems. A heuristic method was adapted, with a large number of popular approaches i.e. single facility location concept, center-of-gravity theory, and decision analysis. We also reviewed a variety of other approaches advanced in the literature on stochastic and robust facility location models. As a result of this study we could see that a third alternative, of the existing one service center and two sub-service centers, would be suitable to be implemented in the company soon. Regarding calculations in the analyzing phase, these gave us the highest expected monetary value and lowest opportunity loss. Nevertheless, service facilities generally function for many years or decades, during which time the environment in which a firm operates may change substantially. Costs, demands, travel times, and other factor inputs to classical facility location models may be highly uncertain; hence this has made the development of strategies for service facility location very risky, with perhaps a major impact on future costs and revenues which a firm will generate. While the goal of revenue maximization is well accepted, just how location decisions relate to this goal is often difficult to ascertain. Although "effective placement or replacement of facilities can dramatically improve bottom-line performance, we fully understand or appreciate the value added through effective location decisions.

There are still some issues left that have to be captured when this project is implemented in the company. Future research should study the results of implementing 3 service centers to assess obligations, impacts and further action.

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This project could only be completed with much support from every party. Without their support I could not have finished this dissertation.

First, I wish to express sincere gratitude to my project advisor Dr.Peeratarat Ittarattanachoke, for continuous patient assistance, guidance, and constant encouragement which has led me to the project's completion. He was always there to listen and to give great advice. He taught me to analyze research problems and to develop approaches systematically. He showed me different ways to approach research problems, and the need to be persistent to accomplish any goal. Next, I also would like to thank all the professional professors in the Master of Science in Supply Chain Management program, from whom I gained knowledge: Dr.Vatcharapol Sukhotu, who taught me Logistics and Distribution Networks: Facility Strategy (DIS 2503). He made me analyze facility location problems and design logistics-hub networks in retail supply chains which is the main aspect in this paper. Also my thanks to Dr.Chayakrit Charoensiriwath, for teaching me Quantitative Modeling and Analysis: Decistion Analysis Techniques (SCM 1202) which is another important part of the approaches applied in this paper.

Third, I would like to express appreciation to all of my graduate project committee members: Dr.Ismail Ali Siad who asked me good hard questions and rescued me from various red tape crises; Dr.Athisarn Wayuparb, who gave insightful comments and reviewed my work at very short notice. Fourth, a special thank-you goes to my family: my parents for giving life in the first place, for educating me with aspects from both arts and sciences, for unconditional support and encouragement to pursue my interests even when the interests went beyond boundaries of language, field and geography. And lastly, let me say "'thank you" to the following people at CHEP (Thailand) Limited: Mr.Praneatra Charoenrat (Country Manager) who enabled, organized and supported me for all the relevant information collection until this project was competed; and Mr.Witchayut Abyim (Operation Manager) who supported me with operational information; and Mr.Wasunti Seesang (Accounting Manager) for helping me by discussing activity base costing and the calculations in each part.

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MATHEMATICAL SYMBOLS

Capitals denote criterion variables and decision variables are denoted by reversed capitals (***X, Y and Z***). Parameters are denoted by Greek Lowercase Letter following:

$MinTC = \sum_i V_i R_i d_i$ Total transportation cost equation

$\bar{X} = \frac{\sum_i V_i R_i X_i / d_i}{\sum_i V_i R_i / d_i}$ Coordinate points of the located facility calculated with distance parameter

$\bar{Y} = \frac{\sum_i V_i R_i X_i / d_i}{\sum_i V_i R_i / d_i}$ Coordinate points of the located facility with distance parameter

$d_i = K\sqrt{\left(X_i + \bar{X}\right)^2 + \left(Y_i - \bar{Y}\right)^2}$ The distance is estimated by d_i if unknown distances

$\bar{X} = \frac{\sum_i V_i R_i X_i}{\sum_i V_i R_i}$ Coordinate points of the located facility calculated without distance parameter

$\bar{Y} = \frac{\sum_i V_i R_i X_i}{\sum_i V_i R_i}$ Coordinate points of the located facility calculated without distance parameter

I. INTRODUCTION

1.1 Background of the Project

In the pallet industry, CHEP's pallet is an equipment pooling system recycled worldwide in the supply chain system. A CHEP Pallet is recognized as a portable platform for the storing or moving of cargoes or freight which facilitates optimum unit load management, improves handling efficiencies, reduces capital expenditures and supports customers focusing on their core business competencies. CHEP (Thailand) Limited is an affiliated company of CHEP global, and was founded in Thailand four years ago. This company provides wood pallets and plastic pallets for rental customers who are manufacturers, distributors and retailers supplying the comprehensive products for domestic and also export markets. Every year, CHEP TH has spent a lot of money in supplying wood pallet processes to providing a great service to satisfy its customers' requirement in the FMCG industry, including such customers as Dumex Limited., Boonrawd Trading Co., Ltd., Dairy Plus Co., Ltd., Kao Co., Ltd., Neptune Food & Beverages Co. Ltd., CP Seven Eleven Public Co., Ltd., Central Retail Group, Total Oil (Thailand) Co., Ltd., and Redbull Beverage Co., Ltd. etc..

CHEP TH has a Pallet Service Center currently located in Ladkrabang district, East of Bangkok. Here is a crucial facility where the company produces new pallets, inspects & repairs damaged pallets, and distributes more than a hundred thousand pallets annually to local pallet consumer in various locations around Bangkok, the suburban areas, and some up-country places. In daily handing, each empty pallet is loaded with comprehensive products on top, by a forklift, and is called a "pack". Other packs are made using the same method. In the case of transferred hire customers, each pack is lifted into trucks ready to be allocated from producers to distributors or retailers. In other words, the transferred pallet places are modern businesses such Tesco Lotus Distribution System Co., Ltd., David Distribution Service Co., Ltd., C.P Seven Eleven Public Co., Ltd., Tops Distribution Center, and Siam Makro Public Co., Ltd., etc. Inevitably there would be many loose pallets and damaged loose pallets mixed and stacked after being used in modern trades and retailers' areas. In general, CHEP TH's used empty pallets are allowed free storage in their areas; in the mean time, CHEP TH has to move these pallets out to a Service Center immediately whenever the number of used pallets exceeds a pallet storage agreement of 2000 units at Tops Distribution Center, 500 units at Tesco Lotus (Distribution Center) and Exel Ditribution (Thailand) Co., Ltd.) and 300 units at C.P. Seven Eleven Public Co., Ltd.. For closed loop customers, it is seldom that used pallets are recycled to CHEP Pallet Service Center as movement of packs exists only in customers' warehouses or depots. In reissuing new pallets for the next transferred rounds, some customers might immediately issue available pallets either at the modern trades or at Ladkrabang Service Center. However, all defective loose pallets transported by customers themselves to Ladkrabang pallet Service Center are supposed to be exchanged for new empty pallets for loading further cargoes, or if reversing damaged loose pallets this is done by CHEP' s transportation

companies for inspection and repair processes to renew available empty pallets for other customers. The underlying problem is to find out the optimum number of new sub-service centers amongst possible locations so as to minimize distances of relocation pallets, and enable an efficient response to existing customers and also to prospective customers for all wood pallets supplied in everyday handling.

1.2 Project Objectives

The main objective of this project is to study and analyze service facility location problems and develop tools to establishing service center and sub-service centers properly, through a heuristic method which minimizes opportunity loss and maximizes revenue to the company.

The objectives of this project are:

- To determine the current service center and new sub-service centers and where they should properly be located;
- To assess the assignment of customers to the service center and new sub-service centers so as to maximize revenue;
- To minimize total transportation cost and expected opportunity loss.

1.3 Scope of the Project

This project is focused on a heuristic method by applying a single facility location concept, center-of-gravity theory and decision analysis technique together. The scope of this project is:

- To study and evaluate service facility locations of the wood pallet industry which impacts on total transportation costs, opportunity loss and revenue in the company, using a heuristic method.

1.4 Limitations of the Project

The following factors are not considered in this service facility location study as these are sales and marketing issues and confidential to the company.

- **Pricing factors**

Information from the sales manager is that the rental price of wood pallets is one of the critical factors of interest customers who lease CHEP pallets rather than purchasing other competitors' services. For example, some of the original customers who have leased CHEP pallets for many years, when their contracts have almost expired may have more bargaining power to request a reduction in rental price. Not only CHEP TH but also other pallet service providers probably retain customers by giving more special rates. Nevertheless, depending on volume sizes and the period of the new contract, the rate would be carefully reviewed with each customer. In addition, most prospective customers, if they are using

other pallet providers, normally accept at equal or lower prices offered, otherwise, they would not consider a service proposal presented by CHEP sales.

- **Switching cost factors**

In the pallet industry, many customers always cover the transportation charges of returning all unused pallets to the pallet service providers whenever they stop using them. Some pallet clients who own trucks can return them themselves. In this case, the switching cost of changing pallet suppliers may be high if there is a large number of recycled rental pallets in the supply chain system, and locations between customers and the return points are long distances. Therefore, changing to new pallet suppliers may be a difficult decision if transportation cost is a big factor for customers.

- **Networking factors**

CHEP TH was recently founded in Thailand, in 2002. The company has relationships with some modern traders i.e. Carrefour Co., Ltd., Makro PLC, BigC Co., Ltd., and others must be strongly developed. The retailers or distributors mentioned will still not accept transferring CHEP pallets with loaded cargoes from manufacturers into their racks. Because of this aspect, CHEP TH's competitors always claim that CHEP prospective customers reject a CHEP pallet service proposal. It is critical in CHEP losing sales opportunities from some manufacturers who want to replenish products into these places if CHEP does not approach pallet networking earlier.

- **Proprietary information**

Some information here is confidential to the company. This paper is allowed indirect expression i.e. Demand of Wood Pallets: ***Figure 4***.

- **Other factors**

In other cases, if customers lose rental pallets anywhere, and these customers cannot find and return these leased pallets back to the pallet providers, these customers nevertheless have to take full responsibility to replenish this loss to the pallet providers. Indeed, customers can purchase new pallets to replace those lost, or customers can pay to compensate for those lost. If the number of lost pallets is high, and thus the amount needed to compensate the pallet providers is high, but customers do not want to pay such large compensation. However, this is an opportunity for pallet service providers to extend the contract period with customers rather than asking customers pay pallet compensation, and this is a way to block competitors. Furthermore, there is deregulation of oligopoly in Thailand to control market competition, as in other countries. For instance, pallet companies in Australia are limited by government to owning a market segment of not more than 80 percent, to prevent imperfect competition and avoid an imbalance in power affecting rental prices of wood pallets in the market.

II. LITERATURE REVIEW

Research Overview

This project is aimed at studying service facility locations by using a step by step solution to determine convenient locations of facilities to serve existing and prospective pallet customers. These will be sub-service centers where the recycled pallets are inspected, sorted and stored, with under-cover protection, where customers are able to retrieve used pallets and issue empty pallets easily. This paper first considers the combination of total transportation costs occurring in each region which supplies wood pallets to existing customers i.e. distances, demand and transportation rates. Next, geographical contemplation of latitude/longitude of departure points and destination points are captured to measure the actual distances along the main roads. Then, these parameters are substituted with a single facility concept and center-of-gravity theory, being further guideline points for a later survey. We go onto sites to have a look and to collect facility information that we want to outsource, and put relevant costs into the calculation format simply provided on Excel 2003. Lastly, each alternative is further examined with decision analysis theory, to determine minimization of opportunity loss and maximization of revenue or sales target.

Many mathematical approaches have been presented in the literature dealing with facility location problems separately. For several years the facilities location decision (FL) problem has attracted a great deal of attention in the management literature. As a result, there is now a variety of methods for solving these problems. Snyder (2005) mentioned that plants, distribution centers, and other facilities generally function for decades, during which time the operations environment may change substantially. Costs, demands, travel times, and other inputs to classical facility location models may be highly uncertain. This has made the development of models for facility location under uncertainty a high priority for researchers in both the logistics and stochastic/robust optimization communities. In fact, a large number of the approaches that have been proposed for optimization under uncertainty have been applied to facility location problems. The intention of Snyder (2005) is to illustrate both the rich variety of approaches for optimization under uncertainty that have appeared in the literature and their application to facility location problems. Giddings et al. (2000) expressed optimality analysis of the cost coefficients in mixed integer linear programming with Response Surface Methodology (RSM). This optimality analysis goes beyond traditional sensitivity and parametric analysis in allowing investigation of the optimal objective function value response over pre-specified ranges on multiple problem parameters. Design of experiments and least squares regression are used to indicate which cost relations have the greatest impact on the optimal total cost surface over the specified coefficient ranges. The mixed integer linear programming problems of interest are the large-scale facility location and allocation problems in supply chain optimization.

Abdinnour-Helm (2001) states that locating hub facilities is important in different types of transportation and communication networks. He used simulation of annealing to solve the p-Hub Median Problem (p-HMP) to address a class of hub location problems in which all hubs are interconnected and each non-hub node is assigned to a single hub. The hubs are uncapacitated, and their number p is initially determined. An Artificial Intelligence (AI) heuristic called simulated annealing is introduced to solve the p-HMP. The results are compared against another AI heuristic, namely Tabu Search, and against two other non-AI heuristics. A real world data set of airline passenger flows in the USA, and randomly generated data sets, are used for computational testing. The results confirm that AI heuristic approaches to the p-HMP outperform non-AI heuristic approaches on solution quality. 4) Sherif H. Lashine, Mohamed Fattouh and Abeer Issa (2006) presented an integrated model for the location of warehouses, the allocation of retailers to warehouses, and finding the number of vehicles to deliver the demand and the required vehicle routing in order to minimize total transportation costs, fixed and operating costs, and routing costs. He assumes that the number of plants has already been determined and answers the following questions: What is the number of warehouses to open? How are warehouses allocated to plants? How are retailers allocated to warehouses? Who are the retailers that will be visited and in what order? How many vehicles are required for each route? What are the total minimum costs?. The findings of Laporte et al. (2006) use a model which was formulated as a mixed integer linear programming model and solved using Lagrange relaxation and sub-gradient search for the location/allocation module and a traveling salesman heuristic for the routing module. The results for the randomly selected problems show that the deviation in objective function value ranges between 0.29 and 2.05 percent from the optimum value.

Jones et al. (2003) conducted research on "the effects of locational convenience on customer repurchase intentions across service types." The location has long been touted as an important competitive factor in retailing and services. However, since convenient, high-traffic locations are costly, an examination of conditions under which locational convenience is more important and those in which it is less important, is critical. They supplement the logic of prior research to examine the importance of location as a function of both customer satisfaction with the core service and service type. Their finding is that a convenient location is critical in more standardized, less personalized services when satisfaction falters, but is not important for less standardized, more personalized services regardless of satisfaction levels. Thus, a convenient location can act as a barrier to defection in more standardized, less personal services such as banks, making it an important strategic factor in minimizing defection when satisfaction with the core service drops. However, contrary to conventional wisdom, locational convenience appears less important to repurchase intentions for less standardized, more personal services such as hairstylists, thus negating its potential as a switching barrier for such services. Lashine et al. (2006) proposed an integrated model for the location of warehouses, the allocation of retailers to warehouses, and finding the number of vehicles to deliver the demand and the required vehicle routing in order to minimize total transportation costs, fixed and

operating costs, and routing costs. The model assumes that the number of plants has already been determined and answers the following questions: What is the number of warehouses to open? How are warehouse allocated to plants? How are retailers allocated to warehouses? Who are the retailers that will be visited and in what order? How many vehicles are required for each route? What are the total minimum costs? Their findings are based on their model which was formulated as a mixed integer linear programming model and solved using Lagrange relaxation and sub-gradient search for the location/allocation module and a traveling salesman heuristic for the routing module. The results for the randomly selected problems show that the deviation in objective function value ranges between 0.29 and 2.05 percent from the optimum value. Also, from the CPU time point of view, the performance was very good.

Gibler (2006) used scorecards to routinely evaluate distribution facility locations. His research gave the background to the decision-making process behind transportation mode selection and distribution center selection, and then on how these locations can gradually become obsolete. He gave examples of how one company identified their key performance indicators and applied them to the facility closure decision-making process. Companies can create a rational, efficient and evenhanded approach to the closure of underperforming facilities. Using those same tools, managers can readily identify whether the root cause of good or bad performance stems from the market, or management. Facility closure decisions are often prompted by the firm's need to reduce losses. This paper proposes using the company's key performance indicators to drive an on-going evaluation of each facility's performance. Using this approach, companies will be able to identify downward trends and their root causes, rather than making a series of trial and error attempts at fixing the problem Thai and Grewal (2005) reported on selecting the location of distribution centre in logistics operations as the outcome of a study of the choice of location for distribution centres in logistics operations. A conceptual framework of location selection for distribution centres is worked out through three main stages. At the first stage, a general geographical area for a distribution centre is identified based on the Centre of Gravity principle, taking into consideration socio-economic factors. The second stage of the selection process involves the identification of alternative locations for the distribution centre and the airports and seaports to be used for in-bound and out-bound cargo flows within the defined general geographical area. The third stage focuses on specific site selection among the identified alternative locations for the distribution centre based on the quantitative approach. This involves a mathematical model which aims to optimise either the total distribution cost or the integration of total distance transport with given relevant volumes of cargo. In order to illustrate the conceptual framework, a case study of a logistics service provider will be provided. Data from the case study proved that the conceptual framework for selection is valid and can be of value to logistics companies in their operations and management.

Korupolu et al. (2000) presented an analysis of a Local Search Heuristic for Facility Location Problems. They studied approximation algorithms for several NP-hard facility location problems. They proved that a simple local search heuristic

yields polynomial-time constant-factor approximation bounds for metric versions of the uncapacitated k-median problem and the uncapacitated facility location problem. (For the k-median problem, our algorithms require a constant-factor blowup in the parameter k.) This local search heuristic was first proposed several decades ago and has been shown to exhibit good practical performance in empirical studies. We also extend the above results to obtain constant-factor approximation bounds for the metric versions of capacitated k-median and facility location problems. Canel and Khumawala, (2001) proposed that companies no longer operate in a single market. To penetrate global markets and obtain their benefits, companies are under tremendous pressure to reduce the price of their products, and thus their production and material costs. When a foreign location is used, the components of a product are produced there and final assembly takes place either at the foreign location or at the parent domestic plant. This paper first presents the issues related to international facilities location (IFL) problems, and provides the framework required to deal with such problems. It then presents a heuristic algorithm for solving the IFL problem. Extensive computational experience was gained by solving a variety of IFL problems of different sizes.

Schutza et al. (2006) addressed the problem of minimizing the expected cost of locating a number of single product facilities and allocating uncertain customer demand to these facilities. The total costs consist of two components: firstly the linear transportation costs of satisfying customer demand and secondly the costs of investing in a facility as well as maintaining and operating it. These facility costs are general and non-linear in shape and could express both changing economies of scale and diseconomies of scale. We formulate the problem as a two-stage stochastic programming model where both demand and short-run costs may be uncertain at the investment time. We use a solution method based on Lagrangean relaxation, and show computational results for a slaughterhouse location case from the Norwegian meat industry.

III. EXISTING STUDY

3.1 Introduction

The good location of service facilities has been an area of considerable research. Determining proper locations for facilities in order to meet growing demand requirements has continued to be of significant interest to researchers. Access to a service center is a critical factor in determining satisfaction of demand for customer zones. A convenient location strategy gives a firm a clear strategic advantage over its competitors. For new types of such services, the location decision is very important because it is through this location that services are made available to existed customers and potential customers. By locating more sub-service centers supporting a firm, this increases its accessibility and hence improves its overall customer service. However, adding more sub-service centers increases the costs of establishing or/and maintaining the service facility and may also erode profit unless there is a sufficient increase in service utilization.

3.2 Service Facility Location and Capability

Consider the present service center location in Bangkok (Ladkrabang district). It is a fixed facility total space of 900 sq.m for pallet production, inspection, repairing, storage and distribution (as displayed in ***Figure 1)***. The 500 sq.m is individually separated and fully utilized for production, inspection, cleaning and repair processes, and 400 sqm is used for storing the used pallets returned for reconditioning and new empty pallets ready for issuing. As mentioned in limitations, here maybe the favored location for many existing customers (41.42 percent of total demand) who are located around in minimal distances for issuing and retrieving pallets conveniently. On the other hand, the 56.58 percent of existing customers in other areas far away may be highly affected by long distances to regular processes. In addition, there are a lot of used pallets for retrieving to the service center in the low demand season every July to October. During this period it is the rainy season in Thailand, and service center space often has insufficient storage space so some of the retrieved pallets do not have under-roof protection. Hence, pallet quality is an inevitalble issue because pallets which get wet are strongly affected with a short life-cycle recycling in the supply chain.

Map of CHEP Service Center Location: ***Figure 1***

3.3 Customer Locations

From collected geographical information, CHEP pallet production plant, manufacturers, distribution centers and retailers are broadly located in three zones in Thailand. The area categorized as Zone 1 is the Ayuthaya area in Wangnoi district, which comprises Tesco Lotus (Distribution Center) and Excel Distribution (Thailand) Ltd. Zone 2 is the Nothaburi area in Bangbuathong district, which consists of Tops (Central Food Retail Co., Ltd.), CP Seven Eleven PLC Ltd., and Dairy Plus Co., Ltd., located in Phayuhakhiri district, Nakornsawan. Zone 3 is the Bangkok area in Landkrabang district, which includes the CHEP service centre, CP Seven Eleven PLC Ltd., Perfect Companion Group Co., Ltd., and Kao Co., Ltd., (a prospective customer in Chonburi province). All this is shown in ***Figure 2***.

Map of Pallet Customer Locations: ***Figure 2***

According to existed customer locations, positioning of latitude/longitude coordinates are listed to obviously pair each point of pallet flow between existing locations. Each delivery path from pallet sources to demand points allows different distances measured from real address to real address. For example, a distance from the CHEP service center to Tesco Lotus (Distribution Center) is approximately 90 kilometres. A couple of points are measured along the real main roads involving truck travelling, as given by transportation companies who CHEP outsource from Ladkrabang district (latitude: 13.73353 and longitude: 100.76674) to Wangnoi district (latitude: 14.22109 and longitude: 100.68820), as displayed in ***Table 1.*** Nevertheless, the reason to state these coordinates in this paper is to support accuracy location calculation. In reality a CHEP service center will be among differential set of customer locations in the supply chain.

Transportation Points: ***Table 1***

Departure Location					Destination Location					Distance
Trading Partner	**Province**	**Address**	**Latitude**	**Longitude**	**Trading Partner**	**Province**	**Address**	**Latitude**	**Longitude**	**(KM)**
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	Tesco Lotus (Distribution Center)	Ayutthaya	Wangnoi	14.22109	100.68820	90
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	Exel Distribution (Thailand) Ltd.	Ayutthaya	Wangnoi	14.216110	100.66806	85
CHEP Service Center	Nonthaburi	Bangbuathong	13.73353	100.76674	Tops Distribution Center	Nonthaburi	Bangbuathong	13.973100	100.39594	119
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	CP Seven Eleven Public Co., Ltd.	Nonthaburi	Bangbuathong	13.97671	100.39301	120
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	Dairy Plus Co., Ltd.,	Nakornsawan	Phayuhakhiri	15.49489	100.14682	240
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	Perfect Companion Group Co.,Ltd	Samutprakarn	Bangbuathong	13.59640	100.81643	35
CHEP Service Center	Bangkok	Ladkrabang	13.73353	100.76674	CP Seven Eleven Public Co., Ltd.	Nonthaburi	Ladkrabang	13.72231	100.80046	7
Exel Distribution (Thailand) Ltd.	Ayutthaya	Wangnoi	14.216110	100.66806	Tops Distribution Center	Nonthaburi	Bangbuathong	13.97310	100.39594	30
Exel Distribution (Thailand) Ltd.	Ayutthaya	Wangnoi	14.216110	100.66806	CP Seven Eleven Public Co., Ltd.	Nonthaburi	Bangbuathong	13.97671	100.39301	35
CP Seven Eleven Public Co., Ltd.	Bangkok	Ladkrabang	13.72231	100.80046	Tops Distribution Center	Nonthaburi	Bangbuathong	13.97310	100.39594	110
Tesco Lotus (Distribution Center)	Ayutthaya	Wangnoi	14.22109	100.6882	Tops Distribution Center	Nonthaburi	Bangbuathong	13.97310	100.39594	30
Tesco Lotus (Distribution Center)	Ayutthaya	Wangnoi	14.22109	100.6882	CP Seven Eleven Public Co., Ltd.	Nonthaburi	Bangbuathong	13.97671	100.39301	35
Tesco Lotus (Distribution Center)	Ayutthaya	Wangnoi	14.22109	100.6882	Dairy Plus Co., Ltd.	Samutprakarn	Phayuhakhiri	15.49489	100.14682	182

3.4 Transportation Costs and Oil Prices

Annual transportation costs of the relocation wood pallets in 2006 totalled ***THB 1,504,610*** with one service center supplying wood pallets to local customers. Basically there are two main categories of costs incurred from production and delivery processes. The pallet production cost is ***THB 4,806,901***, comprising facility rental fee, forklift rental fee, material cost, labor wages and electricity cost etc. The pallet delivery cost consists of delivering new empty pallets to customers (called "pallet issuing" as required by sale conditions with some customers being supported by CHEP for some portions of the transportation cost - ***THB 35,078)***, and the cost of returning damaged empty pallets from distributors areas, manufacturer areas and retailer areas to the CHEP service center is ***THB 1,469,532*** to renew the ready empty pallets for other issuers. All this is shown in ***Table 2***.

Annual Transportation Cost in 2006: ***Table 2***

Departure Location		Destination Location		Volume	Transportation Cost (THB)
Trading Partner	**Address**	**Trading Partner**	**Address**		
Tesco Lotus (Distribution Center)	Wangnoi	Tops Distribution Center	Bangbuathong	10,440	131,500
Tesco Lotus (Distribution Center)	Wangnoi	CHEP Service Center	Ladkrabang	16,614	208,051
Tops Distribution Center	Bangbuathong	Tesco Lotus (Wangnoi).	Wangnoi	720	6,850
Tops Distribution Center	Bangbuathong	Exel Distribution (Thailand) Ltd.	Wangnoi	3,612	50,009
Tops Distribution Center	Bangbuathong	CHEP Service Center	Ladkrabang	16,842	240,301
Tops Distribution Center	Bangbuathong	CHEP Service Center	Ladkrabang	22,565	274,695
Exel Distribution (Thailand) Ltd.	Wangnoi	CHEP Service Center	Ladkrabang	1,662	25,739
CP Seven Eleven PLC-Bangbuathong	Bangbuathong	CHEP Service Center	Ladkrabang	2,002	29,952
Chep Service Center	Ladkrabang	Tesco Lotus (Distribution Center)	Wangnoi	360	4,750
CHEP Service Center	Ladkrabang	Tops Distribution Center	Bangbuathong	510	7,296
Dairy Plus Co., Ltd.	Phayuhakhiri	Chep Service Center	Ladkrabang	6,798	127,607
Dairy Plus Co., Ltd.	Phayuhakhiri	Chep Service Center	Ladkrabang	110	33,973
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Ladkabang	1,482	5,334
CHEP Service Center	Ladkrabang	Perfect Companion Group Co., Ltd.	Bangbuathong	4,320	35,078
Perfect Companion Group Co.,Ltd	Bangsaothong	CHEP Service Center	Ladkrabang	3,300	13,167
Tesco Lotus (Distribution Center)	Wangnoi	CHEP Service Center	Ladkrabang	7,560	99,338
Tops Distribution Center	Bangbuathong	CHEP Service Center	Ladkrabang	2,520	32,987
Exel Distribution (Thailand) Ltd.	Wangnoi	Chep Service Center	Ladkrabang	1,080	14,137
CP Seven Eleven Public Co.,	Bangbuathong	Chep Service Center	Ladkrabang	360	4,709

Ltd.					
Tesco Lotus (Distribution Center)	Wangnoi	Chep Service Center	Ladkrabang	6,840	92,340
Tops Distribution Center	Bangbuathong	Chep Service Center	Ladkrabang	2,880	34,272
Exel Distribution (Thailand) Ltd.	Wangnoi	Chep Service Center	Ladkrabang	1,440	18,360
CP Seven Eleven Public Co., Ltd.	Bangbuathong	Chep Service Center	Ladkrabang	1,080	14,256
			Total		**1,504,610**

In addition, fluctuation of oil prices from January 2006 to January 2007 has had a strong impact by increasing pallet transportation prices in that period, as shown in bold front in the tables below. From January to May 2006, oil prices rose from 18.19 THB/Litre to 22.59 THB/Litre. The average of transportation rates has consecutively risen by 8.19 percent for 6-wheel trucks and 9.42 percent for 18-wheel trucks, as shown in ***Table 3***.

Transportation Prices: Jan-May'06, ***Table 3***

From		To		6 wheel truck		18 wheel truck	
Trading Partner	**Address**	**Trading Partner**	**Address**	18.19 THB/Litre	**22.59 THB/Litre**	18.19 THB/Litre	**22.59 THB/Litre**
CHEP Service Center	Ladkrabang	Tesco Lotus (Distribution Center)	Wangnoi	2300	**2500**	4300	**4700**
CHEP Service Center	Ladkrabang	Exel Distribution (Thailand) Ltd.	Wangnoi	2300	**2500**	4300	**4700**
CP Seven Eleven Public Co., Ltd.	Bangbuathong	Tops Distribution Center	Bangbuathong	2300	**2500**	4300	**4700**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2300	**2500**	4300	**4700**
CHEP Service Center	Ladkrabang	Dairy Plus Co., Ltd.	Phayuhakhiri	3500	**3850**	6200	**6800**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Ladkrabang	500	**550**	1000	**1,100**
Exel Distribution (Thailand) Ltd.	Wangnoi	Tops Distribution Center	Bangbuathong	2,300	**2,500**	4,300	**4,700**
Exel Distribution (Thailand) Ltd.	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2,300	**2,500**	4,300	**4,700**
CP Seven Eleven Public Co., Ltd.	Ladkrabang	Tops Distribution Center	Bangbuathong	2300	**2500**	4300	**4700**
Tesco Lotus (Distribution Center)	Wangnoi	Tops Distribution Center	Bangbuathong	2300	**2500**	4300	**4700**
Tesco Lotus (Distribution Center)	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2300	**2500**	4300	**4700**
Tesco Lotus (Distribution Center)	Wangnoi	Dairy Plus Co., Ltd.	Phayuhakhiri	N/A	**N/A**	6200	**6800**

In the next period, June to December 2006, oil prices again increased, to 26.19 THB/Litre from 22.59 THB/Litre. The average of increased transportation rates was 5.56 percent for 6-wheel trucks and 6.45 percent for 18-wheel trucks, as indicated in ***Table 4***.

Transportation Prices: Jun-Dec'06, ***Table 4***

From		To		6 wheel truck		18 wheel truck	
Trading Partner	**Address**	**Trading Partner**	**Address**	22.59 THB/Litre	**26.19 THB/Littre**	22.59 THB/Litre	**26.19 THB/Littre**
CHEP Service Center	Ladkrabang	Tesco Lotus (Distribution Center)	Wangnoi	2500	**2650**	4700	**5000**
CHEP Service Center	Ladkrabang	Exel Distribution (Thailand) Ltd.	Wangnoi	2500	**2650**	4700	**5000**
CP Seven Eleven Public Co., Ltd.	Bangbuathong	Tops Distribution Center	Bangbuathong	2500	**2650**	4700	**5000**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2500	**2650**	4700	**5000**
Chep Service Center	Ladkrabang	Dairy Plus Co., Ltd.	Phayuhakhiri	3850	**4100**	6800	**7250**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Ladkrabang	800	**850**	1500	**1600**
Exel Distribution (Thailand) Ltd.	Wangnoi	Tops Distribution Center	Bangbuathong	2500	**2650**	4700	**5000**
Exel Distribution (Thailand) Ltd.	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2500	**2650**	4700	**5000**
CP Seven Eleven Public Co., Ltd.	Ladkrabang	Tops Distribution Center	Bangbuathong	2500	**2650**	4700	**5000**
Tesco Lotus (Distribution Center)	Wangnoi	Tops Distribution Center	Bangbuathong	2500	**2650**	4700	**5000**
Tesco Lotus (Distribution Center)	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2500	**2650**	4700	**5000**
Tesco Lotus (Distribution Center)	Wangnoi	Dairy Plus Co., Ltd.	Phayuhakhiri	N/A	**N/A**	6800	**7250**

From January 2007 onwards, oil prices have decreased a little in comparison to the previous increases, from 26.19 THB/Litre to 23.84 THB/Litre. The average of transportation rates has thus decreased by 5.14 percent for 6-wheel trucks and 5.08 percent for 18-wheel trucks, as expressed in ***Table 5***.

Transportation Price: Dec'06-Jan'07, ***Table 5***

From		To		6 wheel truck		18 wheel truck	
Trading Partner	**Address**	**Trading Partner**	**Address**	26.19 THB/Littre	**23.84 THB/Littre**	26.19 THB/Littre	**23.84 THB/Littre**
CHEP Service Center	Ladkrabang	Tesco Lotus (Distribution Center)	Wangnoi	2650	**2500**	5000	**4750**
CHEP Service Center	Ladkrabang	Exel Distribution (Thailand) Ltd.	Wangnoi	2650	**2500**	5000	**4750**
CP Seven Eleven Public Co., Ltd.	Bangbuathong	Tops Distribution Center	Bangbuathong	2650	**2500**	5000	**4750**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2650	**2500**	5000	**4750**
CHEP Service Center	Ladkrabang	Dairy Plus Co., Ltd.	Phayuhakhiri	4100	**3900**	7250	**6900**
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co., Ltd.	Ladkrabang	850	**800**	1600	**1500**
Exel Distribution (Thailand) Ltd.	Wangnoi	Tops Distribution Center	Bangbuathong	2650	**2500**	5000	**4750**
Exel Distribution (Thailand) Ltd.	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2650	**2500**	5000	**4750**
CP Seven Eleven Public Co., Ltd.	Ladkrabang	Tops Distribution Center	Bangbuathong	2650	**2500**	5000	**4750**
Tesco Lotus (Distribution Center)	Wangnoi	Tops Distribution Center	Bangbuathong	2650	**2500**	5000	**4750**
Tesco Lotus (Distribution Center)	Wangnoi	CP Seven Eleven Public Co., Ltd.	Bangbuathong	2650	**2500**	5000	**4750**
Tesco Lotus (Distribution Center)	Wangnoi	Dairy Plus Co., Ltd.	Phayuhakhiri	N/A	**N/A**	7250	**6900**

IV. METHODOLOGY

4.1 Introduction

In the data collection and analysis stage, the following data is used for analysis i.e. sales historical data in 2006 downloaded from the PCMS (Pallet Container Management System); pallet production information; coordinates of latitude-longitude of CHEP service center; potential new sub-service centers, manufacturers, distributors and retailers; transportation rates of 6-wheel trucks and 18-wheel trucks; and distances between locations. However, many of the required data elements are not readily available. The way data is recorded and accounting systems used in the company make it difficult to isolate actual transportation costs. For instance, some customers for whom CHEP covers the delivery charges of issuing pallets, their transportation costs incurred must be precisely determined individually in same-day transactions. For routes which have round trips, a transportation rate is computed from the one trip rate plus the 50 percent of a return trip (a 50 percent discount is offered by CHEP transportation companies). Then the delivery charges for each pallet can be translated into transportation cost per pallet per kilo meter. With the assumption that the CHEP pallet service changes are based on existing factors i.e. transportation rates, distances and oil prices, then by this methodology we can foresee which factors have major impacts, and by how much, in order to take countermeasures in advance.

3.2 Methodology Used

A heuristic method, an approach of step by step solution or trial & error solution, is applied, to solve the problem of facility location using the four steps developed. Baseline cost calculation, survey of potential areas, re-computing and comparing each outcome and decision analysis are applied, with several popular approaches i.e. single facility location theory, center-of-gravity approach and decision making analysis. Single facility theory is used to define and also translate an important combination of total transportation costs occurring in each route of current pallet handling. The center-of-gravity concept is applied to finding a guideline point for setting facilities. Decision making analysis is applied to determine which scenario gives satisfactory outcomes in real natural situations. Thus, the steps are:

Step 1: Baseline Calculation

Step 2: Survey Potential Facility Locations

Step 3: Recalculate and Compare Several Outcomes

Step 4: Decision Making Analysis (decision making under risks)

Step 1: Baseline Calculation

The approach is simple, since the transportation rate and the point volume are the only location factors. This model is classified mathematically as a static

continuous location model. Where should new sub-service center be located given a set of points representing source point and demand points, their volumes that are to be moved to or from a single facility of unknown location, and their associated transportation rate? We seek to minimize the sum of the volume at a point multiplied by the transportation rate to send to a point multiplied by the distance to the point, which is the total transportation cost, that is,

$$MinTC = \sum_i V_i R_i d_i \qquad (3\text{-}1)$$

Where *TC = total transportation cost*

V_i = volume at point i

R_i = transportation rate to point i

d_i = distance to point i from the new sub-service center to be located

And the optimum facility location is found by solving two equations for the coordinates of the location. These exact center-of-gravity coordinates are

$$\bar{X} = \frac{\sum_i V_i R_i X_i / d_i}{\sum_i V_i R_i / d_i} \qquad (3\text{-}2)$$

and

$$\bar{Y} = \frac{\sum_i V_i R_i X_i / d_i}{\sum_i V_i R_i / d_i} \qquad (3\text{-}3)$$

where

$\bar{X}, \bar{Y}$ = coordinate points of the located facility

X_i, Y_i = coordinate points of source and demand points

The distance d_i is estimated if unknown distances

$$d_i = K\sqrt{\left(X_i + \bar{X}\right)^2 + \left(Y_i - \bar{Y}\right)^2} \qquad (3\text{-}4)$$

The solution process involves several steps, which are outlined as follows:

1. Determine the X, Y coordinate points for each source and demand points, along with point volumes and linear transportation rates.
2. Approximate the initial location from the center-of-gravity formulas by omitting the distance term d_i as follows:

$$\bar{X} = \frac{\sum_i V_i R_i X_i}{\sum_i V_i R_i} \qquad (3\text{-}5)$$

and $$\bar{Y} = \frac{\sum_i V_i R_i X_i}{\sum_i V_i R_i} \quad (3\text{-}6)$$

3. Using the solution for $\bar{X}, \bar{Y}$ from step 2, calculate d_i according to Equation (3-4)

4. Substitute d_i into Equation (3-2) and (3-3), and solve for the revised $\bar{X}, \bar{Y}$ coordinates.

5. Recalculate d_i base on the revised $\bar{X}, \bar{Y}$ coordinates.

6. Repeat steps 4 and 5 until the $\bar{X}, \bar{Y}$ coordinates do not change for successive iterations, or they change so little that continuing the calculations is not fruitful.

7. Finally, calculate the total cost for the best location, if desired, by using Equation (3-1)

In this paper, step 1 to step 7 are calculated in Microsoft Excel 2003, and the computation's result is below.

(Source: Business Logistics/SCM "Facility Location Decisions", pp.555-570).

Sales historical data, downloaded from PCMS (Pallet Container Management System) displays transportation routes of wooden pallets from one point to other points, with quantities moved. Transportation prices for each route are found from old quotations given by transportation companies, and real distances for each route can be measured by using ***PointAsia*** **(www.pointasia.com)** which is a fantastic tool using location mapping. Therefore, transportation cost can be calculated with actual quantities delivered either by 6-wheel truck or 18-wheel truck depending on truck load capacity consistent with customer order size, for example a 16- wheel truck can be loaded with ≤150 pallets/trip and an 18-wheel truck can contain ≤360 pallets/trip. The conjunction with the transportation rate for each route is illustrated in ***Table 6***.

Baseline Calculation of Transportation Cost: ***Table 6***

From		To		(V_i)	(d_i)	(R_i)	TP Cost
Trading Partner	**Address**	**Trading Partner**	**Address**	**Volume**	**Distance**	**TP Rate**	**(THB)**
Tesco Lotus (Distribution Center)	Wangnoi	Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	10,440	60	0.210	131,500
Tesco Lotus (Distribution Center)	Wangnoi	CHEP Service Center	Ladkrabang	16,614	180	0.070	208,051
Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	Tesco Lotus (Wangnoi).	Wangnoi	720	60	0.159	6,850
Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	Exel Distribution (Thailand) Ltd.	Wangnoi	3,612	60	0.231	50,009

Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	CHEP Service Center	Ladkrabang	16,842	238	0.060	240,301
Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	CHEP Service Center	Ladkrabang	22,565	238	0.051	274,695
Exel Distribution (Thailand) Ltd.	Wangnoi	CHEP Service Center	Ladkrabang	1,662	170	0.090	25,739
CP Seven Eleven PLC Ltd.	Bangbuathong	CHEP Service Center	Ladkrabang	2,002	240	0.062	29,952
CHEP Service Center	Ladkrabang	Tesco Lotus (Distribution Center)	Wangnoi	360	180	0.073	4,750
CHEP Service Center	Ladkrabang	Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	510	238	0.070	7,296
Dairy Plus Co., Ltd.	Phayuhakhiri	CHEP Service Center	Ladkrabang	6,798	480	0.039	127,607
Dairy Plus Co., Ltd.	Phayuhakhiri	CHEP Service Center	Ladkrabang	110	480	0.643	33,973
CHEP Service Center	Ladkrabang	CP Seven Eleven Public Co Ltd.	Ladkabang	1,482	14	0.257	5,334
CHEP Service Center	Ladkrabang	Perfect Companion Group Co., Ltd.	Bangsaothong	4,320	70	0.116	35,078
Perfect Companion Group Co., Ltd.	Bangbuathong	CHEP Service Center	Ladkrabang	3,300	35	0.114	13,167
Tesco Lotus (Wangnoi).	Wangnoi	CHEP Service Center	Ladkrabang	7,560	90	0.146	99,338
Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	CHEP Service Center	Ladkrabang	2,520	119	0.110	32,987
Exel Distribution (Thailand) Ltd.	Wangnoi	CHEP Service Center	Ladkrabang	1,080	85	0.154	14,137
CP Seven Eleven PLC Ltd.	Bangbuathong	CHEP Service Center	Ladkrabang	360	120	0.109	4,709
Tesco Lotus (Distribution Center)	Wangnoi	CHEP Service Center	Ladkrabang	6,840	90	0.150	92,340
Tops (Central Food Retail Co. Ltd. DC)	Bangbuathong	CHEP Service Center	Ladkrabang	2,880	119	0.100	34,272
Exel Distribution (Thailand) Ltd.	Wangnoi	CHEP Service Center	Ladkrabang	1,440	85	0.150	18,360
CP Seven Eleven PLC Ltd.	Bangbuathong	CHEP Service Center	Ladkrabang	1,080	120	0.110	14,256
				(TC)	**Total**		**1,504,610**

Transportation cost is one available cost. It is incurred in moving new empty pallets to customers; and also by the relocation of empty used pallets between distributors and retailers, but the number of pallets allowed into storage must not exceed the storage agreement between CHEP TH and the place owners; and also the cost of returning damaged pallets from modern traders or retailers to the production plant at ICD Ladkrabang for inspection; and the sorting and

repairing processes. As indicated in ***Table 7***, the transportation cost is 1,504,610 THB, or 23.84 percent of total operational cost input.

Baseline Calculation of Transportation Cost and Operation Cost: ***Table 7***

Description	Fixed Cost	Variable Cost	Total Cost	Cost Ratio
Timber	-	2,048,832	2,048,832	32.46%
Labour	690,000	95,121	785,121	12.44%
Nail	-	292,090	292,090	4.63%
Paint	-	440,550	440,550	6.98%
Rental Service Center	390,000	-	390,000	6.18%
Equipment depreciation	-	54,490	54,490	0.86%
Utilities & others supplied included electricity	66,000	268,146	334,146	5.29%
Supervisor's wage	114,480	18,743	133,223	2.11%
Forklift rental / depreciation	180,000	-	180,000	2.85%
Forklift - fuel & maintenance	-	148,450	148,450	2.35%
Transportation Cost	-	1,504,610	1,504,610	23.84%
Total	**1,440,480**	**4,871,032**	**6,311,512**	100.00%

Step 2: Survey Potential Facility Locations

Once the coordination points of $\bar{X},\bar{Y}$ are known from baseline calculation, here we know $\bar{X} = Longtitude, \bar{Y} = Latitude$ which is the optimal point resulting from mathematical model substitution, then the couple coordinates are plotted on PointAsia–mapping software to find out where this location is geographically. Measuring distances along the main roads between a new potential location, a survey took place around potential area to investigate whether there are some facilities for leasing i.e. medium depots or warehouses. Then recalculate following step 1 until step 4 with new information from the survey collection such as facility rental fee and address, and other information from PointAsia i.e. distances measured from a new facility location to existing destinations, then an outcome can be compared to the baseline calculation. A sample is precisely demonstrated in ***Table 8.*** This step also included site selection considerations i.e. access ability (6-wheel trucks and 18-wheel trucks), visibility from streets, traffic volume on street which may indicate potential impulse buying, and traffic congestion that could be a hindrance, adequate parking (6-wheel trucks and 18-wheel trucks),

expansion if increased volume, and environmental: immediate surroundings should complement the services and locations of competitors.

Step 3: Recalculate and Compare Several Outcomes

Once the baseline cost is completely calculated, the redesigned service center cost, 2 service center costs and 3 service center costs are consecutively computed with the same method. These are compared in ***Table 8***. First, Labor cost of baseline cost, redesigned service center cost and 2 service center costs are unchanged: only the 3 service center labor costs increased, from THB758,121 per year to THB863,121 per year because this facility requires labor support on-site. Other facilities have labor serving the lift, on-lift and off-lift, and pallet issuing. Next, the rental fee of service center is high for 2 service centers and 3 service centers, THB643,800 and THB699: a 600 pallet volume at each location requires space for handing pallets monthly: 318 sqm for Ayuthaya Zone (Wangnoi) and 277 sqm for Nothaburi Zone (Bangbuathong). Third, the cforklift rental fee is increased at 3 service centers, to THB259,356 per year against 2 service centers costing THB180,000 per year, with the facility rental fee already included. And the reverse logistics cost of 2 service centers and 3 service centers increased to THB379,500 and THB304,694 per year: these are only the transportation costs of damaged pallets back to the main service center in the ICD at Ladkrabang. However, only the transportation cost of moving pallets from distributors and retailers to sub-service centers are gradually decreased, to THB1,335,613 per year at a redesigned service center, THB1,054,295 for the 2 service centers and THB793,908 for the 3 service centers.

Comparison of Service Center costs: ***Table 8***

Description	Current Service Center	Redesigned Service Center	2 Service Centers	3 Service Centers
Timbers	2,048,832	2,048,832	2,048,832	2,048,832
Labours	785,121	785,121	785,121	863,121
Nails	292,090	292,090	292,090	292,090
Paints	440,550	440,550	440,550	440,550
Service Center Rental	390,000	336,000	643,800	699,600
Equipment depreciation	54,490	54,490	54,490	54,490
Utilities included electricity	334,146	334,146	334,146	337,746
Supervisor wage	133,223	133,223	133,223	133,223
Forklift rental / depreciation	180,000	180,000	180,000	259,356
Forklift - fuel & maintenance	148,450	148,450	148,450	148,450
Transportation Cost	1,504,610	1,335,613	1,054,295	793,908

Reversed logistics cost	-	-	379,500	304,694
Total cost	**6,311,512**	**6,088,514**	**6,494,496**	**6,376,060**

Total costs of each facility are obviously calculated and comparable in ***Table 9***. THB6,311,512 per year is for the present facility operation, THB6,088,514 per year for the redesigned service center (assuming no present facility serves existing customers). It seems that the total cost is improved; however, CHEP has to subsidize the transportation cost for some customers who would be far away if CHEP changes its pallet service center location. THB6,494,496 is the cost if CHEP installs 2 service centers. This cost is higher than the baseline cost of THB182,984 per year. Finally, the cost is THB6,376,060 if CHEP operates 3 service centers more in Ayuthaya Zone (Wangnoi) and Nonthaburi Zone (Bangbuathong). This total cost is still greater than the baseline cost but only by THB64,548 per year.

Step 4: Decision Analysis

With decision theory, this project is defined as decision making under risk, as there are several possible outcomes for each alternative operating with only the current service center (baseline result), 2 service centers and 3 service centers. And the probability of occurrence of each outcome is known (market situation given by the sales department). Decision making is usually aimed at maximization of expected benefits and minimization of expected opportunity loss (lost sales).

Decision making under risk

Decision making under risk is a decision situation in which several possible state of nature may occur, and the probabilities of these states of nature are known. In this section we consider the most popular method of making decisions under risk: selecting the alternative with the highest value (or simply expected value). We also use the probabilities with the opportunity loss table to minimize the expected opportunity loss.

- **Expected Monetary Value (EMV)**

Given a decision table with conditional value (payoffs) that are monetary values, and probability assessments for all states of nature, it is possible to determine the expected monetary value (EMV) for each alternative. The expected value, or the mean value, is the long run average value of the decision. The EMV for an alternative is simply the sum of possible payoffs of the alternative, each weighteed by the probability of that payoff occurring.

EMV (alternative i) = (payoff of first state of nature)
x (probability of first state of nature)
+ (payoff of second state of nature) (3-7)
x (probability of second state of nature)
+...+ (payoff of last state of nature)

x (probability of last state of nature)

The formula above is substituted with each set of existing information. CHEP currently operates one service center (total baseline cost THB6,311,512 per year) and total annual pallet leasing in 2006 was THB23,063,523. The event pallet market is unfavorable (probability 0.3). CHEP pays nothing for facilities (0). In 2007, pallet leasing target is a challenging year (THB26,271,000, probability 0.3 of a favourable market). If CHEP operates with the current facility assumed, the total baseline cost is unchanged (THB6,088,514). However, if CHEP invests in installing 2 service centers to serve customers, then that total cost is generally increased to THB6,494,496. In this case, if the pallet leasing market is unfavourable (probability 0.7) then CHEP will lose THB182,984. Furthermore, if CHEP operates with an only existing facility assumed, the total baseline cost would be the same (THB6,088,514). Nevertheless, if CHEP invests in installing 3 service centers (Bangbuathong and Wangnoi sub-service centers) that total cost would be increased by THB64,548. If the pallet leasing market is unfavourable (probability 0.7) then CHEP will lose THB64,548. This is shown in EMV Calculation: ***Table 9***.

EMV Calculation: ***Table 9***

Alternatives	State of Nature	
	Favourable Market (THB)	Unfavourable Market (THB)
Current Service Center	23,063,523	0
2 Service Centers	26,271,000	- 182,984
3 Service Centers	26,271,000	- 64,548
Do nothing	0	0
Probabilities	0.3	0.7

Once the formula is substituted, the expected monetary value is already computed into a result in ***Table 10***. By its theory, the alternative with the maximum EMV is then chosen.

EMV Calculation Resulted: ***Table 10***

Alternatives	State of Nature		Maximum in Row (EMV)
	Favourable Market (THB)	Unfavourable Market (THB)	
Current Service Center	23,063,523	0	6,919,057
2 Service Centers	26,271,000	- 182,984	7,753,211
3 Service Centers	26,271,000	- 64,548	**7,836,116**
Do nothing	0	0	-
Probabilities	0.30	0.70	

The largest expected value (THB7,836,116) results from the third alternative, "3 Service Centers". Thus CHEP should proceed with the project and put 3 Service Centers to serve existing customers and prospective customers. The

EVMs for the current service center, 2 Service Centers and doing nothing, are THB6,919,057, THB7,753,211 and THB0 respectively.

- **Expected Opportunity Loss**

An alternative approach to maximizing EMV is to minimize expected opportunity loss (EOL). First, an opportunity loss table is constructed. Then the EOL is computed for each alternative by multiplying the opportunity loss by the probability and adding these together. Using the opportunity loss table, the minimax regret criterion finds the alternative that minimizes the maximum opportunity loss within each alternative. First, find the maximum (worst) opportunity loss for each alternative. Next, looking at these maximum values, pick that alternative with the minimum (or best) number. By doing this, the opportunity loss actually realized is guaranteed to be no more than this minimax value.

The first step is to create the opportunity loss table by determining the loss for not choosing the best alternative for each state of nature. Opportunity loss for any state of nature, or any column, is calculated by subtracting each payment in the column from the best payoff in the same column. For a favorable market, the best payoff is THB26,271,000 as a result of the first alternative, "current service center." If the first alternative is selected, a profit of THB3,207,477 would be realized in a favorable market, and this is compared to the best payoff of THB26,271,000. Thus, the opportunity loss is 26,271,000-23,063,523 = 3,207,477. Similarly, if do nothing is selected, the opportunity loss would be 26,271,000 -0 = 26,271,000.

For an unfavorable market, the best payoff is THB0 as a result of the third alternative, "do noting," so this has 0 opportunity loss. The opportunity losses for the other alternative are found by subtracting the payoff from this best payoff (THB0) in this state of nature as shown in ***Table 11***.

Opportunity Loss Table: ***Table 11***

Alternatives	State of Nature	
	Favourable Market (THB)	**Unfavourable Market (THB)**
Current Service Center	26,271,000 - 23,063,523	0 - 0
2 Service Centers	26,271,000 - 26,271,000	0 – (-182,984)
3 Service Centers	26,271,000 - 26,271,000	0 – (-64,548)
Do nothing	26,271,000 - 0	0 - 0
Probabilities	0.30	0.70

Using the opportunity loss (regret) table, the minimax regret criterion finds the alternative that minimizes the maximum opportunity loss within each alternative. We first find the maximum (worst) opportunity loss for each alternative. Next, looking at these maximum values, pick that alternative with the

minimum (or best) number. By doing this, the opportunity loss actually realized is guaranteed to be no more than this minimax value. In ***Table 12***, we can see that the minimax regret choice is the third alternative,"3 service centers." Doing so minimizes the maximum opportunity loss.

EOL Calculation Resulted: ***Table 12***

Alternatives	State of Nature		Expected Opportunity Loss (EOL)
	Favourable Market (THB)	Unfavourable Market (THB)	
Current Service Center	3,207,477	0	962,243
2 Service Centers	0	182,984	128,089
3 Service Centers	0	64,548	**45,184**
Do nothing	26,271,000	0	7,881,300
Probabilities	0.30	0.70	

This Table gives these results. Using minimum EOL as the decision criterion, the best decision would be the third alternative,"3 Service Centers". It is important to note that minimum EOL will always result in the same decision as maximum EMV, and that the EMV will always equal the minimum EOL.

V. CONCLUSIONS AND RECOMMENDATIONS

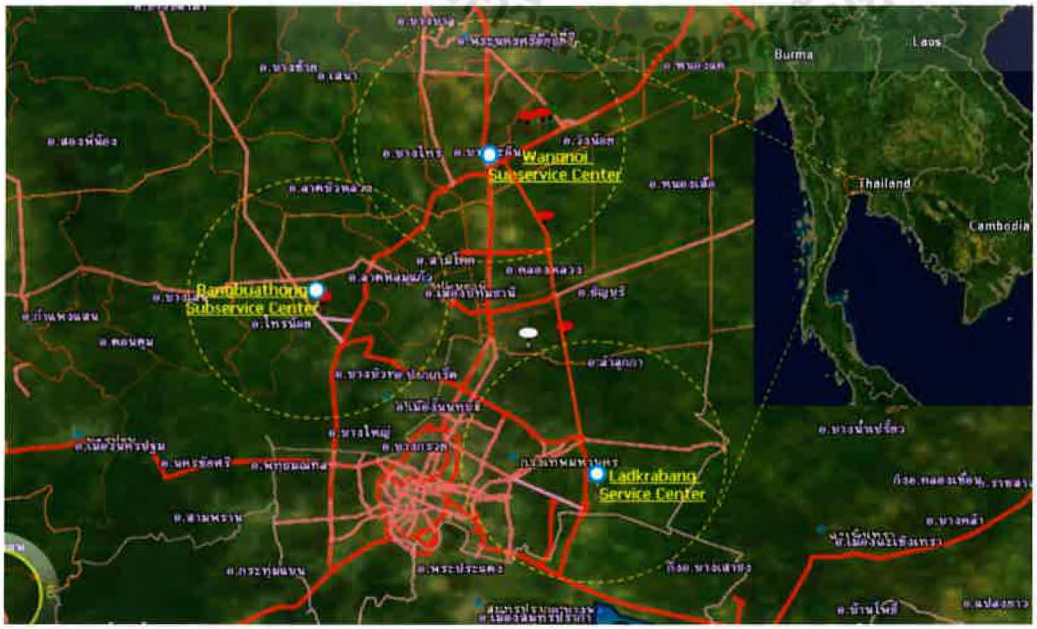
5.1 Conclusions

We have displayed how to solve a facility location problem with heuristic method "step by step solution" objectives to minimize total transportation costs and expect value loss meanwhile to maximize revenue among high competition of pallet leasing providers in Thailand. Four steps of baseline calculation, survey potential facility location, recalculate and compare each outcome and decision analysis are applied with several popular approaches of single facility location principle, center-of-gravity approach and decision making analysis. Single facility theory is used to define and also translate a combination of total transportation costs of each route in current handling, center-of-gravity conceptual is applied to finding the potential point of outsource facilities (x, y coordinators), and a decision making analysis under risk is applied determining to four alternatives under the real situation of state of natures in wood pallet industry.

5.1.1 Service Center Location

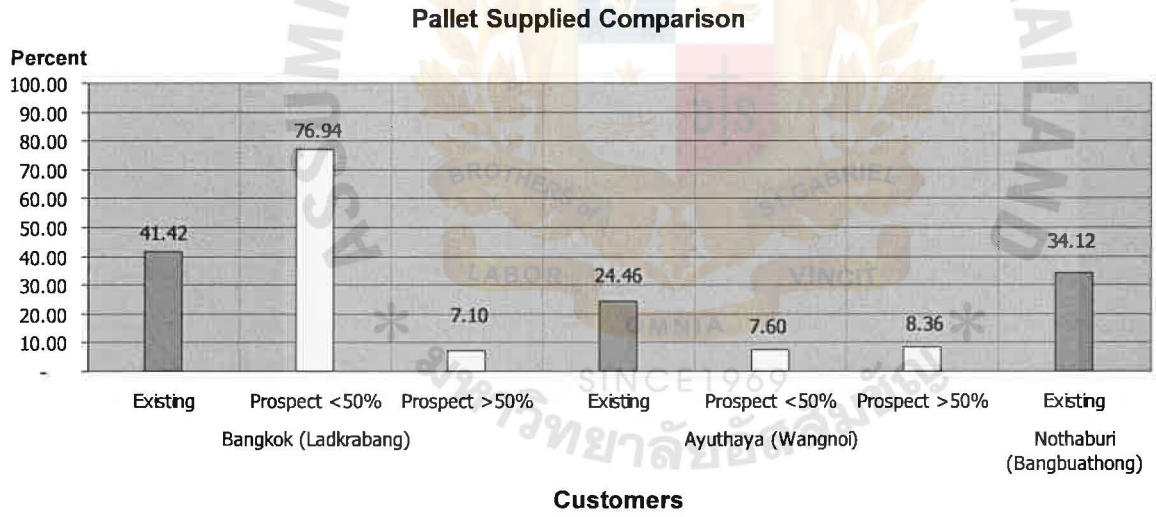
It can be concluded, if CHEP TH wants to gain more revenue of 26,271,000 THB/year (previous year 23,063,523 THB; 12.20 percent increase revenue) that company should have 3 service centers serve pallet rental customers in three regions. First, company should maintain current facility as the main service center, located in Bangkok Zone (Ladkrabang district, Lat: 13.73488; Lon: 100.75921) because there are several original customers of 41.42 percent of total volume, and other is 7.10 percent of prospected pallet customers (expected value per year, THB1,238,400) which given probability of getting business is rather than 50 percent. Second, company should have other of 2 sub-service centers in Ayuthaya Zone (Wangnoi district, Lat: 14.16478; Lon: 100.61598) and in Nothaburi Zone (Bangbuathong district, Lat: 13.98138; Lon: 100.35896) displayed on ***figure 3***.

Map of 3 Service Centers: Figure 3



The reason of existing Wangnoi sub-service ceter, is the 24.46 percent of original customers and the 8.36 percent is potential customers (expected value per year THB1,069,200). For Bangbuathong sub-service center, it would be facilitated only for existed customers of 34.12 percent, at this time no prospected customs illustrated in ***Figure 4***. The size of each facility is required following space; the service center 1,338 sqm (Original 900 sqm) the major purpose for pallet production, inspection, repairing, storage and distribution. A 600 sqm is individually separated and full utilized to production, inspection, cleaning and repaired processes and a 7300 sqm maybe used for storing the used pallets which returned for reconditioning and new empty pallets ready for issuing. Wangnoi sub-service center is required total space 318 sqm/month in storage and sorting retrieval pallets from customers in its zone. And Bangbuathong sub-service center is needed total space 277 sqm/month. In case pallet demand of each zone goes up company probably negotiate with facility owners for additional space and can play paying base on the actual cubic meter of weekly pallet storing, if it is acceptable by facility owners it would be advantage for company as paid only what is being stored in the facilities only.

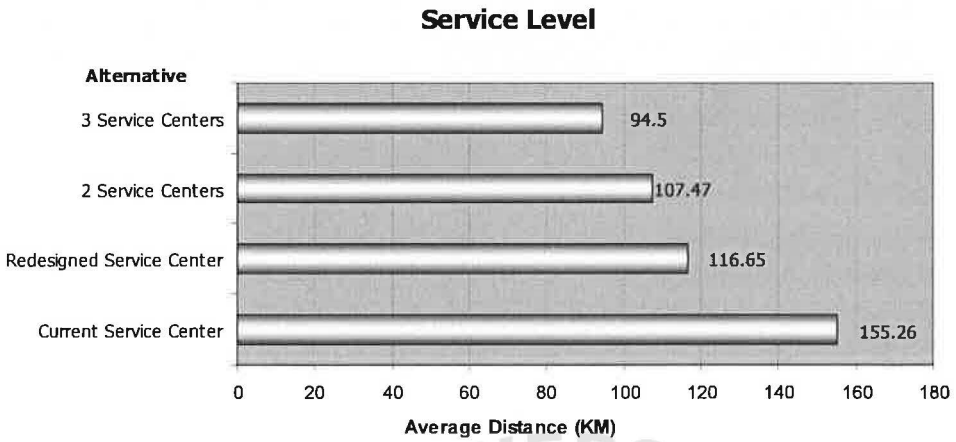
Demand of Wood Pallets: Figure 4



5.1.2 Customer Service

Company have more chance to maintain existed customers and also to get more new customers in each region. A shorter distance in issuing and returning pallets is significantly improved more than 39 percent from average of original distance 155.26 km to 94.5 km. In this case, we can define customer service level is automatically improved that expressed in ***Figure 5***.

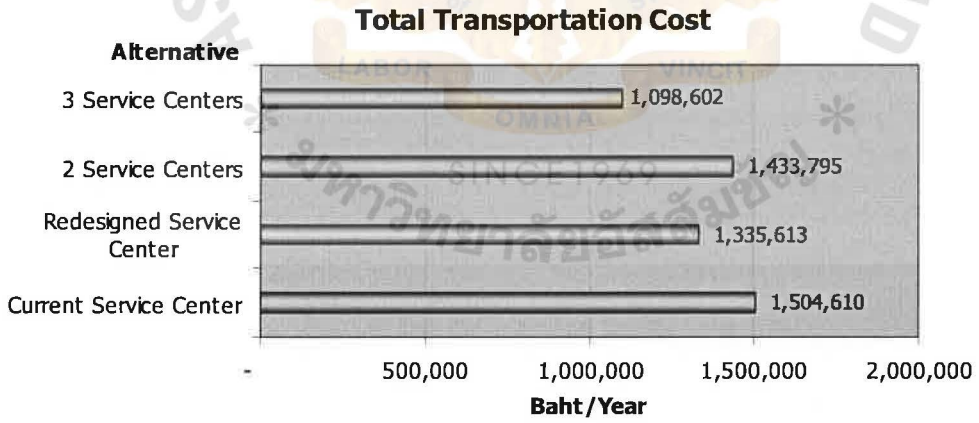
Service Level: Figure 5



5.1.2 Transportation Cost

Existing 3 service centers contribute to not only shorter distance to reach customers but also make customers to save more transportation cost. Total transportation cost of current service center is 1,504,610 THB/year; however, if company installs more 2 sub-service centers that company would pay for transportation cost totally 1,098,602 THB/year or 26.98 percent reduced which expressed in ***Figure 6***

Total Transportation Cost: Figure 6



5.2 Recommendation

5.2.1 Since, CHEP TH has outsourcing the 6 wheel trucks and the 18 wheel trucks for trucking wood pallets from origins to destinations. Company should crate the robust transportation network in each region of Bangkok, Ayuthaya and Nonthaburi with sharing transportation information i.e. routes, delivered schedules and truck capacity with transportation companies who have services in particular zones as they are one of key driver in every handling. Having interviewed the local transportation company owners, in fact most of them are a sub-contractor under global logistics companies or global transportation companies that the hired rates

offered are cheap prices. It is a great opportunity of CHEP TH to approach them to obtaining a competitive transport price and also build a strengthen relationship to utilize vehicle spaces in every travelling. Not only for CHEP TH itself for competitive advantage creation but also other pallets customers who have no own trucks, CHEP TH probably advise for competitive transportation price information to express that CHEP TH has strong transportation network ready to support them all the times.

5.2.2 Company is aware this is decision making under risks. Company should play with leasing either depots or warehouses for short term of contracts. Rental period should be either 1 year or 2 years at an early stage to avoid risk of investment. Later CHEP TH would continually capture total volume of wood pallets flown through each sub-service center assigned in each location to ensure the facilities are exactly utilized and certainly useful the existed and prospected customers to simply access picking required pallets for loading as well as they can return the used wood pallets to nearest locations. Other points would be reviewed and clarified with facility owners are, all of information concerning CHEP pallet that is definitely confidential it will never be revealed to any people and clear responsibility in asset in case of fire , stolen, copyright and natural disasters etc.

5.2.3 A firm should control the level of pallet stock facilities suitable to customer demand and facility capacity. Weekly stocktaking and updating from each location submitting to CHEP TH, it will enable company to further communicate with customs who want to issue empty pallets whenever for loading and retrieve the used pallets to sub-service center effectively. If a number of used pallets at any sub-service center exceeding a facility space, company can react to swap the empty pallets from one location to other location easily with trucking cost and time minimized. Further more, to prevent capitalized by the large retailers or distributors who has not sign a contract of stocktaking permission in their warehouse or distribution centers that whenever CHEP TH is advised there is transferring the used pallets off their facilities, CHEP is ready to truck those pallets containing into the nearest sub-service centers without free using in their places and avoiding unexpected argument.

5.3 Future Research

As service facilities generally function for many years or decade, during which time the environmental in which a firm operates may change substantially. Costs, demands, travel times, and other factor inputs to classical facility location models may be highly uncertain. Next research should study results of implementing 3 service centers to see obligations, impacts and further actions.

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