TRANSPORTATION COST SAVING THROUGH A CONSOLIDATION HUB MODEL

By

KRIT LEELAWIROJRITH

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

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

Martin de Tours School of Management
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Examination Committee:

1. Asst. Prof. Dr. Brian Lawrence (Chair) ....
2. Dr. Piyawan Puttibarncharoensri (Member) ....
3. Mr. Thanapat Panthanapratez (Advisor) ....

Approved for Graduation on: January 21, 2011

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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Assumption University

Martin de Tours School of Management

Master of Science in Supply Chain Management

Form signed by Proofreader of the Graduate Project

I, Asst. Prof. Brian Lawrence, have proofread this Graduate Project entitled Transportation Cost Saving through a Consolidation Hub Model

Mr. Krit Leelawirojrith

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.

Signed

(Asst. Prof. Brian Lawrence)

Contact Number / Email address blawrence@au.edu

Date: %ILA) 2t.) it

Assumption University
Martin de Tours School of Management
Master of Science in Supply Chain Management

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____________**Krit Leelawirojrith**____

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Transport Cost Saving through a Consideration Hub Model ________________
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Advisor

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ABSTRACT

Transportation cost is one of the key success factors in today's competitive market Some firms search for efficient transport routing by redesigning their transport routing network through a consolidation hub model in order to achieve total cost saving.

The purposes of this study are to enhance knowledge and awareness of applying a consolidation model and to study the technique of how to reduce cost by using a consolidation hub in a charcoal trading company. This paper identifies the opportunity for significant cost saving over the present implementation of transportation routing by a future model. From the literature, three scenarios of a consolidation model are presented which can potentially achieve transport cost saving. Excel spreadsheet was applied to identify cost saving. The consequences of the simulation are measured and analyzed in terms of the total transport cost saving, and transport cost (per ton). The research shows a 60% cost saving (about 700,000 Baht) in the company's inland transportation cost in 2010.

At the end of the paper, implementation suggestions are made for manager to decide whether to adopt the consolidation model in their charcoal trading company as a strategic tool to improve their supply chain network and transport routing. This strategy will customize efficient routes, minimize transportation cost, and increase profit to the company.

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Krit Leelawirojrith
Assumption University
November, 2009

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CHAPTER I

GENERALITIES OF THE STUDY

Logistics is a part of the supply chain process that plans, implements, and controls the efficient and effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption, in order to meet customer requirements. As the market becomes more global and competition continues to intensify, the scope and role of the logistics industry has changed rapidly over the past few years.

In the past, logistics played a supportive role to primary departments such as marketing. Recently, logistics has become a primary function that can be found in any organization. It covers transportation, warehousing, distribution, inventory management, and packing. In addition, logistics contributes to reducing costs in organizations and has become a vital aspect of achieving competitive advantage. Consequently, firms are beginning to realize that the competition is not exclusively between one firm and other firms but also a "supply chain against supply chain" phenomenon (Christopher & Towill, 2001). Hence, distribution transportation is a vital component of the economy. It supports production, trade, and consumption by ensuring the effective movement and timely availability of raw materials and finished goods. In consequence, Distribution transportation represents a significant part of the cost of production of any industry (Crainic, 1997).

The physical distribution of goods is one of the key success factors in the fast moving market of today (Ala-Risku, et al. 2002). Many companies are involved in the search for efficient distribution alternatives, to enhance transportation routing in order to improve supply chain performance and shorten lead time, while minimizing the cost and risk. Consolidation hub strategy is one of several strategies which is a distribution model where several shipments originating at different dispatching locations are consolidated into one point of delivery, with/without inventories at the consolidation point (Buffa, 2005). If several shipments could be consolidated, then the company could substantially reduce transportation cost and, in turn, unit cost. Identifying those situations where consolidating shipments and negotiating transportation terms may lead to reduced transportation cost, is only the first step in the analysis.

Consequently, this paper aims to study improved transportation routing so as to lower logistics cost by using a consolidation hub strategy for AP Oversea Trading Co.Ltd.. This company has been selected as it is a SME local charcoal trading company in Thailand whose reputation does not seem to be much recognized in the market.

1.1 Company background

AP Oversea Trading Co. Ltd., established in 2007, is a Thai-charcoal trading company located in Bangkok, Thailand, which has around 22 million/Baht turnover per year. At the beginning, in 2007-8, the company started a business selling picture frames imported from China and distributed to domestic customer. When the trend of business changed, the company seized a new business opportunity in charcoal trading in 2009. The company's strategic customer segment is in East Asia, especially in Japan and Taiwan because both of them mangrove charcoal is very popular in the house for cooking (instead of liquefied petroleum gas). Mangrove charcoal from Thailand is especially popular because it is easy to ignite, emits less smoke, and then cools down slowly in the kiln. The company has exported to several countries not only in Asia. It is also trying to expand the market to Europe, but it is quite challenging because of high competition over price, with many players in the market.

The biggest customer located in Keelung, Taiwan, contributed 80% of turnover per year. About 4-8 containers are exported to this customer monthly. Demand is variable and fluctuates subject to price and contract conditions. A customer is a leading wholesaler of charcoal in Taiwan and has a large market share. The core product of the company is mangrove charcoal, but they also have different kinds of charcoal such as Tabo charcoal, hardwood charcoal and BBQ charcoal to sell to customers. All the products from this company are solely exported to other countries by using only 40' high cube sea freight containers with an approximate volume of 840-900 bags in a container depending on size of package and size of charcoal.

Normally, the company will proceed with the order only when it receives a sales contract from the customer. This avoids risks of order cancellation and ensures a sales commitment on both sides because they cannot afford to advance money due to size and business style. It is reasonable to employ this made-to-order strategy in the business. The customer will send a sample bag to the company to produce and pack the cargo according to the customer requirements in Taiwan, such as logo, brand, color, size and type of package.

One purpose of this study is to identify key activities of the processes from the starting point until to the ending point, and represent them as mapping in order to easily understand the process flow. It is represented on paper by using line, connection, words, and symbols of the existing operation process. A strategic process is the first requirement to cover the overall process operation for each party. It is very significant for a thorough understanding of the supply chain and operational activities.

Figure 1.1 Supply Chain Mapping of the Research

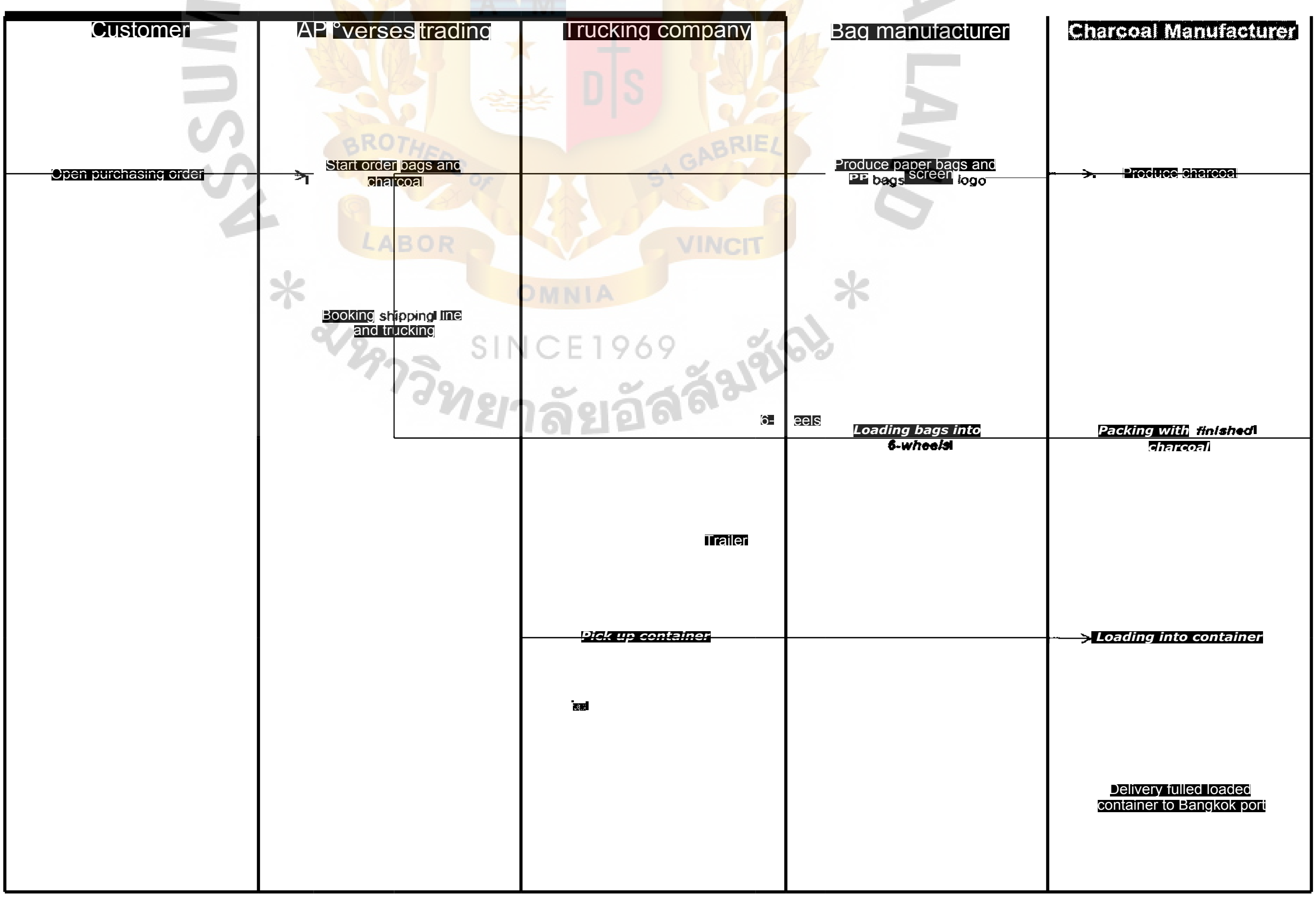


Figure 1.2 illustrates the order fulfillment process, from a customer placing an order to the company, and the flow of information distributed to each party channel such as trucking to pick up a container, bag factory, charcoal factory, loading activity and transport routing, The company is located in Bangkok, but the reliable charcoal supplier is located in Ranong where there are full resources to make quality charcoal. Mangrove trees are imported from Myanmar and cross the border by truck to the factory to make quality charcoal. The bag factory is located in Samutsongkam. It can produce ordered paper according to customer requirements and its price is competitive if compared with the market.

The order of bags, both paper and pp bags can be ordered partially once a bag is finished. The company is responsible for picking up by 6-wheel truck, as in Figure 1.1, and delivering to the factory to combine with material. Normally, the packing lead time for 8,500 bags is about 3 days, subject to amount of labor and the weather. Then, an empty container will be delivered by trailer from Bangkok and loaded at the charcoal factory. A full truck load will move to Bangkok port for shipping to the destination.

1.2 **Statement of the problem**

Transportation costs are significant and an increasing cost of doing business. (Schuster, 1979; Buffa, 2005) demonstrate that shipper and customers can both benefit from a consolidation strategy that would reduce shipper cost in transportation and warehousing. With deregulation of the transportation industry there are now new opportunities that can affect the firm's logistics cost.

Logistics is a critical part of every business. The average logistics cost is about 12% of the world GDP (Simchi-Levi & Kaminsky,2004). While they are the largest component of logistics cost and represent 30% of total cost, almost 50% of logistics activity consists of transport and packing bags and containers from Bangkok to the factory in Ranong. The transportation routing is arranged by the owner of the company who may lack knowledge regarding transport efficiency as well as total logistic management, and is the root cause of the company's vehicle routing problem.

Transportation cost can be minimized if routing efficiency can be enhanced. In this paper, consolidation hub strategy is employed to redesign transportation routing as one of the strategies that should be precisely considered. The ultimate goal is to reduce logistics cost and gain more profit. As a rule, A shipper can choose among three alternatives to transport its material and its consolidation point location by simulating three scenarios.

This study aims to answer the main research problem of "How to improve transportation routing to lower logistics cost?" and studies the transportation routing of the company through using consolidation hub strategy to re-redesign the transportation network. This produces more routing alternatives which can be reduce logistics cost. In order to answer this research question, three research objective were set, as show below.

1.3 Objectives of the research

This focus of this paper is the long-haul (intercity) transportation from Bangkok-to Ranong, which is the transportation mainly concerned with movement of goods, materials, and containers over a relatively long distance, between manufacturer and bag supplier, and also between terminal and cities. It may be costly for the company, so this project attempts to attain three main objectives:

1.3.1 To enhance the knowledge and awareness of applying consolidation hub strategy to develop the transportation routing network.

1.3.2 To study consolidation hub techniques and solutions to solve the particular problem in this trading company.

1.3.3 To reduce logistics cost by optimizing the transportation and increasing profit by using consolidation hub strategy.

1.4 Scope of the research

This case study focuses on transportation routing network redesign to reduce total logistics cost in a trading company which has no own manufacturer and needs to outsource all-in raw material, packaging and transportation. Historical data starting from the beginning of 2010 was used to analyze the total cost per shipment, number of transportation trips of both 6-wheelers and trailers, transportation cost, calculated transportation cost per ton, and shipped volume. Supply chain mapping is identified to understand the flow of physical goods and information of the working process. Operating problems are analyzed and solved by using consolidation hub strategy. The criteria used for this case study is in terms of cost saving and transport efficiency.

Several items from the literature review are used in this study as evidence that a consolidation hub to re-design transport routing can reduce logistics cost and improve transport efficiency. Historical data is gathered for analysis, and is assumed as fundamental to forecast the second half of 2010. Results from the re-design of the transportation network by using the consolidation hub concept are obtained by simulation technique with the Excel program. Three scenarios are tested for results in terms of cost saving, which are compared and reported in detail.

1.5 Limitation of the research

This research focused on the consolidation hub concept to enhance transportation routing and network of AP Oversea Trading by re-designing transport routing, and the expected outcomes are to reduce logistics cost, increase profit, and improve business potential. The result of data analysis and simulation are proof that the consolidation hub can be improved by transport efficiency. However, to be able to evaluate the generality of the result, several limitation of this case are identified.

1.6.1 In this paper, we analyzed three cost elements that are direct material cost, logistics cost and additional fees and we will focus on inland transportation cost.

1.6.2 The transportation cost is based on a trucking company subject to fuel cost in the market at that period. Therefore, transportation may decrease, remain constant, or increase in the second half of the year.

1.6.3 This study's focus is on transportation cost saving only.

1.6.4 This research simulation is conducted in a single industry context so there is not necessarily generalizability of the finding to the firms within charcoal manufacturer or across industries.

1.6 Significance of the study

An understanding of logistics importance has led the firm to seek a competitive advantage derived from logistics and supply chain activities enhancement. This paper aims to reduce logistics cost by using a consolidated hub strategy to improve the transportation routing network. Numerous studies to enhance knowledge of consolidation strategy and implementation are involved, plus potential benefits and limitations. Supporting factors and obstacles relating to consolidation hub implementation are analyzed and can be evidence for further study. This study could be a guideline for managers and entrepreneurs, giving them the option to select between numerous alternatives depending on cost and feasibility parameters and to be another point of view to reducing total logistics cost. The expectation was that the company would achieve significant cost saving in transportation and obtain the benefits of this hub strategy.

1.7 Definition of terms

Consolidation hub: is a place to combine shipments into full truck-load containers. It receives finished goods from many suppliers.

Cost and freight (C & F): The seller quotes a price that includes the cost of transportation to a specific point. The buyer assumes responsibility for loss and damage and pays for the insurance of the shipment.

Direct material cost: The manufacturer of products or goods requires basic material, including charcoal, plus its packaging and labor cost.

FCL (Full Container Load): a term used to describe 40' high cube ocean container, fully loaded; the volume of cargo for loading a truck trailer typically weighs about 21,000 Kgs.

High-cube (HQ): is similar in structure to a standard container, but taller (9'6")

Paper Bag: is a paper bag which is used as inner packaging for the mangrove charcoal product.

PP Bag: is a polypropylene bag which is used as outer packaging of the mangrove charcoal product.

Transportation cost per trip: is transportation cost of two-way travel of a vehicle.

Transportation cost: is concern with the movement of products from a source – such as a bag factory or yard - to their destination.

Transportation fees: Money paid to customs stations to weigh-in a container. It costs 1,200 Baht each time.

Transport route: is the distribution of goods from one point to another by using a particular transport vehicle.

Vehicle Routing Problem (VRP): is the problem of designing the optimal set of routes for a fleet of vehicles

CHAPTER II

REVIEW OF RELATED LITERATURE AND RESEARCH FRAMEWORK

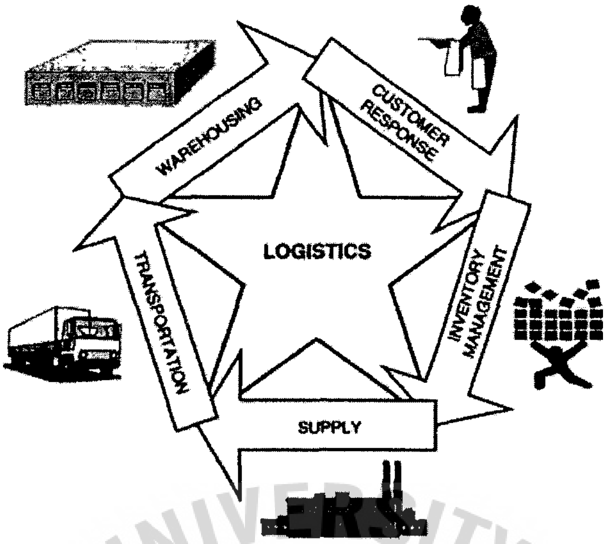
This chapter reviews related literatures. First, a supply chain overview is the focus as well as logistics activities and transportation to cover the overall picture of supply chain management. Then, identification of the vehicle routing problem (VRP) can produce waste in transportation and high logistics cost, but a consolidation hub strategy is able to fix the vehicle routing problem with a proven record in previous studies by many researchers. Lastly, related literature regarding the vehicle routing problem, cross-docking by consolidation point, and consolidation hub strategy are reviewed, together with related case study and results. The details are now presented.

2.1 Supply chain management

Many researchers gave definitions of supply chain management in several aspects. In this report the definition of Uma & Royce, 200 is used to covered all the study's themes. These authors mentioned that SCM aims to integrate the various structures and processes of the supply chain, facilitating, and coordinating the flow of goods and services and the flow of information necessary to provide the value that customers demand.

Logistics is the flow of material, information, and money between consumers and suppliers (Frazelle, 2002) and controls the effective, efficient flow and storage of goods, services, and related information (Chopra & Meindl, 2001). It consists of five interdependent activities: customer response, inventory planning and management, supply, transportation, and warehousing (as shown in Figure 2.1).

Figure 2.1 Interdependent Logistics Activities



Source: Frazelle et al. (2002) p.12

Distribution logistics has always been a key factor the competitiveness of industrial companies, but recently, its importance has grown significantly, due to the evolution of the markets (Zografos & Gunnoulu, 2002).

This report focuses on transportation which is a logistics activity. It is a costly part of total logistics cost, and ideally should be minimized. Redesign of the transportation routing is required through using a consolidation hub strategy to optimize the transportation network.

2.2 Vehicle routing problem (VRP)

Vehicle Routing has become a central problem in the fields of logistics and freight transportation. In some market sectors, transportation costs constitute a high percentage of the value-added of goods. Therefore, the use of computerized methods for transportation can result in savings ranging from 5% to as much as 20% of the total costs (Toth & Vigo, 2002).

The vehicle routing problem (VRP) has been addressed in the literature, in textbooks, trade journals, and academic journals, however, these treatments of this subject have been largely descriptive in nature. VRP is not a new issue, as can be seen by reviewing transportation and logistics texts, In fact, transportation in the manufacturing business is not only an incurred cost but also an instrument for higher competitive advantage in the market, so that a good distribution performance of the transportation is required for the effective logistics function of a company (Meixell & Norbis, 2008). The core of this problem, which is defined as the process of selecting transportation routing, was inefficiency.

Bertsimas and Simchi-Levi (1993) explained that VRP has highlighted the importance of designing efficient distribution strategies to reduce freight transportation cost. Typically, a common objective is to find a set of routes for vehicles which satisfy a variety of constraints so as to minimize operating cost.

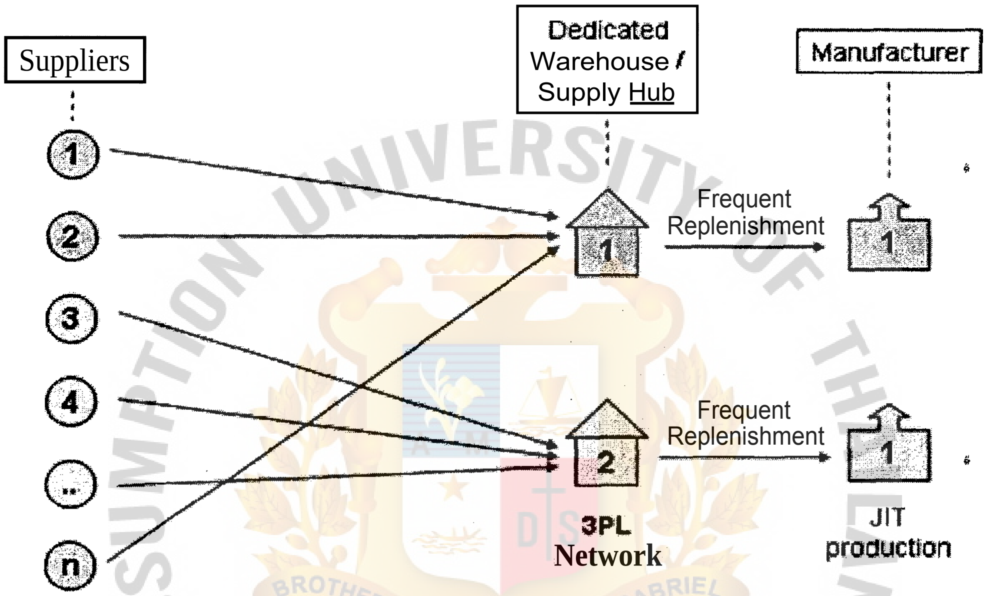
Sungur and Dessouky (2006) also added that many industries deal with the problem of routing a fleet of vehicle, for example automotive, electronics and garment industrial. VRP is a real problem with finite resources and finance. Therefore, they introduced a robust optimization approach to solve the vehicle routing problem with demand certainty, by redesigned transport routing using the proposed shipment consolidation concept, which yielded efficient routes that minimize transportation cost while incurring a small additional cost over determined optimal routes.

This report considered many organizations which are on their way toward implementing consolidation hub strategy, and some organization which have fixed their vehicle routing problem successfully. The specific strategies corresponding with the nature of each firm should be performed for each firm. In the next section, we describe in detail consolidation hub strategy and study a previous model to solve the problem.

2.3 Consolidation hub strategy

The focus is on managing the suppliers for more than one manufacturer, each of whom operates an assembly process. Such a logistics arrangement is known as a supply hub (Barnes, Dai, Deng, Down, Goh, Lau, & Sharafali,2003). Here, the consolidation hub is a dedicated as warehouse, located close to the manufacturer's facility, where all or some of the manufacturer's supplies are consolidated, with an agreement that the materials and components will be paid for only when consumed. The dedicated hub is committed to replenish the manufacturer frequently, to support just-in-time (JIT) production. This strategy is especially common in the electronics industry, to reduce transportation cost and improve responsiveness, due to the short life-cycle and high demand variation. Examples of industry players who are active in using the supply hub concept are Compaq, Hewlett Packard, Apple and Dell.

Figure 2.2 Consolidation Hub Concepts



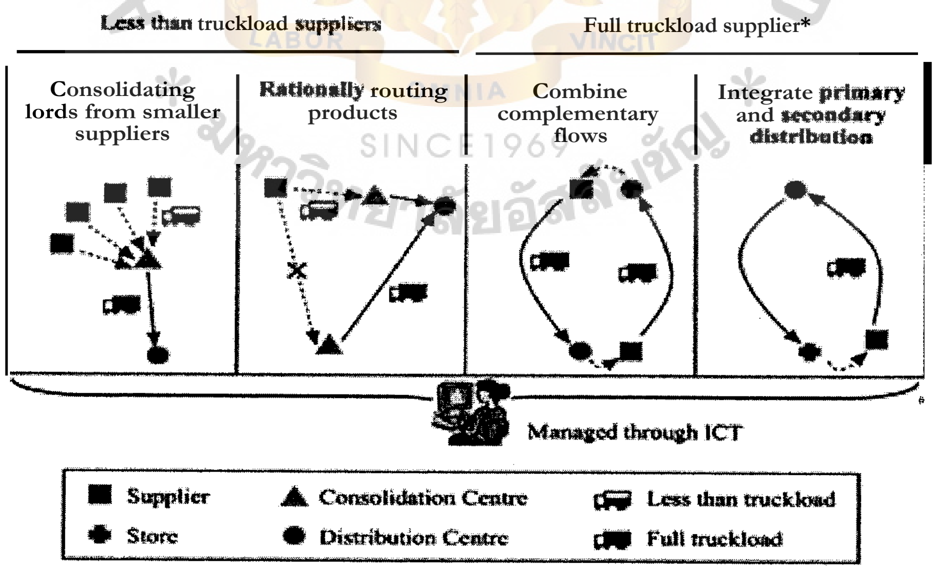
Source: Michelle (2005)

Meanwhile, Ala-Risku, et al. (2002) had studied consolidation hub strategy in the same industry as Michelle (2005). She also commented that apart from reducing transportation cost and improving responsiveness it can lower the number of stock keeping units (SKUs) in the distribution warehouse. Both researchers commented that consolidation hub strategy potential network cost saving can be achieved by identifying a suitable hub location and effective transportation routing. However, it is safe to say that consolidation hub strategies have not yet been fully investigated.

Croom (2000) continued research on consolidation with a survey of freight consolidation practices. This research was a study of the state of consolidation strategy by approximately 50 companies practicing freight consolidation. The author attempted to study why and how these companies use consolidation. The author used questionnaires to gather information from companies across more than 10 industries about their consolidation practices and strategy. More than half of these companies were in the manufacturing industry. The first topic discussed deals with the reasons companies engage in freight consolidation. The authors reported that 84% of companies found consolidation very important for cost reasons, and 77% found consolidation beneficial for service. Among the cost factors, companies reported transportation cost reduction was more of a motivation than inventory carrying costs. Among the service level factors, the reduction of transit time was of the highest importance. The main disadvantages reported were longer order cycle and staffing. Most researchers have employed this strategy in the electronic and food industries which have a short life cycle and highly valuable component parts, but there seem to be no research studies in charcoal business or low value products.

Potter, et al (2003) commented that in a consolidation network from a single point, it is possible to reduce by 23-25% the total distance products travels between supplier and destination. He also added that effective transportation techniques can reduce the total distance products (as Figure 2.3).

Figure 2.3 Transport Management Technique Using Consolidation Hub for LTL and TL



Source: Potter, et al. 2003

Buffa, (2005) claimed that in either case the potential saving that might result from the reduction of transportation cost must be balanced against the potential increasein inventory costs because the consolidation itself represented only a direct cost. In this paper, the company produces "made-to-order" when a customer places an order due to size of business and they sell without inventory. When evaluating shipment consolidation opportunities, it is convenient to classify the relevant variable costs into three categories – consolidation/material-handling, transportation, and inventory. Table 2.1 presents the variables and costs for each classification.

Table 2.1 Interrelationship of Variables and Costs by Classification

[illegible]	[illegible]	[illegible]
Consolidation/Handling	Delivery and pick up	Handling Storage
	Loading/Unloading Warehouse handling Consolidation waiting time	
Transportation Cost	Shipping distance Shipping weight/volume Freight Classification Shipping class:TL or LTL	Shipping

Source: Adapted from Buffa et al (2005)

This Table explained the interrelationship of variables and costs of consolidation shipment. There are two major costs concerned for a consolidated shipment, consolidation/handling and transportation costs.

Consolidation Cost

Here one should include costs of services provided, such as handling cost for loading and unloading cargo at the consolidation point, and storage cost for waiting or storing at the consolidation point Handling cost and storage costs at a consolidation point are flexible. Deregulation now allows for additional flexibility that the shipper can use to his benefit when discussing the cost of these services. (Deming, 1987) has statistically estimated handling time as a function of shipping weight for loading and unloading freight under various conditions. With this information the shipper can develop a clearer understanding of the determinants of handling costs and actually estimate these costs.

Transportation Costs

Apart from consolidation cost, a shipper should also estimate transportation cost. It is important not only because it is a substantial part of the total cost of each consolidation alternative, but also because it affects the unit cost of each item. Distance will have a relationship with cost of transportation automatically, therefore weight and volume also impact with size of trucking, type of chassis, and vehicle type, which reflect direct on transportation cost. Also, in this research, when each scenario has been proposed, consolidation, handling, and transportation costs must be considered (as shown in Chapter 4)..

2.4 Review of related studies

In this research the focus is on developing transportation routing to re-design a transportation network as well as minimizing travel distance of trucking to decrease the cost of transportation through a consolidation hub strategy. Thus, the consolidation in a distribution network has received considerable attention in the literature. Many research papers have studies this, in heuristics and case studies. Most researchers have given solutions, methodologies, and simulation models together with results after implementing a proposed consolidation model in their specific case and situation, in view of related issues such as consolidation hub, cross-docking, truck utilization and merge-in-transit. Previous literature is shown below in Table 2.Z

Table 2.2 List of Literature reviewed in this Research

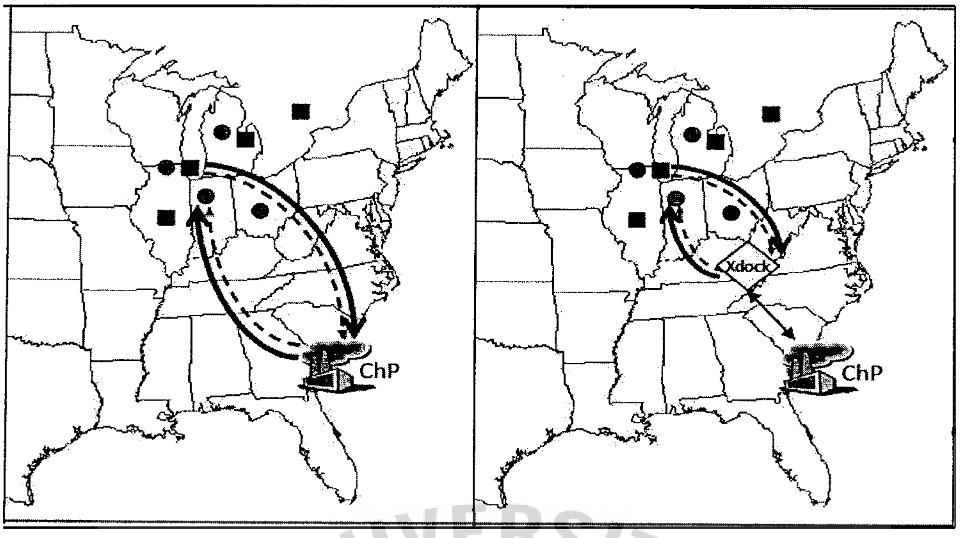
Study	Objective	Research Questions	Result/Finding
Caputo & Fratocchi (2006). "A genetic approach for freight transportation planning."	Present a methodology for optimising long-haul road transport activities in separate full-truckload shipments in order to minimize total transportation costs	How doeslong-haul transport routing affects total transportation cost?	The paper demonstrates that evolutionary computation techniques may be effective in tactical planning of road transportation activities
Michelle (2005). "New Models in Logistics Network Design and Implications for 3PL Companies."	New consolidated logistics design using consolidation hubs to increase effectiveness of resulting network and the utilization of facilities in the network	Study the capability to design efficient and effective networks using consolidation hubs so as to add value to their clients' business	Potential network cost savings can be achieved by designing a network maximizing the utilization of the facilities and shipping links
Kittithreerapronchai (2009). "Design of single hub cross docking networks: Geometric relationships and case study."	To minimize total logistics cost by using hub consolidation	How do facility locations, the operational cost of a cross dock and mode of shipments influence the shipping decision? Should a shipment be consolidated through a cross dock or outsourced?	Distribution network predicts savings in transportation cost by re-allocation of shipment and re-location of hub
Wen (2007). "Vehicle Routing with Cross-docking."	Using the hub to minimize the total traveled distance	Can cross-docking and consolidation strategy solve the transportation problem?	The problem was modeled and solved by efficient procedure since a consolidation point was set up
Yildiz, et al. (2008). "Optimization of Customer & Supplier Logistics at Bosch."	Identifies the opportunity for significant cost savings over the current system by transportation management	Study vehicle routing problem for a subset of customers and suppliers of Bosch, and combine their shipments on the same routing	Rearrange vehicle routing by setting up cross-docking can produce 11% saving in transportation and enhance service response
Attanasio, et al. (2007). "Integrated Shipment Dispatching and Packing Problems: a Case Study."	To examine a consolidation and dispatching problem which has to decide routinely the best way of delivering a set of orders to its customers over a multi-day planning horizon	How orders have to be consolidated by presenting a mathematical formulation.	Algorithm allows achieving significant savings to cut non creative operation framework
Ala-Risku, et al. (2002). "Evaluating the applicability of consolidation: A step by step process for supply chain managers."	To present a systematic procedure for the evaluation of the consolidation in a specific supply chain of a particular company.	How to evaluate the applicability of consolidation for the particular business situation.	To provide better decision support for supply chain managers considering consolidation
Mason (2007). "Combining vertical and horizontal collaboration for transport utilization."	To assess whether some of the new collaborative models for transport management are delivering better optimized solutions	The paper sets out to argue that new innovative solutions are emerging for better transport optimization, that exploit the competitive power of collaboration, both vertically with supply chain partners and horizontally with other logistics service providers	A collaborative approach for transport management through combining shipments with vertical supply chain partners, with collaboration on a horizontal basis. It has demonstrated that this approach can improve logistics performance.

Source: The Author

Table 2.2 reviews relevant journals, research papers, and case studies to support the consolidation hub strategy in the logistics business. (Caputo and Fratocchi., 2006) had research undertaken with the aim of developing new and effective methods for optimal planning of long-haul road transport activities through consolidated shipments, both FTL and LTL, in order to minimize total transportation costs. In the case study, they could save around 35% from the consolidation concept.

Cheong (2005) also studied a potential network cost saving by locating a consolidation hub appropriately for 3PL and considered the possibility of a set of available shipping alternatives which minimize the network cost. She found that an optimal decision to locate the hubs and use the optimal shipping option cannot be decided without proper analysis. After re-designing the transport network they can achieve network cost saving of between 6%-12% by a consolidation hub. Sean (2008) studied other aspects in LTL by using the concept of consolidated products, and selecting appropriate hub locations in suitable areas allow each individual shipment to take a choice of routes that allows for more opportunities to find significant logistics cost and saving configurations. Meanwhile, Kittithreerapronchai (2009) and Wen (2007) experienced similar vehicle routing problem inefficiency due to a large of group-set of supplier. They proposed cross-docking (VRPCD) to minimize the total travel distance while respecting time window constraints at the nodes and a time horizon for the whole transportation operation. Both of them used cross-docking as a consolidation point from suppliers, to reduce distance, transportation cost, and produce effective transport routing. Yildiz, et al.(2008) studied the inbound logistics and outbound logistics of Bosch LLC, a leading automotive part manufacturer, and identified the opportunity for significant cost saving by re-arranging the transport system by using a consolidation hub, as in Figure 2.4

Figure 2.4 Optimize Road Transport by using Consolidation Hub Model



Source: Yildiz, et al. (2008)

Uneven flow from and to the suppliers and customer are represented by squares and circles. In both directions, going over long distances can be matched with a consolidation hub. From the case study of Bosch, rearranging vehicle routing by a consolidation hub can decrease cost by 11% and enhance service response

However, Attanasio, et al. (2007) considered a similar problem to that in this report - integrated shipment dispatching and packing problem. They have many suppliers to serve semi-products but the company has to order packing themselves. Particularly, he suggested that consolidation strategy can be achieved in the following three ways:

Small shipments which have to be transported over long distance may be consolidated by a consolidation hub

The location of hub relative to the location of the sourcing unit

Shipment schedules may be adjusted for optimal transport round trips

This theory was also applied in a practical case situation at a retailer in the Netherland, with remarkable results. On the transportation budget for dry grocery alone, potential savings already exceeded 5 million euro per year (Piet van der Vlist & Broekmeylen, 2006)

In 2002, Ala-Risku, et al., employed consolidation strategy to re-design a supply chain in a particular business and provided systematic procedures to support supply chain managers considering consolidation as well as presenting the evaluating method by comparing the logistics cost of consolidation distribution with the current distribution operation using an activity based costing model in term of transportation cost, inventory cost, storage cost, and cost per unit. In addition, they highlight that there are two reasons why transportation is becoming a more strategic business function. Firstly, transportation costs are accounting for a large percentage of the cost of goods sold, and secondly there is more realization of the strong correlation between customer service levels and transportation performance. Mason (2007) extended the study in combining vertical and horizontal collaboration for transport optimization to assess whether some of the new collaborative models for transport management are delivering better optimized solutions and exploit the competitive power of collaboration transport

2.5 Summary

To minimize logistics cost through a consolidation hub strategy is the focus in this paper. The related literature is reviewed. From previous study, transportation cost is one of the key success factors of the company in competing with rivals in rapid markets. Consolidation hub strategy is just one of several strategies to minimize the cost of transportation and improve logistics performance. However, this project studies how to improve transportation routing to lower logistics cost and what the company would gained and lose from applying this strategy, to gain maximum benefits to the company, at both strategic and operational levels.

CHAPTER III

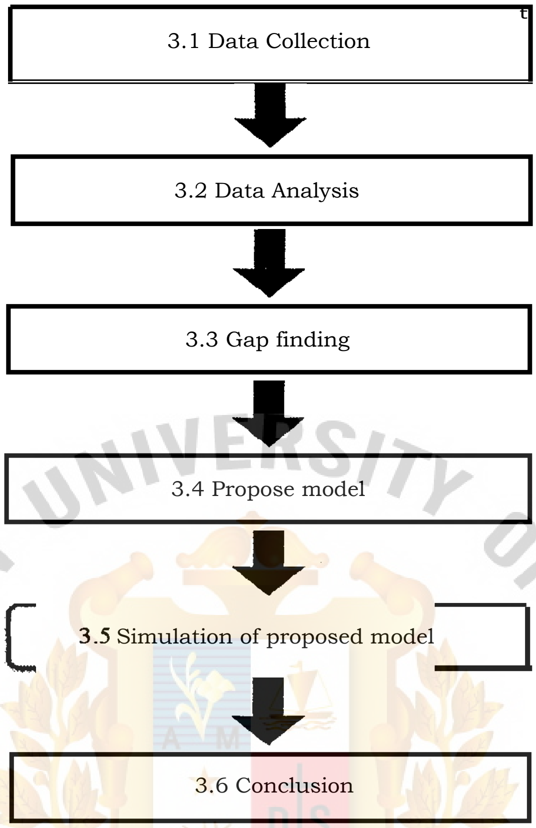
RESEARCH METHODOLOGY

This is a case study of AP Oversea Trading Co., Ltd which is a Thai charcoal trading company with 100% exports overseas especially its main market segment in Japan and Taiwan. It concentrates on shipments to Keelung, Taiwan, as its key account customer there contributed 80% of total revenue. There was deep research of the literature regarding consolidation hub strategy and re-arrangement of transport network design in particular: Books, written documents, theses, previous research, papers, and articles were used to gather relevant information.

This chapter comprises six sections. The first section presents the data collection method of this research. It consists of in-depth interviews, documentation review, and observation techniques, to gather company information such as delivered volume, cost, and transportation routing, to provide data for analysis. The second section describes data analysis to explain cost structure and analyze cost of shipment, so that it can also classify cost type through breakdown cost of each activity. It is divided into direct material cost, logistics cost, and additional costs. The third section discusses the specific problem in gap-finding to explain the existing process by plotting the existing transportation routing to provide an overview of the operating activities and work flow, procedures, and transactions, of several parties involved in the supply chain, such as customer, bag factory and charcoal factory. The fourth section demonstrates a proposed model to find optimal scenarios to minimize transportation cost. It can be simulated into three scenarios, which are tested for the possibility of setting up a consolidation hub in each area by analysis the cost saving of each scenario. In addition, the proposed model is considered in terms of cost saving and cost comparison. The proposed models are supported by the literature review and concepts of various researchers who experienced similar cases. The fifth section presents simulation of proposed models, how the simulation is analyzed, tools, and data.

The stages of conducting the research, based on the research design, are graphically illustrated in Figure 3.1 below:

Figure 3.1 Research Conduct of the Research



3.1 Data collection

This section explains the source of information and describes the process of data collection. To ensure the reliability and validity of the data, multiple sources of data are prioritized in order to ensure data accuracy and to avoid data discrepancy. The collected data was subjected to analysis. Data was collected through the following techniques;

3.1.1 In-depth interviews

In-depth interviews are one of the most common qualitative methods. One reason for their popularity is that they are very effective in giving a human face to research problem. In addition, conducting and participating in interviews can be rewarding experiences for participants and interviewers alike.

In-depth interviewing is a technique designed to elicit a vivid picture of the participant's perspective on the research topic. During an in-depth interview, the researcher attempted to learn everything the participant can share about the research topic i.e. order fulfillment process, order frequency, transportation routing, transportation cost, for both 6-wheelers and trailers.

3.1.2 Documentation review

Documentation records are used to collect information about the company. This includes lead time for packing material, quantity per container, and loading material time from January to October 2010. Most of this information is kept in hard copy such as purchase order, delivered volume, transportation cost for both 6-wheelers and trailers, and material cost. The data was used to analyze total cost of shipment, and also created a cost structure Table to explore the actual cost in each activity

3.1.3 Observation

The observation was done to gather data on the operation process in charcoal manufacturing, such as detailed activities of workers, lead time for the operation activity, and the flow of materials. Some physical evidence was gathered, such as type of material, dimension of cargo, and loading plan for a container. The observations were made five times and the average of data from all observations used in further data analysis.

3.2 Data Analysis

Cost structure analysis was conducted to explore the actual total cost, which could then be broken down into each cost element for direct material cost, logistics cost and additional costs.

Most of the shipments were C&F (O'Connor, 2000). This type of sales contract requires the seller to pay the costs and freight necessary to bring the goods to the named destination, but the risk of loss or damage to the goods, as well as any cost increases, are transferred from the seller to the buyer when the goods pass the ship's rail at the port of shipment. Insurance cost is the buyer's responsibility. The Table below shows the details.

Table 3.1 Product Cost Structure of Shipment

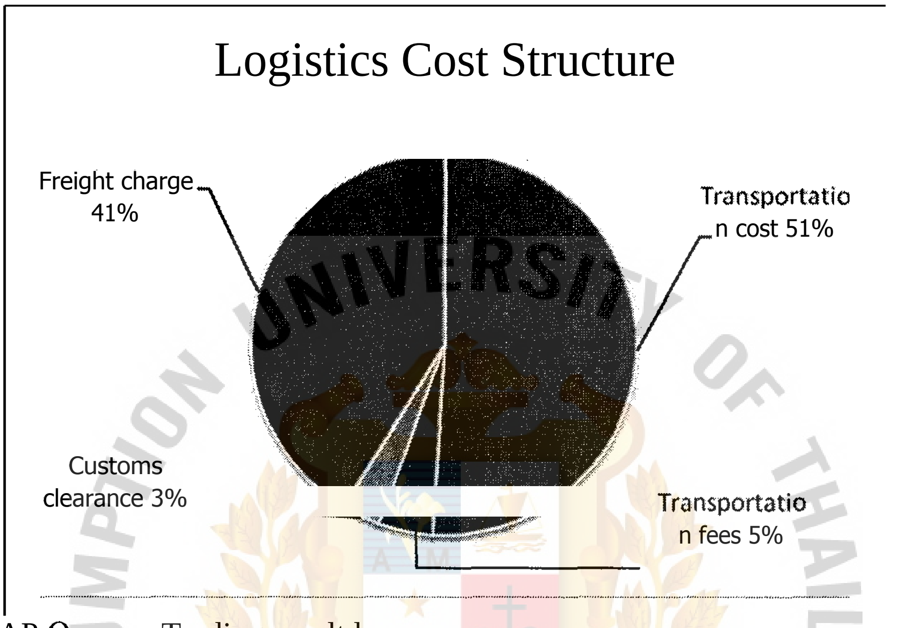
	Cost (Baht)	Percentage
Direct material cost		
Raw material	163,800	59.35%
Bag packaging	28,686	10.39%
Labor	3,000	1.09%
Total production cost	195,486	70.83%
Logistics cost		
6-Wheel truck (Samutsongkram – Ranong)	12,000	4.35%
Trailer (BKK-Ranong)	28,000	10.15%
Transportation fees (3 customs stations)	3,600	1.30%
Freight charge (BKK Port – Keelung port)	32,400	11.74%
Customs clearance	2,500	0.91%
Total logistics cost	78,500	28.44%
Administration Cost	2,000	0.72%
Total Cost	*275,986*	*100.00%*

Source: AP Oversea Trading co., ltd.

Table 3.1 shows a total shipment cost of around 275,986 Baht, loading quantity is 21 tons per container, and selling price is 13,500 per metric ton. So we can classify costs into three types: direct material, logistics, and administration. Direct material consisting of charcoal, bag and labor cost, equals 70.83% of total cost. Logistics cost consists of transportation cost both 6-wheels and trailer from Bangkok and Samutsongkram to Ranong, transportation fees, customs clearance, and freight charges.

The product cost structure shows which costs have spent in each shipment, based on historical record data. It explains the proportion of raw material equals 60% of total cost, and another 10% for bag packaging. It means that direct material cost equals 70%. Most of the rest came from logistics cost. This includes transportation costs: 10% of trailer and another 4% of 6-wheels, freight cost 12%, Customs clearance 1%, transportation fees 1%, and labor 1%. The total logistics cost equals 29% and the remaining 1% is for administration cost. Logistics cost is the highlight of this research involving inland transportation, shipping and customs activities, which were 28.44% of total cost, the remaining costs were in the additional cost category, such as administration cost. If we closely investigate the logistics cost structure we find that a large amount of logistics cost belong to transportation cost, as illustrated below.

Figure 3.2 Logistics Cost Structure in this Research



Source: AP Oversea Trading co., ltd.

The logistics cost structure major item is transportation cost and transportation fees 51% and 5% respectively, plus freight 41% and customs clearance 3% under C&F contract terms. This shows that over 50% of logistics costs depended on transportation cost of 6-wheels and trailers, and this is why this research concentrates on that, to reduce transportation cost by using a consolidation hub strategy. Transportation routing has to be rearranged, with a shorter distance, to save on transportation cost. We forecast that the company may have cost savings in transportation which decreases total cost and increases profit. The Table below shows container delivered shipments from Jan-July 2010

Table 3.2 Total Transportation Cost Recorded in 2010

[illegible]	[illegible]	um on	[illegible]	[illegible]	[illegible]	Tota Sp Ill	[illegible]
January		84	1,163,400	13,000	31 000	172,000	2047.62
February	5	105	1,454,250	13,000	30,000	215,000	2047.62
March	8	168	2,326,800	12,000	28,000	320,000	1904.76
April	6	126	1,745,100	12,000	28,000	240,000	1904.76
May	4	84	1,163,400	12,000	28,000	160,000	1904.76
June	5	105	1,454,250	12,000	28,000	200,000	1904.76
July	4	84	1,163,400	12,000	28,000	160,000	1904.76
August	4	84	1,163,400	12,000	28,000	160,000	1904.76
September	5	105	1,454,250	12,000	28,000	200,000	1904.76
October	2	42	581,700	12,000	28,000	80,000	1904.76
[illegible]	[illegible]	[illegible]	[illegible] 50	[illegible]	[illegible]	1,907,0[illegible]	933 33

Source: AP Oversea Trading co., ltd.

Remarks:
[a] The data on volume (in container) was gathered from the company record
[b] The data on volume in ton calculated by 21 tons/cont * (a)
Revenue is calculated by price/ton 13,850 * (b)
[d] The data on 6-Wheels cost was gathered from the company record
[e] The data on Trailer cost was gathered from the company record
[f] Total transportation cost calculated by (d)*(a)+(e)*(a)
g Transportation cost per ton calculated by (g)/(b)

Table 3.2 shows that the number of delivered container monthly total of 36' high cube container held around 21 tons or 842 bags. The company sold an average of US$ 433 per/Ton, and the revenue per shipment can be calculated. Next is transportation cost of containers by two types of transportation from Bangkok-Ranong that were 6-wheels and Trailer. Transportation cost per ton has been calculated as about 1900-2050 Baht/tons after the proposed consolidation hub. We expect that it can assist company to save cost per ton. Finally, these data will be used in a simulation model for each scenario to see what the company can save in transportation cost in each scenario and how much profit increase there would be in each scenario. The simulation method will be shown in next chapter.

3.3 Gap finding

From the supply chain mapping, a transport route was designed by the company for both 6-wheels and trailer, but this is not efficient because of lack of knowledge to design a transportation routing network. At this point, we foresaw that if we can arrange transport well as well as the company supply chain we will have opportunity to increase total profit by improving transportation cost.

From the cost structure, we also see that logistics cost spending is around 29% of total cost. This results from the long travel distance of transport routing for both 6-wheels and trailer from Bangkok to the factory in Ranong. The cost of transportation is related to travel distance of the transport routing. To understand the existing transport routing of the company, this is illustrated in Figure 3.3 below.

Figure 3.3 The Existing Transportation Routing of AP Oversea Trading Co.

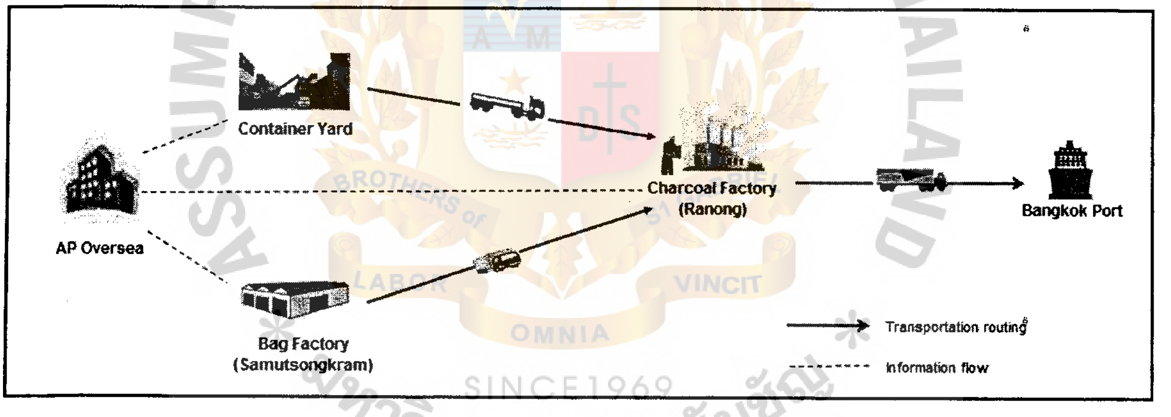


Figure 3.3 shows that there are three parties involved: charcoal factory, bag factory, and trucking Company. The process starts from the shipper ordering from the bag manufacturer the bags screen with customer logo, and ordering charcoal at the same time. They have no inventory and use a made-to-order strategy because irregular demand depends on price competitiveness. Bag manufacturing has the capacity to produce 10,000 bags within 2 days and they deliver the finished bags to the charcoal manufacturer in Ranong by 6-wheels truck in order to pack with finished charcoal once the final products are ready to export to the destination. The transportation company will arrange a trailer to pick up empty containers somewhere in the Bangkok

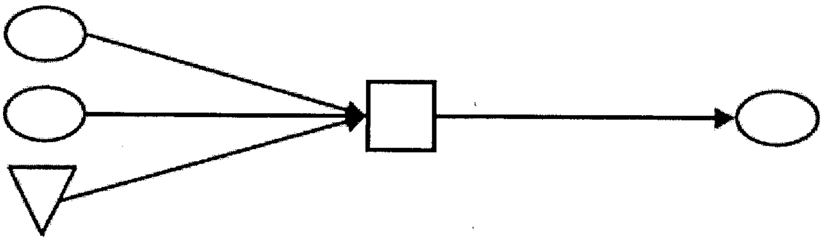
area subject to shipping line dispatch of empty container from Bangkok to Ranong in order to load cargo which takes 3 hours by using 12 laborers to arrange the product in the container together with sealed bags and then return direct to Bangkok port

The problem statement is about transportation cost because of ineffective transportation routing. The main factors which produce high transportation cost are shown in Figure 3.3 which automatically increase the total logistics cost of the company. This means that the company has competitive weakness. From gap finding we can see that the company has an opportunity to reduce the logistics cost. Thus, the project aims to study and analyze transportation routing that a company can adopt and redesign transportation routing to enhance cost efficiency and lower the total cost. We have to rearrange transportation routing and reduce distance to save cost. The root cause of the problem comes from transportation ineffectiveness, so this project tries to propose a model that may result in cost saving for transportation and improve transportation efficiency.

3.4 Proposed models and solutions

From the data analysis, the researcher found that the main problem of the company is that the logistics cost is about 29% of total cost. When we investigated it deeply we found that almost 56% belongs to transportation cost and transportation fees due to an unsuitable transportation network. In order to solve this problem, the researcher studied solutions and methodologies to re-design transportation routing and make a hub design in an appropriate location to reduce the transportation cost of the company and increase profit. Shipment consolidation is an option for long-haul to combine orders within a hub. The consolidation hub strategy will be applied, with expected benefits in improved transportation routing and cost saving

Figure 3.4 The Constructed Consolidation Hub Scenario for the Case Company



Source: Ala-Risku, et al. 2002

Based on the constructed consolidation hub scenario in Figure 3.4, circle represents suppliers, and a triangle represents a warehouse. A consolidation point is represented as a square, and delivery to a customer is described by a circle. This model was set up as a consolidation hub to combine shipments from supplier and warehouse. Thus, the consolidation point took place to combine shipment and move them on to the customer destination. This model is fundamental to this research, as a proposed model and for simulating consolidation scenario. In addition, previous case studies from various industries have been considered and applied to our particular case.

Specifically, when evaluating consolidation opportunities it is convenient to classify the relevant variables and costs into three categories: consolidation & handling cost, transportation, and inventory (Buffa, 2005). Here, one should include costs of services provided, such as handling cost for loading and unloading shipments, at a consolidation point, and storage cost for waiting or storing at the consolidation hub if a shipment must wait for the arrival of other shipments to form the consolidation. Transportation cost is also involved when transportation routing is changed from the existing process which is loading and packing at the manufacturer to deliver finished products from the factory, dispatched by 22-wheelers to the consolidation hub. It is an additional one added from the existing process and influences the total cost. Last, a hub will be set up in a suitable area near to the bag manufacturer and container yard in order to reduce a distance and transportation cost. A hub could be rented from another supplier to consolidate products. In this paper, the researcher attempted to propose a model according to the consolidation hub concept and truck utilization, and to design a hub location in an appropriate area which is expected to save transportation cost and produce effective routing.

After completing a thorough literature review to determine the current state of shipment consolidation research and methods in the important field of study associated with shipment consolidation, the researcher modeled three scenarios based on the concept of Mason (2007) for truck utilization to manage the trailer itself to pick up material for one round trip before heading to the factory. The next scenario is based on Michelle (2005) and Sean (2008). By locating consolidation hubs appropriately, the company can design a consolidation network and a number of hubs near to the suppliers, and the hub will combine all the components in the same place before shipping. The third scenario will have different hub locations based on optimal decisions where to locate the hubs. Such a consolidation hub model is designed to minimize transportation cost.

Figure 3.5 Scenario I: Stand-by Overnight Chassis at Charcoal Factory

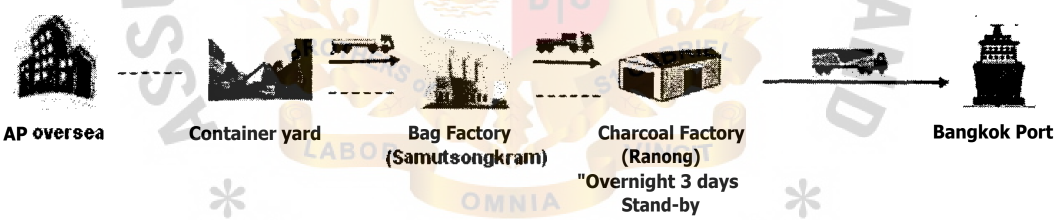


Figure 3.6 shows the first scenario. The company has sent information once it received a purchase order (PO) from the customer, and delivered the information to the three parties, which are container yard, bag factory, and charcoal factory. The transportation routing was developed by using only round-trips of the trailer to pick up bag packaging in order to eliminate the cost of 6-wheelrs, while the company must be responsible for the overnight chassis for around three days at the charcoal factory. The cost for overnight chassis is around 15,000 Baht per night, so this cost will be strictly calculated. Then, trailer with empty container will stand-by at the charcoal

factory with non-activity during packing of the product. It usually takes around 3 days, subject to workers and weather. Once, finished loading, a fully loaded truck will travel to Bangkok port for shipping out.

Figure 3.6 Scenario II: Proposed Consolidation Hub in Samutsongkam

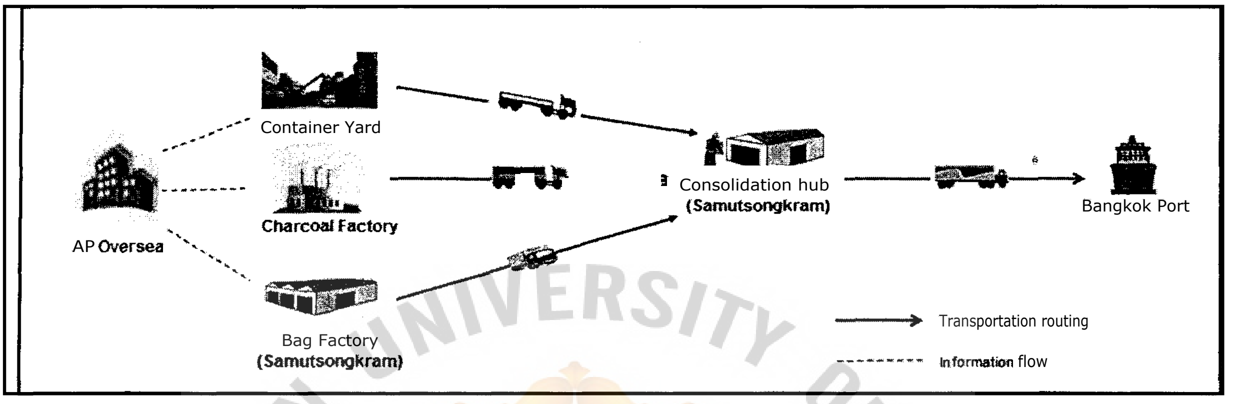
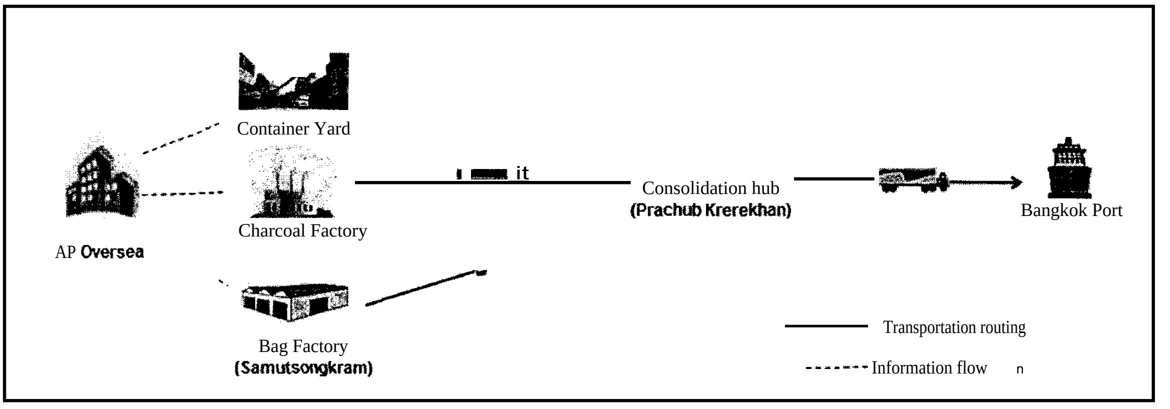


Figure 3.7, the second scenario, shows transportation routing by a dedicated hub located close to the supplier in Bangkok. Such a logistics arrangement is known as a consolidation hub (Barnes et al., 2003). Here, the hub is the consolidation point to pack finished charcoal together with paper bags as the inner package and PP bag as the outer package. There are labor costs and hub rent to be considered. The charcoal factory transports materials by 22-wheelers from Ranong to the hub. This cost is a direct transportation cost for the company. Also, it created new transport routing. The travel distance of a container and 6-wheeler cost has decreased due to the shorter distance of a round trip. Once stuffing the container has finished, it is moved to Bangkok port for shipping to the destination. In this model, the goal was to minimize the transportation cost in a new system. From this scenario, we can see that hub location has a relationship with travel distance and cost of transportation, so the next scenario will identify another province for hub location to contrast the cost saving.

Figure 3.7 Scenario III: Proposed Consolidation Hub in Prachub Krerekhan



The last scenario will use the same concept as the second scenario but it will have a different hub location that will impact transportation cost, distance, and rent cost.

A consolidation hub will be located in Prachub Krerekhan midway between Ranong and Bangkok. Therefore, it is justified to use the same activity cost in all distribution models (which are compared in the next chapter).

3.5 Simulation of the proposed model

A simulation is used for the purpose of either understanding the behavior or evaluating strategies of the system over a period of time (Khan, 1999). Excel-spreadsheet is widely used for strategic decision making in trade, finance, and other commercial areas, but recent developments of modern spreadsheets have provided an interactive modeling environment in which the user can apply power quantitative management tools to develop models for the purpose of system analysis.

In Excel, sets of input data can be created and saved to produce different results as scenarios, with a worksheet model or a report to provide a summary of all the details. It will compare each scenario based on the cost table below. To show the cost of transportation in each model we have simulated three scenarios. Each scenario was analyzed in term of its cost saving dimension.

Table 3.3 Cost Comparison in each Scenario in this Research

os types	s is	cenerio	r Scenei io	Scenerio#3
6-Wheels truck	x	-	x	x
Trailer	x	x	x	x
22-Wheels truck	-	-	x	x
Hub rent	-	-	x	x
Overnight chassis		x	-	-
Labors	-	-	x	x
Total	x	x	x	x

The most significant benefits when setting up a consolidation hub can be expected to arise from reducing the operational and transportation costs. The resulting cost of transportation depends on the location of hubs and travel distances. We expected to save transport sosts. The objective of simulation models was to determine which scenario is most effective in cost saving and has lower total transportation cost. If the scenario results in higher costs than exist in current operations, restructuring the scenario may be useful. Lastly, computational results show that our purposed models to re-design transportation routing allows can achieve remarkable cost saving

3.6 Summary

From the proposed model we can see that a consolidation hub has been added to the company supply chain, and has changed the transportation routing and created a new process to assist the company to reduce transportation cost, reduce total cost, and enhance cost efficiency. We have to be sure that the consolidation hub concept is able to assist the company to increase transport efficiency better than the existing process. Significantly, it can it be implemented in practicality?. This research tests the result by comparing the cost saving of transportation in each scenario after setting up a consolidation hub. The model is tested in the dimension of cost transportation cost, effective routing, and enhancement of a systematic transportation network.

A critical analysis of this purposed model will be presented in the next chapter, and the outcome from the analysis is expected to provide sufficient information for the company in its making-decision whether to adopt this model into its supply chain management

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter comprises five sections. The first section is an analysis of current transportation routing of AP Oversea Trading Co., Ltd., including the product cost structure analysis for January-October 2010 to explore logistics cost of the company, 1 focusing on improving the inland transportation cost. The second section explains the solution procedure and computational test of all three proposed scenarios, and the way to evaluate model performance. The third section applies the consolidation hub model and shows the calculations for all three scenarios. Also provided is a comparison of results between the existing transportation route and proposed scenarios in terms of the cost saving dimension. The fourth section simulates annual cost saving in 2010 and shows the cost saving result for total transportation costs per year. Finally, the fifth section is a summary of the critical analysis, calculations, and cost saving result for all three proposed scenarios.

4.1 Analysis of current transportation routing

Chapter 3 identified the problem has in the company as the vehicle routing problem (VRP). The company has spent major expense in direct material cost and logistics cost. It is has a core supplier of the main products which are packaging in Bangkok and charcoal in Ranong, which are located in different provinces. Hence, trucks have to drive across the province in order to pick up material. Additionally, distance between destinations is considerable and is costly, which is the reason why the company has to spend big amounts on its transportation activity.

According to the face-to-face interview session with the company owner, it was found that transportation activity has become an important issue with its other competitors, as logistics cost equals 28.44% of total cost, while inland transportation activity is about 55% of logistics cost. For this industry, the average yield is high because of the value of the product itself, leading to price cutting in the market, and many suppliers have obtained only a low profit on each container. Each container is loaded with around 21 metric tons of packed charcoal, and its selling price per metric ton is 13,500 Baht approximately. The summary of Raw Material per Container is shown in Table 4.1.

Table 4.1 Summary of Raw Material per Container

Container	Volume (Metric Ton)	Price per Metric ton (Baht)
1	21	13,500

Source: The Author

In this paper, the researcher uses the above information as the base-line for the calculation and simulation, find the project cost saving by measuring transportation cost per metric ton and total transportation cost. In order to illustrate total cost clearly we collected details of delivered volume per container and customer demand in tons, revenue, direct material cost, and logistics (as in Table 4.2).

Table 4.2 Product Cost Structure of Current Transportation Routing

Mo[illegible]	[illegible]	M[illegible]	[illegible]	[illegible]	[illegible]
January	4	84	1,163,400	824,036	330,871
February	5	105	1,454,250	1,030,045	413,589
March	8	168	2,326,800	1,648,072	661,742
April	6	126	1,745,100	1,236,054	496,306
May	4	84	1,163,400	824,036	330,871
June	5	105	1,454,250	1,030,045	413,589
July	4	84	1,163,400	824,036	330,871
August	4	84	1,163,400	824,036	330;871
September	5	105	1,454,250	1,030,045	413,589
October	2	42	581,700	412,018	165,435
To[illegible]	47[illegible]	[illegible]	1[illegible]9,95[illegible]	[illegible]	88 34

Remark: [a] Direct Material Cost is calculated by Revenue x 70.83%
[b] Logistics Cost is calculated by Revenue x 28.44%

Table 4.1 shows that the delivered volume of the company from January to October 2010 equals 47 containers or 987 metric tons. Revenue is calculated by using volume per metric ton multiplied by the selling price of 13,500. The result is that the company gained 13,669,950 Baht from January to October 2010. It had spent about 9,682,426 Baht in direct material cost, about 70.83% of total revenue, while logistics cost equals

3,887,734 Baht, 28.44% of total revenue. The researcher aims to customize the routing of inland transportation so as to reduce total logistics cost of the company through the consolidation hub model.

Therefore, this paper aims to focus on inland transportation cost in order to reduce logistics cost and total cost saving, and the consolidation hub model is the chosen strategy to re-design the transportation network. The researcher proposed three possible scenarios in which it is expected that the cost of transportation would be reduced.

4.2 Solution procedure and computational test

In order to find the optimal scenario we applied the consolidation hub model, adjusting the transport routing network of the company to achieve cost saving benefit for the AP Oversea Trading Co., Ltd.. In the problem statement we stated that 28.44% belongs to logistics cost, and 56% of that logistics cost is for inland transportation. Therefore, we proposed three possible scenarios from previous researchers who are Mason (2007), Michelle (2005) and Sean (2008), to minimize inland transportation of the company. The summary of the proposed model concept will be followed strictly as in Table 4.3

Table 4.3 Summary of Proposed Model Concept

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	Mason	2007	Stand-by Overni ht Chassis at Charcoal Factory
2	Michelle	2005	Proposed Consolidation Hub in Samutsongkam
3	Sean	2008	Proposed Consolidation Hub in Prachub Krerekhan

Source: The Author

Scenario I: This scenario concept is based on Mason (2007), that maximizing of trailer utilization through pick up of empty container in Bangkok and pick up packaging in Samutsongkram in order to consolidate shipments at the factory in Ranong. Three days will be spent on packing 8,420 bags and stuffing the finished product into a container, and the deliver a full container loaded to the Bangkok port. In this scenario, the company is able to eliminate 6-wheels transport for packaging. On the other hand, they have to be responsible for the cost of three-days overnight chassis.

Scenario II: This scenario concept is based on Michelle (2007) as the researcher proposed a consolidation hub in Samutsongkram. There is about 75 m^2 of hub space with equipment and labor support. The hub represents a central combination of materials (Bag and Mangrove charcoal) at the consolidation hub. The transportation pattern will be changed by 22-wheels in transporting pure mangrove, with canvas covering in order to prevent the product from rain, wet and moisture during transportation to the consolidation hub. Hub rental in Samutsongkram is 80 Baht/m^2, so the all-in rate would 6,000 Baht per month.

Scenario III: This scenario concept is based on Sean (2008).it is similar to scenario II but the researcher proposed a consolidation hub in a different area in order to find the best transport saving by a dedicated consolidation hub in Prachau Keerekhan. There is 80 m^2 warehouse space, while the rental cost is only 50 Baht/m^2 or 4,000 Baht in total.

For the simulation scenarios we used the Microsoft Excel program to analyze data and compare the result among scenario. The possible results in optimizing total transportation cost will be put to manager as one strategic decision to assist the company achieve remarkable cost saving and answer the paper's research question.

4.3 Applying a Consolidation Hub Model

A consolidation hub model is a core model to improve a transportation routing network in this paper, which is expected to achieve cost saving and find the optimal inland transportation. The first scenario proposed a consolidation hub at the charcoal manufacturer by utilizing trailer transport in round trips. Bag packing would be picked up by 6-wheelers as usual.

Scenario I: Stand-by Overnight Chassis at Charcoal Factory. We apply a simulation by using a trailer to pick up. Not only is an empty container received from the container yard in Bangkok but it also stops at the bag manufacturer to pick up bag packing (both paper bag and pp bag) in order to combine with charcoal in Ranong. The operating time usually takes 3 days for packing 8,420 bags for one container, so it needs to have the chassis for 3 days overnight. It is 5,000 Baht per day for opportunity cost. Thus, the monthly and total transportation costs spent in this scenario are illustrated in Table 4.4

Table 4.4 Consolidation Hub Model is implemented under Scenario I

[redacted]						
January	4	84	30,000	15,000	180,000	2142.86
February	5	105	30,000	15,000	225,000	2142.86
March	8	168	28,000	15,000	344,000	2047.62
April	6	126	28,000	15,000	258,000	2047.62
May	4	84	28,000	15,000	172,000	2047.62
June	5	105	28,000	15,000	215,000	2047.62
July	4	84	28,000	15,000	172,000	2047.62
August	4	84	28,000	15,000	172,000	2047.62
September	5	105	28,000	15,000	215,000	2047.62
October	2	42	28,000	15,000	86,000	2047.62
Tot	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]

Remark: [a] The data on Volume (Cont) was gathered from the company record
[b] Volume (Ton) is calculated by 21*(a)
The data on Trailer was gathered from the average market price
The data on overnight chassis charge 5,000 Baht per day based on average market price calculated by 5,000 x 3
[e] Total cost is calculated by (c)+(d)*(a)
[f] Transportation cost per ton is calculated by (e)/(b)

In Table 4.4, a total of 47 containers, or 987 tons, was delivered to the customer. We simulated the transportation cost in scenario I and found that transportation cost is 2,039,000 Baht in total, while the transportation cost is 2066.67 Baht per ton after applying truck utilization, which is higher than the current system.

Scenario II: A Consolidation Hub in Samutsongkam, near the suppliers, is proposed to minimize the travel distance of transportation between suppliers.On the other hand, material will be transported from the factory in Ranong to the consolidation hub by

22-wheelers. For the transportation cost of the 22-wheelers we use the average transportation cost as the market price, which is 15,000 Baht. Scenario II is calculated in Table 4.5 below

Table 4.5 Consolidation Hub Model as implemented under Scenario II

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
January	4	84	2,500	15,000	6,000	6,000	100;000	1190.48
February	5	105	2,500	15,000	6,000	6,000	123,500	1176.19
March	8	168	2,500	15,000	6,000	6,000	194,000	1154.76
April	6	126	2,500	15,000	6,000	6,000	147,000	1166.67
May	4	84	2,500	15,000	6,000	6,000	100,000	1190.48
June	5	105	2,500	15,000	6,000	6,000	123,500	1176.19
July	4	84	2,500	15,000	6,000	6,000	100,000	1190.48
August	4	84	2,500	15,000	6,000	6,000	100,000	1190.48
September	5	105	2,500	15,000	6,000	6,000	123,500	1176.19
October	2	42	2,500	15,000	6,000	6,000	53,000	1261.90
								1187.. 8;1

Remark: The data on Volume (Cont) was gathered from the company record
[b] Volume (Ton) is calculated by 21*(a)
The data on 6-wheels trucks was gathered from the average market price
[d] The data on 22-wheels truck was gathered from the average market price
[e] The data on Trailers was gathered from the average market price
[f] Hub rental price was gathered from the average market price
g Total cost is calculated by (c+d+e)+(f)*(a)
Transportation cost per ton is calculated by (h)/(b)

From the Table we can see the simulated result. The proposed consolidation hub reduced the transportation to 1,164,500 Baht in total, while the average transportation cost per ton is 1,187.38 Baht. In this scenario, the transportation cost per kg is lower, due to the low distance travelled between destinations.

Scenario III: Proposed Consolidation Hub in Prachub Krerekhan. A consolidation hub is set up in Prachau Keerekhan where is far away from Bangkok but closer to the charcoal manufacturer in Ranong. The purpose is to reduce the transportation cost of 22-wheelers and have a lower hub rental per month. The details are in Table 4.6.

Table 4.6 Consolidation Hub Model is implemented under Scenario III

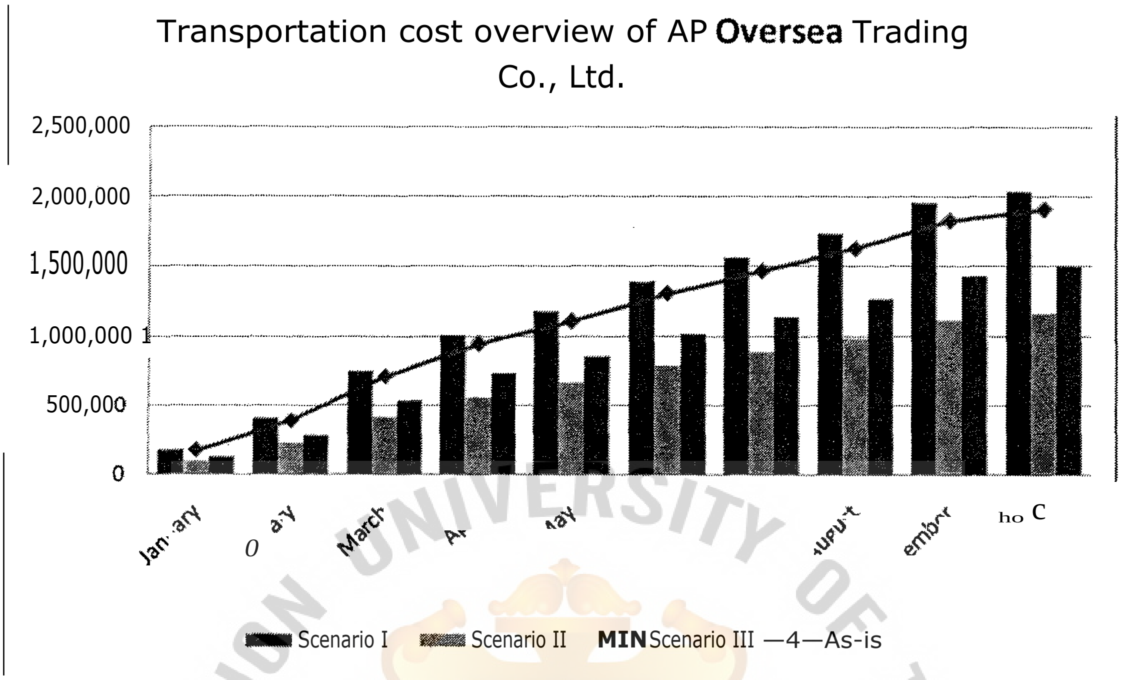
out	[illegible]	[illegible]	6 [illegible]	[illegible]	cost Ai	[illegible] rental	Total cost	Transportation cost/ton
January	4	84	6,000	10,000	15,000	4,000	128,000	1523.81
February	5	105	6,000	10,000	15,000	4,000	159,000	1514.29
March	8	168	6,000	10,000	15,000	4,000	252,000	1500.00
April	6	126	6,000	10,000	15,000	4,000	190,000	1507.94
May	4	84	6,000	10,000	15,000	4,000	128,000	1523.81
June	5	105	6,000	10,000	15,000	4,000	159,000	1514.29
July	4	84	6,000	10,000	15,000	4,000	128,000	1523.81
August	4	84	6,000	10,000	15,000	4,000	128,000	1523.81
September	5	105	6,000	10,000	15,000	4,000	159,000	1514.29
October	2	42	6,000	10,000	15,000	4,000	66,000	1571.43

Remark:
[a] The data on Volume (Cont) was gathered from the company record
[b] Volume (Ton) is calculated by 21*(a)
[a] The data on 6-wheels truck was gathered from the average market price
[d] The data on 22-wheels truck was gathered from the average market price
e The data on Trailer was gathered from the average market price
[f] Hub rental price was gathered from the average market price
g Total cost is calculated by (c+d+e)+(f)*(a)
[h] Transportation cost per ton is calculated by (h)/(b)

We can see that transportation cost is 1,497,000 Baht in total, and the average transportation cost per ton is 1,521.75 Baht. Meanwhile, 22-wheelers cost is 10,000 Baht per trip to transport charcoal from Ranong to the consolidation hub in Bangkok, and the hub rental is cheaper than the nearby capital city. The Hub cost is 4,000 Baht in Prachub Keerekhan

All scenarios have been simulated with historical data from January-October 2010 in order to have a clearer understanding. The following graph presents the existing implementation and the simulated of all three scenarios (in Figure 4.1)

Figure 4.1 Transportation cost overview of AP Oversea Trading Co., Ltd.



To illustrate the transportation cost of each scenario, it was measured in terms of cost saving between the existing implementation and after applying the possible scenarios for a consolidation hub. We can see that even though every scenario has applied the consolidation hub model, the result is still different which means that a dedicated hub location has an impact on the transportation cost. Scenario **II** seems to be the optimal solution by having the lowest transportation in total.

4.4 Comparison result of transportation costs of each scenario

The analysis of data and findings in this study are categorized into two parts to find the highest cost saving for the company. There are transportation cost per ton and total transportation cost, which are analyzed through simulation in Microsoft Excel so that all three scenarios were compared with the original cost base. The cost saving of transportation cost per ton is presented in Table 4.7

Table 4.7 Comparison of Transportation Cost of each Scenario per Ton

[illegible]	[illegible]	s orta ion ost (Baht)		
	[illegible]	cenario	Scenario II	Scenai io
ranspo [illegible]	1,933.33	2,066.67	1,187.38	1,521.75
ost saving eac [illegible]		133	(745)	(412)
os saving ea [illegible] nan o i e	-	+6.90%	-63.00%	-27.00%

This Table shows the cost saving per ton. From the overall analysis and the findings in this study, the current transportation per ton is 1,933 Baht, while The scenario I, average transportation cost after simulation has resulted in the cost per ton increasing by 133 Baht/ton or 6.9%. Further, scenario II had the highest transportation cost per ton saving. It costs about 745 Baht/ton or 63%. Scenario III also saves the same as scenario II, 412 Baht/ton or 27% saving. From the comparison result table, if the company can implement the best model (scenario II) it would benefit the company in case of increase in orders. In addition, the finding of the total transportation cost has been analyzed, and the results are presented in the following Table.

Table 4.8 Comparison of Total Transportation Cost of each Scenario

Cost	Transportation Cost (Baht)			
	As-is	Scenario I	Scenario II	Scenario III
Total transportation cost	1,907,000	2,039,000	1,164,500	1,497,000
Cost saving each scenario (Baht)	-	132,000	(742,500)	(410,000)
Cost saving each scenario in percentage	-	+6.90%	-63.00%	-27.00%

This comparison Table of total transportation cost uses the current implementation as the base-line for comparing scenarios. Scenario I has a total transportation cost around 2,039,000 Baht. It is higher than current implementation by about 132,000 Baht or 6.9% even through other researchers have proposed to achieve cost reduction by reducing the transportation cost, such as the automobile industry, electric industry and food industry. Unfortunately, in our environment, a trading industry is unlikely to be a good option due to long travel distances of transportation between suppliers, and the need for stand-by chassis cost when calculate the total cost..

Scenario II proposed a consolidation hub, and achieved its cost saving goal. Its total transportation cost was around 1,164,500 Baht in total. In addition, it can save total transportation cost around 742,500 Baht or 63.0% after testing the simulation scenario against the data record for January-October 2010. Lastly, scenario III also produced savings but lower than scenario II, with total transportation cost around 1,497,000 Baht. Also, it can save total transportation cost around 410,000 Baht or 27.0% saving. This scenario saves less than scenario II due to the different locations of the consolidation hub .

4.5 Simulating the Annual Cost Saving in 2010 under Scenario II

In order to forecast annually until year end 2010, the researcher conducted simple calculations in Excel spreadsheet to describe the yearly saving. The result of forecasting annual savings will be compared between transportation cost without consolidation and with an applied consolidation hub under scenario II together with cost saving from the base-line both in Baht and percentage

Table 4.9 Simulating the Annual Cost Saving in 2010 under Scenario II

Year	Average Volume (Month)	Total Volume (Year)	Transportation cost without consolidation hub (Baht)	Applied consolidation hub model #2	Annual Cost Saving (Baht)	Percentage of Cost Saving
2010	4.7	56	2,284,200	1,397,400	886,800	63%

Source: The Author

According to Table 4.9 the average volume per container in 2010 was calculated by the delivered volume from the company record for January to October 2010. There was a total of 47 containers or 4.7 containers per month and the approximate volume per year equal 56 containers.

When using the retrospective data of 2010 to forecast annual transport cost saving, the transportation cost without a consolidation hub model is about 2,284,200 Baht in 2010. If the company applied the consolidation hub model under scenario II, they would have total transportation cost of 1,397,400 Baht. It saves around 886,800 Baht, or 63%, annually.

4.6 Summary

The product cost structure of AP Oversea Trading Co.,Ltd. hanged after applying the consolidation hub model to their supply chain to improve transportation routing network as well as to create a new effective routing by using the hub strategy. The transport cost saving in the simulation in 2010 is extremely huge, as large as 63% (reduced from 1,907,000 Baht to 1,164,500 Baht) for January to October. Meanwhile, the annual transport cost saving in 2010 would be 886,800 Baht (reduced from 2,284,200 Baht to 1,397,400 Baht) if the company applied a consolidation hub model.

Nevertheless, scenario I contributed disappointing results, higher than the as-is process. The transportation cost in Scenario I was 2,039,000 Baht in 2010, and the average cost per ton equals 2,066 Baht. It was higher than actual by around 132,000 Baht, or 6.9 percent, for January to October 2010.

In scenario III it was 1,497,000 Baht, and the average cost per ton equals 1,521 Baht It is also saves around 27 percent in January to October 2010. Thus, the location of a consolidation hub has an impact on the inland transportation cost, so scenario II has a delightful result in setting up consolidation near to suppliers in order to shorter travel distance of transport round trips.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter has three major sections. The first section consists of the conclusions and discussions of the consolidation hub models results, derived from the detailed analysis. The second section consists of suggestions for implementation at the managerial level for adoption of a consolidation hub together with recommendations. The last section contains recommendation for future research in order to assist other researchers who undertake extensive studies in consolidation hub models or who develop the current model.

5.1 Conclusions and Discussions

The simulation result from applying a consolidation hub model by using data from 2009 in scenario II found that the inland transportation cost was 1,164,500 Baht, which is a reduction from existing spending on inland transportation of1,907,000 Baht. The company obtained savings of 742,500 Baht, or 61 percent. At the same time, the consolidation hub under scenario II resulted in the cost of transportation per ton being equal to 1,187 Baht, although the original transportation cost was 1,933 Baht. Meanwhile, we have simulated this scenario with forecast data for 2010 as 2,000 tons of customer demand, and it reveals that the company has about 67 percent saving over the original transportation route. Thus, the company would gain benefit from the proposed consolidation hub model under scenario II. We identified the potential for significant cost savings over the currently implement transport route based on our analysis

However, scenario I and scenario III were not selected as options for adopting a new model, after analyzing the possibility of transport cost saving. As mentioned before, even scenario I tried to customize the transportation route by utilizing vehicles and consolidating at the manufacturer, but the necessary stand-by chassis charge would be the responsibility of the company as they have to outsource the trucking. From our calculation, the transportation cost in scenario II was 6.9 percents higher than the original, or a total cost of 2,039,000 Baht. While many researchers and practitioners have obtained benefits from an aligned transport model, in our business environment it was not suitable because of the long travel distance, the expensive stand-by chassis charge, and the packing and loading operating lead time of the suppliers. Meanwhile, scenario III had 27 percents saving even through it used a similar concept to scenario II which has the lowest total saving, but it set up a different hub location which is why the transport saving in total was different. We concluded that distance travelled has an impact on transportation cost as the hub location is a significant consideration.

Thus, based on the consolidation hub model, we propose that a consolidation hub can reduce the inland transportation cost, lower the transportation cost per ton, and reduce the total cost. This simulation was applied in a particular case situation at the trading company in Thailand, with a remarkable result. On the inland transportation alone, the potential saving already exceed 60 percent. However, after reviewing the percentage cost saving of each scenario, this reveals that in the most significant scenario II the absolute saving also carries a high percentage of saving, as large as 67 percent. From this perspective, this result is likely to be very highly likely, and encourages the management to consider the adoption of a a consolidation hub model.

5.2 Suggestions for Implementation

This study of the cost saving for trading company in Thailand consisted of a cost saving project on inland transportation by rearranging transportation routing through a consolidation hub model, and proposed a new efficient route. To ensure the smooth implementation of a consolidation hub model, there are a few suggestions for the managerial level, as follows.

5.2.1 The difficulty of implementing a consolidation hub is to get co-operation among suppliers. Therefore, we have to make sure that there will be a high level of attractiveness in adopting a new transportation model for them, and they would gain mutual benefits such as cost reduction, reduced operating time, and improved process excellence. Senior management are responsible for convincing their suppliers and explaining the consolidation benefits for its suppliers to make sure it is not weak in operation.

5.2.2 A consolidation hub is a key successful factor to achieve remarkable cost saving, so selecting a hub is a top priority to be consider in terms of facility, equipment, and labor to ensure that it can handle the smooth loading, unloading, and stuffing of cargo, to prevent risk, damage, and claims.

5.2.3 The company can expand its product variety, with not only one supplier for any one kind of particular product but they can outsource to other suppliers who have a lower price, good quality, and are available for support when customers order a big amount, by using a consolidation hub to combine product from several suppliers. This can save inland transportation cost and logistics cost over a long-term period.

5.3 Recommendation for future Research

In this study, the consolidation hub model has been tested in a local trading company in Thailand. For future research, researchers can also use the concept of a consolidation hub model to achieve cost saving in inland transportation in other industries, such as manufacturing, logistics, and the supply chain industry. As far as, this study is focused only on the cost saving dimension, it did not cover inventory holding, production lead-time, risk, and responsiveness to the customer demand aspect.

Research might be conducted in order to ensure that a consolidation hub can be supported for other reasons. In addition, further research could try to extend the model to accommodate delays at the consolidation hub, since these delays can increase the available load at the consolidation hub, needed for efficient hub operation.

Finally, this is basically a particular problem of the company in its logistics and supply chain due to the person who arranged transport routing lacking knowledge in transportation management and having a vehicle routing problem. It was solved through using a consolidation hub model, which is one of several model to help the company to resolve its vehicle routing problem and reduce its logistics cost. Further research could explore other strategies and models.

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APPENDIX

APPENDIX

Material and packing type images

Material packed in polypropylene bags (PP bags)

Material packed in paper bags