THE IMPACT OF BACKHAUL TO LOGISTICS COST IN BEVERAGE DISTRIBUTION: A CASE STUDY IN AN ENERGY DRINK MANUFACTURING

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ABSTRACT

The beverage manufacturing industry is one of the most competitive industries in the world, and has become more mature with the rapid development of the market economy. Profit margins are already wafer-thin because of the high level of competition among players in the industry. In order to succeed in such a competitive environment, enterprises need to pay more attention today to logistics and related costs than ever before, rather than focusing solely on production and sales costs.

This study aims to extend the previous research by modeling a case enterprise, an energy drink manufacturer that implements a private, in-house trucking fleet using backhauling, thus offsetting transport costs and improving its market competiveness. As the case enterprise needs to allocate extra time for backhauling in its operations, it therefore must take into account the various requirements such as rescheduling departure times; there are two scenarios' operational processes involved: Scenario 1 and Scenario 2. When departure times are fixed, it then becomes necessary to add new trucks to support backhauling operations (Scenario 2: on-time departures using different trucks for backhauling). The other scenario uses variable departure times, where there is no need to add any new trucks (Scenario 1: truck-S and truck-L depart alternatively). This study establishes a transportation cost model in order to evaluate the transport costs of a private trucking fleet that implements backhauling. Through a comparison with current transport costs (outsourced), the validity and feasibility of the proposed method is validated. On this basis, analysis of the sensitivity of transport cost impact factors is

performed to determine the main factors influencing transport costs, so as to implement key controls on these factors toward reducing operating costs and improving overall operational efficiency.

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ABBREVIATIONS

3PL	=	Third-Party Logistics
BIP	=	Binary Integer Programming
DC	=	Distribution Center
EDM	=	Energy Drink Manufacturer
FMCG	=	Fast Moving Consumer Goods
LC	=	Logistics Company
SOFM	=	Self-Organizing Feature Map
TC	=	Transportation Cost
THB	=	Thailand Baht
Truck-S	=	Group of truck-Service in short haul
Truck-L	=	Group of truck-Service in long haul
VNS	=	Variable Neighborhood Search
VRP	=	Vehicle Routing Problem
VRPB	=	Vehicle Routing Problem with Backhaul
VRPBTW	=	Vehicle Routing Problem with Backhauls and Time Windows

CHAPTER I

INTRODUCTION

Background

Recently, manufacturers have been facing the problem of looking for new profit growth points and increasing their competitiveness. With the development of markets, space has become very limited for enterprises to conduct in-depth exploration of the "first profit resource" and the "second profit resource," and managers are paying more attention to discovering potential sources of profit. Many empirical studies indicate that more and more enterprises are facing a super-competitive environment in which customer demands have become more diversified and personalized and competition more intense. Moreover, this super-competition not only exists in rapidly developing high-tech industries, but also in industries originally of a relatively less competitive degree (Yang and Wang, 2009).

For example, the cost structure in beverage manufacturing mainly includes production cost, selling cost and logistics cost. For beverage manufacturers, procurement of equipment, testing equipment and other equipment is uniformly implemented throughout production. Furthermore, they adhere to very strict production standards. Production flexibility in the beverage market requires further damage cost/benefits of mass production simultaneously; it is difficult to continually reduce production costs. With fierce competition, sales promotion is more and more frequent, leading to greater pressure in marketing costs. Thus, managers of beverage manufacturers pay more attention to modern logistics for development and economic benefit to create competitive advantage (Ming Yang 2009).

The beverage industry generally has a short turnover period and short shelf-life, where customers can purchase products conveniently. Further characteristics include:

A. Heavy, low-value cargoes because the main material in beverages is water.

B. Short shelf life. Normally the shelf life of a beverage is 12 months, but there are large discrepancies in the shelf life of different product categories, which is limited by their packing material.

C. Seasonal variations in consumption. Low and high seasons in the beverage industry are well recognized, and multi-level distribution channels are used throughout the industry. Typically, distribution channels include exclusive distributor, second tier wholesaler, retailer, etc., making the bullwhip effect more acute.

D. Product homogeneity becomes increasingly prominent. Most companies and products in the industry are indistinguishable from one another, except, for, example, the Coca-Cola brand, which has a unique formula. The vast majority of beverage manufacturers do not have the core technology, so their products are easy to duplicate (Li, 2014).

All of the beverage industry above-mentioned characteristics demand that a higher priority be given to logistics, as inefficient logistics directly lead to high costs in beverage manufacturing. For example, the logistics cost in Coca-Cola is up to 60 percent of total cost (Xu, 2006), as shown in Figure 1. In addition, it is well known that transportation has the most direct and closest contact with customers, and generally accounts for most of the logistics cost. For instance, a recent logistics survey of beverage companies' shows that the logistics cost is approximately 7.87% of total sales on average, 44% of which is transportation cost, as shown in Figure 2. For Thailand, the logistics cost as a percentage of sales is more than 20% on average; 47.2% of this proportion contributes to the transportation cost (Ongtang and Sirivunnabood, 2014). Therefore, transportation is an important element of modern logistics. Effective management of transportation can reduce logistics cost and improve efficiency.

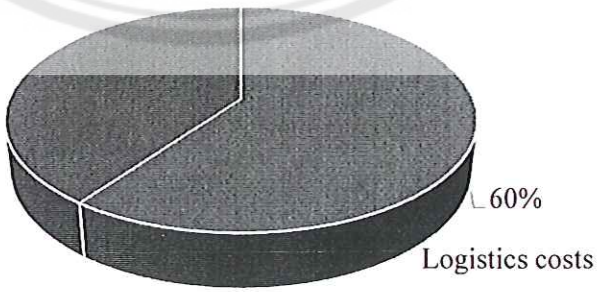

Figure 1 Proportion of logistics cost in total costs of Coca-Cola

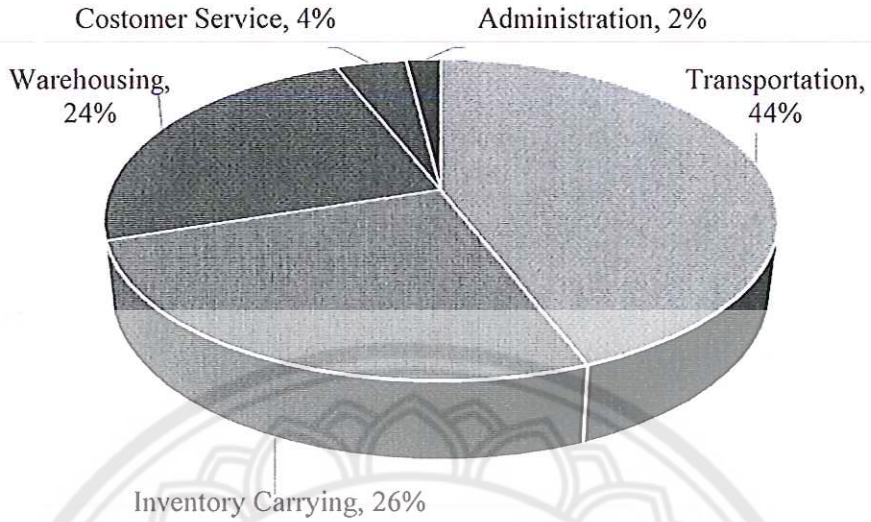

Figure 2 Structure of logistics cost

At present, backhauling has become an attractive cost-saving approach in logistics (Ongtang and Sirivunnabood, 2014). In trucking, a backhaul is hauling cargo back from a consumption point to the originating point. It has been revealed that more than 85.75% of weekly truck runs come back empty in the Bangkok area, which has resulted in high energy consumption and a waste of 37.42 in fuel expenses of empty backhauls (Chaiyot Peetijade, 2012). If companies can integrate logistics resources and reduce empty backhauls, it would considerably drive down their transportation costs.

Objectives

This study is designed to evaluate the impact of backhauls on logistics cost in beverage distribution. Consequently, an effort is made to explore a set feasible approaches that can reduce logistics costs for the case company—an energy drink manufacturer (EDM), so as to create a competitive advantage. Furthermore, the impact factors on transport costs, including backhauls are analyzed in this study.

1. Explore a set of feasible scenarios that can help to reduce transport costs for the case enterprise.

There are many methods that can reduce transportation costs, but this study focuses only on the integration of backhaul resources toward exploring a feasible approach to reduce transportation costs for an energy drink manufacturer.

2. Analyze the factors that influence transport costs.

In general, transportation costs are the largest cost item in logistics. The factors that influence transport costs comprise fuel price, driver salaries, vehicle price, etc. It is important to analyze and understand the extent to which these factors influence transport costs, so as to organize transportation reasonable, reduce transport costs and increase benefit to enterprises.

Statement of problems

1. What are the reasonable scenarios for backhauling? And what are their effects on transport cost reduction?

In general, trucks need to spend about 2-3 hours extra (compared with unilateral business) to pick-up and deliver back cargo. This can also interrupt the original schedule of transport fleet, which can result in higher than normal transportation costs. The focus of this study is to analyze an energy drink manufacturer's current situation and try to simulate a backhaul operation process, followed by an analysis of transport costs after backhauling.

2. What is the impact of the extra time (spent backhauling) on transport costs?

The purpose of trucks backhauling is to offset transportation costs on return trips. But obviously, trucks driving to pick-up and deliver back cargos will spend some extra time. In this study, the extra cost is fixed at 2 hours, but in practice, sometimes the extra time may be shorter or longer; so how will the transport cost be? This is an important question, to be answered in this study.

3. What are the main impact factors on transportation costs after implementing backhauling?

There are many factors that influence transport costs after implementing backhauling. If any one of them is increased or reduced, how will transport costs change?

What are the main factors that have an impact on transport costs after implementing backhauling? Knowing well about the driving factor of transportation, will it benefit transport cost reduction, help to reduce costs rapidly and thus gain more profit for enterprises? It is therefore necessary to analyze these impact factors of transportation cost.

Scope of research

1. Simulation of the EDM's backhaul operations for one part of its transport routes: "warehouse to agents"

The case enterprise (the EDM) is a beverage manufacturer; its agents are distributed all around the country. Its transport routes can be grouped into several categories, the details of which are discussed in Chapter IV of this case study. This study focuses on analysis of only one of all the EDM' transport routes – from warehouse to agents, and calculates the monthly cost in private a transport fleet for delivery tasks in the selected transport route. In addition, the operation process of backhauling is simulated (also concentrates on delivery task of the selected transport route) by an in-house transport fleet.

2. Reduce logistics costs by cutting transportation costs

In total cost of logistics, transportation costs account for a very high percentage. When transportation costs decrease, logistics costs will be reduced at the same time. Therefore, this study focuses only on transportation cost reduction; i.e., reducing logistics costs by cutting transportation costs.

3. Factors analysis

The factors analysis includes the extra time spent in backhauling and other driving factors in transport cost models based on the case enterprise (the EDM).

4. Restrictions in transport cost calculation

A. The transport is fully loaded every round trip, and the extra time for picking up and delivering back cargo includes time spent in loading and unloading back cargo, set at 2 hours.

B. This study does not include overall operational transport costs.

C. This study does not include the influence of uncertain factors such as traffic jams, road works, breakdowns and natural factors.

Research framework

The remainder of this thesis is divided into five sections, as shown in Figure 3: Content frameworks.

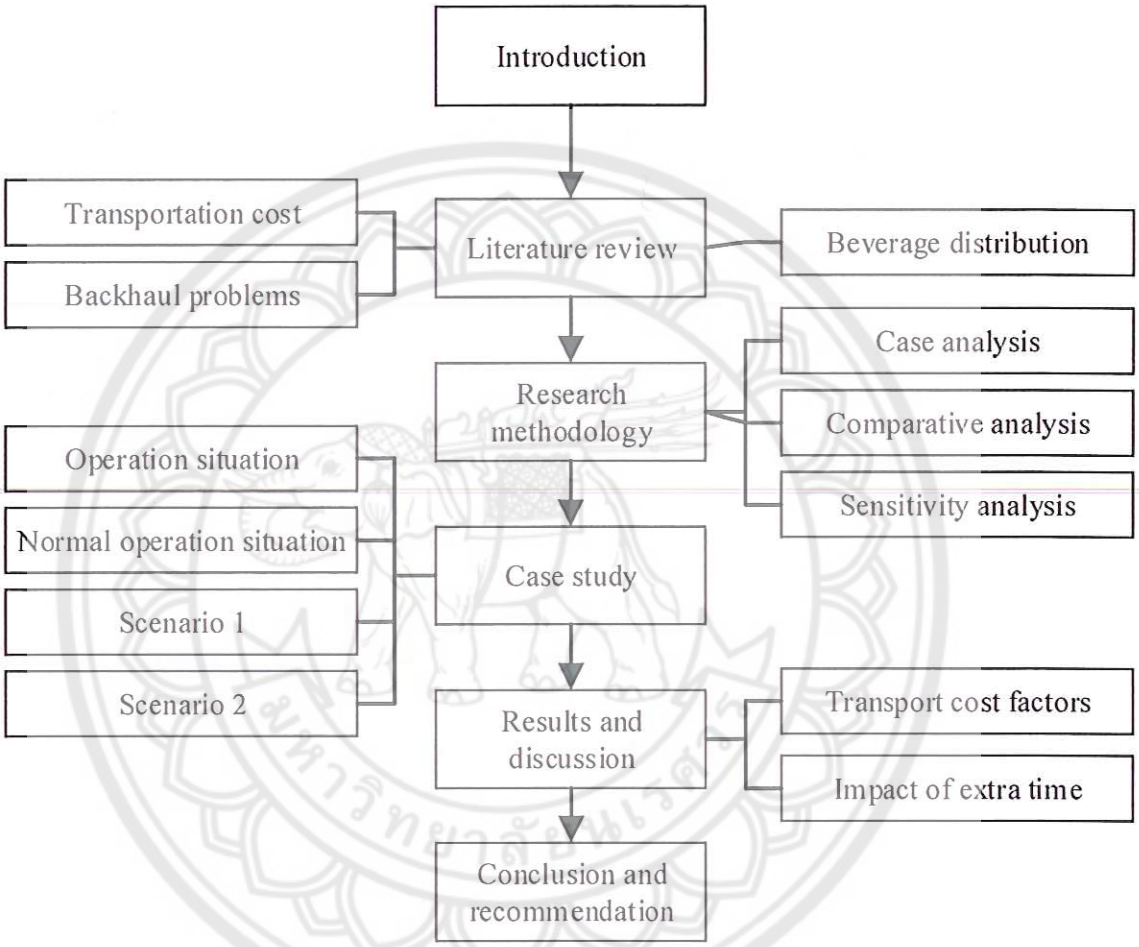

Figure 3 Research framework

Chapter II briefly reviews key prior relevant studies in the field of transportation costs, backhaul problems and beverage distribution.

Chapter III is a description of the research methodology used in this study, which includes case analysis and sensitivity analysis methodologies.

Chapter IV covers the energy drink manufacturer's special situation – in-house transport fleet (normal operational situation), and designing two scenarios to simulate

the operational process in backhauling,, working out the vehicle schedules and monthly transport costs of all normal operational situations, and two backhaul scenarios.

The meaningful results are presented in Chapter V. There are two main contents: the results analysis of case study, and a series of discussions on the factors of transport costs.

Chapter VI draws this thesis to a conclusion and points out future research directions.

CHAPTER II

REVIEW LITERATURE

This chapter intends to provide a basis for the later research on the given topic. Firstly, a focus on the research literature related to the fields of transportation cost reduction, backhauling problems and beverage distribution. And then, further based on the research literature, to point out the gaps in related academic fields this study attempts to fill.

Research literature

1. Literatures screening

Considering the wide variety of papers on backhauling and the transportation cost control, the selection criteria as papers is defined as follow:

A. Have a strong relation to transportation cost, backhaul, cost control, distribution in the title, the abstract or the keywords.

B. Have been published between years 1995-2015.

C. The papers were written in English or in Chinese.

D. Show a concentration on transportation by trucks.

E. Are not literature review papers.

After using this first filter, 77 papers were selected. Two groups were formed. Among them, 48 papers focus on transportation cost reduction and have given solutions via research methods application, 31 papers related to backhaul problems.

2. Transportation cost

Transportation is a term which can be defined as the physical movement of inventories such as raw materials, semi-finished goods and finished goods from one location to another. Analysis of the logistics costs of enterprises reveals that transportation costs are an important part of the costs of logistics enterprises. It constitutes the huge part of logistics, because of its relative size in total logistics costs. The rate of the transportation in all logistics activities is approximately around 50-65 percent, however, that might be different sector by sector (Ozdemir and Ergulen, 2013). Therefore, it is very important to study how transportation costs can be optimized in

logistics (Yan and Zhang, 2015). Many past studies have been dedicated to determining how to achieve the lowest possible transportation cost. For example:

McCann (2001)addressed two interrelated questions: the optimum size of a vehicle or vessel and the structure of transportation costs with respect to haulage distance (McCann, 2001).

Pilot and Pilot (1999) focused on minimizing the total costs involved in a transportation problem (Pilot and Pilot, 1999).

Jha, Somani, Tiwari, Chan, and Fernandes (2011) considered a joint-location inventory problem and minimized the transportation cost involved in a joint inventory location model by using a modified adaptive different evolution algorithm (Jha, Somani, Tiwari, Chan, and Fernandes, 2011).

Chanas and Kuchta (1996) proposed what they see as an optimal solution to the transportation problem, which makes use of fuzzy cost coefficients and an algorithm determining the nature of the solution (Chanas and Kuchta, 1996).

Research fields out of 48 papers that focus on transportation cost reduction as shown in the figure 4.

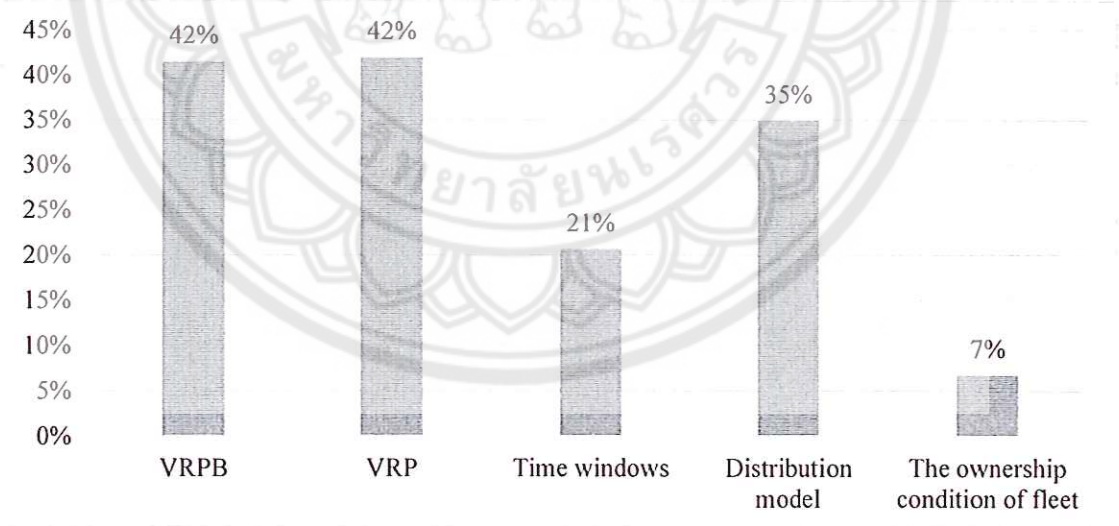

Figure 4 Research fields in reducing transportation cost

It is clear that most of the current study try to do research in the vehicle routing problem (VRP) and vehicle routing problem with backhaul (VRPB), with the purpose of reducing transportation cost.

Belmecheri, Prins, Yalaoui, and Amodeo (2012) studied a complex vehicle routing problem called HVRPMBTW which concerns a logistics/transport society, purpose a Particle Swarm Optimization (PSO) with a local search (Belmecheri, Prins, Yalaoui, and Amodeo, 2012).

Wang and Cao (2008) focus on solve a problem of demand change in the vehicle routing problem with backhaul and time window. (Wang and Cao, 2008).

Toth and Vigo (2001) purpose an extra algorithm for the vehicle routing problem with backhaul to improve the transport efficiency and effectiveness of transport management (Toth and Vigo, 2001).

Although much work has been done in relevant researches, there still lack of researches about the ownership condition of fleet which is an important problem in transportation cost reduction is not explicitly mentioned in most of the papers.

3. Backhaul problem

3.1 The definition of backhaul

There are some study focus on the problem of backhaul and define it. They are shown as follow:

From Wikipedia, backhaul has been defined as follow: In trucking, a backhaul is a hauling cargo back from point B to the originating point A. Since it costs almost as much time and fuel to drive empty as fully loaded this makes economic sense as it pays for the trip back for the trucker.

On the website of "ShipNorthAmerica Transportation", backhaul is the return movement of a truck from its original destination to its original point of origin, especially when carrying goods back over all or part of the same route.

Backhauling means that a truck carries a load when returning from a destination to the area of the origin of the first load(PALANDER, VÄÄTÄINEN, LAUKKANEN, and HARSTELA, 2000).

3.2 Trend of research in backhaul problem

Trend of research in backhaul problem out of 31 papers as shown in figure 5.

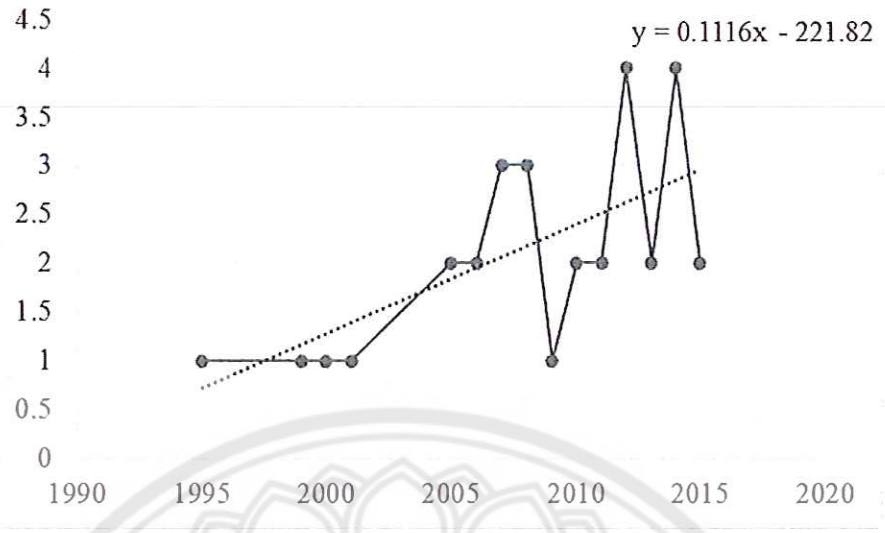

Figure 5 Trend of research about backhaul

Obviously, backhaul problem draws more attention in recent years. Along with the development of the exploration in reducing transportation cost, backhaul problems have emerged, in order to reduce empty backhaul, a growing body of research focus on the improvement and resolve backhaul problems. Previous contributions in the area of backhaul analysis and optimization models mostly examine vehicle routing problem with backhauls (VRPB), which is a class of pick-up/delivery problem. For instance:

T.Kiranoudis (2012) deals with a practical transportation model known as the Vehicle Routing Problem with Backhauls (VRPB), which aims at designing the minimum cost route set for satisfying both delivery and pick-up demands. To effectively diversify the conducted search, the author propose the metaheuristic method and introduce the concept of promises which is a parameter-free algorithmic mechanism based on the regional aspiration of Tabu Search. The proposed methodology was applied to 62 well-known VRPB benchmark instances, exhibiting fine performance. In specific, it managed to match the best-known solution scores for all 62 test problems (T.Kiranoudis, 2012).

Juan, (2011) considering the cost of arranging freight in carriage, set up a mathematic model of vehicle routing problem with backhauls and was solved by using tabu search algorithm. Calculation result shows that the model and the algorithm reduce

the workloads of dispatchers and save the transport costs of logistics enterprises(Juan, 2011).

Xing (2011)Research the vehicle routing problem with backhaul considering uncertain condition, designing efficient reconnoiter search algorithm and conjugate optimization algorithm based on imprecise distance matrix. The effectiveness of reconnoiter search algorithm is validated by calculation example (Xing, 2011).

Hu and Cheng (2010) summarized the vehicle routing problem with reverse logistics and its classification. A mathematical model of the vehicle problem with reverse logistics was constructed based on Vehicle Routing Problems Mixed Pickups and Deliveries with Time Windows (VRPPDTW) and a max-min ant colony algorithm was designed to solve this model. The result was also compared with the results from Tangian and simulated annealing algorithm. It was found that the max-min ant colony algorithm was superior to other algorithms to some extent(Hu and Cheng, 2010).

S. Liu, Liu, and Zhang (2008) research the Vehicle Routing Problem with Backhauls and Time Windows (VRPBTW), develop a model for solving the problem, and improve the Variable Neighborhood Search(VNS) algorithm so as to solve the problem(S. Liu, Liu, and Zhang, 2008).

Yan and Zhang (2015) considered a transportation cost problem with time-window constraints as a biobjective problem in which the size of a fleet of vehicles and total transportation costs are minimized, while capacity and time-window constraints are not violated (Yan and Zhang, 2015).

There are many other studies of backhaul problem looking at backhaul matching problem and the location of distribution notes, for example:

The proposed a backhaul matching optimization model in this research of Ongtang and Sirivunnabood (2014) based on Binary Integer Programming (BIP), provides a promising scheme to improve the network's backhaul matching operation and yield a competitive advantage (Ongtang and Sirivunnabood, 2014).

The study of Hou, Gao, Lu, and Chen (2012) objective is to minimize used vehicles， travelling distances and penalty due to task delay. Based on the collaborative logistics operation mode, the distribution center transportation scheduling optimization model is established Numerical experiment under different problem scales

shows that the hybrid genetic algorithm with initial solutions from sweep heuristics has the best performance (Hou, Gao, Lu, and Chen, 2012).

S. Zhang, Pei, Gao, and Dong (2010) analysis the characteristic of the returning goods distribution and establish the self-organizing feature map (SOFM) location model for the returning goods distribution network. The model was simulated and analyzed using Witness simulation software in two cases with and without the returning goods distribution network. It is verified that the scientific and rational returning goods distribution network is favorable for improving the distribution efficiency and decreasing the operation cost (S. Zhang, Pei, Gao, and Dong, 2010).

3.3. Current situation of backhaul problems in Thailand

The Thailand's backhaul situation as shown in figure 6. Which has revealed that more than 85.75% of weekly truck runs on the road came back empty in Bangkok area, which resulted in high energy consumption and a waste of 37.42% of the expense for fuel on empty backhauls (Chaiyot Peetijade, 2012). In consequence, there are large amount of back trucks are deadhead in Thailand, which is an enormous potential market for companies both of the shipper and the carrier.

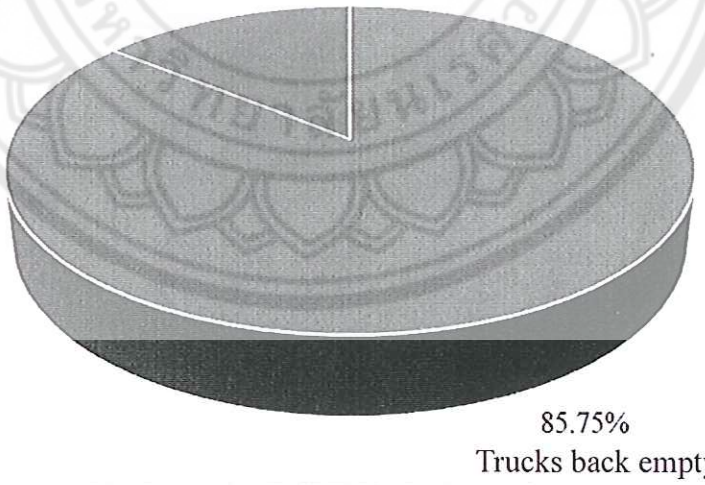

Figure 6 The current situation of backhaul in Thailand

4. Beverage distribution

A number of the relevant researches focus on analysis the characters and developing situation of beverage distribution. As the following papers shown:

T. Li (2012) from the view of logistics and distribution system, use an example of Yanjing Brewery (Chifeng) Limited Liability Company, analyze and evaluate the process of the entire logistics system. At the part of introduce the distribution circumstances of the beer industry, from the beverage logistics circumstances to indicate the situation: The logistics of drinking industry are highly intensive managed by Big Groups and Small regional operation system.

According to the case study, the beer manufacturer's logistics existing strengths and potential disadvantages are summarized as follows:

A. Highway transportation is the most dominating transportation in beer distribution.

B. The main profit source of beer industry is large quantities of low cost of transportation. Therefore the pursuit of low cost strategy is one of the goals of the beer manufacturer.

C. Problems of logistics distribution system in the beer manufacturer:

a. Because of the one-sided pursuit of short distance transportation, go against to expand markets.

b. Possession of most of the market share cause lax management in internal system, outdated logistics distribution mechanism, are not conducive to the innovation and development of the logistics industry.

Another studies look at the optimization of the beverage distribution according to its feature, so as to reduce logistics cost gain more profit of beverage manufacturer (T. Li, 2012).

Zhang Yongjie (2014) proposed some pertinent suggestions to optimize the logistics cost management in the Fast Moving Consumer Goods (FMCG) company, based upon analysis the problems in the different links of the logistics cost management process of a typical FMCG company--the Coca Cola Company.

A. To strengthen the consciousness of logistics cost, optimize the transportation cost.

a. To optimize the transportation path.

b. To advocate road transportation.

B. To strengthen the connecting at the end of the supply chain, optimize the transportation process.

C. To establish the transportation information network, optimize the information management system.

D. To perfect the talent mechanism, optimize the professional personnel training (Zhang Yongjie, 2014).

Gaps in research

In a comprehensive study of the research literature referred to above, almost all of the relevant papers acknowledge the importance and effectiveness of backhauling in reducing transportation costs. However, existing research lacks the factor of fleet ownership, one of the most important factors impacting transportation costs. This study aims to fill this gap by studying a case enterprise (the EDM) using its own transport fleet while simulating the backhaul operation process toward factoring in the transport costs of an in-house transport fleet, including transport costs both before and after backhauling. By comparing the results of an in-house transport fleet (before and after backhauling) with an outsourced fleet, this study shows which ownership condition of a transport fleet (in-house or outsourced) is more cost-effective for the case enterprise.

In addition, there are few studies that address the problem of how backhauling impacts transportation costs in beverage distribution. Moreover, almost no research has considered applying the solution of backhauling to a specific enterprise for the purpose of reducing transportation costs. As such, this innovative and practical approach has been addressed in this study. Therefore, taking the existing research into account, this research on beverage distribution, using case analysis, sets an example for the practice of transport cost reduction by applying backhauling in beverage distribution.

CHAPTER III

RESEARCH METHODOLOGY

The purpose of this chapter is to provide the reader with an understanding of the methodology and relevant research approaches adopted in the research. This study takes an energy drink manufacturer as an example, evaluating the transport costs of a private transport fleet, and analyzes through a simulation the possible impacts of incorporating backhauling into their distribution process on transport costs. In this chapter, the research methods of case analysis, comparative analysis and sensitivity analysis are explained.

Case analysis

1. Purpose of case analysis

The case enterprise in this study is an energy drink manufacturer (EDM). EDM stores products in their warehouse, and then distributes them to their customers located in all around the country. Currently, EDM outsources almost all of their transport business to third party logistics (3PL).

With the development of the business volume and enterprise, in order to strengthen control of the logistics cost and each link in the supply chain, the case enterprise considers taking full control of logistics. In addition, due to the poor management of its 3PL, EDM has to pay for its lack of backhaul management according to its agreement with the 3PL. Occasionally, trucks do arrive from the 3PL provider delivering backhauls, but the manufacturer must to pay for a round trip. The enterprise managers become increasingly interested in changing their logistics mode to an in-house transport fleet, in order to control all processes in logistics operations and thus gain a new profit source through offsetting transport costs; i.e., by running their own logistics operations, including backhauls.

This study collected widely related data from the case enterprise — an energy drink manufacturer (EDM), selected a part of the distribution business, built a virtual transport fleet, and constructed a transport cost model to estimate transportation & logistics costs. Two feasible scenarios for backhauling are proposed in this study for

the purpose of analyzing how backhauling impacts transport costs.

2. Steps of the case analysis

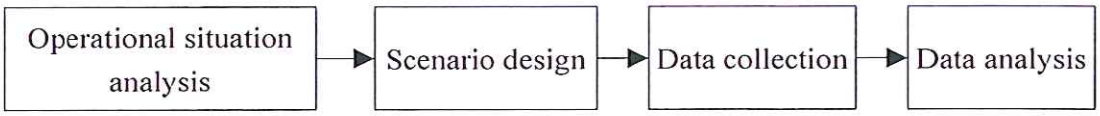

Figure 7 Steps of case analysis

A. Operational situation analysis. This section provides a foundation for scenario design of the private trucking fleet. It provides a brief description of EDM, including background information and operational processes of a private trucking fleet.

B. Scenario design. First of all, the normal operational situation (private trucking fleet but no backhauling) is introduced. Subsequently, two scenarios are designed to simulate operations which include backhauling by a private, in-house trucking fleet. Transport costs of all the three scenarios are calculated in this section.

C. Data collection. All the data used in this study comes mainly from a particular case enterprise (EDM); some are from market data collection, which has the reliability and authenticity for research data.

D. Data analysis. The data analysis is shown in Chapter V by means of comparative analysis and sensitivity analysis methods of the obtained results. Below is the detailed introduction of the comparative analysis method and sensitivity method.

Comparative analysis method

Comparison as the basis of understanding is an effective way for people to understand, distinguish and determine the similarities and differences between things. This comparison includes identification of all related factors toward a complete and comprehensive understanding. At work and in life, comparison is one of the basic ways and also one of the most important methods for human beings to understanding the essence or characteristics of many issues. Currently, the comparative analysis method is routinely used in various fields of scientific research.

The comparative analysis method is a research and judgement method, used to identify similarities or differences at different levels between any two items, and

between human beings themselves. This study mainly focuses on the comparative differences between an in-house, private trucking fleet vs. outsourcing transportation. It also compares three possible scenarios of a private trucking fleet (normal operational situation, Scenario 1, and Scenario 2), which are detailed in Chapter IV: Case study. The comparative study aims to confirm the feasibility of an in-house, private trucking fleet and the validity of the two possible scenarios, in which this study proposes implementation of backhauling.

Sensitivity analysis method

Sensitivity analysis is an important component of traditional economic evaluation. The purpose is to analyze and forecast, within a certain period of time in the future, how conditions will change when objective change occurs (such as the macro environment, government policies, market conditions, economic environment, etc.). The degree to which variations can occur in operations results from each attribute of the project. The model can generally be assumed to be $y = f(x_1, x_2, \dots\dots, x_n)$, (where x_i is the attribute value of i in the model), which results in the attribute i changing within the range of possibilities. The study and forecast of the effects of different attributes thus changes the model value(s).

Put simply, sensitivity analysis is a method that demonstrates the degree of importance and influence that different attributes and input variables have on a model's output variable values in a quantitative way. In this study, the sensitivity analysis method is applied to evaluate the sensitivity of transportation costs to uncertain factors. The core purpose of sensitivity analysis in this study is to determine the impact of each factor in the transport cost model, confirm the key factors influencing transportation costs, and finally to control and supervise these factors in actual operations of the trucking fleet. This is the key to controlling and improving the high sensitivity factors.

1. Sensitivity analysis: steps and content

This study applies single factor sensitivity analysis to discuss factors that impact transportation costs and backhauling implementation. This analysis assumes that other factors are fixed, and changes only one factor at a time for the sensitivity analysis.

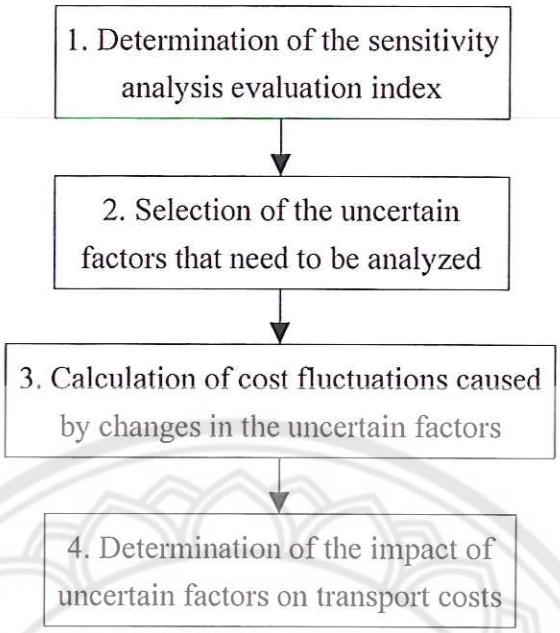

Figure 8 Steps of sensitivity analysis

A. Determination of the sensitivity analysis evaluation index. Selection of the economic index is related to the purpose of the sensitivity analysis. Therefore, unit distance transport cost and monthly transport cost are selected for the evaluation index in this study.

B. Selection of the uncertain factors that need to be analyzed. Although there are usually many factors that can affect the evaluation index, and strictly speaking, all factors that influence the evaluation index have a degree of future uncertainty, it is unnecessary to perform sensitivity analysis for all of these factors; rather, uncertain factors should be selected carefully in advance. There are two guiding principles: Firstly, it is estimated that within their possible range of changes, the factors that change will strongly influence changes in the evaluation index. Secondly, the accuracy of the data used in evaluating is not 100% certain. Combining these two principles, the uncertain factors selected in this study are fuel price, driver salary, vehicle price, maintenance price, administration expenses, tire price, insurance price, toll rates, price of GPS and vehicle tax.

C. Calculation of cost fluctuations caused by changes in the uncertain factors. Analysis of the effect degree of the evaluation index influenced by the changes

of uncertain factors, must start with a normal evaluation index (uncertain factors do not change) for reference. Therefore, the values in the evaluation indexes must be calculated under normal circumstances at first, which was done in the content of the case study. Subsequently, according to the selected uncertain factors, a number of variations are set (at 10% in this study), assuming other factors remain unchanged. Only one factor is changed at a time, and the evaluation indices' value caused by the variations is calculated separately. Repeating the above, the evaluation indices' value is calculated for all factors within their possible range of changes in turn.

D. Determination of the impact of uncertain factors on transport costs. Performing the sensitivity analysis diagram or table to determine the sensitive factors in transportation costs.

CHAPTER IV

CASE STUDY

This chapter selects a part of the EDM's transport rounds to build a transport fleet. A transport cost model was constructed to estimate the transport cost of private logistics by the EDM. Two scenarios were proposed to simulate the feasibility of implementing backhauling by a trucking fleet of the EDM, and work out their transport cost after backhauling implementation.

The following contents of this chapter will describe the operational situation first, including the operation process of the private trucking fleet in general. And combining the situation of the case enterprise (the EDM), separately analyzing the normal operation situation (deadhead), scenario 1 (doing backhaul business and without adding new trucks), and scenario 2 (doing backhaul business and adding new trucks for the purpose of planning and scheduling trucks).

Operation situation analysis

1. Background information

There are two kinds of transport routes used by beverage manufacturers, one is for modern trade and the other one is for traditional trade. Transport routes for modern trade are from warehouse to modern trade DC. Transport routes for traditional trade are of two types, one is direct delivery to their agents, and the other one is delivery to their distribution center (DC) first, their sub- agents will order from the manufacturer's DC, then the products are delivered to the sub-agents from the DC, as shown in Figure 7.

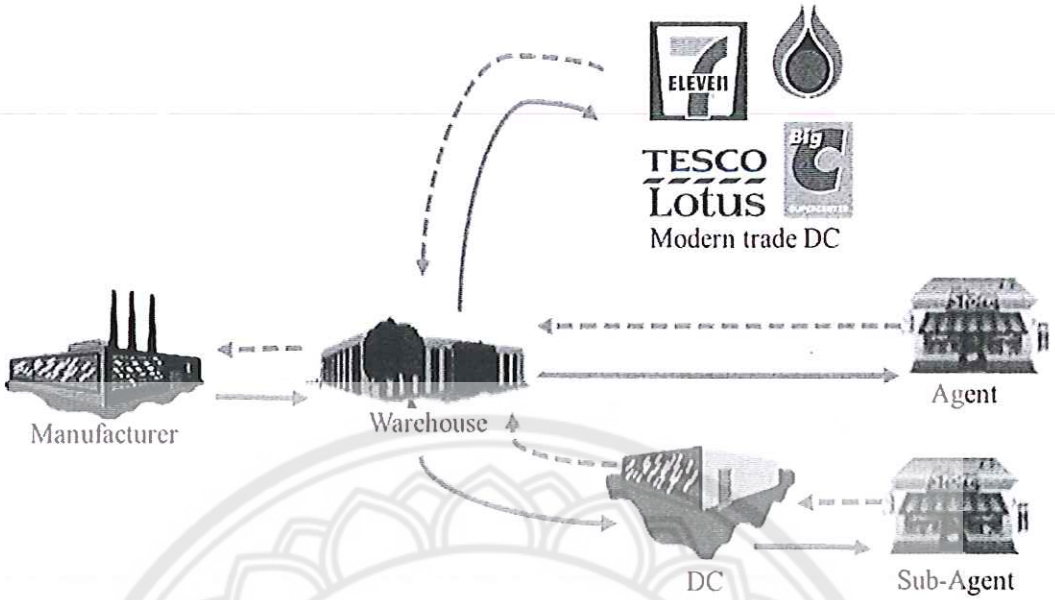

Figure 9 Transport routes of manufacturer

Note: ——→ From manufacturer / warehouse / DC

- - - -→ Return to manufacturer / warehouse / DC

All the EDM's distribution business can be divided into short haul and long haul according to the transport distance in a round trip. Trucks running at a higher speed on an expressway, sometimes driving at a lower speed even stopping to rest, so on average, the trucks speed is about 60 km/hour. Average distance of short haul is 240km, therefore, it needs to spend 4 hours running to the destination for a short haul, adding the same time on the back trip, it needs 8 hours for a round trip for a short haul, and every truck can deliver for two round trips within a day. Average distance of long haul is 720 km, which needs 12 hours to the destination of long haul, and 24 hours for a round trip of long haul. Trucks of long haul can just run a round trip within a day. This study only analyzes the transport route from warehouse to agents. This selected part of the transport business includes 10 round trips of short hauls per day, and 5 round trips of long hauls per day. So 5 trucks are needed to run short haul and 5 trucks to run long hauls every day. The information above is summarized in Table 1.

Table 1 Basic information of the EDM's transport business

Item	Transport type		Unit
	Short haul	Long haul	
Average distance	240	720	km
Average truck-Speed	60	60	km/hour
Time spent in a round trip	8	24	hours
Trucks number	5	5	trucks
Round trips per day / truck	2	1	Round trips
Total round trips per day / truck	10	5	Round trips/day

Table 2 show the charge of 3PL to the EDM, every round trip of short haul costs 6,000 THB, every round trip of long haul costs 20,000 THB.

Table 2 The Costs of 3PL

Item	Cost	Unit
Short haul	6,000	THB/round trip
Long haul	20,000	THB/round trip

2. Operation process

When the EDM uses a private trucking fleet, in general, the operation process can be illustrated as shown in Figure 8. At the point of origin (Site A), a vehicle is loaded fully and then run to the point of destination (Site B), cargos are unloaded at Site B (customers' place), where the need for freight transport is uncertain. In the case of transport needs at Site B, the vehicle is loaded and may go back to Site A. Otherwise (in the case of no transport needed at Site B), the vehicle may return without loading, and finally, parking at Site A.

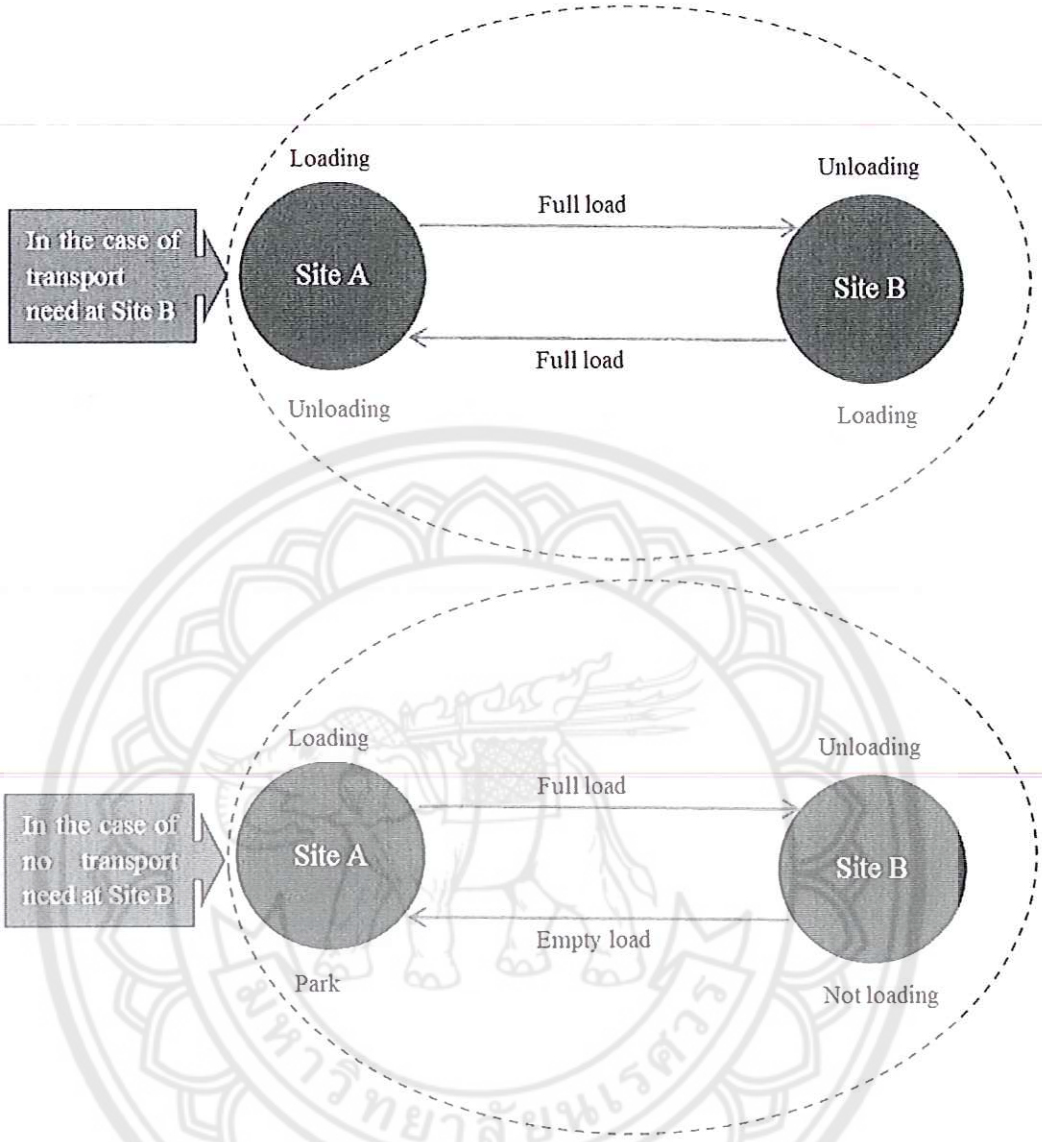

Figure 10 The basic operation process of transport road freight

Normal operational situation: Without backhaul business

1. Vehicle schedule

In normal operation there is no backhaul, so truck-S returns to warehouse immediately after the merchandise is delivered to the destination agents. The vehicle schedule is shown in Figure 9. In this Figure, truck-S represents the group of trucks running short haul, and truck-L means the group of trucks running long haul. Truck-S and truck-L depart from the warehouse at 6:00 every day, 4 hours later, truck-S arrives at the agents' location, after unloading, truck-S returns to the warehouse for the next

round trip. Truck-S arrives at the warehouse (having finished the first round trip's delivery task) and departs from the warehouse again at 14:00. 8 hours later (at 22:00) truck-S has already finished its daily delivery tasks and is waiting for the departure time next day.

Truck-L needs to spend 12 hours to deliver to agents, and 12 more hours again on the return trip, so after truck-L finishes a round trip's delivery and arrives at the warehouse, it is 6:00 on the next day, which is also the time to depart for a new delivery task.

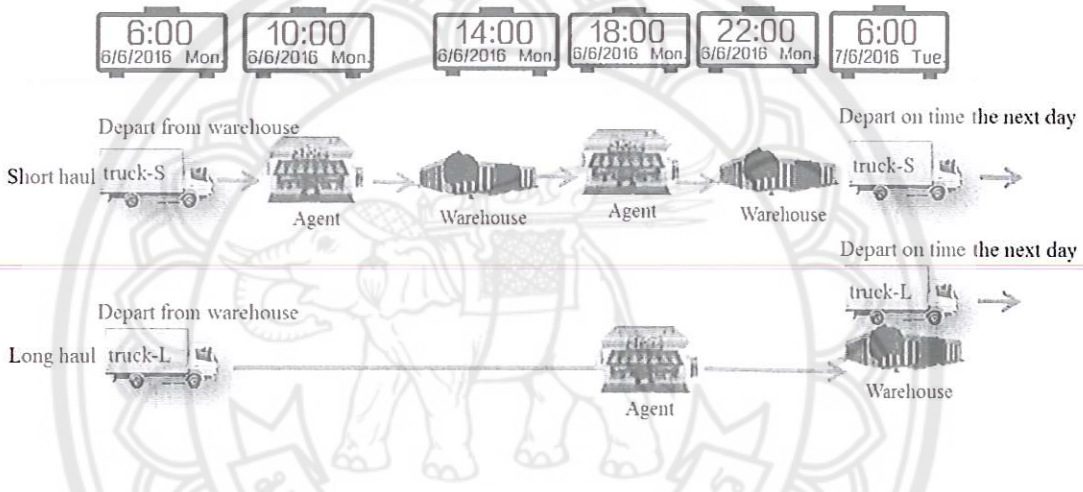

Figure 11 Vehicle schedule of normal operational situation

2. Cost analysis

2.1 Transport cost model construction

In either case (costs for the go trip and costs for the return trip), the cost for the vehicle is the same when it is loaded with the same volume of cargo. The only exception lies on the loading and unloading charges, which could be different depending on different types of cargo. Therefore, the influencing factors are directly related to the transport cost which will be studied only.

Transport costs mainly include the fixed costs and the variable costs. Fixed costs refer to those costs which are unaffected by changes in the level of production, including the administration expense, the depreciation charge, insurance expense, vehicle tax, cost of GPS, and the drivers' salary. The variable costs refer to the

changes in cost for transport distance and transport time, including the fuel surcharge, maintenance expense, tire costs and toll.

Based on the above illustration, the transport cost calculating model can be set up as below.

$$TC = C_{fixed} + C_{variable} \quad (1)$$

In the equation (1),

C_{fixed} indicates the fixed costs;

$C_{variable}$ represents the variable cost.

The function is concluded as:

$$C_{fixed} = C_{admin} + C_{depre} + C_{insure} + C_{vehicle} + C_{GPS} + C_{driver} \quad (2)$$

For the equation (2),

C_{depre} refers to the monthly depreciation charge;

C_{insure} covers the monthly insurance expense;

$C_{vehicle}$ is the monthly vehicle tax;

C_{GPS} represents the monthly cost of GPS;

C_{driver} is the monthly divers salary.

Thus the variable costs is concluded as the equation (3),

$$C_{variable} = C_{fuel} + C_{main} + C_{tires} + C_{toll} \quad (3)$$

C_{fuel} is the monthly fuel surcharge;

C_{main} means the monthly maintenance expense;

C_{tires} represents the monthly tires fee;

C_{toll} refers to toll spent in each month;

2.2 Parameters setting

1. Administration expense

The calculation of the administration expense is based on the expense of the similar business.

Administration expense = Salary of managerial staff + Administration expense of fleet + Training expense + Rental of office equipment + Operating costs

1) Salary of managerial staff

Salary of managerial staff includes monthly wages and other expenses, for example, social security, and welfare etc. Other expenses are for the manager of transport and distribution department including 10% of monthly wages, and including 20% of monthly wages for staff in other positions. Detailed information is shown in Table 3.

Table 3 Salary of managerial staff (THB/month)

Position	Number	Wages	Other expense	Total
Manager	1	80,000	10,000	90,000
Supervisor	2	25,000	5,000	60,000
Transportation officers	2	15,000	3,400	36,800
General officers	3	12,000	2,200	42,600
Total monthly expense				229,400

Expenses for the management fleet are 8,000 THB/month in average.

Expenses in training officers to manage the fleet is 800 THB/month.

Rental of office equipment is 5,000 THB per month. Operating costs (telephone charges, electricity, water, faxes and printing) average 7,000 THB/month.

Administration expenses = 229,400 + 8,000 + 800 + 5,000 + 7,000 = 250,200 (THB/month)

2. Depreciation charge

The depreciation charge is calculated according to the formula:

$$A = \left(P - \frac{F}{(1+i)^N}\right)\left(\frac{i(1+i)^N}{(1+i)^N - 1}\right)$$

A: Depreciation of vehicles (charge in monthly)

P: The current value of the vehicles

F: Vehicle's resale value (count in 35% of current value)

i: Investment interests (count in 12% per month)

N: Service life (calculated for 7 years = 84 months)

Calculation results are shown in Table 4:

Table 4 Depreciation costs of vehicles

	P (THB)	F (THB)	N (month)	i (monthly)	A (THB/month)
Value	2,817,000	985,950	84	0.12	35,182

Depreciation costs for each vehicle is 35,182 THB/month. Therefore, the total depreciation costs for 10 trucks is 351,820 THB/month.

3. Insurance expenses

According to the market price, the vehicle insurance charges include. The insurance fee for a ten wheel truck is 40,000 THB/ year, or 3,333 THB/month. Insurance costs for 10 trucks is 33,330 THB/month.

4. Vehicle tax

The current tax for each vehicle is 4,350 THB /year, including 362.5 THB/month. Vehicle tax for 10 trucks is 3,625 THB/month.

5. Cost of GPS

Cost of GPS according to the current selling price is 9,000 THB/year, maintenance cost is monthly 250 THB. Therefore, the costs of GPS work out to 1,000 THB/month. Cost of GPS for 10 trucks is 10,000 THB/month.

6. Drivers' salary

Monthly expenditure in hiring drivers is calculated from the fixed salary of drivers, not including the special revenues that drivers get from each trip. The fixed salary here means the money that drivers will get, no matter what their workload. In addition, monthly expenditure in hiring drivers still includes the relevant costs to hire employees, for example, social security, health insurance, and uniform fees.

Calculations include the number of employees working on each vehicle, which is calculated by the number of shifts transport related staff working each year divided into shifts for the number of staff working each year.

The following table shows the monthly expenditure for hiring drivers.

Table 5 Drivers' salary (THB)

	Base salary	1 shift	2 shifts	Total
Wage	20,000	22,000	45,452	
Number of drivers	0	10	10	
Monthly expense	0	220,000	454,520	674,520

The drivers' salary is 674,520 THB/month.

The calculation result of fixed costs in shown in Table 6.

Table 6 Fixed cost

Item	Value (THB/month)
Administration expense	250,200
Depreciation charge	351,820
Insurance expense	33,330
Vehicle tax	3,625
Cost of GPS	10,000
Drivers' salary	674,520
Fixed cost in total	1,323,495

7. Fuel surcharge

$$\text{Fuel surcharge (THB/km)} = \frac{\text{Price (THB/L)}}{\text{Fuel consumption(km/L)}}$$

The price of fuel fluctuates each year, but the government has a policy of fixing the price not higher than 30 THB/L, to help the business sector. So the fuel price is calculated at 30 THB/L.

Table 7 Fuel surcharge

	Price(THB/liter)	Fuel consumption(km/liter)	Fuel(THB/km)
Value	30	4.3	6.98

Fuel surcharge is 6.98 THB/km.

8. Maintenance expenses

In transportation operations, maintenance expensse include the costs of components, labor expenses, and consumable fees. Hence, the maintenance expenses can be estimated based on the distance traveled for each vehicle, which follows the maintenance schedule from thevehicle manufacturer, plus twenty percent additional maintenance expenses.

From the maintenance schedule, the maintenance expenses of a ten wheeled truck is 0.8 THB/km, plus 20% additional maintenance work out of the total maintenance expenses of 0.96 THB/km.

9. Tire costs

The average cost of tires is 0.71 THB/km.

10. Tolls

A toll is the charge for using the expressway. During the transportation operation, it is necessary to take the expressway, in order to save time. The general rates for ten wheeled truck are 75 THB per time, or 150 THB per round trip.

Table 8 Variable Costs

Item	Value	Unit
Fuel surcharge	6.98	THB/km
Maintenance expense	0.96	THB/km
Cost of Tires	0.71	THB/km
Toll	150	THB/round trip

$$C_{variable} = 8.65x_d + 150x_r \quad (4)$$

For the equation (4),

x_d represents the total monthly running distance of transport fleet;

x_r refers to the total number of round trips per month of transport fleet.

Thus the above total transport cost is:

$$TC = 1{,}323{,}495 + 8.65x_d + 150x_r \quad (5)$$

From the analysis above, the parametric hypothesis and value of each factor in the normal operational situation are shown in Tables 9 and 10.

Table 9 Parametric Hypothesis

Parameters	Setting value	Unit
Salary of managerial staff	229,400	THB/month
Administration expense of fleet	8,000	THB/month
Training expenses	800	THB/month
Rental of office equipment	5,000	THB/month
Operating cosst	7,000	THB/month
Current value of vehicles	2,817,000	THB/month
Surplus value	985,950	THB/month
Service life	84	Month
Interest on investment	12%	THB/month
Insurance expenses	3,333	THB/month
Vehicle tax	362.5	THB/month
Price of GPS	9,000	THB/year
Maintenance cost of GPS	250	THB/month
Drivers' salary (1 shift)	22,000	THB/month
Drivers' salary (2 shift)	45,452	THB/month
Fuel price	30	THB/liter
Fuel consumption	4.3	Km/liter
Maintenance expenses	0.8	THB/km
Additional maintenance	20%	
Cost of Tires	0.71	THB/km
Toll	150	THB/round trip
Charge of backhaul	15,000	THB/round trip
Overtime fee (150% of drivers' salary)	189	THB/hour

2.3 Cost of normal operation situation

Combining the information of Table 1, truck-S running 10 round trips/day × 30 day/month = 300 round trips/ month, truck-L running 5 round trips/day × 30 day/month = 150 round trips/ month.

Round trips/ month = Round trips/day × 30 day/month;

Distance/month = Distance/round trip × Round trips/month;

The final results of the calculation are shown in Table 10.

Table 10 Cost of normal operational situation

Item	Transport type		Total	Unit
	Short haul	Long haul		
Round trips/month	300	150	450	Round trips/month
Distance/month	144,000	216,000	360,000	Km/month
Fixed cost/month	529,398	794,097	1,323,495	THB/month
Variable cost/month	1,290,131	1,890,197	3,180,328	THB/month

Total cost in normal operation situation = 1,323,495 + 3,180,328 = 4,503,823 (THB/month).

Average cost per unit distance = total cost ÷ monthly distance = 4,503,823 ÷ 360,000 = 12.51 (THB/km).

Scenario 1: Doing backhaul business without adding new trucks

Generally, backhaul mainly applies to long haul not short haul. The main reason is that from the "list of countries by vehicles per capita" shows that, as of 2011, most people prefer to deliver cargos by themselves in short hauls. It is difficult to find backhaul cargos for short haul transport operations, or to earn backhaul business at the expense transport fee reduction. Therefore, it is not worth using backhaul for short delivery services. Thus, this study focuses on using backhaul in long haul operations.

The extra costs are different in doing backhaul with and without trucks added, therefore two scenarios are simulated respectively with and without new trucks added to do backhaul business in this study. First to introduce scenario 1, the transport fleet is

able to process backhaul business operation using its existing vehicles. This scenario is only available for the situation when the departure time of a short haul can be delayed for 2 hours (the extra time in doing the backhaul). This specific method of operation is introduced below.

1. Vehicle schedule of scenario 1

The vehicle schedule of scenario 1 is shown in Figure 10. Truck-S and truck-L depart at 6:00, truck-S completes two round trip deliveries as usual. For the 2 hours extra time spent in picking up and delivering cargos, truck-L which has arranged to do backhaul business, cannot go back to the warehouse at the usual departure time (at 6:00 the next day). In order to make full advantage of the logistics resources and to satisfy the demand of all customers for daily transport, truck-S has arranged to depart at 6:00 on running a long haul on the next day instead of truck-L, which has been delayed for doing backhaul business. Two hours later (at 8:00), backhaul trucks (truck-L) arrive at the warehouse, and they will be assigned to run short haul trips instead of the truck-S.

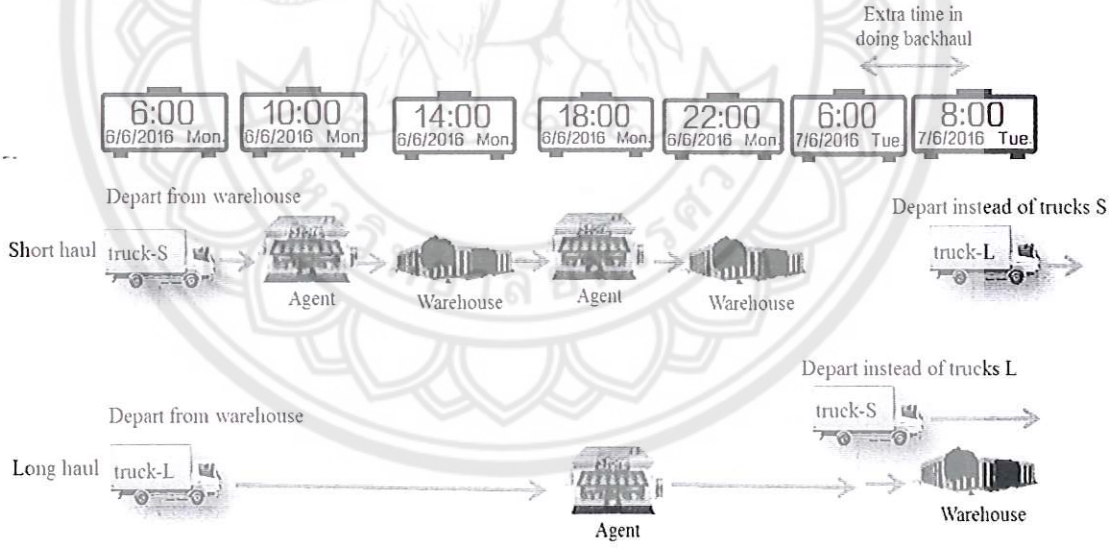

Figure 12 Vehicle schedule of scenario 1

2. Transport cost of scenario 1

Since scenario 1 does not add new trucks into the transport fleet, the fixed costs are the same as the normal operational situation, which is equal to 1,323,495

THB/km. the only difference being in variable costs, because of the extra time spent in doing backhaul business, including fuel surcharge, maintenance expense, tire costs fee and overtime fees of the drivers. Note that because the number of total round trips remains unchanged in scenario 1, therefore, there is no change in any of the factors of variable costs.

Table 11 Extra costs after doing backhaul in scenario 1

Item	Extra costs
1	Fuel surcharge
2	Maintenance expense
3	Tire costs
4	Overtime fees

Computational formula as follows:

Monthly extra fuel surcharge = fuel surcharge/unit distance × monthly extra distance;

Monthly extra maintenance expenses = maintenance expenses/unit distance × monthly extra distance;

Monthly extra tire costs = tire costs/unit distance × monthly extra distance;

Monthly overtime fee = overtime/hour × monthly overtime.

From the description above, combining the computational formula as follows, the basic information of scenario 1 can be summarized in Table 12.

Extra distance/round trip = extra time/round trip × average speed of trucks;

Monthly round trips doing backhaul = round trips (doing backhaul)/day × 30 days;

Monthly extra distance = extra time/round trip × round trips/month;

Monthly overtime = extra time/round trip × round trips/month.

Table 12 Basic information of scenario 1

Item	Value	Unit
Extra time/ round trip	2	Hours
Trucks number doing backhaul (running long haul)	5	trucks
Extra distance/round trip	120	Km/round trip
Monthly round trips doing backhaul	150	Round trips/month
Monthly extra distance	18,000	km
Monthly overtime	300	hours

If we combine Tables 11 and 12, we can obtain the extra costs in scenario 1 as shown in Table 13.

Table 13 Extra cost of scenario 1

Item	Value	Unit
Fuel surcharges	125,581	THB/month
Maintenance expenses	17,280	THB/month
Tire costs	12,780	THB/month
Overtime fees	56,815	THB/month
Total	212,456	THB/month

The total costs of scenario 1 are fixed costs and variable costs plus extra costs in scenario 1. Fixed costs and variable costs have the same value of normal operation situation, so the total costs = 1,323,495 + 3,180,328 + 212,456 = 4,716,276 (THB/month);

Monthly charge of backhaul = charge of backhaul/round trip × round trips/month = 15,000 × 150 = 2,250,000 (THB/month);

Monthly cost after offsetting the charges for backhaul = Total cost of scenario 1 - monthly charge of backhaul = 2,466,279 (THB/month)

Average cost per unit distance = monthly total cost after offsetting ÷ monthly distance = 2,466,279 ÷ 378,000 = 6.52 (THB/km).

Scenario 2: Add new trucks to support backhaul business

This scenario simulates the situation when departure time of both short haul and long haul is fixed at 6:00, this means that if the truck-L is doing backhaul, we have to add the same number of new trucks to depart alternately with the backhaul trucks. The details of this operation are explained as follows.

1. Vehicle schedule of scenario 2

The vehicle schedule of scenario 2 is shown in Figure 11. Truck-S and truck-L depart at 6:00, truck-S runs at the same time as the normal operation. For the 2 hours extra time spent in picking up and delivering back cargos, truck-L which is assigned to do backhaul business, cannot return to the warehouse for the usual departure time. In order to make sure the necessary transportation requirements are satisfied, it is necessary to add new trucks to depart on time at the next day instead of the backhaul trucks, which causes delays for doing backhaul business. Two hours later, backhaul trucks (truck-L) arrive at the warehouse, and wait for the next departure time.

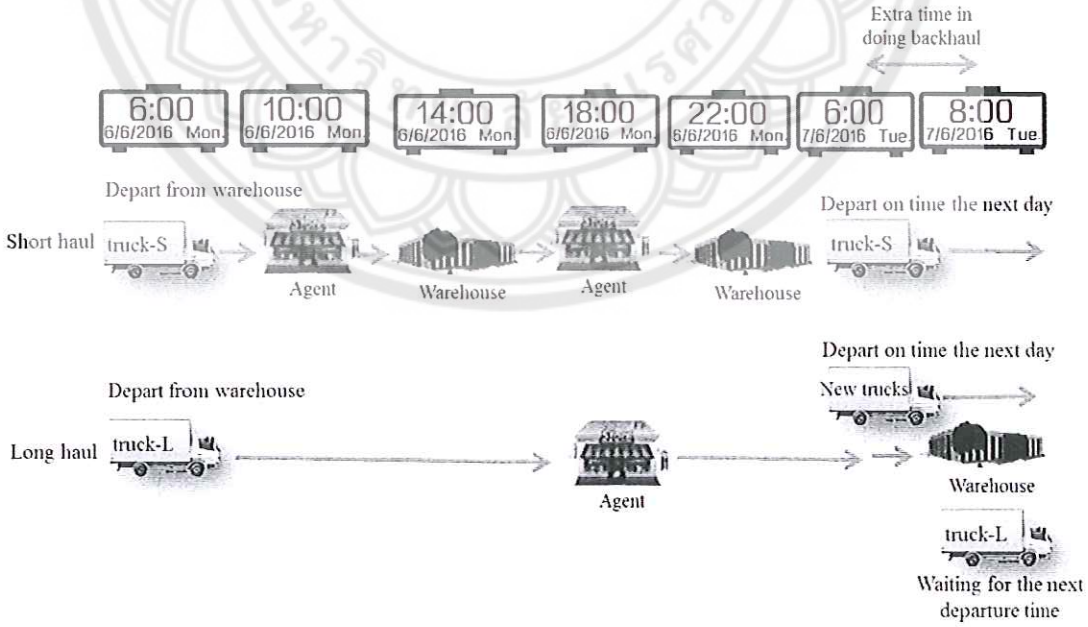

Figure 13 Vehicle schedule of scenario 2

2. Transport cost of scenario 2

Since scenario 2 adds new trucks into the transport fleet, the fixed costs which relate to the number of trucks will change, including depreciation charges, insurance expenses, vehicles tax, cost of GPS and drivers' salary variable costs change which are the same as in scenario 1, including fuel surcharges, maintenance expenses, tire costs fee and overtime fees of drivers. Table 14 below summarizes all of the extra costs in scenario 2.

Table 14 Extra costs after doing backhaul in scenario 2

Item	Extra cost
1	Fuel surcharge
2	Maintenance expense
3	Tires fee
4	Overtime fees
5	Depreciation charges
6	Insurance expenses
7	Vehicle taxes
8	Cost of GPS
9	Drivers' salaries

The computational formula is as follows:

Monthly extra fuel surcharge = fuel surcharge/unit distance × monthly extra distance;

Monthly extra maintenance expense = maintenance expense/unit distance × monthly extra distance;

Monthly extra tires fee = tires fee/unit distance × monthly extra distance;

Monthly overtime fee = overtime/hour × monthly overtime;

Monthly extra depreciation charge = monthly depreciation charge/truck × new trucks number;

Monthly extra insurance expense = monthly insurance expense /truck × new trucks number;

Monthly extra vehicles tax = monthly vehicles tax /truck × new trucks number;

Monthly extra cost of GPS = monthly cost of GPS/truck × number of new trucks;

Monthly new drivers' salaries = monthly new drivers' salaries/truck × number of new trucks.

There are 5 long haul trucks in the transport fleet of the EDM, all the 5 trucks doing backhaul need to add 5 more new trucks. It is necessary to hire at least 2 drivers for each new truck, therefore, the increase in drivers' salaries for each truck is equal to 45,452 × 2 = 90,904 (THB/month). If we combine these details with Table 8, the results of the calculations of the extra costs in scenario 2 are shown in Table 15.

Table 15 Extra cost of scenario 1

Item	Value	Unit
Fuel surcharges	125,581	THB/month
Maintenance expense	17,280	THB/month
Tire costs	12,780	THB/month
Overtime fees	56,815	THB/month
Depreciation charges	175,910	THB/month
Insurance expense	16,665	THB/month
Vehicle taxes	1,813	THB/month
Cost of GPS	5,000	THB/month
Drivers' salaries	454,520	THB/month
Total	866,364	THB/month

The total costs of scenario 2 are fixed costs and variable costs plus extra costs in scenario 2. Fixed costs and variable costs have the same value as the normal operation, so the total costs of scenario 2 = 1,323,495 + 3,180,328 + 866,364 = 5,370,187 (THB/month);

Monthly charge of backhaul = charge of backhaul/round trip × round trips/month = 15,000 × 150 = 2,250,000 (THB/month);

Monthly costs after offsetting with backhaul charges = Total cost of scenario 2 - monthly charge of backhaul = 3,120,187 (THB/month)

Average cost per unit distance = monthly total cost after offsetting ÷ monthly distance = 3,120,187 ÷ 378,000 = 8.25 (THB/km).

CHAPTER V

RESULTS AND DISCUSSION

Based on the transport cost model and the details of the case study (the EDM) transport routes and other parameters, this chapter presents a comparison for the results between a private trucking fleet and outsourcing and with and without backhaul. This is followed by a discussion about the impact of the extra time spent in backhauling, and the impact factors on transport costs as a result of backhauling.

Results

Based on the set of parameters and the transport cost model, out the transport cost structure is shown in Figure 12.

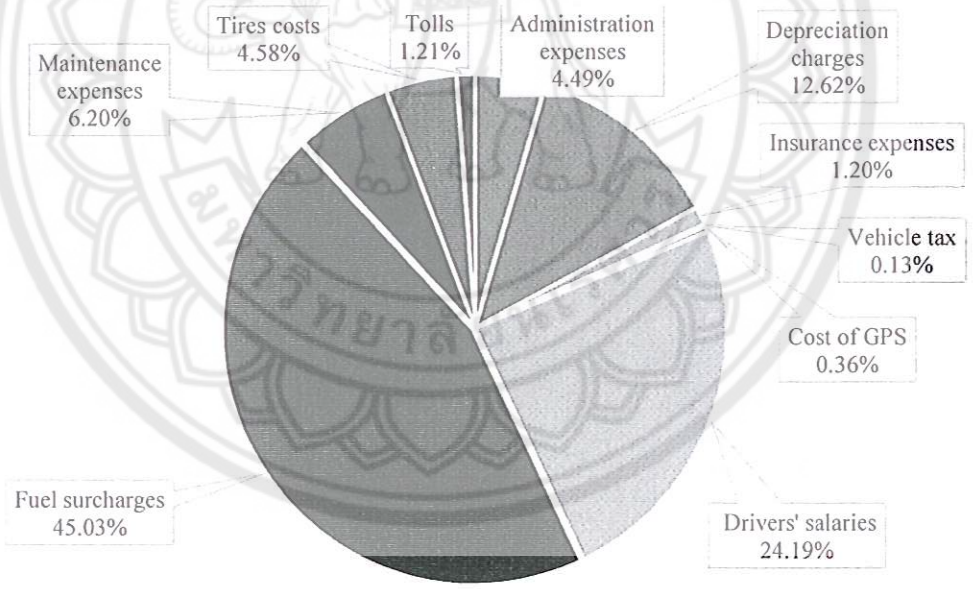

Figure 14 The transport cost structure based on the case study calculations

Thus, is can be seen that fuel surcharges and drivers' salaries are the main costs.

The proportion of fuel surcharges for transport costs more than 50%, which means that for every increase in fuel price, the transport costs will increase by more than 5%. Clearly, the increase in fuel prices directly causes transport costs to increase sharply.

The proportion of transport costs for drivers' salaries is about 15%. In recent years, as the national average for wages has increased, so freight drivers' salaries have also showed an increasing trend. At the same time, long distance freight nowadays requires the drivers' to understand technology and have driving experience, consequently the salaries of long haul drivers' rise year after year.

The sum of depreciation charges, maintenance expenses, tire costs, administration expenses, tolls, insurance expenses and costs of GPS is about 30%.

1. Comparison between private trucking fleet and outsourcing

From the results for transport cost above, monthly transport costs of a normal operation situation is 4,503,823 THB, scenario 1 is 2,466,279 THB, and scenario 2 is 3,120,187 THB. From Table 2, the 3PL charge is for 6,000 THB for a short haul round trip of, and 20,000 THB for a long haul round trip of. In all of the three scenarios (normal operational situation, scenario 1 and scenario 2), the total of monthly round trips for short haul is 300 round trips, and for long haul is 150 round trips, so the monthly charges for short haul are 1,800,000 THB, and the monthly charges for long haul are 3,000,000 THB. Thus, the total charge is equal to 4,800,000 THB per month. This means that the EDM's current monthly transport cost (outsourcing costs) is 4,800,000 THB.A comparison between current outsourcing and a private trucking fleet is shown in Figure 13. It can be seen that the monthly transport costs of all three scenarios are lower than current outsourcing. The percentage of savings for private logistics compared to outsourcing is shown in Figure 14. Private logistics doing backhaul business can reduce transport costs to the greatest extent with 49% savings (without adding trucks), and 35% savings (adding new trucks), respectively.

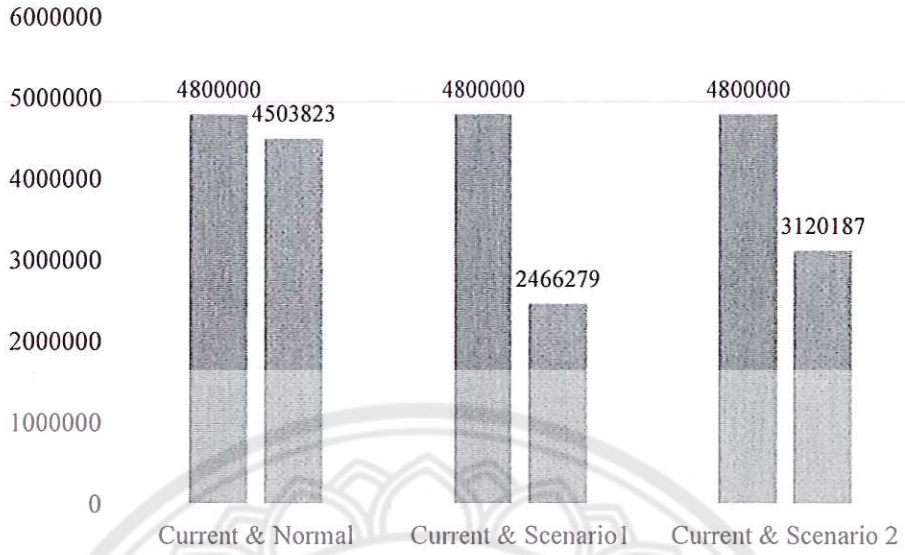

Figure 15 A comparison of the monthly costs between current outsourcing and a private trucking fleet

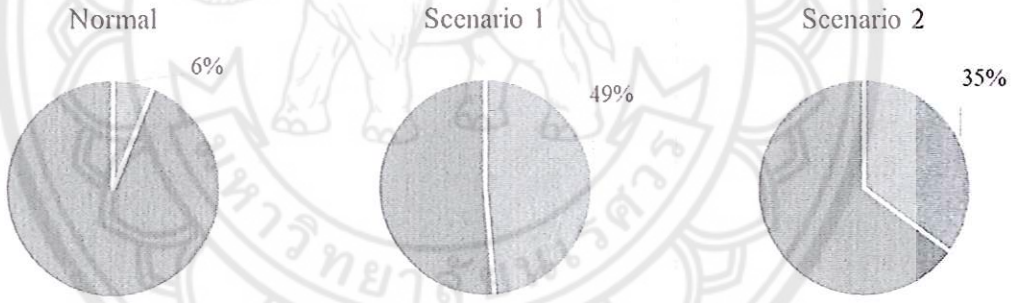

Figure 16 The percentage savings of self-running logistics compared to outsourcing

In summary, due to EDM completing distribution business on its own, it is unnecessary to negotiate the related transportation costs with the 3PL, which avoids the transaction results' indetermination, and in the meantime, reduces transaction risks and costs. In addition, by carrying out the logistics business and backhauling, the logistics resources (trucking fleet) can be fully utilized. The EDM will gain a new source of profit to offset transportation costs. Furthermore, as shown in the final results, whether doing

backhaul or not, a private trucking fleet is more cost effective than current outsourcing for the EDM.

Therefore, to minimize transport costs, it is beneficial to have a private trucking fleet by the EDM.

2. Comparison between backhaul and no backhaul

The calculation of the results for the transport costs shown in Figure 15, indicates that private logistics for the transport route of the EDM from the warehouse to agents requires 4,503,823 THB per month (normal operational situation). But if the transport fleet is doing backhaul business and it is only able to use its existing logistics resources (scenario1), the monthly transport costs will be reduced to 2,466,279 THB, because the costs of backhauling cargos offsets a large amount of the total transport costs. Furthermore, if the existing trucks cannot fulfill the requirements of delivery on time, new trucks should be added to the transport fleet (scenario 2). In this way, the monthly transport costs will increase to 3,120,187 THB, which is 26.5% higher than scenario 1, but still 30.7% lower than for normal operational situations.

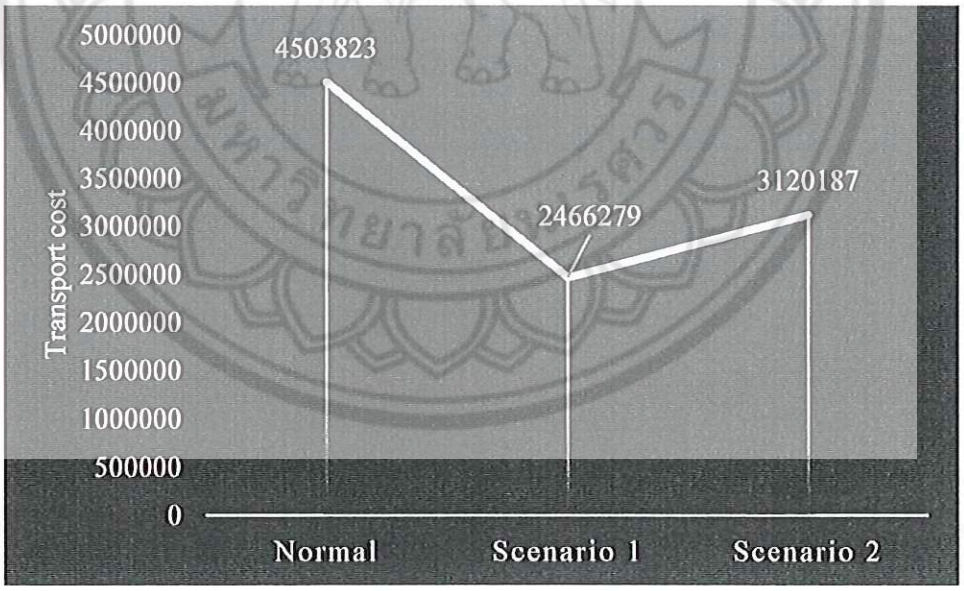

Figure 17 Transport Costs for each Scenario

The transport costs per unit distance of each scenario are shown in Figure 16. The results indicate that self-running logistics and utilizing existing logistics

resources to do backhaul business will obtain the lowest unit distance transport costs, 6.52 THB/km. In addition, adding new trucks to do backhaul takes second place, which is 8.25 THB/km. While the EDM private transport fleet just satisfies its own transport requirements, but does not take into consideration back cargos at all, for which the maximum costs will be 12.51 THB/km.

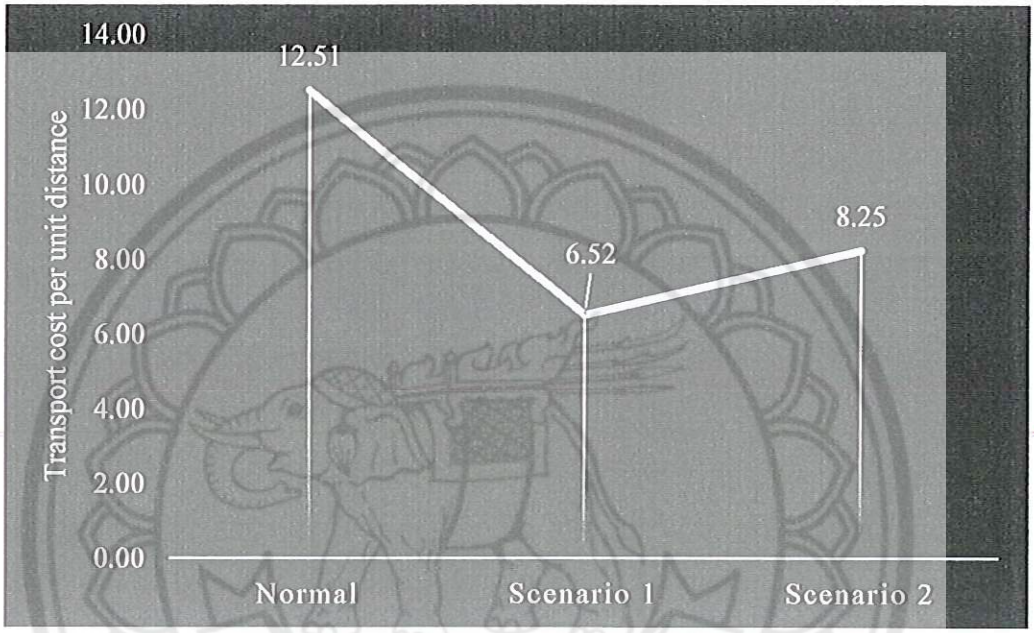

Figure 18 Transport costs per unit distance for each scenario

Discussion

This study uses a case study to explore the feasibility of running a private trucking fleet, for which it also proposes two possible scenarios in backhauling implementation. The results show that a private trucking fleet is more cost effective than outsourcing, especially when the trucking fleet uses backhauling. This study discuss below the impact of extra time (spent on backhauling) on transport costs, and the main factors in transportation costs after implementing backhauling.

1. The impact of extra time (spent on backhauling) on transport costs

Since in Scenario 1, if trucks are only idle 8 hours at most, and if the extra time spent on picking up and delivering back cargos is over 8 hours, the existing number of trucks will not be sufficient to make alternate deliveries. However, the trucks in

Scenario 2 are idle for 22 hours per day at most, because new trucks have been added to the fleet. By increasing the extra time in doing backhaul to both Scenario 1 and Scenario 2, by one hour at a time, starting at 1 hour. Scenario 1 will end at 8 hours, and Scenario will end at 22 hours. The results of the calculation of the transport costs are shown in Figure 16. The specific data is shown in Appendix I.

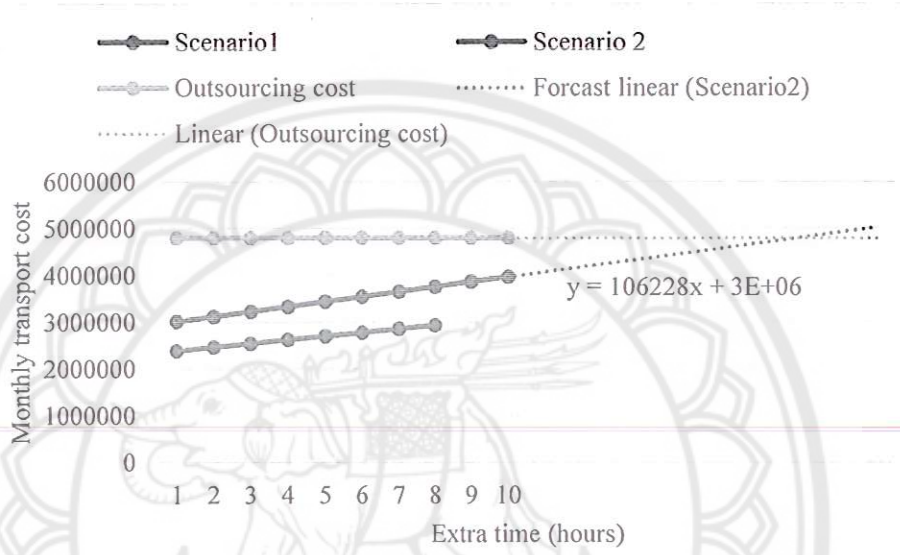

Figure 19 Changes in the transport costs according to increases in time spent

It is clear from Figure 16 that transport costs increase with the amounts of extra time. When the extra time is 17.81325 hours, the transport costs for Scenario 2 are 4,800,000 THB/month above the costs of outsourcing. Therefore, the longer the extra time the higher the transport costs using private logistics and doing backhaul. Thus if the extra time is more than 17.81325 hours, it is not cost effective to use private-build logistics (Scenario 2).

2. The influence of the factors in transport costs for backhaul deliveries

The cost of the transport model includes 10 factors that cause a change in transport costs, namely, fuel price, drivers' salaries, vehicle prices, maintenance prices, administration expenses, tire costs, insurance prices, toll rates, price of GPS and vehicle tax. In order to find the main factors that affect the transport costs of doing backhaul

deliveries, this study considers Scenario 1 and Scenario 2, which are related to the main factors of this case study, for which a sensitivity analysis will be conducted.

The results of the sensitivity analysis for Scenario 1 (Appendix II) and Scenario 2 (Appendix III) are shown in Figures 18 and 19. The horizontal axis is the percentage of factors that change, and the vertical scale is the average unit of transport cost per distance.

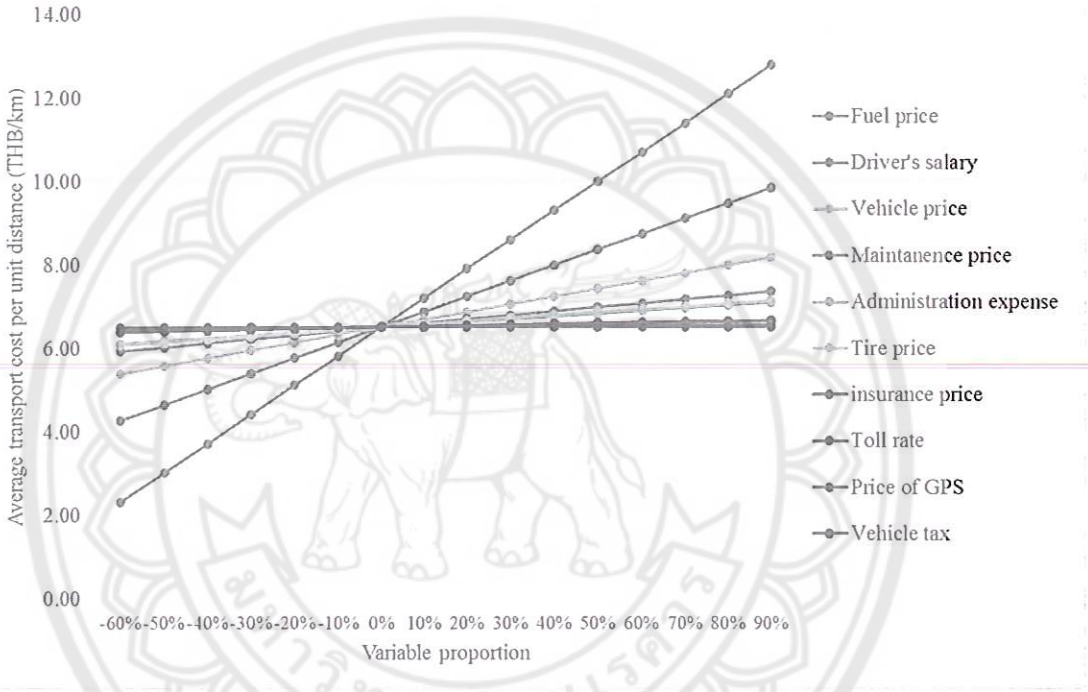

Figure 20 Sensitivity analysis of transport costs per unit distance for Scenario 1

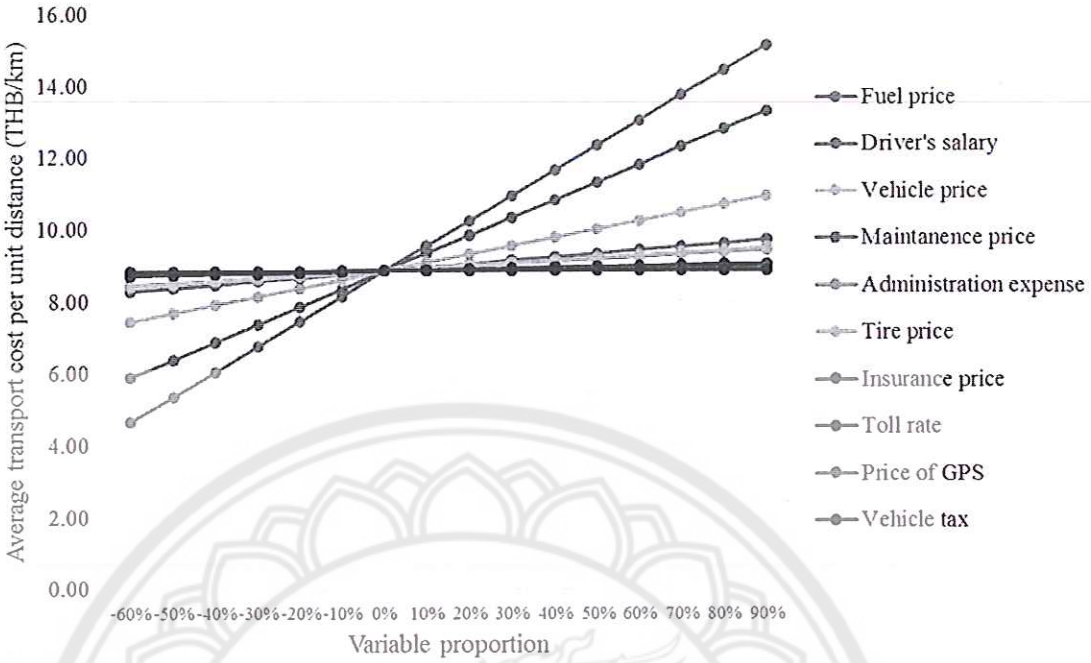

Figure 21 Sensitivity analysis of transport costs per unit distance for Scenario 2

For Scenario 1 of the case study, the changes in the total transport costs caused by every 10% change of each factor are illustrated in Figures 20. As can be seen from the figure, fuel prices changes lead to the biggest variation in monthly transport cost, every 10% rise in fuel prices, monthly transport cost will increase 263,721 THB, every 10% drop in fuel price, monthly transport cost will reduce 263,721 THB. The second is drivers' salaries, every 10% rise in drivers' salaries, monthly transport cost will increase 140,586 THB, every 10% drop, monthly transport cost will reduce 140,586 THB.

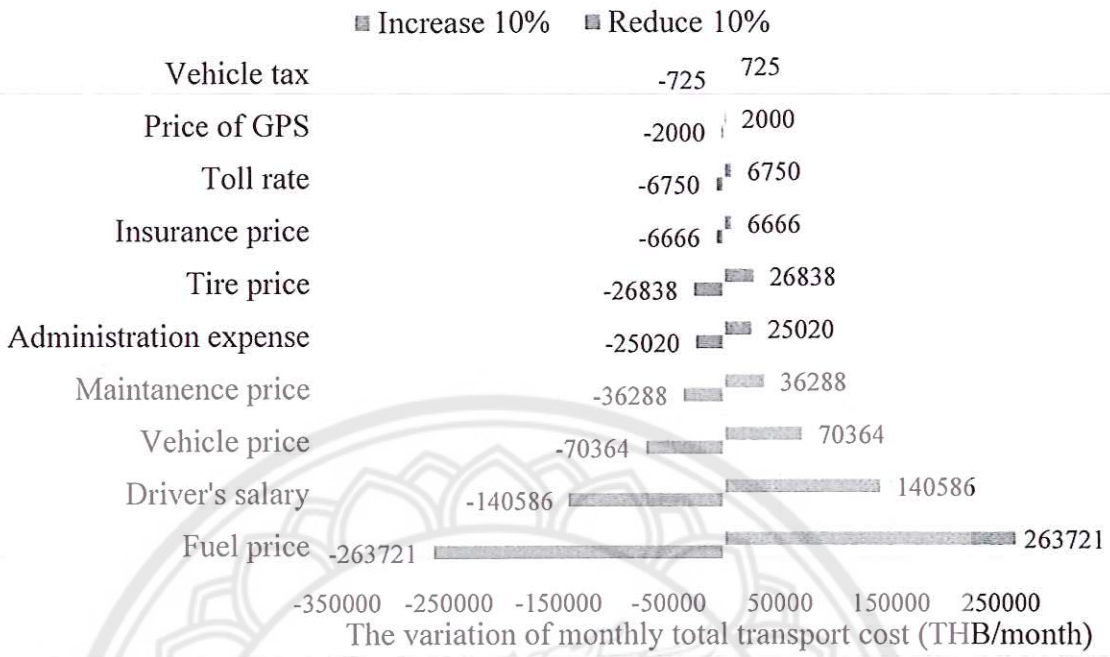

Figure 22 The variations in the total monthly transport costs of Scenario 1 when the single factors are changed

For Scenario 2 of the case study, the changes in the total transport costs caused by every 10% change of each factor are illustrated in Figures 21. From the figure, every 10% rise in fuel prices, monthly transport cost will increase 263,721 THB, every drop 10% in fuel price, monthly transport cost will reduce 263,721 THB. The second is drivers' salaries, every 10% rise in drivers' salaries, monthly transport cost will increase 186,038 THB, every 10% drop, monthly transport cost will reduce 186,038 THB.

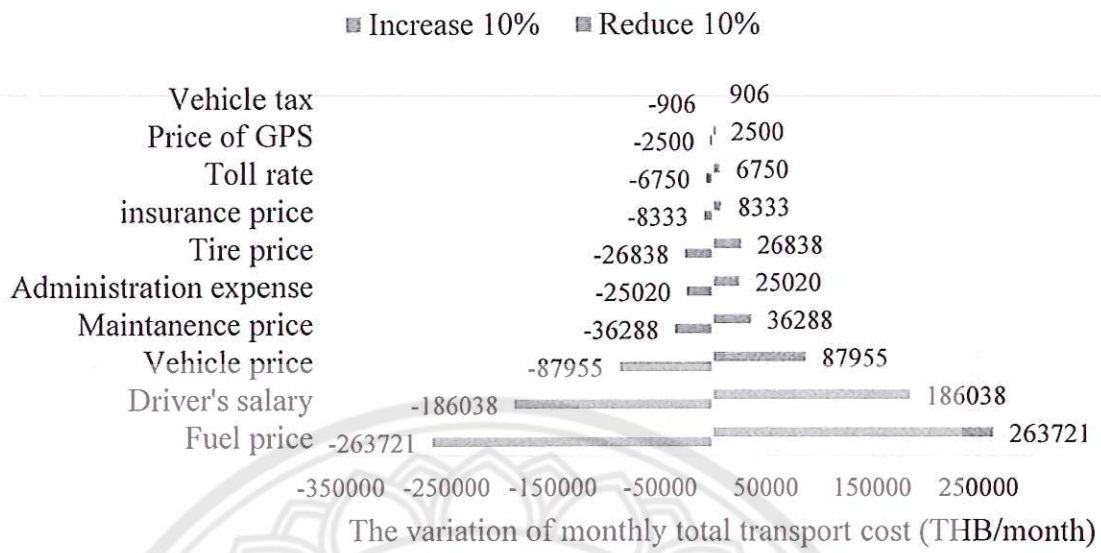

Figure 23 The variations in the total monthly transport costs of Scenario 2 when the single factors are changed

Combining the information from four figures above (Figure 18, 19, 20, 21), we find that although there are some differences in the values of the variations for the total monthly transport costs when single factors in Scenario 1 and Scenario 2 are changed, the sensitivity of each factor is basically the same in both scenarios. According to the impact of the factors to on the average transport costs per unit distance from the highest to the lowest, these factors can be divided into 5 categories.

The first category is the high sensitive factors, which means that the average unit distance will result in a rapid increase in transport costs as cost of each factor increases. In this study, the fuel price is the high driving factors in transport costs. Every 10% increase in fuel price will lead to an increase of 0.7 THB for an average unit distance, and the total monthly transport costs will increase to 263,721 THB/month.

The second category is the medium to high sensitive factors, which means that as the growth of the factors of price or cost, the average unit distance transport cost will increasing comparatively rapidly. Drivers' salaries and vehicle prices are at a medium to high level in the transport costs. In recent years, with a general increase in basic salaries, the drivers' salaries have also increased proportionately, leading to increases in transport costs to some extent.

The third category is at the level of medium to low sensitive factors, which means that as the prices or cost grow, so, the transport costs for the average unit distance will also show an increasing trend. Maintenance prices, administration expenses and tire costs are at the medium to low level of the factor in transport cost. These factors increase the total monthly transport cost by 10%, which will increase the total cost to about 3,000 THB/month.

The fourth category is at a low sensitive level in the factors affecting costs, because it may not be obvious the increases in transport costs for the average unit distance is directly related to the general growth of prices or costs of the various factors, such as insurance costs, toll rates, costs of GPS and vehicle tax, which are at a relatively low level in the list of factors, these factors increase the total monthly transport cost by 10% which is less than 1,000 THB/month.

CHAPTER VI

CONCLISION AND RECOMMENDATION

Conclusions

On the basis of previous research in the relevant area, combining the current situation of the case study of an energy drink manufacturer, this study proposed to investigate a private trucking fleet and using backhauling in the beverage distribution, offsetting transport costs with the use of backhauling to improve market competitiveness.

In order to explore a set of feasible scenarios that can reduce transport costs for the case study, a private trucking fleet was proposed and its operational costs calculated (normal operational situation) in this study, which is based on the situation of the case study (the EDM) for the purpose of reducing logistics costs. Furthermore, to find out reasonable scenarios for backhauling to offset transport costs by charging for backhauling, this study simulates two scenarios of a private trucking fleet using backhauling, including their vehicle scheduling simulation and calculations of the transport costs. The results show that a private trucking fleet will help the EDM reduce 6% of the transport costs. If the transport fleet can use backhauling as in Scenario 1 (without new trucks being added), it will help to reduce 49% of the transport costs, or reduce 35% while the trucking fleet is using backhauling as in Scenario 2 (adding new trucks to support backhauling).

The results show that the transport costs increase with increasing extra time spent in picking up and delivering backhaul cargoes. If the extra time is equal or shorter than 8 hours, both Scenario 1 and Scenario 2 are feasible for the EDM, because transport costs will still be lower than outsourcing. When the extra time is longer than 8 hours, only Scenario 2 works as usual but it is still better than outsourcing. But if the extra time is longer than 17.8 hours, the transport costs for Scenario 2 are higher than outsourcing logistics. Therefore, it is not feasible to use private logistics when the extra time is too long.

From the results of the sensitivity analysis of the transport cost factors, it is clear that fuel price is the most important factor to impact on transport costs, then the

drivers' salaries and maintenance costs. But such factors as vehicle tax, price of GPS, toll rates and insurance costs, do not have much effect on the total transport costs.

This study provides references for businesses which are considering whether or not to use a private trucking fleet, and how to implement backhauling with minimal transport costs while using a private trucking fleet. Moreover, this study provides an evaluation of the use of a private trucking fleet in deciding whether to implement backhauling, and whether it is necessary to retain key prevention measure and to take into account which impact factors play an important role in using backhauling.

Recommendations

Firstly, this study only focuses on an analysis of the EDM's transport routes: "warehouse-agents", that are only one part of all the EDM's distribution business, so that future research should include other approaches to different transport routes: for example, "warehouse-modern DC" and "warehouse-the EDM's DC-agents", or even research on other companies in different industries.

Secondly, this study does not consider the influence of uncertain factors or the operational costs in choosing the right 3PL, which has resulted in errors in the calculation of the results for this study. It is of importance to conduct some research on how to measure the uncertain factors and the operational costs involved in choosing the right 3PL in future research, so as to reduce or eliminate possible errors.

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APPENDIX

APPENDIX I CHANGES IN THE TRANSPORT COSTS WITH DIFFERENT EXTRA TIME

Extra time (hours)	Transport cost of scenario 1 (THB/month)	Transport cost of scenario 2 (THB/month)
1	2388459	3013959
2	2466279	3120187
3	2544100	3226415
4	2621921	3332643
5	2699741	3438871
6	2777562	3545099
7	2855383	3651328
8	2933203	3757556
9		3863784
10		3970012

APPENDIX II CHANGES IN THE UNIT DISTANCE TRANSPORT COST ALONG WITH THE CHANGE OF FACTORS IN SCENARIO 1

Variable proportion	Fuel price	Driver's salary	Vehicle price	Maintenance price	Administration expense	Tire price	insurance price	Toll rate	Price of GPS	Vehicle tax
-60%	2.34	4.29	5.41	5.95	6.13	6.10	6.42	6.42	6.49	6.51
-50%	3.04	4.66	5.59	6.04	6.19	6.17	6.44	6.44	6.50	6.51
-40%	3.73	5.04	5.78	6.14	6.26	6.24	6.45	6.45	6.50	6.52
-30%	4.43	5.41	5.97	6.24	6.33	6.31	6.47	6.47	6.51	6.52
-20%	5.13	5.78	6.15	6.33	6.39	6.38	6.49	6.49	6.51	6.52
-10%	5.83	6.15	6.34	6.43	6.46	6.45	6.51	6.51	6.52	6.52
0%	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52
10%	7.22	6.90	6.71	6.62	6.59	6.60	6.54	6.54	6.53	6.53
20%	7.92	7.27	6.90	6.72	6.66	6.67	6.56	6.56	6.54	6.53
30%	8.62	7.64	7.08	6.81	6.72	6.74	6.58	6.58	6.54	6.53
40%	9.32	8.01	7.27	6.91	6.79	6.81	6.60	6.60	6.55	6.53
50%	10.01	8.38	7.46	7.00	6.86	6.88	6.61	6.61	6.55	6.53
60%	10.71	8.76	7.64	7.10	6.92	6.95	6.63	6.63	6.56	6.54
70%	11.41	9.13	7.83	7.20	6.99	7.02	6.65	6.65	6.56	6.54
80%	12.11	9.50	8.01	7.29	7.05	7.09	6.67	6.67	6.57	6.54
90%	12.80	9.87	8.20	7.39	7.12	7.16	6.68	6.69	6.57	6.54

GLOSSARY

GLOSSARY

Backhaul	:	The process of a transportation vehicle returning from the original destination point to the point of origin.
Carrier	:	A firm that transports goods or people via land, sea, or air.
Cargo	:	Merchandise carried by a means of transportation.
Deadhead	:	The return of an empty transportation container to its point of origin.
Distribution	:	This includes costs associated with warehouse space and management, finished goods receiving and stocking, processing shipments, picking and consolidating, selecting carriers, and staging products/systems.
Fixed Costs	:	Costs which do not fluctuate with business volume in the short run. Fixed costs include items such as depreciation on buildings and fixtures.
Freight	:	Goods being transported from one place to another.
Freight Charge	:	The rate established for transporting freight.
Outsource	:	To utilize a third party provider to perform services previously performed in house. Examples include manufacturing of products and call center/customer support.
Payment	:	The transfer of money, or other agreed upon medium, for provision of goods or services.
Private Trucking Fleets	:	Private fleets serve the needs of their owners, and do not ordinarily offer commercial trucking services to other customers. Private fleets

		typically perform distribution or service functions.
Resources	:	Economic elements applied or used in the performance of activities or to directly support cost objects. They include people, materials, supplies, equipment, technologies, and facilities.
Shelf Life	:	The amount of time an item may be held in inventory before it becomes unusable. Shelf life is a consideration for food and drugs which deteriorate over time, and for high-tech products which become obsolete quickly.
Shipper	:	The party that tenders goods for transportation.
Third Party Logistics (3PL)	:	A firm which provides multiple logistics services for use by customers. Preferably, these services are integrated or bundled together, by the provider. These firms facilitate the movement of parts and materials from suppliers to manufacturers, and finished products from manufacturers, and finished products from manufacturers to distributors and retailers. Among the services they provide are transportation, warehousing, cross docking, inventory management, packaging, and freight forwarding.
Transaction	:	A single completed transmission, e.g., transmission of an invoice over an EDI network. Analogous to usage of the term in data processing in which a transaction can be an inquiry or a range of updates and trading transactions. The definition is important for EDI service operators who must interpret invoices and other documents.

Variable Cost	:	A cost that fluctuates with the volume or activity level of business.

BIOGRAPHY

BIOGRAPHY

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