BID PRICE GENERATION MODEL FOR CARRIERS IN COMBINATORIAL TRANSPORTATION AUCTION

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พิทวัส เอื้อสังคมเศรษฐ์: แบบจำลองการสร้างราคาประมูลของผู้ประกอบการขนส่งในการประมูลเชิงจัดกลุ่มเพื่อการจัดหาบริการขนส่ง (Bid Price Generation Model for Carriers in Combinatorial Transportation Auction) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. มาโนช โลหเตปานนท์, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม : รศ. ดร. พงศา พรชัยวิเศษกุล, 108 หน้า.

สำหรับการประมูลเชิงจัดกลุ่มเพื่อการจัดหาบริการขนส่งในงานวิจัยนี้ ผู้วิจัยได้นำเสนอกลยุทธ์การประมูลราคาสำหรับผู้ประกอบการขนส่งที่ประสบปัญหาการประเมินราคาต่อเส้นทางการให้บริการขนส่งต่างๆ ทั้งนี้สมการถดถอยในงานวิจัยนี้ใช้ราคาประมูลต่อต้นทุนการปฏิบัติการของผู้ประกอบการขนส่งรถบรรทุกประเทศไทยเป็นตัวแทนในการนำเสนอพฤติกรรมการประมูลเชิงจัดกลุ่ม โดยสมการดังกล่าวช่วยผู้ประกอบการขนส่งในการประเมินราคาค่าบริการขนส่งต่อรูปแบบการขนส่งและสภาพแวดล้อมของการแข่งขันของงานประมูลต่างๆ สำหรับผลลัพธ์ของการทดสอบสมมติฐานด้วยการวิเคราะห์เชิงสถิติแบบ t-test พบว่ารูปแบบเส้นทางการให้บริการขนส่งของงานประมูล, จำนวนของคู่แข่ง, ระยะทางของรถเที่ยวเปล่าปัจจุบันต่อระยะทางของเส้นทางใหม่และ ผลคูณระหว่างจำนวนของคู่แข่งและระยะทางของรถเที่ยวเปล่าปัจจุบันต่อระยะทางของเส้นทางใหม่ มีผลกระทบต่อราคาประมูลต่อต้นทุนการปฏิบัติการขนส่งอย่างมีนัยสำคัญทางสถิติ นอกจากนี้เพื่อการหาราคาประมูลที่เหมาะสมที่สุดในการแข่งขันสำหรับแพ็กเกจของการประมูลเชิงจัดกลุ่มซึ่งผู้เข้าแข่งขันไม่ทราบข้อมูลของคู่แข่ง ด้วยเหตุนี้วิธีการวิจัยของวิทยานิพนธ์ฉบับนี้จึงใช้วิธีการจำลองสถานการณ์ซึ่งประยุกต์วิธีมอนติคาร์โล, สมการถดถอย, ปัญหาการคัดเลือกผู้ชนะ และแบบจำลองค่าที่เหมาะสมแบบไม่มีความแน่นอน ซึ่งผู้ประมูลสามารถหาราคาประมูลที่เหมาะสมที่สุดเพื่อให้ได้รับกำไรที่คาดหวังมากที่สุดของแต่ละแพ็กเกจ ยิ่งกว่านั้นผลการทดลองแสดงผลว่าราคาประมูลที่เหมาะสมที่สุดของผู้ประมูลสามารถเพิ่มผลกำไรที่คาดหวังได้มากกว่าราคาประมูลของตลาดขนส่งอย่างชัดเจน ขณะที่ผู้ว่าจ้างขนส่งได้ประโยชน์จากการลดต้นทุนการจัดซื้อบริการขนส่งจากราคาดังกล่าวที่ได้จากวิธีการวิจัยนี้

สาขาวิชา การจัดการด้านโลจิสติกส์	ลายมือชื่อนิสิต ....
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	ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม ....

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PITTAWAT UEASANGKOMSATE : BID PRICE GENERATION MODEL FOR CARRIERS IN COMBINATORIAL TRANSPORTATION AUCTION. ADVISOR : ASST. PROF. MANOJ LOHATEPANONT,Ph.D., CO-ADVISOR : ASSOC. PROF. PONGSA PORNCHAIWISESKUL,Ph.D., 108 pp.

In combinatorial auction for truckload transportation service procurement, we introduce the bidding strategy for carrier facing the hard valuation problem to all possible routes. The regression model uses a bid-to-cost ratio of carriers surveyed in Thailand to represent the bidding behavior in combinatorial auction. This model facilitates carrier to value the bid price for interested packages that involve with pattern of transportation service under different competitive environment. The results of analysis with hypotheses by t-test reveal significantly that a pattern of transportation service, a number of competitors, and a pre-empty backhaul to new lane distance ratio with number of competitors do impact negatively on a bid-to-cost ratio of carrier, whereas a pre-empty backhaul to new lane distance ratio does impact positively on a bid-to-cost ratio of carrier in combinatorial auction. To find optimal bid price for interested packages in the incomplete information game, the research methodology in which captures Monte-Carlo Simulation, Regression Model, Winder Determination Problem and Stochastic Optimization Model could provide the best solution to acquire the maximum expected profit. The results present that the benefit with optimal solution of bidder is more than the average market price in the competition considerably. While in turn the results also show that shipper could potentially reduce the cost of transport service procurement with this model.

Field of Study : Logistics Management Student's Signature ....
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Contents

Chapter Page

List of Tables

Table Page

Table Page

List of Figures

Chapter 1

Introduction

1.1 Background and Problem Review

The transportation plays an important role in driving the economy because it is crucial to distribute goods or materials from producer to marketplace according to demand and supply of market throughout transportation network into each area. In Thailand, one of the most important and favored transportation modes for domestic shipment is land transport by trucks. This is because they are expedient, fast and flexible to shipments base on geographic and infrastructure constraint. Hence, the land transport by truck in Thailand is more practical in order to meet consumers' requirement and provides higher quality of service than other modes. Regarding the statistics of Department of Land Transport in Thailand, It reported that land freight transportation in 2010 accounted for 419.3 million tons per year or more than 82.6% of total domestic transportation market (1st ranking).

Table 1.1: Domestic Transportation (During 2006-2010)

Transport Mode	2006	2007	2008	2009	2010
Land Transport	427,581	428,123	424,456	423,677	419,318
Rail Transport	11,579	11,055	12,807	11,133	11,288
Water Transport	40,340	47,229	47,687	41,561	48,185
Coastal Shipping	31,574	31,216	29,615	29,311	29,004
Air Transport	122	110	106	103	121

Source: Department of Land Transport, Thailand (Unit Kg.-Ton.)

The majority of the cost in land transport comes from fuel, of which carriers cannot control its price. It is subject to high volatility according to global oil market in which relates to international trade and political situation. Thus, having an effective management and planning on land transport by truck is very imperative to transportation cost management.

The demand for transportation was created by shippers e.g., manufacturers and retailers who need freight to be transported to marketplace (Lee et al., 2007). However, the scheme of providing the transportation service for goods or materials of producer or manufacturer has been developed in order. At first, shippers used their private fleets to distribute the products by themselves (Song and Regan, 2003). While, the demand of transportation service regarding requirement of consumer has increased significantly because of expanding of local and global market continuously, it then impacts directly to shippers who has not been sufficient of in-house transportation capacity.

Therefore, shippers have initially used the *Request for Proposal* (RFP) to invite a set of carriers to participate in the auction in order to procure transportation service from them with lane by lane, from which contract prices and service period are based (Sheffi, 2004). This process is the same as a simple sealed-bid auction in which each bidder is able to submit their bids for an interested item individually (Song and Regan, 2003). In RFP, shippers announce the contract for a set of distinctive delivery routes (called lanes) in which specifies an origin-destination pair for particular shipment with different path and delivery schedule (Vried et al., 2003). To procure transportation service by RFP, most shippers have used it until the late 1990, while some shippers still manipulate this method (Sheffi, 2004) including shippers in Thailand.

Each bidder engaging in this traditional auction has to submit bids on interested individual lane separately. After that shipper will assess bids with lane submitted by carriers, and shipper then assigns lanes to the winners according to various criteria e.g., price, business requirements (Lee et al., 2007). Thus, traditional transportation auction does not guarantee carriers to acquire a complete set or cycle route of individual lanes, and may cause an empty backhaul or repositioning cost called *Exposure Problem* (Kwasnica et al., 2005). In Thailand, the Department of Land Transport revealed in 2006 that the land transport by truck had the empty back haul at 46% of total truck shipments or 33 million hauls. It indicated that carriers consumed fuel uselessly estimated in amount of 22.5 billion baht lost per year (Department of Land Transport, 2006). Specifically, this problem is still the critical economic issue in Thailand up to the present time particularly.

To overcome this problem, *Combinatorial Auction* (CA) has been considering in the matter. That is, it allows carrier to submit multiple bids in combination of individual lanes (Elmaghraby and Keskinocak, 2002). Combinatorial auctions have been applied extensively in transportation service procurement in USA. Carriers joining in combinatorial auction could reduce empty backhaul or repositioning cost to meet economies of scope while shippers also cut their cost of transport procurement (Sheffi, 2004). For example, Sears Logistics, who is shipper, designed and used combinatorial auction in 1993 to procure transportation truckload service from carriers in which can save cost around 84 million dollars per year (Song and Regan, 2005; Vries et al., 2003). In addition, many companies e.g., Ford Motor, Wal-Mart, K-Mart, Home Depot, Compaq etc. have also used combinatorial auctions to procure transport service effectively. Furthermore, shippers have used the optimization model called *Winner Determination Problem* (WDP) to allocate the awarded bids to the winner in order to minimize the total cost of transportation service procurement (Vries et al., 2003; Caplice and Sheffi, 2003; Song and Regan, 2003).

However, the number of possible routes (called packages) for carriers to submit bids into combinatorial auction is exponential in the number of individual lanes announced by shipper. Thus, carriers face the hard valuation problem to determine the bid price for interested packages, and also they make a hard decision on which packages should be bided for into the combinatorial auction (An et al., 2005). Moreover, the study on competitive bidding strategies for carriers to submit the optimal bid price into combinatorial transportation auction in order to obtain the maximum expected profit has less attention so far.

By these reasons, the author realizes the importance and contribution of this necessary part. Thus, in this dissertation the author will focus on the bidding price for carrier with competitive bidding strategies in combinatorial transportation auction in Thailand. Carriers then could apply the model formulation developed in this dissertation to find the optimal bid price in combinatorial transportation auction under different characteristic of competition. That is, it could facilitate carriers to submit their bids including optimal bid price of each potential packages appropriately according to transportation network requirement of shipper. Specifically, carrier could obtain the maximum expected profit with probability of winning in the combinatorial transportation auction.

1.2 Research Objectives

Based on the previous discussion, this dissertation aims to achieve the research objectives as the following:

1. To develop the bid price generation model for carriers in combinatorial transportation auction in Thailand.
2. To find the optimal bid price for carriers in order to obtain the maximum expected profit in combinatorial transportation auction.
3. To determine the relationship and impact between involved factors to bid price of combinatorial transportation auction.

1.3 Scope of Study

For scope of study in this dissertation, the author focuses on bid price generation model in combinatorial transportation auction. The author employs a bid-to-cost ratio of carriers in Thailand to represent the behavior of bidding in freight transportation service market. Because the full truckload operation has been sensitive on the economies of scope, therefore, we study the full truckload carrier in combinatorial transportation auction. In addition, the conceptual framework of this study seeks to test the hypotheses with involved factors how they do impact to a bid-to-cost ratio of carriers for combinatorial transportation auction in Thailand. Besides the author simulates the combinatorial transportation auction in single round with first-price sealed bid in which carriers could submit their bids to reduce their empty backhaul problem and gain benefit from economies of scope. For simulation game, carrier can apply the simulation technique in the incomplete information game by which each carrier does not know information of each other. This is to find out the optimal bid price for each package in the auction. The result in bidding simulation will show the optimal solution so that carrier could submit the best price in order to obtain the maximum expected profit in the combinatorial transportation auction.

1.4 Contribution

1. Carriers can apply the bid generation model developed to find the optimal bid price in order to obtain the maximum expected profit with probability of winning in the combinatorial transportation auction.
2. Carriers in Thailand can understand the mechanism of bid price in combinatorial transportation auction and also estimate the transportation market price in combinatorial auction with interested package against different characteristics of competition.
3. Lead to develop and apply combinatorial transportation auction between shippers and carriers in Thailand by which could enhance an efficiency of transportation network, reduce the empty backhaul problem in the transportation network and also decrease the amount of useless fuel consumption in Thailand.

Chapter 2

Literature Review

In this chapter, the relevant literatures on land freight transportation and the empty backhaul problem of transportation operation is first discussed. Then transportation service procurement with traditional auction and combinatorial auction including auction theory are reviewed respectively. In addition, the carrier assignments model in combinatorial transportation auction has been explained. Next, the bidding price of combinatorial transportation auction in previous study has been summarized. As the competitive bidding strategy is described at the end in which this concept will be applied in our research accordingly.

2.1 Land Freight Transportation

Land freight transportation by truck is one of the most practical service in nationwide shipment because it is expedient, fast and flexible based on geographic and infrastructure constraint in many countries including Thailand. In motor truck transportation service industry, there are partial shippers (e.g., manufacturers and retailers) using their private fleets to distribute products to marketplaces, while a large number of shippers have already used third party logistics to transport products instead (Foster and Strasser, 1991). This is because of expanding in the business including limited in-house capacity and cost management.

For freight transportation service by truck, it is distinctive mainly to Truckload (TL) and Less-than-Truckload (LTL) (Chen, 2003). For each pattern, there is both advantage and disadvantage that consideration to select which one is better depends on factors and regulation. For TL, it represents direct operation. It transports full loads from an origin to a destination without any intermediated stop. All freights are unloaded at destination points only. In addition, this kind of transportation service is called Direct System. While LTL means the consolidating and hauling multiple shipments in one truck on regular route basis (Caplice and Sheffi, 2003). Thus, we study in this paper on TL operation since it is particularly sensitive on economies of scope in freight transportation service.

In Thailand, the pattern of freight transportation used widely is Truckload operation (Theeratham Meethet, 2008). Because TL may cause the empty backhaul straightforwardly when carrier transports the freight only one way from origin to destination and also leads to the inefficiency transportation network inevitably. In Figure 2.1, it shows the empty backhaul example that carrier faces the empty backhaul problem from lane B to lane A while TL serving lane A to lane B for shipper in one way only. Carrier therefore has to increase fee for transportation service to shipper in order to cover the empty backhaul cost while in turn shipper also has more cost for the transportation service procurement. Thus, the efficient transportation plan in TL is the necessary matter to lead carrier and shipper to have the efficiency transportation cost. In addition, it could enhance them to use resource in the transportation service market more efficiently.

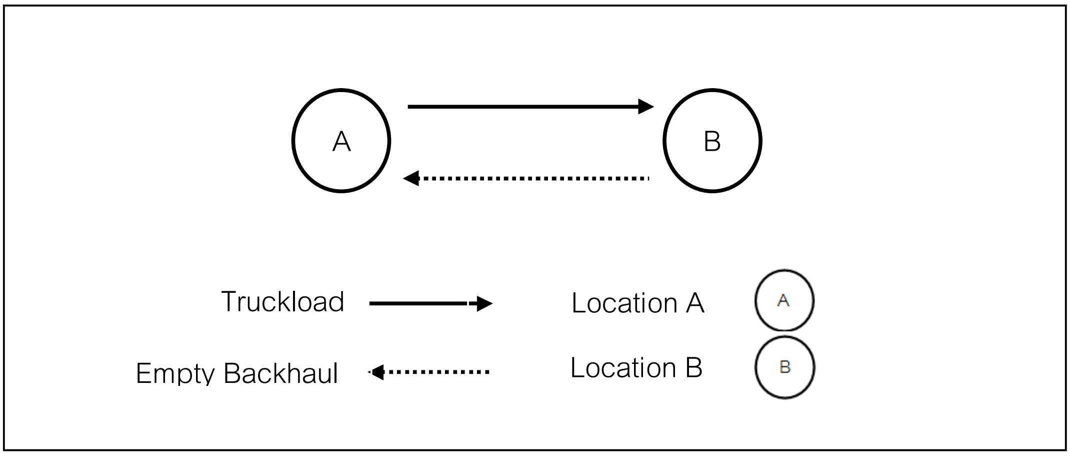


Figure 2.1: Example of Empty Backhaul Problem

2.2 Empty Backhaul Problem in Thailand

Regarding the statistics of Department of Land Transport in Thailand, it showed that land freight transportation in 2010 has penetrated at 83% of total domestic transportation market (Department of Land Transport, 2010). This is because land transport has more advantage than other modes to distribute all freights to cover all area with door to door service in Thailand suitably. By this reason, nation development including economics and public living then have related to this kind of transportation significantly. In 2006, the number of total trucks to transport is at 689,512 trucks from total 320,000 carriers. With all 71.7 million hauls, they can be calculated to be all distances at 12,145.4 million kilometers and totally uses diesel fuel more than 3,470 million liters per year.

Table 2.1 Summary of Truck Carriers in Thailand

Information of Carriers	
Number of Trucks	689,512 trucks
Number of hauls	71.74 million hauls / year
Average Distance per haul	169.30 kilometers
Total distance per year	12,145.41 million kilometers / year
Fuel consumption per haul	48.37 liters / haul
Total fuel consumption per year	3,470.02 million liters / year

Source: Department of Land Transport, Ministry of Transport (2006)

The ratio of the cost in land transport is penetrated by fuel mostly of which carriers cannot control the fuel price. Because high volatility regarding fuel price mechanism in global market, thus reducing cost of transport operation and enhancing the efficiency of transportation management on land transport by truck is very essential to be considered inevitably.

In Thailand, the Department of Land Transport revealed in 2006 that the land transport by truck had the empty backhauls at 46% of total truck shipments or 33 million hauls with 5,587 million kilometers (Manoj Lohatepanont and Yossiri Adulyasak, 2006). It showed that carriers consumed fuel uselessly estimated in amount of 22.5 billion baht lost per year or around 1,596 million liters (Department of Land Transport, 2006). Specifically, this problem is still the critical economic issue in Thailand up to the present time particularly.

Table 2.2 Summary of Empty Backhaul Problem in Thailand

Information of Empty Backhaul	
Empty Backhaul	33 million haul
Total Distance of Empty Backhaul	5,586.89 million kilometer
Average Distance per haul	169.30 kilometer
Total distance per year	12,145.41 million kilometer / year
Fuel consumption per haul	48.37 liter / haul

Source: Department of Land Transport, Ministry of Transport (2006)

2.3 Traditional Transportation Auction

In freight transportation service procurement, there are 2 main parties between shipper and carrier in this mechanism. The basic item of transportation service procurement is called a lane that specifies a unidirectional shipment from an origin to a destination. The shipper has initially used RFP in which is the simply auction to invite a set of carriers and provides useful information for them to participate in the competition auction. The fundamental information is based on price and period of contract (Sheffi, 2004). This process is similar to a simple first-price sealed-bid auction in which each carrier is able to submit his bids for interested items (Song and Regan, 2003).

Procurement of transportation services is an important outsourcing of logistics activity in order to manage shipment required by firms or shipper. Transportation service in term of truckload involves the movement of freight by dedicated trucks (Kwon et al., 2009) from origin to destination according to network requirement of many shippers.

For using traditional auction in truckload procurement, shipper tenders freight transportation service from carriers by applying the request for proposal (RFP) for the network of lanes (Foster and Strasser, 1990; Sheffi and Caplice, 2003; Rodrigues et al., 2006) where a lane represents a commitment for one-way movement from origin to destination with a specific volume for a period covered by the RFP.

For RFP process, shipper initially provides a list of lanes to carriers to bid for; Carriers then quote the prices at which they are willing to haul shipment. Once bids are received then shipper evaluates bids with lane by lane, and decides the winners using a single price criterion usually (Sheffi, 2004) that this process is called a simultaneous multiple-unit auction (Krishna, 2002) while most shippers look at it as a set of individual auction, one for each lane.

2.3.1 Auction Theory

The auction has occupied the attention of trading product and service both individual and business-to-business over thousands of years. One of the earliest examples of auctions was described by Greek historian that they sold the women to be wives in Babylonia around the fifth century B.C.; Also in China the deceased Buddhist monks were sold at auctions as early as the seventh century A.D (Cassady, 1980; Milgrom and Weber, 1982).

So far, auctions account for a great volume of economic activity significantly. In many countries, government use auctions to sell treasury bills and notes (using a sealed-bid auction every week), mineral right, radio frequency spectrums, foreign exchange, electricity including using auctions for procurement some products ranging from office supplies to specialized equipment or even service in transportation; In these cases definitely auctioneer is looking for a low price more than a high price. Besides, other common products are sold by auctions also e.g., antiques, art work, flowers, livestock, house, car, publishing rights, stamps and wine etc. (Klemperer, 1999).

Auctions are simple, useful and practical for price discovery mechanisms to extract buyers' or sellers' valuations, especially when there is unclear about the value of object or service. The term of auction normally refers to the case that involves one seller and many buyers (*forward auctions*) in which buyers have a valuation of product or service to be purchased. While procurement auctions are the case that there is only one buyer against many sellers (*reverse auction*) which model and intuition derived can be applied from forward auction (Rothkopf and Harstad, 1994).

Auction is one of the most successful applications in branch of such a game theory obviously that involves with how bidders decide how much to bid, effect of bidding strategies of each bidder, outcome of auctioneer regarding auction design, and which auctions are an efficient mechanism for allocation because game theory formulations of auctions formally express market competition and strategic interactions.

Also auctions represent explicit trading rules that fix the “rules of the game”. In particular, they are valuable as illustration of games of incomplete information since private information of each bidder is the main factor affecting strategic behavior (Wilson, 1992). Furthermore, auctions are modeled as non-cooperative strategic games in which the players are the buyer(s) and the seller(s). The bidders decide how much to bid for whereby the auctioneer decides the auction format and rules (the auction design); Payoff depends on the design of the auction and the bids (Kuyzu, 2007).

2.3.2 Definition of Auction

Auction is a market clearing mechanism to meet demand and supply between buyer and seller. Within the class of market mechanisms, they can allocate both general and scarce resources; one particular characteristic of the auction is that the price formation process is explicit. Therefore, the rule that determines the final price is usually well known by all parties involved.

In addition, auctions are often used in the sale of goods for which there is no established market. Rare or unique objects are typically sold in auction format as the markets for these objects. Furthermore auctions are more flexible than a fixed price sale and perhaps less time-consuming than negotiating a price (Menezes and Monteiro, 2005).

Nevertheless, there are many possible designs or sets of rules for an auction and typical issues studied by auction theorists include the efficiency of a given auction design, condition, optimal and equilibrium bidding strategy, and revenue and payoff comparison.

2.3.3 Auction Type

In general, there are 2 types of auctions; First type is single-item auctions in which they involve particularly in one identical item at the same time. Single-item auctions are well known because they have been applied in general practices considerably and studied in economics as games of incomplete information for more than 40 years (Vickrey, 1961); Second type is multi-item auctions that they trade more than one identical item at the same time accordingly.

Various models for the auctions of a single-item with varying assumptions on the behavior of bidders have been studied according to the information available to each bidder. Nevertheless, auctions have been considered mainly with four standard auctions in details: (1) *English auction*, also known as an open ascending price auction, is the most common form of auction in use now (Krishna, 2002), the auctioneer starts with a low asking price which is increased until some bidder bids at the highest price in public; (2) *Dutch auction*, also known as an open descending price auction, is that the auctioneer begins with a high asking price which is lowered until some bidder is willing to accept the auctioneer's price; (3) *First-price sealed-bid* is that each bidder independently submits a single bid without seeing others' bids, and then the object is sold to the bidder who makes the highest bid while the winner pays the amount offered; (4) *Second-price sealed-bid* (sometimes called a *Vickrey auction*) is the same as first-price sealed-bid except that the winner pays the second highest price in the bidding game (Klemperer, 2004).

Besides a single item auction, there is another type of auction applied recently. That is the multi-item auctions in which the multiple objects are to be sold at the same time called combinatorial auctions. It is a simultaneous multiple item auctions that allow bidder to place a single bid on a set of distinct items. The multi-item auctions have been widely considered and applied in many fields e.g., multiple cases of the same wine or treasury bills, spectrum auctions etc. including transportation service.

2.3.4 Auction Mechanism

Auction is an important market mechanism that approaches market clearing between demand of buyer and supply of seller efficiently. In competitive market each bidder joining the auction would like to be a winner undoubtedly. Information of player (e.g., valuation of goods, payoff function etc.) is likely to be sensitive and unrevealed usually. Hence, the study of games of incomplete information also called *Bayesian games* has been studied to address this mechanism.

In a game of incomplete information, the payoff functions for player are not common knowledge since there is at least one player which player is unsure about another player's payoff function whereas on the other hand a game of complete information is common knowledge that all players know their payoffs (Gibbons, 1992; Aliprantis and Chakrabarti, 2000). For example, an incomplete information game is first-price sealed-bid auction as shown in Figure 2.2. There are *n* bidders, labeled i =1,2,..,*n*; Each bidder has a valuation (b_i) for good. If bidder i is a winner with bid price (b_i). Therefore, the bidder i's payoff is at $v_i - b_i$ accordingly.

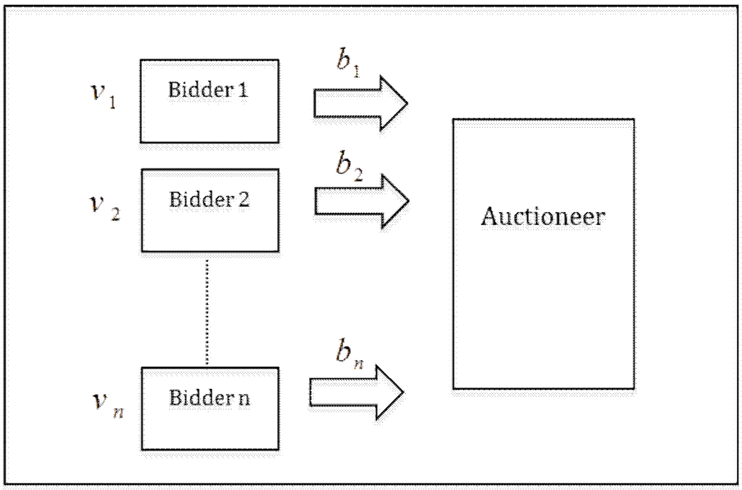


Figure 2.2: Sealed-Bid Auction Formulation

The bidders submit their bids simultaneously to auctioneer. The highest bidder is awarded the goods and then pays the price submitted to auctioneer while other bidders do not get and pay nothing. As a Bayesian game, the model has to identify the action spaces, the type spaces, the beliefs, and payoff function. Player i's action is to submit a bid (b_i) and bidder's type is valuation (v_i).

Let $b = (b_1, b_2, ..., b_n)$ be a vector of bids for each bidder i. If b_{-i} is the (n-1) dimensional vector of bids obtained from b by deleting the bid b_i of player i, then we can denote the payoff function of $u_i(b_1, b_2, ..., b_n)$ by $u_i(b_i, b_{-i})$; Therefore the payoff function of the players is

$$u_i(b_i, b_{-i}) = \begin{cases} v_i - b_i & \text{If } b_i > b_{-i} \\ (v_i - b_i)/r & \text{If } i \text{ is among the } r \text{ finalists} \\ 0 & \text{If } b_i < b_{-i}. \end{cases}$$

However bidders do not know the true valuation of the object by other bidders. Due to lack of information about the true valuation of the other, each player has a belief or an estimate of the valuation of the other. So bidder i must consider the value v_{-i} as a random variable that means that the belief of bidder i regarding true value of v_{-i} expressed by distribution function.

Given the lack of information among bidders, the best strategy that any player can do is to choose a bid that maximizes her expected payoff. The expected payoff of player i is shown by

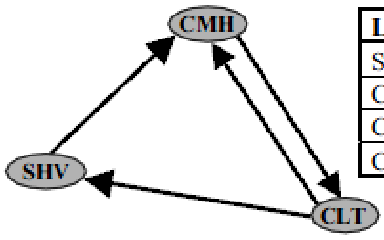
$$E_i(b_i,b_{-i}) = (v_i - b_i)\Pr(b_i > b_{-i}) + (\frac{v_i - b_i}{r})\Pr(b_i = b_{-i}).$$

So far auction mechanism has been widely applied by many industries from various fields (e.g., Government, Manufacturing or Business Company) for selling and buying both product and service including transportation service procurement also. At present, many industries procure the transportation service particularly by using the auction mechanism to full fill their requirements efficiently.

However, even RFP process in freight transportation service is not different from goods and services (Sheffi, 2004) in general but there is the most important aspect that it differs from them significantly. That it is transportation costs influenced to a greater extent by economies of scope than by economies of scales in transportation services. In traditional auction format for transportation procurement, *individual lanes are auctioned separately disallowing the carriers to express complementarities and substitutes of lanes* (Viswanath and Knapp).

Thus, in transportation service industry, carriers have realized the importance of economies of scope. They aim to have cost effectiveness in transportation network with minimum empty backhaul and repositioning cost. Carrier, therefore, could reduce cost of transportation service to obtain higher profit, while the result in turn also potentially lowers the shipper's cost for transportation service procurement (Caplice and Sheffi, 2003). However, carriers engaging in RFP have to submit bids on individual lane separately, this format does not guarantee carriers for acquiring a cycle route or a complete set of individual lanes, and it may likely cause empty backhaul or repositioning cost in the transportation network (Chen, 2003).

For Figure 2.3, it explains the mechanism of auction of traditional transportation auction (Sheffi, 2004). In this traditional auction, there are 2 carriers to submit bid into the game. Due to players join in traditional auction, thus, they have to submit bid with lane by lane separately.



Lane	QUIK	FAST
SHV→CMH	500	525
CMH→CLT	525	500
CLT→SHV	500	525
CLT→CMH	475	500

Figure 2.3: Traditional Transportation Auction

The result shows that QUIK carrier is the winner with 3 lanes including Lane SHV->CMH, CLT->SHV, and CLT->CMH, whereas FAST carrier get award only 1 lane in Lane CMH->CLT. In Figure 2.4, they express that both carriers face the empty backhaul problem obviously from joining in traditional transportation auction. By this reason, the combinatorial auction has been studied in transportation industry to overcome this problem recently.

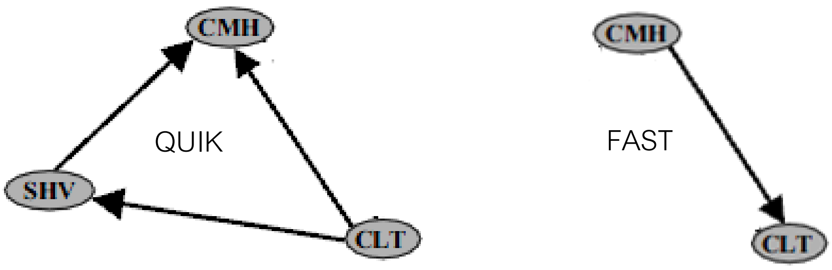


Figure 2.4: The Empty Backhaul Problem of Traditional Transportation Auction

2.4 Combinatorial Transportation Auction

The report of S&P mentioned that transportation expense in USA was around 713 million dollar or 8% of total GDP in 2001 by which mostly it came from land transport by truck or 83% of all transportation modes. Thus reducing the transportation cost is the critical issue to transportation industry undoubtedly. Large Shippers in USA has already applied the combinatorial auction to procure transportation service from carriers widely in order to reduce cost of procurement. By combinatorial transportation auction, shipper was able to decrease their cost at 15% and also maintain the quality of transportation service at the same (Sheffi, 2004).

In combinatorial transportation auction, carriers joining in the auction can bid both lane and package to match with their existing transportation network properly. This is the economies of scope which carriers could use their existing network to reduce cost of transportation service. In addition, carriers can use their resources efficiently as well as eliminate the empty backhaul in the transportation network. While, economies of scales is different from economies of scope in transportation industry, because increasing new lane to carriers does not mean that it will reduce cost of transport service.

For an example, one carrier has been assigned by shipper to provide freight service from Bangkok to KhonKhan with 10 hauls per week. In this case, carrier has to provide truck for 10 hauls. If shipper needs to have more 10 hauls per week. Thus, carriers also have to offer truck for more 10 hauls. It indicates that increasing of number of hauls with same route, it does not support carrier positively to reduce the cost. However, if shipper procures freight from KhonKhan to Bangkok for 10 hauls, therefore carrier get the advantage from economies of scope. The empty backhaul is eliminated with new assignment by shipper. It makes the transportation network of carrier to be more efficient. For Figure 2.5, it shows the mechanism of combinatorial transportation auction (Sheffi, 2004). To submit bid into the combinatorial auction, carrier could submit bid both one lane and the combination of lanes. For making possible package, it shows that each path in combination of lanes for package will be connected and have related direction. With all 9 packages, carriers can decide which package should be bided for in the auction. In addition, carriers are able to match the existing transportation network with new package in order to eliminate the empty backhaul and also have more chance to manage resource efficient.

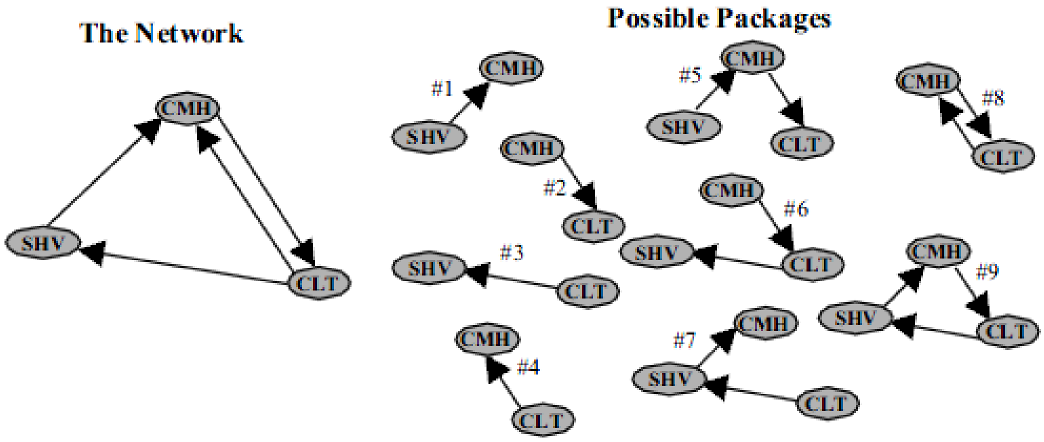


Figure 2.5: Combinatorial Transportation Auction

2.4.1 Definition of Combinatorial Transportation Auctions

Combinatorial auctions (CA) have been suggested for truckload transportation procurement to solve the exposure problem so that carrier could gain the benefit from economies of scope and lead to have more efficient allocations (Ma et al., 2010). There are many papers relating to combinatorial auctions for transportation service procurement. They mentioned the definition of CA as summarized the following:

Combinatorial auction is *a simultaneous multiple item auction format that allows bids to place a single bid on a set of distinct items to express synergies with existing for certain items* (Parkes, 1999). *Shipper asks the bidding carriers to quote prices on groups or packages of lanes in addition to individual lanes* (Sheffi, 2004); *Auctioneer places a set of heterogeneous items out to bid simultaneously and bidders can submit multiple bids for combinations or bundles of these item*s (Song and Regan, 2003); *Bidders are allowed to submit bids on combinations of items* (Vries et al., 2003); *Bidders can name their prices on combinations of items, as opposed to individual items. Each combination of items submitted to the auctioneer is called a bundle or a package* (Elmaghraby and Keskinocak, 2004); *Simultaneous multiple item auction formats that allow a single bid for a set of distinct items* (Kwon et al., 2009).

Combinatorial Auction where bidders can submit bids on combinations has received much awareness. There are many industries not only transportation industry applying combinatorial auction to enhance their efficiency as early as for instance, radio spectrum markets (Jackson, 1976; Rothkopf et al., 1998), airport time slots (Rassenti et al., 1982), trading financial securities (Srinivasan and Whinston, 1998). In additional, improving in computing competency has made combinatorial auctions more interest to implement and use widely.

2.4.2 Combinatorial Auction Process

Caplice and Sheffi (2003) mentioned the standard process for transportation auction into 3 steps including bid preparation, bid execution, and bid analysis as the followings details:

<u>Bid Preparation</u>

- Shipper has determined the requirement for transportation procurement with details of transport route both individual lane and packages of lane.
- Shipper assigns the number of carriers to join the auction. Normally shipper will invite the carriers who have ever provided transportation service previously. This is because shipper needs to keep the confidential information of company accordingly.
- Shipper specifies the information for bidder to quote the bid such as freight fee with flat rate, number of trucks, equipment and necessary tools, time, loading and unloading time etc.

<u>Bid Execution</u>

- Shipper or auctioneer has to communicate with carriers by several channels. For example: FAX, website, or EDI etc. for information of auction.
- Carriers do analysis the transportation route in which they will search for the package that could fit with the existing transportation network. In addition,

carriers will calculate the cost in each lane or package as well as consider possible risk so that they can estimate the bidding price for auction properly.

- Carriers sent the bidding proposal to shipper or auction for consideration the bid price and condition.

Bid Analysis and Assignment

- After shipper or auctioneer has received the proposal from all bidders, then shipper or auctioneer will input information into the computer program to execute and award to the winners with lane or package in the auction.
- Shipper could award the bids submitted to the winners by consideration from the lowest bidding price including level of service expected from carrier as well.
- Do service agreement with bidder specified in auction. Normally transport contract will be around 1-2 years.

2.4.3 Carrier Assignment Model

With combinatorial transportation auction, this mechanism is extremely complicate because of a lot of lanes and number of bidders. Thus, shipper or auctioneer faces the hard decision to award bid to the winner in bid analysis and assignment step. Vries et al., (2003) mentioned that combinatorial auction has to adopt the mathematical program to solve this problem called *winner determination problem* so that shipper could select the winner in the auction with the optimal cost. At present, there are many programs to support shipper such as i2 Inc., Manugistic Inc., Schneider National Inc. etc. Leasing shippers in USA have applied WDP in the combinatorial transportation auction. The result shows that they can reduce cost of transport procurement at 20% of transportation expense.

Sears Logistics Services and The Home depot, Inc. are two examples of companies using combinatorial auction for procurement of logistical service; Sears Logistics Services can save over $84 million running six combinatorial auction (Ledyard et al., 2002). In addition, many famous firms including Wal-Mart Stores Inc., Compaq

Computer Corporation Co., Staples Inc., The limited, and several other companies have been implemented combinatorial auction for their transportation procurement as well.

Shipper or auctioneer has to decide to select the winner of package submitted by carriers from solving the optimization problem or winner determination problem. This is to allocate the packages of lanes to winners. The winner determination problem (WDP) is a NP-Hard combinatorial optimization problem. Vries et al., (2003) and Rothkopf et al., (1998) explain about this in their papers. The objective is to minimize the total cost in transportation procurement according to transport network requirement. There are several mathematical-programming formulations and procedures to solve this problem. The mathematical-programming for shipper to execute in WDP has been summarized in Table 2.3. For example, it is a Set Partitioning Problem (Song and Regan, 2003) expressed as follows:

$$\text{Min } \sum_{j=1}^{n} b_j x_j$$

$$\text{s.t. } \sum a_{ij} x_j = 1 \qquad \forall i \in V$$

$$x_j \in \{0,1\}$$

, where j = 1, …, *n* is the index of valid cycles in which include a new lane (V); b_j is the bid price of cycle j; x_j indicates whether cycle j is in the optimal allocation; and a_{ij} is a binary coefficient which indicates whether lane i is included in cycle j.

Another formulation of winner determination problem is explained to address the bid construction strategy (Song and Regan, 2005) by which last formulation could omit some important opportunities for substitutable bids due to the strict constraint that bids contain mutually exclusive groups of new lanes. Song and Regan (2005) formulated the objective function to minimize the total empty movement cost which is Set Covering Problem as follows:

Min $\sum_{j=1}^{j} e_j y_j$

s.t. $\sum_{j=1}^{J} b_{ij} y_j \geq 1 \qquad \forall i \in I$

$y_j \in \{0,1\}$

$b_j \in \begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$ *if new lane i is in bid j* / *othewise*

, where y_j is a binary decision variable in set J; e_j is empty movement cost of set J; i is a new lane in set I.

Table 2.3: The Mathematical-Programming Formulations for Carrier Assignment Model

Author	Objective	WDP
Sheffi (2004)	Minimize the total expenditure on transportation subject to the constraint that each lane be served by one carrier	Set Covering
Caplice (1996)	Minimize the sum of cost assignment of carrier to traffic lanes within the shipper's distribution network	Set Partitioning
Song and Regan (2005)	Minimize the total empty movement cost under an optimal allocation of these new lanes that each new lane will be served by exactly one route.	Set Partitioning

2.5 Bidding Price in Combinatorial Transportation Auction

In combinatorial auction, there is one issue that has not been discussed expansively that is bid generation model for carrier for transportation procurement. Most combinatorial auction models assume that bidder knows which set of lanes to bid for but in fact it is difficult for bidders to evaluate the packages from the bidding since there are an exponential number of possible relevant packages. Also due to carriers have concerns about economies of scope and really need supply to routes in order to have no repositioning cost. Therefore, bid generation model is important area for carriers to obtain the optimal bid price for interested packages in which is both individual lane and combination of lanes (Lee et al., 2007).

The first carrier model that uses the optimal bidding strategy involves carriers' perspective of their true valuation of each bundle of new lanes and the decision on the final submitted bids presented by Song and Regan (2003). They considered only decision that involved each carrier's own resources and did not consider other competitors' decision (assume that bidder's bids base on their true valuations). The bidding price for this package could be formulated by set partitioning problem in which the objective function is to minimize the total operating cost or total empty cost as follows:

$$\text{Min} \sum_{j=1}^{n} c_j x_j$$

$$\text{s.t.} \quad \sum a_{ij} x_j = 1 \qquad \forall i \in U \cup V$$

$$x_j \in \{0,1\}$$

, where j =1, 2, …, n denotes the index of valid cycles which include either a current lane (U) or new lane (V) or both of them; c_j is the cost of cycle j; x_j is binary variable (x_j=1 if cycle j is in the optimal allocation; otherwise 0); a_{ij} is binary coefficient (a_{ij}=1 if lanes i is included in cycle j; otherwise 0). Furthermore, they formulate the bidding price model for carriers in making bids in which is to calculate the bidding price (p) for new lane an atomic bid as follows:

$$p = C_i(1+\beta) + C_j\alpha_j$$

, where C_i denotes the total cost of serving new lane in the bid; C_j denotes the empty cost of bid; β denotes the carrier's average profit, normally ranges during 4% - 6%; and α_j denotes the carrier's risk of not acquiring any demand from this empty back haul j. (assume that a carrier's cost is proportional to mileage). Nevertheless, Song and Regan (2003) modified the model to compatible with the presence of pre-existing commitments by using an appropriate set cover model and bid augmentation method.

An et al. (2005) studied the bidding strategies and their impact on revenues in combinatorial auction. The objective of research is to answer the question of how bidders should bid in combinatorial auction by focusing to generate the bundles. Thus, they applied the bidding strategies in pricing term by assuming that all bidders price for their auctions using a fixed profit margin. The bidding price and profit of auction with this bidding strategy are shown as the following:

Bidding Price = $(1-PM)*V$

, where PM is the profit margin; V is value.

Profit = Valuation – Bidding Price.

= $V-(1-PM)*V$.

= $PM*V$.

Even the bidding strategy in pricing is quite simplistic, but it is commonly practical. Due to in the logistics industry, 33% of third-party logistics companies (3PL) in North America have adopted cost-plus pricing in the transportation service (Smyrlis, 2000). While Ergun et al. (2007) mentioned about stage of placing bids on the lanes auctioned by carrier that it impacts to the other carriers' revenue. The stochastic optimization model is designed to determine the optimal bids. In order to address the uncertainty regarding the outcomes of the auctions, he assumed that the lowest bid price of competitors for each lane was modeled as random variable in which was uniform distribution function. Therefore, the optimization problem applied game theory in term of the expected profit for the carrier on lanes being auctioned has the following term:

$$\text{Max}\,\pi(b) = \sum_{S \subseteq L} \{P(S,b)Q(L-S,b)[R(S,b)-C(S)]\}$$

$$\text{s.t. } b_i \in [l_i, u_i] \ , \qquad \forall_i \in L$$

, where b denotes vector of bids for the lane (decision variables); $P(S,b)$ denotes probability of winning the set of lanes S with bids (b); $Q(L-S,b)$ denotes probability of losing the set of lane $L-S$ with bids (b); $R(S,b)$ denotes revenue obtained from the set of lanes S with bids; $C(S)$ denotes incremental cost of serving the set of lanes S. Due to competitor's bids are uniformly and independently distributed (assume that carrier knows the lowest (l_i) and highest (u_i) possible value of x_i).

$$P(S,b) = \prod_{i \in S} \mathrm{P}\{X_i \geq b_i\} = \prod_{i \in S} \left(\frac{u_i - b_i}{u_i - l_i} \right).$$

$$Q(L-S,b) = \prod_{i \in L-S} \mathrm{P}\{X_i \leq b_i\} = \prod_{i \in S} \left(\frac{b_i - l_i}{u_i - l_i} \right).$$

$$R(S,b) = \sum_{i \in S} b_i$$

Table 2.4: Bidding Strategies for Combinatorial Transportation Auctions

Subject	Authors	Gaps
Combinatorial Auctions for Transportation Service Procurement: The Carrier Perspective	Song and Regan, 2002	- Apply the average profit margin in which typically ranges from 4%-6%. - Neglect the benefit of existing transportation service network with new lanes proposed. - Not consider competitor's bidding behavior.
Bidding Strategies and their Impact on Revenues in Combinatorial Auctions	An et al., 2005	- Apply a fixed profit margin in bidding strategies to value the price bidding with their bundles. - Neglect the interaction of competition among carriers in the auction.
Bid Price Optimization for Simultaneous Truckload Transportation	Ergun et al., 2007	- Use the random variable as the lowest bid of the competitor(s) which is uniformly distributed on the interval assigned. - Unconcern the bid price of competition regarding the actual bidding of transportation service market. - Consider the interaction among carriers with lane by lane simultaneously whereas the model does not capture in the package format with combination of lanes according to combinatorial auction basis.

2.6 Competitive Bidding Strategies

For transportation service procurement auction, the term of auction applies in reverse auction between one shipper and several carriers. Each carrier joining in the auction would like to be a winner undoubtedly. Information of each carrier, therefore, is likely to be sensitive and unrevealed as a game of incomplete information called Bayesian game. Due to lack of information about the true valuation for packages of all competitors in combinatorial transportation auction, thus the best strategy for bidder for bidding is a bid price that maximizes the expected payoff (Aliprantis and Chakrabarti, 2000). In reverse auction, the expected profit of bidder could be shown by *Expected Profit of Bidder = (Bid Price - Cost)*Probability of Winning with Bid Price* (Friedman, 1955). The bidding strategy for bidder in the incomplete information game has the importance to determine how much to bid for so that bidder may obtain the maximum expected profit with the best solution.

Friedman (1955) presented a bidding strategy for bidder to compete in the first-price sealed-bid auction. To create a bidding behavior of competitors, he applied the concept of the average bidder by combining all data of competitors to obtain one distribution function with competitors' bid over cost as random variable. In Figure 2.6, it showed the bidding patterns of average bidder by normal distribution function, f(r), with probability of winning. In addition, the probability of being lower than competitors by bidding with any bid-to-cost ratio (x/C) was the area to the right on competitors' distribution curve.

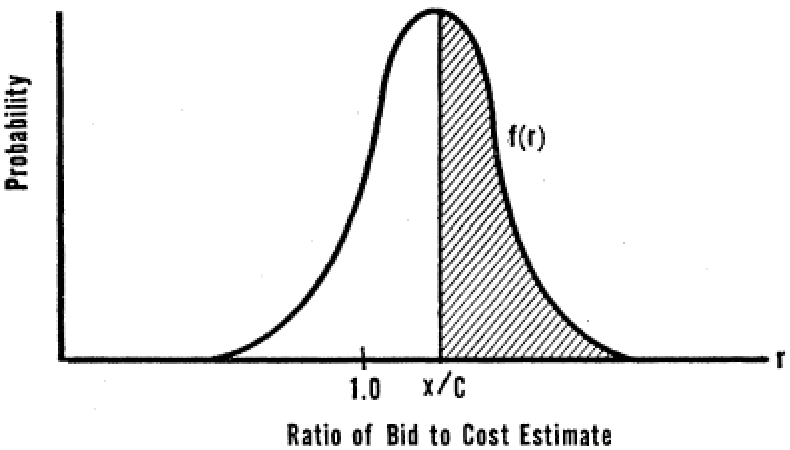


Figure 2.6: Bidding Pattern of Average Bidder

He then used stochastic optimization model to determine where the optimum bid was. Finally, bidder could submit a sealed-bid in competitive bidding with optimal solution in order to obtain the maximum expected payoff.

Sugrue (1982) presented a competitive bidding model with the construction industry. He described how to find the optimal bid price with Friedman`s model. This model assumed that the cost of performing the operation was known prior to submitting the bid into the auction to get the maximum expected value. The paper also showed the computation of the expected value for bids with estimated cost. The bidder's objective would be to select the bid which maximized the expected value of the profit from contract. This expected value for a bid can be expressed as

$$E(P) = (B - C) * \prod_{k} G(Y_0)$$

, where $G(Y_0)$ represents the probability of winning with the bid to cost ratio of competitor k exceeds Y_0. The optimal bid on the contract with an estimated cost of &80,000 in Table 2.5 is $85,700 in which it could provide the maximum expected profit at $1,103.

Ioannou and Leu (1993) studied the average-bid method comparing with the low-bid method by which both methods based on the same assumption as Friedman`s model. Each bid of competitor was standardized by using bidder`s cost to be a bid-to-cost ratio. They introduced the competitive bidding model in which the bidding has been analyzed by Monte Carlo Simulation and Mathematics. While Derek et al., (2001) researched the effect of client, type, size of construction work on a bidding strategy, the result of study by regression analysis presented that the size of project and client type have impacted significantly to bidder's bidding behavior. Robert et al., (1978) generated the multiple regression for bidding strategy. This model studied on the contractor's bidding behavior to determine the optimum markup. The number of competitors from the neighboring state over total number of competitors, total number of competitors, total job cost has been considered as independent variables to calculate the output.

Table 2.5: Computation of the Expected Values for Bids on a Contract

Bid (Bi) ($)	Bid to cost ratio	Profit if contract won ($)	Prob. comp. 1 bid Bi	Prob. comp. 2 bid Bi	Prob. comp. 3 bid Bi	Prob. of win with bid of Bi	Expected monetary value ($)
83,840	1.048	3840	0.50499	0.64484	0.80234	0.26127	1003
83,920	1.049	3920	0.50249	0.64218	0.80001	0.25815	1012
84,000	1.050	4000	0.50000	0.63951	0.79767	0.25506	1020
84,080	1.051	4080	0.49751	0.63683	0.79531	0.25198	1028
84,160	1.052	4160	0.49501	0.63415	0.79294	0.24891	1035
84,240	1.053	4240	0.49252	0.63146	0.79055	0.24586	1042
84,320	1.054	4320	0.49003	0.62876	0.78814	0.24283	1049
84,400	1.055	4400	0.48753	0.62606	0.78572	0.23982	1055
84,480	1.056	4480	0.48504	0.62335	0.78328	0.23683	1061
84,560	1.057	4560	0.48255	0.62063	0.78083	0.23385	1066
84,640	1.058	4640	0.48006	0.61791	0.77836	0.23089	1071
84,720	1.059	4720	0.47757	0.61519	0.77588	0.22795	1076
84,800	1.060	4800	0.47508	0.61245	0.77337	0.22505	1076
84,880	1.061	4880	0.47259	0.60971	0.77085	0.22212	1080
84,960	1.062	4960	0.47011	0.60697	0.76832	0.21923	1084
85,040	1.063	5040	0.46762	0.60422	0.76577	0.21637	1087
85,120	1.064	5120	0.46514	0.60147	0.76321	0.21352	1090
85,200	1.065	5200	0.46265	0.59871	0.76063	0.21069	1093
85,280	1.066	5280	0.46017	0.59594	0.75804	0.20788	1096
85,360	1.067	5360	0.45769	0.59317	0.75543	0.20509	1098
85,440	1.068	5440	0.45521	0.59040	0.75280	0.20232	1099
85,520	1.069	5520	0.45274	0.58762	0.75016	0.19957	1101
85,600	1.070	5600	0.45026	0.58484	0.74751	0.19684	1102
85,680	1.071	5680	0.44779	0.58205	0.74484	0.19413	1102
85,760	1.072	5760	0.44532	0.57926	0.74215	0.19144	1103
85,840	1.073	5840	0.44285	0.57646	0.73945	0.18877	1103
85,920	1.074	5920	0.44038	0.57367	0.73674	0.18612	1102
86,000	1.075	6000	0.43792	0.57086	0.73401	0.18350	1102
86,080	1.076	6080	0.43546	0.56806	0.73127	0.18089	1101
86.160	1.077	6160	0.43300	0.56525	0.72852	0.17830	1100

Chapter 3

Research Methodology

In this chapter, we describe the research methodology with simulation model in order to answer the critical questions regarding the combinatorial transportation auctions as the following:

- How to find the optimal bid price for carriers so that carrier could submit bids into the combinatorial transportation auction?
- What are the factors that impact to a bid-to-cost ratio of carriers for the combinatorial transportation market significantly?
- In what circumstance does represent the efficient transportation network of carrier in the market?

In addition, the research methodology in this chapter includes research design, conceptual framework of research, and simulation technique.

3.1 Research Design

This research focuses on the bidding strategy in bidding price for truckload carrier in combinatorial transport auction. To represent the bidding behavior of truckload carrier in transport market in Thailand, thus, the author uses the bid-to-cost ratio as the dependent variable in regression model, and all measured items are collected by questionnaire. Due to the details in survey are subsequently complicate. Also the output as the bid-to-cost ratio is very confidential for each company in this kind of business. Therefore, the author has to collect the data by personal in-depth interview to explain how to respond the questionnaire regarding the objective of research. For population in this survey, we focus on truck carrier companies in Thailand by which provide the transport service normally to many shippers in various industries. Then the all collected data in the questionnaire could represent the bidding price of transport market very well. The measured items for all constructs in survey are presented as below:

3.1.1 The Number of Competitors (*n*)

The survey contains the number of competitors to find the impact to a bid-to-cost ratio. The respondent will input the bid price into each pattern of combinatorial transport auction in which each of them has several numbers of competitors.

3.1.2 The Size of Package (*s*)

The respondents are asked to input the bid-to-cost ratio when there is different size of package in the questionnaire for each pattern of transport in combinatorial auction. Therefore, the size of package is offered how to impact the output of this study.

3.1.3 The pre-empty backhaul to new lane distance ratio (μ)

With various pattern of transport in combinatorial auction, it thus is expressed by the pre-empty backhaul to new lane distance ratio; the target could provide the bid-to-cost ratio with different μ. in which is the pre-empty backhaul distance over new lane distance.

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$$\mu = \frac{l_{pre}}{l} \tag{3.1}$$

3.1.4 The decrease in ratio of pre-empty backhaul (γ)

The decrease in ratio of pre-empty backhaul is another one factor that explains the pattern of transport in combinatorial auction. Respondents can input the value of bid-to-cost ratio against various pattern of transport. The result can show how different γ

impacts to the bid-to-cost ratio of bidding with different pattern of transport in combinatorial auction.

.
$$\gamma = \frac{l_{pre} - l_{post}}{l_{pre}} \tag{3.2}$$

Pretesting a questionnaire is an important process in questionnaire design. The benefit of pretesting the survey is to verify the structure, language, concept and understanding before using the final questionnaire to the respondents practically.

This study uses personal interviews to pretest the preliminary questionnaire in which is useful method. This is for researcher to have in-depth interview with selective respondents in order to correct the error and meaning of contents in questionnaire including improving the understanding of respondents clearly. Dissertation advisor and co-advisor, and five carrier companies that directly involves with transport auction are consulted and interviewed for checking the validity of the preliminary questionnaire. After all revisions, a final questionnaire has been finished and then used to respondents in the step of data collection.

For collecting data, the researcher plans to collect them around 1 month as shown in Table 3.1. The sample size is designed at 50 truck carrier companies in various businesses to represent the average bid-to-cost ratio of combinatorial transport auction in transport market.

Table 3.1: Time Periods of Collecting the Data

Activities	Time Periods					
	September/11		October/11		November/11	
1. Pre-test the questionnaire	↔	↔				
2. Depth-Interview with final questionnaire			↔	↔		
3. Visit Transport Seminar with final questionnaire				↔		

3.2 Conceptual Framework

In this research, we have the conceptual framework as expressed in Figure 3.1 in which the objective is to find the relationship among involved factors to a bid-to-cost ratio of carrier in combinatorial auction. The number of competitors, size of package, and pattern of transport in combinatorial auction are factors that the researcher needs to seek the connection between them and the output. Therefore, this study leads us to test the hypotheses as the following:

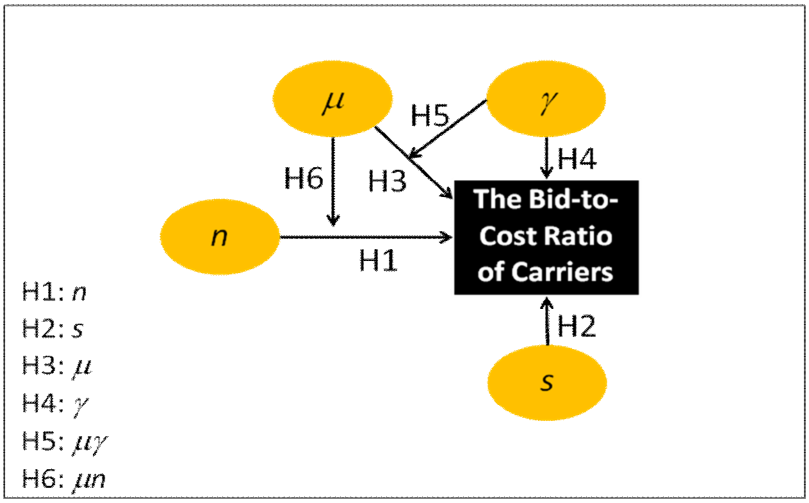


Figure 3.1: Conceptual Framework

- Hypothesis 1: The number of competitors (n) has no impact a bid-to-cost ratio in combinatorial transportation auction.

- Hypothesis 2: The size of package (s) has no impact a bid-to-cost ratio in combinatorial transportation auction.

- Hypothesis 3: The pre-empty backhaul to new lane distance ratio (μ) has no impact a bid-to-cost ratio in combinatorial transportation auction.

- Hypothesis 4: The decrease in ratio of pre-empty backhaul (γ) has no impact a bid-to-cost ratio in combinatorial transportation auction.

- Hypothesis 5: The pattern of transportation service ($\mu\gamma$) has no impact a bid-to-cost ratio in combinatorial transportation auction.

- Hypothesis 6: The product of pre-empty backhaul to new lane distance ratio and number of competitors (μn) has no impact a bid-to-cost ratio in combinatorial transportation auction.

For hypotheses 1 and 2, they help us to realize the importance both n and s whether it impacts to a bid-to-cost ratio of combinatorial transport auction. Whereas μ and γ in hypothesis 3, 4, 5 and 6 with n are the new factors in which are used to test and express the characteristic of transport in combinatorial auction considerably.

3.3 Simulation Technique

In this study, we present the bidding strategy in a first-price sealed-bid combinatorial transportation auction for truckload service operation. This model focuses on the bid price generation problem of bidder with the interaction among carriers to interested package. For interested package, we consider both new lanes proposed by shipper and current servicing lanes of carrier simultaneously in order to meet economies of scope. Due to incomplete information game, the information of competition is confidential and unrevealed. Thus, the best strategy of submitting bid price in combinatorial auction is the optimal bid price that provides the maximum expected profit in the bidding game. The research methodology applies the simulation model in which captures Monte-Carlo Simulation, Regression Model, Winner Determination Problem, Stochastic Optimization Model to find the optimal solution as shown in Figure 3.2.

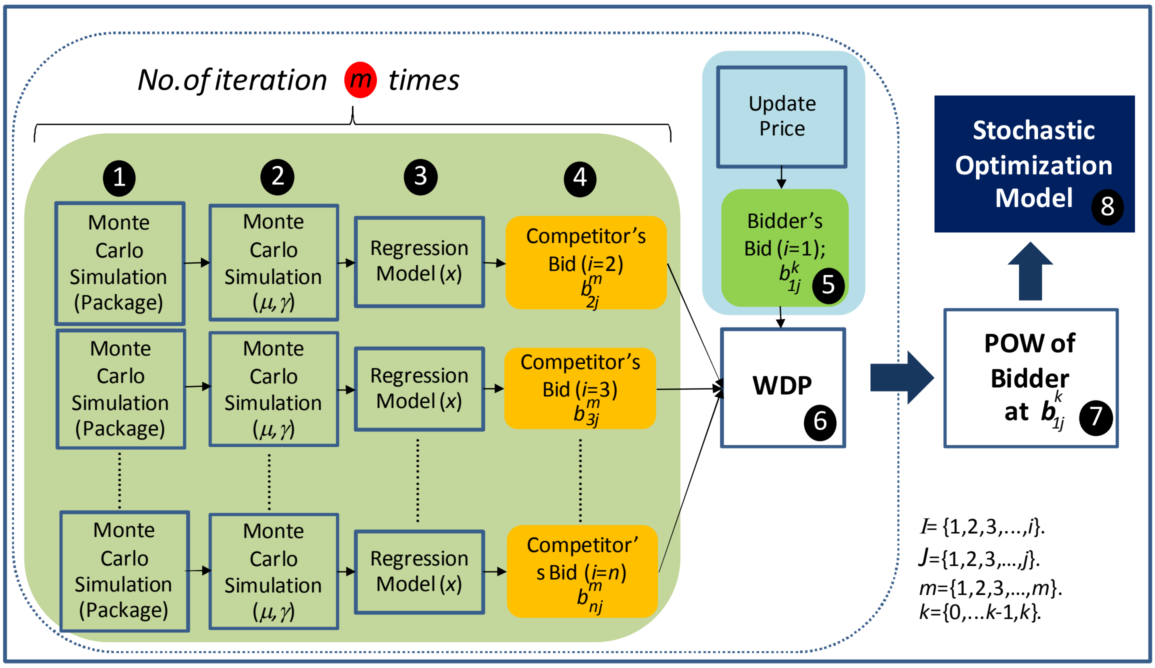


Figure 3.2: Simulation Methodology

For simulation model in the incomplete game between bidder and competitors, we assume the details in this study as the following:

- Bidder and Competitor(s) are risk neutral.

- Bidder and Competitor(s) do not have collusion.

- Bidder and Competitor(s) have incomplete information.

- Bidder and Competitor(s) would bid in combinatorial transport auction in order to reduce empty backhaul problem and have more transport network efficiency.

- Cost of freight transportation service is proportional to servicing distance only.

- Unit Cost of transportation and volume of freight among carriers is the same.

In addition, we summarize the notation for variable and symbol to apply in the simulation model as below:

- x_{ij} is the bid-to-cost ratio of carrier i for package j.
- $\pi(b_{ij})$ is the expected profit with the bid price of carrier i for package j.
- b_{ij} is the bid price of carrier i for package j.
- $\Pr(b_{ij})$ is the probability of winning with bid price of carrier i against the competitors' bid for package j.
- mc_{ij} is the marginal cost of carrier i for package j.
- oc_j is the operating cost for package j.
- μ_{ij} is the pre-empty backhaul to new lane distance ratio of carrier i with package j.
- γ_{ij} is the decrease in ratio of pre-empty backhaul of carrier i with package j.
- γ_l is the minimum of decrease in ratio of pre-empty backhaul of carrier i with package j.
- γ_u is the maximum of decrease in ratio of pre-empty backhaul of carrier i with package j.
- n is the number of competitors.

- s_j is the size of package j.
- l_j is the new lane distance for package j.
- l_{posij} is the post-empty backhaul distance of carrier i for package j.
- l_{preij} is the pre-empty backhaul distance of carrier i for package j.
- a_j is the shortest distance for a direction from an origin to a destination point of package j.
- α is a step size.
- ϕ_f is a unit cost of full truckload servicing.
- ϕ_e is a unit cost of empty backhaul.
- I is the set of carriers; $\{1,2,3,\ldots, i\} \subset I$.
- J is the set of possible packages; $\{1,2,3,\ldots, j\} \subset J$.
- m is the number of iterations for combinatorial auction.
- k is the number of factor to update the bid price of bidder.
- β is coefficient of regression model.

3.3.1 Monte-Carlo Simulation

Because we study the combinatorial transport auction in the incomplete information game, therefore we design to use Monte-Carlo methodology so that we can obtain the possible bidding price of competitor(s) in the combinatorial auction. Initially, we randomize all possible packages of each competitor in which they would perhaps submit bids for these packages into the bidding game. To randomize submitted packages of competitors, we employ the uniformly distribution function with the same number of packages proposed in the bidding game. After we obtain randomized packages of competitors uniformly, we will find the possible μ_{ij} and γ_{ij} with developed constraints to express the pattern of transportation of competitors in combinatorial auction. In addition, we also employ the uniform distribution function in this step to obtain the possible pattern of transportation of competitors.

For example: in this game, there are all 3 possible packages (j =1,2,3) with 2 competitors; carrier A (i =2) and carrier B (i =3). To submit bid in the combinatorial auction of this example, we assume that each competitor submits only one package into the bidding game. This is for reader to understand the research methodology simply. The randomized packages thus for each competitor with uniform distribution function at m times could be summarized as Table 3.2 below:

Table 3.2: Randomized Package of Competitors in the Auction

No.	**CompetitorA (*i*=2)**	**CompetitorB (*i*=3)**
	Package j	
1	1	2
2	3	3
3	3	2
⋮	⋮	⋮
m-1	2	1
m	1	2

We then find the possible μ_{ij} and γ_{ij} of competitors regarding constraints (3.3), (3.4) and (3.5). For constraint (3.3), we assume that the decrease of ratio for empty backhaul with package j is during γ_l to γ_u. While constraint (3.4) and constraint (3.5), we could find the maximum μ and minimum μ of competitors respectively. In Table 3.3, it shows the possible μ_{ij} and γ_{ij} of competitor A and competitor B for the combinatorial transport auction.

$$\gamma_l \le \gamma_{ij} \le \gamma_u \qquad ;\forall i \in I - \{1\}, \forall j \in J. \tag{3.3}$$

$$\mu_{ij} \le \frac{1}{\gamma_{ij}} \qquad ;\forall i \in I - \{1\}, \forall j \in J. \tag{3.4}$$

Constraint (3.4)
Pre-Empty Backhaul Distance $\le$ New Lane + Post-Empty Backhaul Distance. $lpre_{ij} \le l_j + lpos_{ij}$. $\mu_{ij} * l_j \le l_j + lpre_{ij} * (1-\gamma_{ij})$. $\mu_{ij} * l_j \le l_j + \mu_{ij} * l_j * (1-\gamma_{ij})$. $\mu_{ij} \le 1 + \mu_{ij} * (1-\gamma_{ij})$. $\mu_{ij} \le 1 + \mu_{ij} - \mu_{ij}\gamma_{ij}$. $\mu_{ij} \le \frac{1}{\gamma_{ij}}$.

$$\mu_{ij} \ge \frac{a_j}{l_j * (2-\gamma_{ij})} \qquad ;\forall i \in I - \{1\}, \forall j \in J. \tag{3.5}$$

Constraint (3.5)
Pre-Empty Backhaul Distance + Post-Empty Backhaul Distance $\ge$ Distance of Shortest Link. $\mu_{ij} * l_j + \mu_{ij} * l_j * (1-\gamma_{ij}) \ge a_j$. $\mu_{ij} + \mu_{ij}(1-\gamma_{ij}) \ge \frac{a_j}{l_j}$. $\mu_{ij}(2-\gamma_{ij}) \ge \frac{a_j}{l_j}$. $\mu_{ij} \ge \frac{a_j}{l_j * (2-\gamma_{ij})}$.

, where

$$\mu_{ij} = \frac{lpre_{ij}}{l_j} \qquad ;\forall i \in I, \forall j \in J.$$

$$\gamma_{ij} = \frac{(lpre_{ij} - lpos_{ij})}{lpre_{ij}} \qquad ;\forall i \in I, \forall j \in J.$$

Table 3.3: Randomized Transportation Pattern of Competitors in the Auction

No.	Com. A (i=2)				Com. B (i=3)			
	γ_{2j}	Max μ_{2j}	Min μ_{2j}	μ_{2j}	γ_{3j}	Max μ_{3j}	Min μ_{3j}	μ_{3j}
1	0.37	2.71	0.61	2.08	0.51	1.98	0.67	0.72
2	0.76	1.32	1.61	1.46	0.46	2.17	1.30	2.11
3	0.56	1.77	1.39	1.52	0.68	1.47	0.76	0.87
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
m-1	0.83	1.21	0.85	1.07	0.24	4.24	0.57	3.18
m	0.36	2.81	0.61	1.47	0.79	1.26	0.83	1.19

Assume: $0.2 \le \gamma_{ij} \le 1$

3.3.2 Regression Model

When bidder receives all possible μ and γ of competitors in the auction by Monte-Carlo simulation, we then formulate the regression model to represent the behavior of bidding for carrier in combinatorial auction. We apply a bid-to-cost ratio as dependent variable in this regression whereas independent variables include number of competitor, size of package, the decrease ratio of empty backhaul, the pre-empty backhaul over new lane distance, the product between the decrease ratio of empty backhaul and the pre-empty backhaul over new lane distance (pattern of transport in combinatorial auction), the product between number of competitor and the pre-empty backhaul over new lane distance. This is to express the bidding price of carrier in the market price. The regression model can be shown as the follows:

$$x_{ij}^{m} = \beta_0 + \beta_1 n + \beta_2 s_j + \beta_3 \gamma_{ij} + (\beta_4 + \beta_5 \gamma_{ij} + \beta_6 n)\mu_{ij}. \qquad (3.6)$$

$$;\forall i \in I - \{1\}, \forall j \in J, m = \{1,2,...,m\}.$$

To obtain the bid-to-cost ratios of competitor with *m* times in the combinatorial auction, we input all possible values both of them with m times and into the regression model. In Table 3.4, it shows the bid-to-cost ratio of competitors submitted into the combinatorial auction.

Table 3.4: The Bid-to-Cost Ratios of Competitors in the Auction

No.	**Com. A (*i*=2)**			**Com. B (*i*=3)**		
	x_{21}	x_{22}	x_{23}	x_{31}	x_{32}	x_{33}
1	1.05	0.00	0.00	0.00	1.17	0.00
2	0.00	0.00	0.71	0.00	0.00	0.90
3	0.00	0.00	0.90	0.00	1.02	0.00
⋮	⋮	⋮	⋮	⋮	⋮	⋮
m-1	0.00	0.83	0.00	1.21	0.00	0.00
m	1.15	0.00	0.00	0.00	0.81	0.00

Then we could acquire the bidding price of competitors with m times from equations (3.7) and (3.8) as shown in Table 3.5. The bidding price of carrier i for package j (b_{ij}) equals the product between operating cost for package j (oc_j) and the bid-to-cost ratio of carrier i for package j (x_{ij}). In this case, we assume that $l_1 = 150$ km; $l_2 = 150$ km; $l_3 = 300$ km; and $\phi_f = 7.5$ baht/km;

$$b_{ij}^{m} = oc_j * x_{ij}^{m} \tag{3.7}$$

$$oc_j = \phi_f * l_j . \tag{3.8}$$

Table 3.5: The Possible Bidding Price of Competitors in the Auction

No.	**Com. A (*i*=2)**			**Com. B (*i*=3)**		
	b_{21}	b_{22}	b_{23}	b_{31}	b_{32}	b_{33}
1	1,180	0	0	0	1,312	0
2	0	0	1,599	0	0	2,018
3	0	0	2031	0	1147	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮
m-1	0	934	0	1363	0	0
m	1293	0	0	0	906	0

3.3.3 Winner Determination Problem

Subsequently, we input the bidding price of bidder against all randomized bid prices of competitors with *m* times into the combinatorial transport auction. To execute the winners in the auction, we apply the Winner Determination Problem regarding Set Partitioning conception to perform the assessment. The objective function is to minimize cost of transport procurement. While, the decision variable which is v_{ij}^{mk} could indicate who are the winners in each round of *m* times. The WDP model in this study can be explained as the following:

$$\min \sum (b_{1j}^{k} + b_{ij}^{m}) * v_{ij}^{mk}. \tag{3.9}$$

$$\text{s.t.} \quad \sum \sigma_{qj} * v_{ij}^{mk} = 1 \qquad ; \forall q \in Q. \tag{3.10}$$

$$\sigma_{qj} \in \{0,1\}; v_{ij}^{mk} \in \{0,1\}; m = \{1,2,3,\ldots,m\}.$$

In addition, the notation for variable and symbol in WDP has been described as below:

- k = {0,…, k -1, k }.
- m = {1, 2, 3,…, m }.
- σ_{qj} = Arc of lane q for package j .
- b_{1j}^{k} = Bidder’s bid for package j at k number against competitors’ bid.
- b_{ij}^{m} = Competitor i ’s bid for package j which is randomized at m times against bidder’s bid; $\forall i \in I - \{1\}$.
- v_{ij}^{mk} = Decision variable of carrier i for package j between all possible bidding prices of competitors with m times and the bidding price of bidder at k number.

- *Q* = Set of all new lane.

With the update pricing by k factor in equations (3.11) and equation (3.12) for bidding price of bidder in the combinatorial auction, then we could obtain the value of decision variable for bidder and competitors by execution with WDP (v_{1j}^{mk}) whether it is 1 or 0 at m time and k number in the interested package j.

$$b_{1j}^{k} = b_{1j}^{0} + k\alpha. \qquad (3.11)$$

$$b_{1j}^{0} = mc_{1j} \qquad (3.12)$$

, where $$mc_{1j} = \phi_f * l_j + \phi_e * (l_{pos1j} - l_{pre1j}). \qquad (3.13)$$

$$\forall j \in J; k = \{0, \ldots, k-1, k\}.$$

In Figure 3.3, they express how to run between bidder's bidding price and competitors' bidding price in WDP for each k factor with m times. The example shows the bid price of bidder to compete with 2 competitors in package 3 in the combinatorial auction. In this combinatorial auction with incomplete information game, there are 2 competitors who submit bid for 3 packages into the auction. The result of running WDP will show the outcome whether bidder is winner or loser with his bid price for each k factor and m times. With Figure 3.4, it explains the result of bidding of bidder in each k factor and m time for package 3 in combinatorial auction.

k=0

No.	b^0_{13}	Com. A (*i*=2)			Com. B (*i*=3)		
		b_{21}	b_{22}	b_{23}	b_{31}	b_{32}	b_{33}
1	*mc*	1180	0	0	0	1312	0
2	*mc*	0	0	1599	0	0	2018
3	*mc*	0	0	2031	0	1147	0
⋮	*mc*	⋮	⋮	⋮	⋮	⋮	⋮
m-1	*mc*	0	934	0	1363	0	0
m	*mc*	1293	0	0	0	906	0

k=1

No.	b^1_{13}	Com. A (*i*=2)			Com. B (*i*=3)		
		b_{21}	b_{22}	b_{23}	b_{31}	b_{32}	b_{33}
1	$mc+\alpha$	1180	0	0	0	1312	0
2	$mc+\alpha$	0	0	1599	0	0	2018
3	$mc+\alpha$	0	0	2031	0	1147	0
⋮	$mc+\alpha$	⋮	⋮	⋮	⋮	⋮	⋮
m-1	$mc+\alpha$	0	934	0	1363	0	0
m	$mc+\alpha$	1293	0	0	0	906	0

k=*k*

No.	b^k_{13}	Com. A (*i*=2)			Com. B (*i*=3)		
		b_{21}	b_{22}	b_{23}	b_{31}	b_{32}	b_{33}
1	$mc+k\alpha$	1180	0	0	0	1312	0
2	$mc+k\alpha$	0	0	1599	0	0	2018
3	$mc+k\alpha$	0	0	2031	0	1147	0
⋮	$mc+k\alpha$	⋮	⋮	⋮	⋮	⋮	⋮
m-1	$mc+k\alpha$	0	934	0	1363	0	0
m	$mc+k\alpha$	1293	0	0	0	906	0

$k=\{0,\ldots,k-1,k\}$; $m=\{1,2,3\ldots m\}$; $\forall j \in J$.

Figure 3.3: The Bidding Price of Bidder and Competitors in WDP (k, m)

k=0

No.	b^0_{13}	v^0_{13}
1	*mc*	1
2	*mc*	0
3	*mc*	1
⋮	*mc*	⋮
m-1	*mc*	1
m	*mc*	1

k=1

No.	b^1_{13}	v^1_{13}
1	$mc+\alpha$	1
2	$mc+\alpha$	0
3	$mc+\alpha$	1
⋮	$mc+\alpha$	⋮
m-1	$mc+\alpha$	1
m	$mc+\alpha$	0

k=*k*

No.	b^k_{13}	v^k_{13}
1	$mc+k\alpha$	0
2	$mc+k\alpha$	0
3	$mc+k\alpha$	0
⋮	$mc+k\alpha$	⋮
m-1	$mc+k\alpha$	0
m	$mc+k\alpha$	0

Figure 3.4: The Results of Bidder's Bid Price in Combinatorial Auction (k, m)

3.3.4 Stochastic Optimization Model

With result of WDP, we next could find the probability of winning (POW) with bidding price of bidder for each *k* factor in all *m* times. This can help bidder estimate how much to win in the combinatorial auction when bidder submits bids into the bidding game. With equation (3.14) regarding the incomplete information game, it shows the method to discover the probability of winning in the auction with bid price of bidder. In Table 3.6, we also summarize the example in package 3 to express how to find the probability of winning of bidder for each *k* factor in combinatorial auction.

$$\Pr(b_{1j}^{k}) = \frac{\sum_{m=1}^{m} v_{1j}^{mk}}{m}. \tag{3.14}$$

$$\forall j \in J; k = \{0,\ldots,k-1,k\}.$$

$$m = \{1,2,\ldots,m\}.$$

$$v_{1j}^{mk} \in \{0,1\}.$$

Table 3.6: Probability of Winning of Bidder's Bid Price for each *k* factor

k	b_{13}^{k}	$Pr(b_{13}^{k})$
0	*mc*	98%
1	*mc+*α	96%
2	*mc+2*α	93%
⋮	⋮	⋮
k-1	*mc+(k-1)*α	5%
k	*mc+k*α	0%

To gain the optimal bid price for each package in combinatorial transportation auction with incomplete information game, because the best strategy for bidding is the bid price that could obtain the maximum benefit for bidder, thus we apply the stochastic optimization model with the objective of maximizing a bidder's expected profit in the simulation model. That is bidder can acquire the optimal solution in order to obtain the maximum expected profit for interested package in combinatorial auction. We hence present the bidding strategy formulation with stochastic optimization model for truckload carriers as described in equation (3.15) below:

$$\max \pi(b_{1j}^{k}) = (b_{ij}^{k} - mc_{1j}) * \Pr(b_{1j}^{k}). \tag{3.15}$$

With all complete data in Table 3.7, bidder could finally find the optimal bid price for interested package with probability of winning in which leads to the maximum expected benefit with this solution. Moreover, bidder also could estimate the situation of winning with each biding price submitted in the bidding game by probability of wining as well.

Table 3.7: Simulated Bids of Bidder for Package in Combinatorial Auction

k	b_{13}^{k}	mc_{13}	$Pr(b_{13}^{k})$	$\pi(b_{13}^{k})$
0	mc	mc	98%	0
1	$mc+\alpha$	mc	96%	?
2	$mc+2\alpha$	mc	93%	?
⋮	⋮	⋮	⋮	⋮
k-1	$mc+(k-1)\alpha$	mc	5%	?
k	$mc+k\alpha$	mc	0%	0

Chapter 4

Result Analysis

In this section, we initially summarize characteristics of respondents and factors, and next we use statistical analysis to test the hypotheses by t-test for independent variables in regression model whether they have impacted on a bid-to-cost ratio of carrier in combinatorial auction significantly or not. We then create a bidding simulation game for bidder and competitors in the next part. This is to find the optimal bid price in order to gain the maximum expected profit for interested packages and also to acquire the expected cost of shipper in combinatorial auction accordingly.

4.1 Characteristics of Respondent

4.1.1 Sample and Data Collection

The respondents surveyed in this research are truck carriers who provide freight service to shippers in Thailand. The author has collected data by in-depth interview with 50 respondents. With all data summarized, about half of the total respondents have income between 20-100 million baht per year. They normally provide the transport service to shippers in various industries including agriculture, construction, energy, consume product, electronic part and container. The type of trucks consists of semi-trailer truck (18 wheels), 4-wheel truck, 6-wheel truck and 10-wheel truck. For majority of respondents (37% of total), they are facing the problem of empty backhaul per total haul distance over 40%. Moreover, most 65% of respondents confront the empty backhaul (EBH) experience above 25% of EBH per total haul distance. While most of them have experience in the auction with lane-by lane basis generally, but the comprehension in combinatorial transport auction has been less attention.

Table 4.1: Characteristics Respondents

Respondents (n=50)	Mean	Frequency	Percentage
Income Per-Year	474.9		
Below 20 Million Baht		7	0.14
20-100 Million Baht		21	0.42
100-500 Million Baht		12	0.24
Above 500 Million Baht		10	0.20
EBH per Total Distance	29%		
Below 10%		6	0.18
10%-25%		6	0.18
25%-40%		9	0.27
Above 40%		12	0.37
Type of Business			
Agriculture		18	0.15
Construction		29	0.24
Energy		6	0.05
Consumer Product		18	0.15
Electronic Part		15	0.13
Container		22	0.18
Others		12	0.10

4.1.2 Questionnaire

For using questionnaire, at first we have to do pre-test with the preliminary questionnaire. We then test with 5 selective carriers by in-depth interview to ensure and get any suggestion. This is to check and improve the validity of this final version questionnaire before collecting the real practice. After that we start collecting the data by in-depth interview with truck carriers within around 2 months. To represent a bid-to-cost ratio of carriers in combinatorial auction for transport market in Thailand, we do survey with all 50 truck carriers. Because they usually provide transport service to shippers in various industries, therefore, these targets could represent the behavior of bidding in combinatorial transport auction regarding purpose of this study.

4.1.3 Opinion and Others

The surveyed respondents who are truck carriers in Thailand express their opinion that now the situation of competition for transportation industry has been aggressive. Around 41% of questionnaires show that it is in serious situation of competition whereas 46% of respondents express that the situation of competitor in transport service is almost serious nearby. Each surveyed carrier knows the circumstances onwards obviously. Thus, they try to improve and enhance their capability to compete with other players in the transport market. They seek to decrease their cost of operation in transportation service with the same level of service efficiently.

4.2 Statistics Results and Data Analysis

4.2.1 Regression Model with Hypothesis Results

We initially use the statistical analysis by F-test to check that there is at least one independent variable that impacts to a bid-to-cost ratio of combinatorial transportation auction. It shows in Table 4.2 that they do impact on dependent variable significantly at the 0.05 level.

Table 4.2: Statistics Analysis with F-test

Research Statistics	
Multiple R	0.594
R Square	0.353
Adjusted R Square	0.352
Standard Error	0.309
Observations	2394

ANOVA	***Df***	**SS**	**MS**	**F**	***Significance F***
Regression	6	125.191	20.865	217.3107	0.000*
Residual	2387	229.188	0.096		
Total	2393	354.378			

*Significant at the 0.05 level

To find relationship of each independent variable to a bid-to-cost ratio of carrier in the market regarding conceptual framework, then we use the statistical analysis by t-test to execute the data with each independent variable. The result of this research shows that a number of competitors (n), a pre-empty backhaul to new lane distance ratio (μ), a pattern of transportation service in combinatorial auction ($\mu\gamma$), and the product between a pre-empty backhaul to new lane distance ratio and number of competitors (μn) do impact on a bid-to-cost ratio of carrier in combinatorial transportation auction significantly at the 0.05 level. In addition, the coefficient and standard error of each independent variable are shown in Table 4.3.

Table 4.3: Statistics Analysis with T-test

Independent Variable	Coefficients	Standard Error	t-Stat	P-value	Hypothesis
Intercept	1.385	0.0253	54.840	0.000	-
n	-0.023	0.0052	-4.389	0.000*	Rejected H1
s	-0.005	0.0032	-1.471	0.141	Accepted H2
μ	0.150	0.0107	0.007	0.000*	Rejected H3
γ	0.009	0.0234	0.371	0.711	Accepted H4
$\mu\gamma$	-0.743	0.0270	-27.547	0.000*	Rejected H5
μn	-0.007	0.0026	-2.717	0.007*	Rejected H6

*Significant at the 0.05 level

The results of statistical analysis can explain that the bidding price of competitive auction to package *j* with a large number of competitors (*n*) will be lower comparing with a small number of competitors. Because a large number of competitors represent the high competitive situation in combinatorial auction, thus, carrier understands the condition and accepts to decrease a bid-to-cost ratio to compete in the competition market inevitably. While a pre-empty backhaul to new lane distance ratio (μ) does impact positively to the bid-to-cost ratio of carrier. It indicates that carrier considers submitting a higher bid-to-cost ratio when new lane distance decreases with constant distance of pre-empty backhaul. In addition, a bid-to-cost ratio of carrier in the market has decreased obviously when a value of pattern of transportation service ($\mu\gamma$) increases. The maximum value of $\mu\gamma$ is equal 1 regarding constraints (3.4) and (3.5). For example: μ_{11}=1, γ_{11}=1; $\mu_{11}\gamma_{11}$=1, l_1=150, it presents that the new lane for package1 proposed by shipper at 150km matches with the existing empty backhaul of carrier1 completely (γ_{11} =1). A carrier1 can eliminate the existing empty backhaul with package 1 totally ($lpos_{11}$=0) and enhance transportation network efficiency.

Because the marginal cost of carrier1 (mc_{11}) in this package could be low due to no post-empty backhaul ($lpos_{11}$=0) regarding equation (3.11). Thus, carrier1 has the competitive advantage to compete with competitor, and he could submit bid price with the low bid-to-cost ratio into the auction. On the other hand, if carrier1 has no competitive advantage in package1, for example: μ_{11} =1, γ_{11} =0.2, $\mu_{11}\gamma_{11}$ =0.2, l_1 =150, the new lane in package1 is able to eliminate the empty backhaul of carrier1 only at 20% (γ_{11} =0.2, $lpos_{11}$=120). The marginal cost (mc_{11}) in this example should be higher than the previous one. Therefore, in this case carrier1 has to submit the bid price with the higher bid-to-cost ratio to cover more marginal cost for package1 into the auction necessarily.

From testing by statistical analysis, because we include few independent variables which are not significant but they may be important to dependent variable in bidding game, therefore, we can present the regression model for the average bid-to-cost ratio of carrier in combinatorial transportation auction as follows:

$$x_{ij} = 1.385 - 0.023n - 0.005s_j + 0.009\gamma_{ij} + (0.15 - 0.743\gamma_{ij} - 0.007n)\mu_{ij} \quad (4.1)$$

To obtain the average bid price of interested package in the auction, carrier could use the regression model with μ, γ, n, s of each package into equation (4.1) to generate a bid-to cost ratio of bidding in the transport market practically. Then they could also find the average bid price by the product between a bid-to-cost ratio and operating cost accordingly.

In Figure 4.1, it shows the example how to find the bid-to-cost ratio in the auction with regression model in this research. Initially, we have to find $\mu_{11}, \gamma_{11}, n, s_1$ regarding this auction. With existing transportation service, l_{pre11} = 150 km, whereas l_1 =150 km (s_1=1), thus μ_{11}=1. To match the new lane with existing transport network, $l_{pos11}=0$ km; thus $\gamma_{11}=1$ subsequently. In addition, there is only 1 competitor in this example game, *n*=1; Therefore, we finally could find the average bid-to-cost ratio for this package or lane in Figure 4.1 regarding equation (4.1) as the following:

$$x_{11} = 1.385 - 0.023 - 0.005 + 0.009 + (0.15 - 0.743 - 0.007) * 1.$$
$$= 0.766.$$

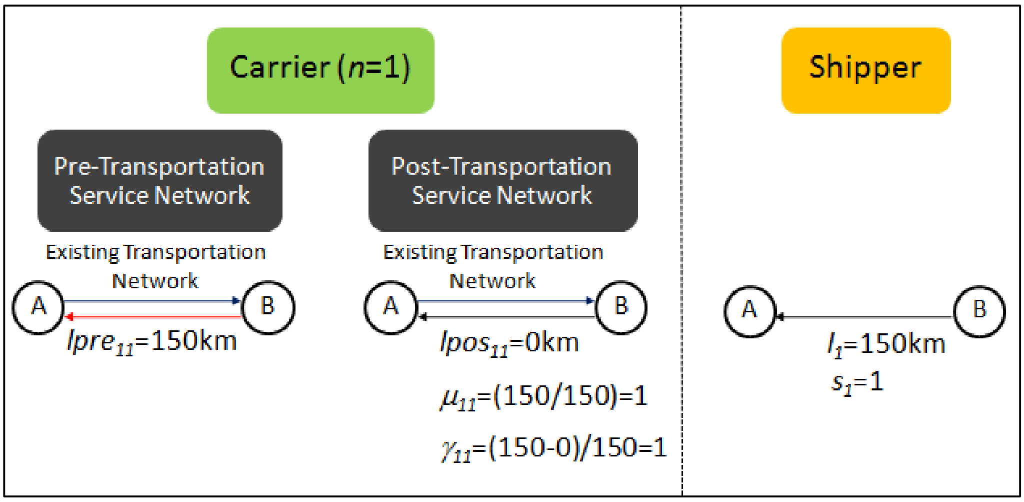


Figure 4.1: Existing Transport Network with New Lane announced by Shipper

4.2.2 Data Analysis

In Figure 4.2, we show the average bid-to-cost ratio of carrier with $n=1$, $a/l=1$ and $s=1$ as an example. This is to explain the relationship between μ and γ to a bid-to-cost ratio of transport market in Thailand. It explains that at value of γ is low, the average bid-to-cost ratio will be decreased less than when μ increases compared with high value of γ. While, under the same value of μ the average bid-to-cost ratio of carriers will lower when γ is higher. In addition, the trend of average bid-to-cost ratio of carriers will be decreased when μ increases with constant value of γ.

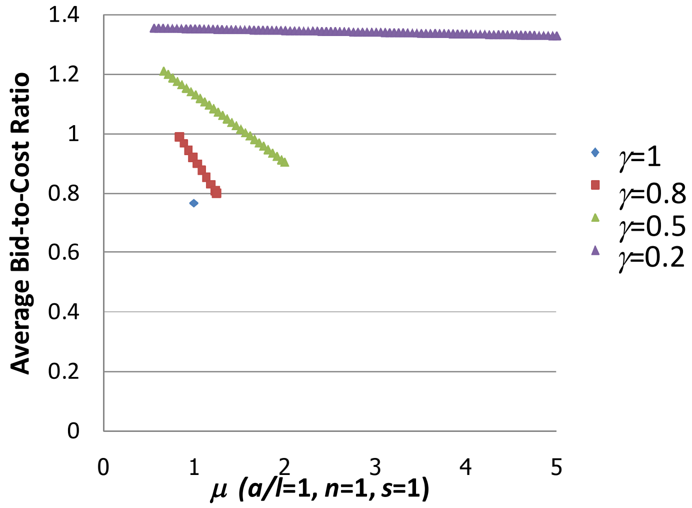


Figure 4.2: The Average Bid-to-Cost Ratio of Carrier in Transport Market

To find the bid-to-cost ratio in which is lower than 1 called the efficiency transportation zone, we can use regression model generated in this study to find the possible area. Due to carrier could gain the benefit from existing transport network with new package proposed by shipper regarding economies of scope. Thus, some packages probably could be submitted in the low bidding price by which the bid-to-cost ratio is below 1 in the auction. For example, with n=1 and s=1 in the combinatorial auction, it could find the efficiency transportation network of carriers so that carrier would realize which transport pattern that they could submit the low bid price in combinatorial auction to gain the benefit regarding economies of scope. The efficient transportation network of carriers is expressed in Figure 4.3.

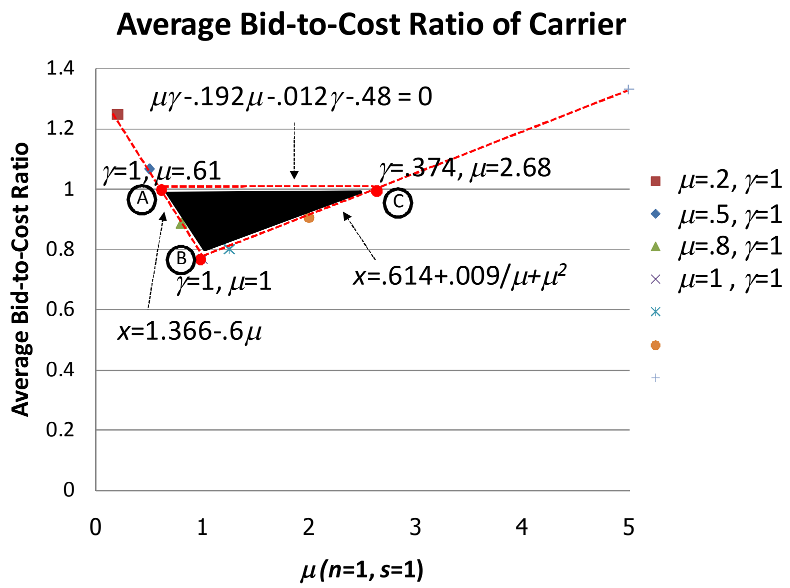


Figure 4.3: The Efficient Transportation Network of Carrier in the Market

4.3 Simulation Results

To find the optimal bid price for interested package, we simulate the bidding game in combinatorial auction with incomplete information between bidder and competitor who are truck carrier. By the research methodology in chapter 3, we simulate the two bidding games in combinatorial auctions to present the optimal bid price with maximum expected profit including expected cost of transport service procurement. For running the winner determination problem in this dissertation, we use Microsoft Excel 2010 with Solver function in Macro to execute the data and award bids submitted to the winners in combinatorial auction.

4.3.1 Combinatorial Auction Simulation with 2 competitors and 2 lanes

In this auction (Example 1), there are 2 competitors (n=2) and 2 lanes proposed by shipper (10-wheeled Truck). Due to having only a few lanes, thus, the packages in which carriers can select to bid for have not many accordingly. The combinatorial transport auction for bidder against 2 competitors can present in Figure 4.4.

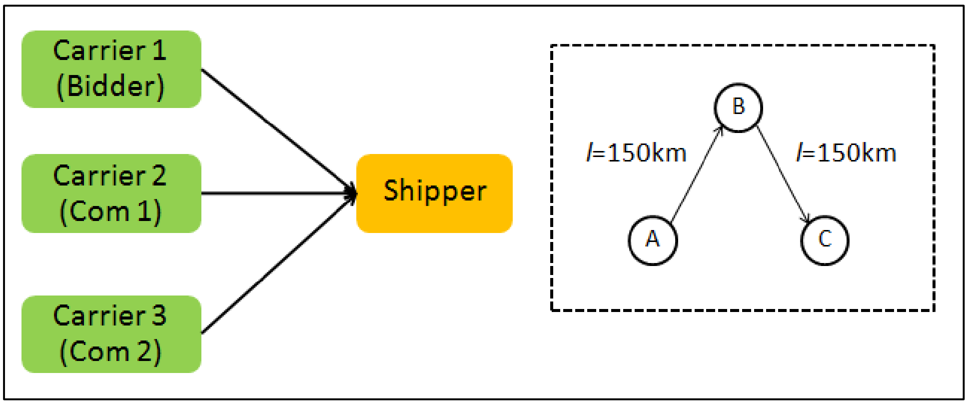


Figure 4.4: The Combinatorial Auction with 2 competitors and 2 lanes (Example 1)

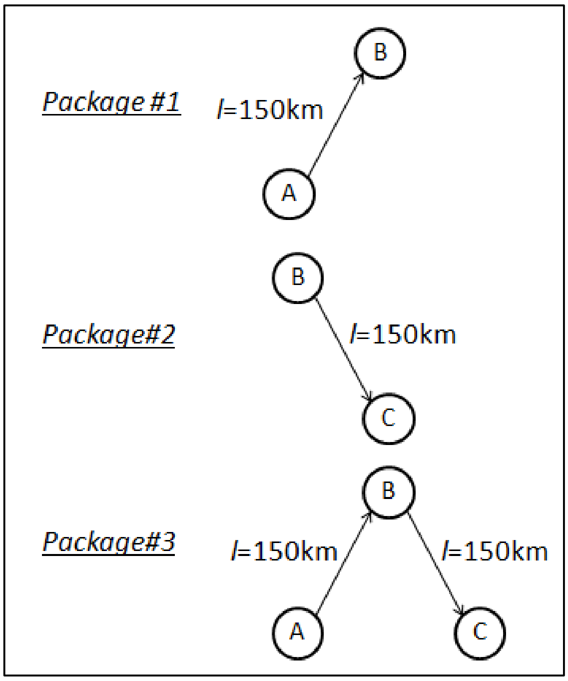


Figure 4.5: All Possible Packages (Example 1)

The randomized packages of combinatorial auction could be introduced to be 3 packages as shown in Figure 4.5. Then, the research methodology in bidding simulation with incomplete information game starts finding randomized packages and next randomized bid-to-cost ratios of competitors with μ and γ of competitors regarding constraints (3.3), (3.4) and (3.5). We therefore use the Monte Carlo method to randomize packages of competitors and generate random number between μ and γ of competitor. In this example, we assume to randomize competitor's γ_{ij} during 0.2 (γ_l) to 1 (γ_u) as Example 1.1. Bidder then could evaluate the randomized bid-to-cost ratios of competitor by regression model. With bidding price of bidder, we submit bidding price of bidder into the WDP to find probability of winning with bidder's bid. Consequently, we use the stochastic optimization problem to acquire the optimal bid price of bidder in which reaches the maximum payoff for the competition. The example in Figure 4.6 shows the existing transport network of bidder with new lane for each package.

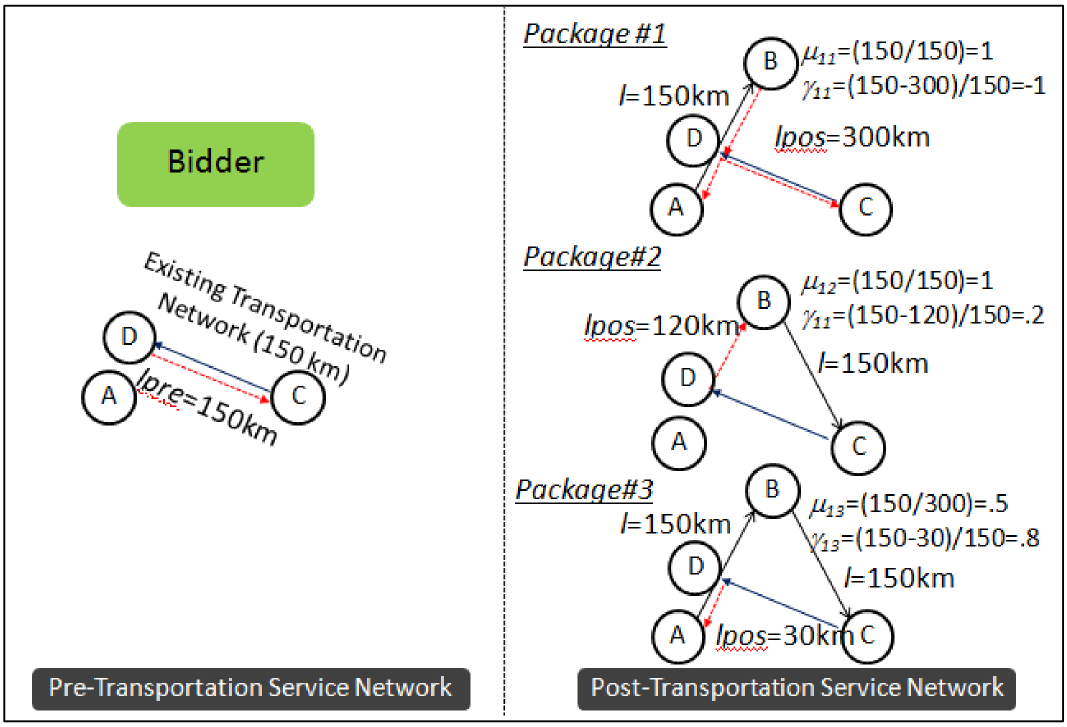


Figure 4.6: Existing Transport Network of Bidder with New Lanes (Example 1)

By this research methodology, the simulated bid price of bidder for package 1, 2, and 3 in combinatorial transport auction could be explained in Table 4.4, 4.5, and 4.6 respectively. The results show that the optimal bid price can be reached for both package 2 and package 3 while packages 1 is not able to find the optimal solution. For package 1, there is no optimal solution due to have expected loss in the auction. While we could find the optimal solution at 1,225 baht in package 2, and 1,925 baht in package 3 respectively. In addition, the expected profit with bidding price of bidder in each package in combinatorial auction could be shown in Figure 4.7.

For outcome of bidding simulation with optimal solution for each package obtained by simulation methodology, then we submit all optimal bid price of bidder in both package 2 and package 3 into combinatorial auction. The results in Table 4.7 show that bidder joining in combinatorial auction can gain the expected profit with optimal solution more than around 358% comparing with average bid price of bidder in the transport market significantly.

With this optimal solution, it expresses that bidder has the maximum expected profit at 275 baht with the probability of winning at 70%. (mc_3 = 1,530 baht). While, in turn the result of bidding simulation presents that expected cost of transportation service procurement by shipper has potentially decreased, the shipper gains the benefit from the optimal solution of bidder to might possibly lower expected cost of transport service procurement significantly at -8.4% or around 1,892 baht from average market price at 2,067 baht. In addition, we could summarize the mutual benefit both bidder and shipper in Figure 4.8.

Table 4.4: Simulated Bids of Bidder for Package 1 (Example 1.1)

Bidding Price	MC	Probability of Winning(%)	Expected Profit
2,025	2,025	0	0
2,100	2,025	0	0
2,200	2,025	0	0
2,300	2,025	0	0
2,400	2,025	0	0
2,500	2,025	0	0
2,600	2,025	0	0
2,700	2,025	0	0
2,800	2,025	0	0
2,900	2,025	0	0
3,000	2,025	0	0
3,100	2,025	0	0
3,200	2,025	0	0
3,300	2,025	0	0
3,400	2,025	0	0
3,500	2,025	0	0

Unit: THB

* $\mu_{11} = 1$, $\gamma_{11} = -1$, $n = 2$, $s = 1$.

* No. of iterations (m) = 500

* ϕ_f = 7.5 THB/km; ϕ_6 = 6 THB/km

* $0.2 \le \gamma_{ij} \le 1 \; ; \forall i \in I - \{1\}, \forall j \in J.$

* $0 \le lpos_{1j} \le 120.$

Table 4.5: Simulated Bids of Bidder for Package 2 (Example 1.1)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
500	945	83	-370
600	945	81	-280
700	945	78	-190
800	945	73	-106
900	945	57	-26
950	945	46	2
1,000	945	37	20
1,050	945	29	30
1,100	945	25	38
1,150	945	20	41
1,175	945	19	43
1,200	945	17	43
1,225	945	16	44
1,250	945	14	43
1,300	945	10	36
1,350	945	7	30
1,400	945	6	26
1,450	945	5	23
1,489	945	3.8	21
1,500	945	3	18
1,600	945	2	12
1,700	945	2	12
1,800	945	1	7
1,900	945	0	2
2,000	945	0	0

Optimal Bid Price — 1,225

Average Market Price — 1,489

Unit: THB

$\mu_{12} = 1,\ \gamma_{12} = 0.2,\ n = 2,\ s = 1.$

Table 4.6: Simulated Bids of Bidder for Package 3 (Example 1.1)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
1,300	1,530	100	-230
1,400	1,530	100	-130
1,500	1,530	100	-30
1,530	1,530	100	0
1,600	1,530	100	70
1,650	1,530	100	120
1,700	1,530	98	166
1,750	1,530	94	207
1,800	1,530	88	238
1,850	1,530	81	258
1,900	1,530	74	275
1,925	1,530	70	275
1,950	1,530	65	272
2,000	1,530	55	260
2,050	1,530	48	248
2,100	1,530	41	234
2,200	1,530	31	206
2,300	1,530	18	142
2,400	1,530	10.8	94
2,500	1,530	6	62
2,503	1,530	6	62
2,600	1,530	4	41
2,700	1,530	2	23
2,800	1,530	1	13
2,900	1,530	0	0

Optimal Bid Price

Average Market Price

Unit: THB

* $\mu_{13} = .5$, $\gamma_{13} = 0.8$, $n = 1$, $s = 2$.

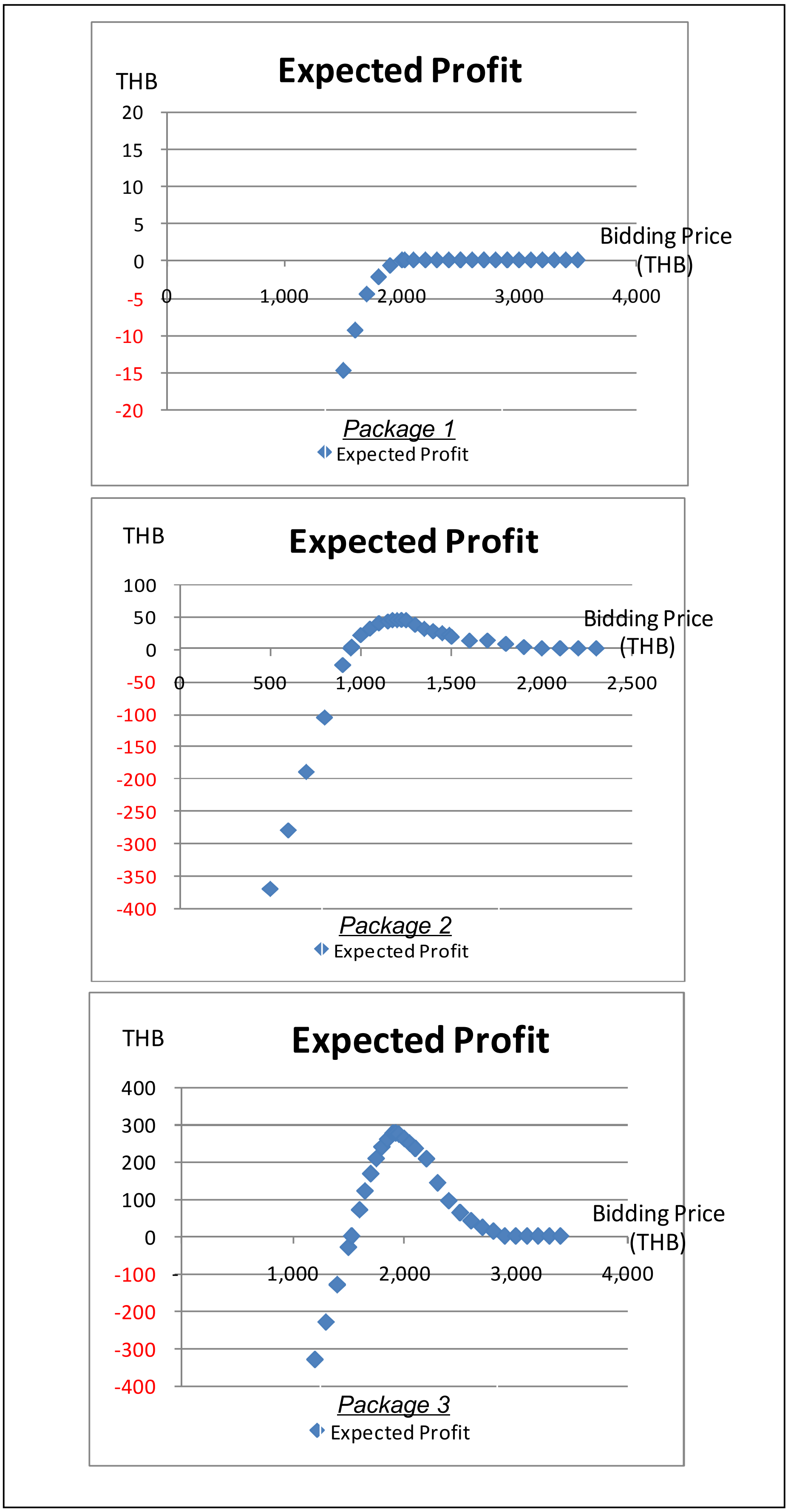
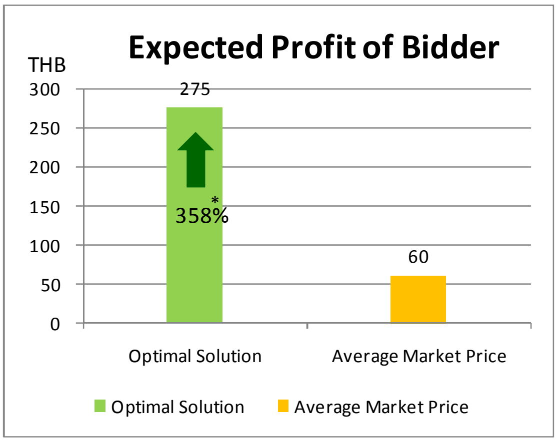


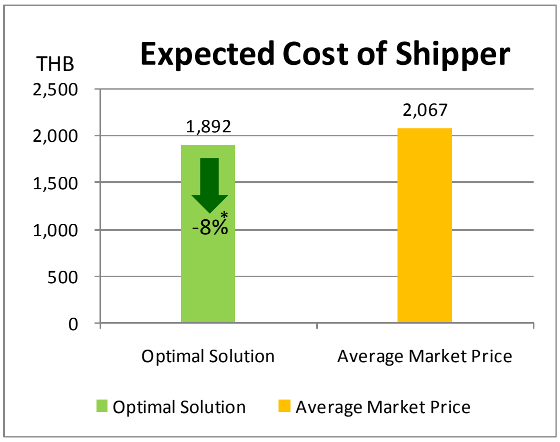
Figure 4.7: Expected Profit of Bidder for Each Package (Example 1.1)

Table 4.7: Result of Bidding Simulation in Example 1.1

Situation	Package	Bidder				Shipper
		Expected Profit (THB)	Bid Price (THB)	Marginal Cost	POW	**Expected Cost (THB)**
Average Market Price	#2	17	1,489	945	3.2%	
	#3	43	2,503	1,530	4.4%	
	Total	60				2,067
Optimal Solution	#2	**0**	**1,225**	**945**	**0%**	
	#3	**275**	**1,925**	**1,530**	**70%**	
	Total	**275*** **(+358%)**				**1,892*** **(-8.4%)**

Note: *significant at the 0.05 level.





Note: *significant at the 0.05 level.

Figure 4.8: Mutual Benefit (Example 1.1)

As mentioned by Song and Regan (2002) and N. An , et al. (2005), they have applied the fixed margin to calculate the bidding price for combinatorial transportation auction in practice. For validation, we thus confirm by comparing the optimal solution with fixed margin in various values during 80% - 120% of operating cost. The expected profit of optimal solution shows that the benefit with optimal bid price is higher than the expected profit with all constant margins obviously. In Table 4.8, it shows the all data in which it could be represented by the chart to confirm our model with validation in Figure 4.9.

Table 4.8: Validation of Bidding Simulation (Example 1.1)

Scenario	Expected Profit (THB)	Bidding Price of Package (THB)			Cost of Shipper
		#1	#2	#3	
Optimal Solution	275	-	1,225	1,925	2,128
Average Market Price	60	-	1,489	2,503	2,280
%80	198	-	900	1,800	1,713
%85	213	-	956	1,913	1,980
%90	189	-	1,013	2,025	2,057
%100	135	-	1,125	2,250	2,124
%105	111	-	1,181	2,363	2,180
%110	76	-	1,238	2,475	2,227
%120	42	-	1,350	2,700	2,299

$oc_2 = 1{,}125; oc_3 = 2{,}250.$

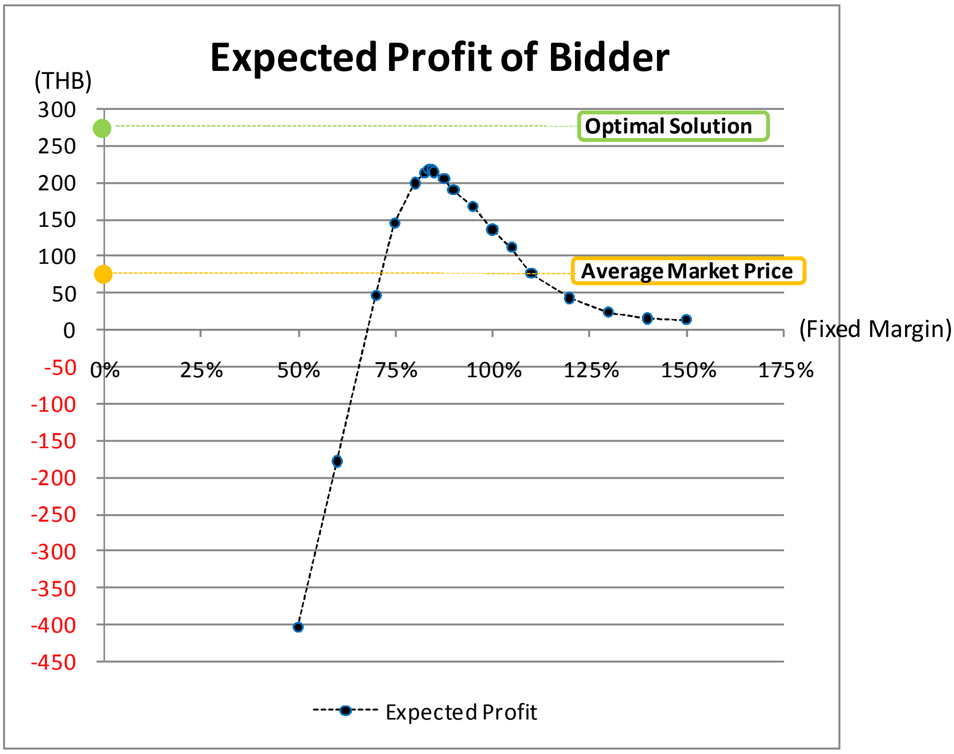


Figure 4.9: Expected Profit with Optimal Solution of Simulation (Example 1.1)

To study more on range of competitor's γ_{ij} in order to randomize the bid price of competitors for combinatorial auction in the incomplete information game, thus, we then vary the range of γ_{ij} from 0.2 – 1 ($0.2 \le \gamma_{ij} \le 1$) to 0.5 – 1 ($0.5 \le \gamma_{ij} \le 1$). It means in this matter that the decrease ratio of pre-empty backhaul of competitors joining into the auction has increased from previous example. It also expresses that competitors in the auction have more competitive advantage to compete with players in the transport market because they could gain benefit of pre-empty backhaul in the combinatorial auction regarding economies of scope. To find the optimal bid price of each package according to research methodology, thus, we simulate bids for bidder to acquire the optimal solution in combinatorial auction in Tables 4.9, 4.10, and 4.11 as Example 1.2.

Table 4.9: Simulated Bids of Bidder for Package 1 (Example 1.2)

Bidding Price	MC	Probability of Winning	Expected Profit
2,025	2,025	0	0
2,050	2,025	0	0
2,150	2,025	0	0
2,250	2,025	0	0
2,350	2,025	0	0
2,450	2,025	0	0
2,550	2,025	0	0
2,650	2,025	0	0
2,750	2,025	0	0
2,850	2,025	0	0
2,950	2,025	0	0
3,050	2,025	0	0

* No. of iterations (m) = 500

* ϕ_f = 7.5 THB/km; ϕ_6 = 6 THB/km

* $0.5 \le \gamma_{ij} \le 1$; $0 \le lpos_{1j} \le 120$; $\forall i \in I - \{1\}, \forall j \in J$.

Table 4.10: Simulated Bids of Bidder for Package 2 (Example 1.2)

	Bidding Price	MC	Probability of Winning	Expected Profit
	945	945	40	0
	950	945	38	2
	1,000	945	28	15
	1,025	945	24	19
Optimal Bid Price	1,050	945	21	22
	1,075	945	16	21
	1,100	945	13	20
	1,150	945	10	20
	1,200	945	7	19
	1,225	945	6	16
	1,250	945	5	15
	1,300	945	4	14
	1,350	945	4	15
	1,450	945	2	10
Average Market Price	1,489	945	2	10.9
	1,500	945	2	11.1
	1,550	945	1	7
	1,600	945	1	8
	1,650	945	1	6
	1,700	945	0	0
	1,900	945	0	0
	2,000	945	0	0
	2,100	945	0	0
	2,200	945	0	0
	2,300	945	0	0

Table 4.11: Simulated Bids of Bidder for Package 3 (Example 1.2)

	Bidding Price	MC	Probability of Winning	Expected Profit
	1,530	1,530	100	0
	1,550	1,530	100	20
	1,600	1,530	100	70
	1,650	1,530	100	120
	1,700	1,530	98	166
	1,750	1,530	88	194
	1,775	1,530	82	202
	1,800	1,530	77	207
Optimal Bid Price	1,825	1,530	71	210
	1,850	1,530	65	207
	1,900	1,530	52	194
	1,925	1,530	46	181
	1,950	1,530	41	172
	2,000	1,530	29	138
	2,050	1,530	21	108
	2,100	1,530	16	93
	2,150	1,530	13	79
	2,200	1,530	9	62
	2,250	1,530	6	43
	2,300	1,530	5	35
	2,400	1,530	3.4	30
Average Market Price	2,503	1,530	2.2	21
	2,600	1,530	0.6	6
	2,700	1,530	0.2	2
	2,800	1,530	0	0
	2,900	1,530	0	0

Table 4.12: Result of Bidding Simulation (Example 1.2)

Situation	Package	Bidder				Shipper
		Expected Profit (THB)	Bid Price (THB)	Marginal Cost	POW	**Expected Cost (THB)**
Average Market Price	#2	11	1,489	945	2%	
	#3	10	2,503	1,530	1%	
	Total	21				1,938
Optimal Solution	#2	**0**	**1,050**	**945**	**0%**	
	#3	**210**	**1,825**	**1,530**	**71%**	
	Total	**210**				**1,806**

With range of γ_{ij} from 0.2 - 1 in Example 1.1 ($0.2 \le \gamma_{ij} \le 1$) to 0.5 – 1 in Example 1.2 ($0.5 \le \gamma_{ij} \le 1$), the result in Table 4.12 shows that the optimal solution in Example 1.2 has been decreased 14.3% from 1,225 to 1,050 in package 2. In package 3, the optimal bid price also drops around 5.2% from 1,925 baht to 1,825 baht while the expected profit lowers around 23.63% to 210 baht comparing with Example 1.1 too. It could explain that the competitor has more competitive advantage with the benefit of existing transportation network regarding economies of scope. Due to low marginal cost, thus, bid price of competitor in transportation market is able to lower to compete with players in the bidding game. By this reason, the optimal bid price of bidder in Example 1.2 to submit into the combinatorial auction for each package should be lower than the optimal solution in Example 1.1 to compete into the auction.

In addition, the expected cost of transportation service procurement for shipper in combinatorial auction has also been reduced with γ_{ij} during 0.5 - 1. This is because competitors could submit the lower bid price to compete with others into the auction due to have competitive advantage from existing transportation network. Shipper thus could gain benefit from competitors regarding economies of scope to reduce the cost of transportation service procurement considerably. The results with optimal solution between $0.2 \le \gamma_{ij} \le 1$ and $0.5 \le \gamma_{ij} \le 1$ of competitors in bidding game are expressed as Table 4.13.

Table 4.13: The Optimal Results with Different Range of Competitors' γ

Results	$0.2 \le \gamma \le 1$		$0.5 \le \gamma \le 1$	
	Package2	Package3	Package2	Package3
Optimal Bid Price	1,225	1,925	1,050	1,825
POW	0%	70%	0%	71%
Expected Profit of Carrier	275		210	
Expect Cost of Shipper	1,892		1,806	

Unit: THB

4.3.2 Combinatorial Auction Simulation with 4 competitors and 9 lanes

For this bidding simulation in example 2, there are 4 competitors (n=4) and 9 lanes in which is so complicated for both carrier to submit bids to auctioneer and shipper to award bids to the winners. In Figure 4.10, it presents the all new lanes by which are proposed by shipper in combinatorial transport auction between bidder and 4 competitors. Due to having 9 lanes, thus, there are many packages in which carriers can select to bid for in the combinatorial auction.

Regarding the concept of the possible packages with Sheffi (2004), it could be expressed the all packages as Table 4.14. Therefore, the bidder initially has to calculate γ initially to decide which package should be bided for. With our assumption in this example, the bidder will submit the package in which has γ not less than 0.2 including new package with no empty backhaul. This is to decrease or eliminate the existing empty backhaul in pre-transport service network as well as gain benefit to have more profit with low marginal cost for economies of scope.

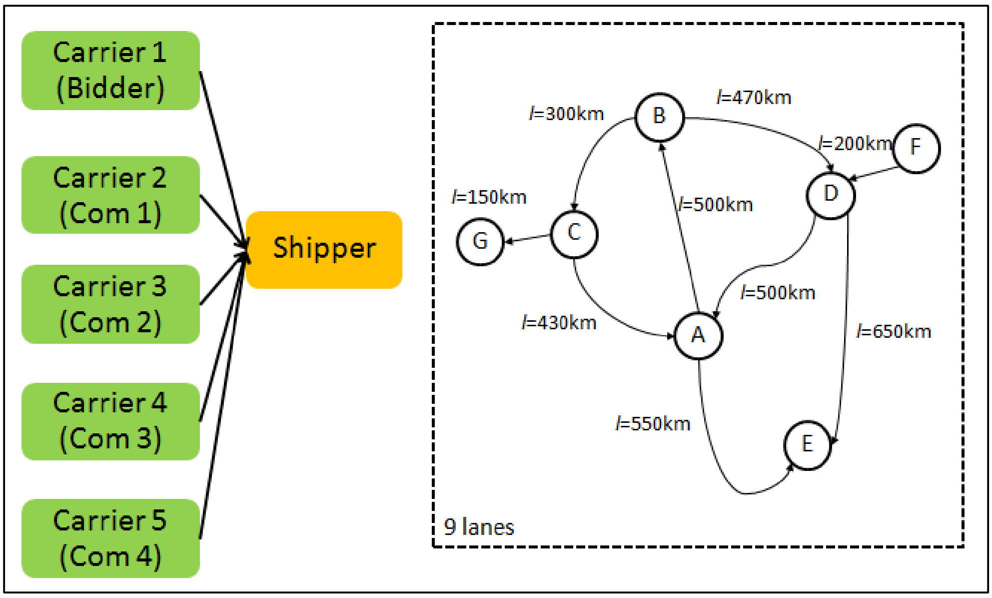


Figure 4.10: The Combinatorial Auction with 4 Competitors and 9 Lanes (Example 2)

Table 4.14: All Packages in Bidding Simulation (Example 2)

Package	Lane	Package	Lane
1	AB	18	AB, DA
2	AE	19	AE, DA
3	BC	20	DA, FD
4	BD	21	DE, FD
5	CA	22	AB, BC, CA
6	CG	23	AB, BD, DA
7	DA	24	AB, BC, CG
8	DE	25	AB, BD, DE
9	FD	26	AE, BC,CA
10	AB, BC	27	AE, BD,DA
11	AB, BD	28	AB, BD, CA
12	BC, CA	29	AB, BC,DA
13	BC, CG	30	AE, DA, FD
14	BD, DA	31	AB, DA, FD
15	BD, DE	32	AB, BC, CG, DA
16	AB, CA	33	AB, BC, DA, FD
17	AE, CA	34	AB, BC, CG, DA, FD

With benefit of existing network of bidder in Figure 4.11, therefore, the bidding simulation for bidder has selected for package 2, 8, 15, 19, 21, 22, 23, 25, 26, 27 and 30 to be bided in this combinatorial auction. We then use the simulation technique generated in this study to find the optimal bid price of each package. The results of interested packages with range of competitors' γ_{ij} during 0.2 -1 have been described in Table 4.15 - 4.25 respectively.

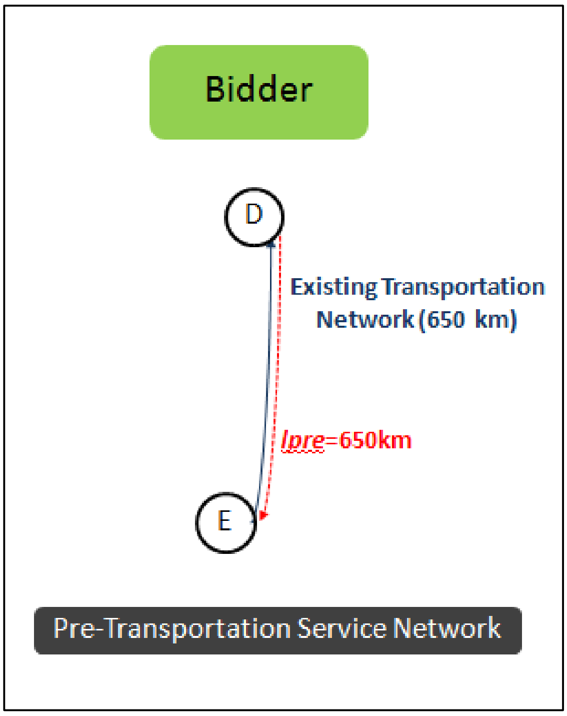


Figure 4.11: Existing Transport Service Network of Bidder (Example 2)

Table 4.15: Simulated Bids of Bidder for Package 2 (Example 2)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	3,500	3,225	19.1	53
	3,600	3,225	16.3	61
	3,700	3,225	14.2	68
	3,800	3,225	13.2	76
	3,900	3,225	11.1	75
	4,000	3,225	9.6	74
	4,050	3,225	9.6	79
Optimal Bid Price	4,100	3,225	9.6	84
	4,150	3,225	8.8	81
	4,200	3,225	8.3	81
	4,300	3,225	7.5	81
	4,400	3,225	7.1	83
	4,500	3,225	5.6	72
	4,600	3,225	5.4	74
	4,700	3,225	5.0	74
	4,800	3,225	4.1	65
	4,900	3,225	3.9	66
	5,000	3,225	3.5	62
Average Market Price	5,035*	3,225	3.3	60
	5,100	3,225	3.3	62
	5,200	3,225	3.1	61
	5,300	3,225	2.3	47

Unit: THB

* μ_{12} = 1.18, γ_{12} = 0.23, n = 4, s = 3.66.

* No. of iterations (m) = 500

* ϕ_f = 7.5 THB/km; ϕ_6 = 6 THB/km

* $0.2 \leq \gamma_{ij} \leq 1$; $0 \leq lpos_{1j} \leq 520$; $\forall i \in I - \{1\}, \forall j \in J$.

Table 4.16: Simulated Bids of Bidder for Package 8 (Example 2)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	1,800	975	91.3	753
	1,900	975	90.2	834
	2,000	975	89.6	918
	2,100	975	88.3	994
	2,200	975	87.5	1,072
	2,300	975	87.3	1,157
	2,400	975	86.9	1,238
	2,500	975	86.3	1,316
	2,600	975	84.7	1,377
	2,700	975	82.8	1,429
	2,800	975	81.5	1,487
	2,900	975	78.1	1,503
	3,000	975	76.1	1,540
	3,100	975	73.8	1,568
	3,150	975	72.1	1,567
Optimal Bid Price	3,200	975	70.8	1,576
Average Market Price	3,221*	975	69.9	1,570
	3,250	975	68.5	1,557
	3,300	975	65.5	1,522
	3,400	975	56.9	1,380
	3,500	975	51.0	1,287
	3,600	975	46.2	1,214
	3,700	975	41.8	1,138
	3,800	975	37.6	1,062

Unit: THB

* $\mu_{18} = 1$, $\gamma_{18} = 1$, $n = 4$, $s = 4.33$.

Table 4.17 Simulated Bids of Bidder for Package 15 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
8,400	7,320	7.47	80.7
8,500	7,320	7.04	83.1
8,600	7,320	7.04	90.1
8,700	7,320	6.40	88.4
8,800	7,320	5.79	85.6
8,900	7,320	5.17	81.6
9,000	7,320	4.76	80.0
9,100	7,320	4.34	77.2
9,200	7,320	4.34	81.6
9,300	7,320	4.12	81.6
9,400	7,320	3.71	77.2
9,500	7,320	3.71	80.9
9,600	7,320	3.51	79.9
9,700	7,320	3.30	78.5
9,800	7,320	3.29	81.6
9,900	7,320	3.08	79.5
10,000	7,320	2.87	77.0
10,100	7,320	2.87	79.9
10,187*	7,320	2.87	82.4
10,200	7,320	2.87	82.8
10,300	7,320	2.67	79.5
10,400	7,320	2.67	82.2
10,500	7,320	2.67	84.9
10,600	7,320	2.67	87.6
10,700	7,320	2.47	83.5
10,800	7,320	2.47	85.9

Average Market Price

Unit: THB

Table 4.17: Simulated Bids of Bidder for Package 15 (Example 2 - Continued)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
10,900	7,320	2.47	88.4
11,000	7,320	2.47	90.9
11,100	7,320	2.47	93.3
11,200	7,320	2.27	88.0
11,300	7,320	2.27	90.3
11,400	7,320	2.27	92.5
11,500	7,320	2.27	94.8
11,600	7,320	2.06	88.1
11,700	7,320	2.06	90.1
11,800	7,320	2.06	92.2
11,900	7,320	2.06	94.2
12,000	7,320	2.06	96.3
12,200	7,320	2.06	100.4
12,300	7,320	2.06	102.5
12,350	7,320	2.06	103.5
12,400	7,320	2.06	104.5
12,450	7,320	1.85	95.0
12,500	7,320	1.85	95.9
12,600	7,320	1.44	76.2
12,800	7,320	1.24	67.9
13,000	7,320	1.24	70.4
13,200	7,320	1.24	72.9
13,400	7,320	1.24	75.4
13,600	7,320	1.04	65.0
13,800	7,320	1.04	67.1

Optimal Bid Price

Unit: THB

* μ_{115} = 0.58, γ_{115} = 0.277, n = 4, s = 7.47.

Table 4.18: Simulated Bids of Bidder for Package 19 (Example 2)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	4,800	3,975	59.6	491
	4,900	3,975	58.0	537
	5,000	3,975	56.5	579
	5,100	3,975	54.4	612
	5,200	3,975	51.0	625
	5,300	3,975	47.5	629
Optimal Bid Price	5,400	3,975	45.9	654
	5,500	3,975	41.6	634
	5,600	3,975	38.6	627
	5,700	3,975	34.8	600
	5,800	3,975	31.3	572
	5,900	3,975	27.1	521
	6,000	3,975	23.9	484
	6,100	3,975	20.9	445
	6,200	3,975	18.0	400
	6,300	3,975	16.4	382
	6,400	3,975	14.1	342
	6,500	3,975	12.7	319
	6,600	3,975	11.6	304
	6,700	3,975	10.5	285
	6,800	3,975	10.1	285
	6,900	3,975	8.8	258
Average Market Price	6,971*	3,975	8.4	251
	7,000	3,975	8.0	241

Unit: THB

* μ_{119} = 0.619, γ_{119} = 1, n = 4, s = 7.

Table 4.19: Simulated Bids of Bidder for Package 21 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
4,300	3,675	64.9	406
4,400	3,675	59.7	433
4,500	3,675	53.7	443
4,600	3,675	49.3	456
4,650	3,675	47.4	462
4,700	3,675	45.5	466
4,750	3,675	43.9	472
4,800	3,675	41.4	466
4,900	3,675	36.2	444
5,000	3,675	32.9	436
5,100	3,675	30.7	437
5,200	3,675	27.7	423
5,300	3,675	26.3	427
5,400	3,675	23.8	411
5,500	3,675	21.7	396
5,600	3,675	19.6	377
5,700	3,675	18.3	370
5,800	3,675	17.0	361
5,900	3,675	15.8	351
6,000	3,675	14.0	325
6,100	3,675	12.7	308
6,200	3,675	11.9	300
6,204*	3,675	11.9	300
6,300	3,675	11.0	290

Optimal Bid Price

Average Market Price

Unit: THB

* μ_{121} = 0.765, γ_{121} = 0.692, n = 4, s = 5.66.

Table 4.20: Simulated Bids of Bidder for Package 22 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
9,600	9,225	0.21	1
9,700	9,225	0.21	1.0
9,800	9,225	0.21	1.2
9,900	9,225	0.21	1.4
9,950	9,225	0.21	1.5
10,000	9,225	0.21	1.6
10,050	9,225	0.21	2
10,100	9,225	0.00	0
10,200	9,225	0.00	0
10,300	9,225	0.00	0
10,400	9,225	0.00	0
10,500	9,225	0.00	0
10,600	9,225	0.00	0
10,700	9,225	0.00	0
10,800	9,225	0.00	0
10,900	9,225	0.00	0
11,000	9,225	0.00	0
11,100	9,225	0.00	0
11,200	9,225	0.00	0
11,300	9,225	0.00	0
11,400	9,225	0.00	0
11,500	9,225	0.00	0
11,550*	9,225	0.00	0
11,600	9,225	0.00	0
11,700	9,225	0.00	0

Optimal Bid Price

Average Market Price

Unit: THB

* $\mu_{122} = 0$, $\gamma_{122} = 0$, $n = 4$, $s = 8.2$.

Table 4.21: Simulated Bids of Bidder for Package 23 (Example 2)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	11,200	11,025	0.21	0
	11,400	11,025	0.21	1
	11,600	11,025	0.21	1
	11,800	11,025	0.21	2
	12,000	11,025	0.21	2.0
	12,100	11,025	0.21	2.2
	12,200	11,025	0.21	2.5
	12,300	11,025	0.21	2.7
	12,350	11,025	0.21	2.8
Optimal Bid Price	12,400	11,025	0.21	2.9
	12,450	11,025	0.00	0
	12,500	11,025	0.00	0
	12,600	11,025	0.00	0
	12,700	11,025	0.00	0
	12,800	11,025	0.00	0
	12,900	11,025	0.00	0
	13,000	11,025	0.00	0
	13,100	11,025	0.00	0
	13,200	11,025	0.00	0
	13,300	11,025	0.00	0
	13,400	11,025	0.00	0
	13,500	11,025	0.00	0
	13,600	11,025	0.00	0
	13,700	11,025	0.00	0
Average Market Price	13,715*	11,025	0.00	0

Unit: THB

* $\mu_{123} = 0$, $\gamma_{123} = 0$, $n = 4$, $s = 9.8$.

Table 4.22: Simulated Bids of Bidder for Package 25 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
14,000	11,250	1.04	29
14,100	11,250	1.04	30
14,200	11,250	0.83	25
14,300	11,250	0.83	25
14,400	11,250	0.83	26
14,500	11,250	0.83	27
14,600	11,250	0.83	28
14,700	11,250	0.83	29
14,800	11,250	0.83	29
14,891*	11,250	0.83	30
14,900	11,250	0.83	30
15,000	11,250	0.83	31
15,100	11,250	0.83	32
15,200	11,250	0.83	33
15,300	11,250	0.83	34
15,400	11,250	0.83	34
15,500	11,250	0.83	35
15,600	11,250	0.83	36
15,700	11,250	0.83	37
15,800	11,250	0.83	38
15,900	11,250	0.83	39
16,000	11,250	0.83	39
16,100	11,250	0.83	40
16,200	11,250	0.83	41
16,300	11,250	0.83	42
16,400	11,250	0.83	43

Average Market Price

Unit: THB

Table 4.22: Simulated Bids of Bidder for Package 25 (Example 2 - Continued)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
16,500	11,250	0.83	44
16,600	11,250	0.83	44
16,650	11,250	0.83	45
16,700	11,250	0.83	45
16,750	11,250	0.83	46
16,800	11,250	0.62	35
16,900	11,250	0.62	35
17,000	11,250	0.62	36
17,500	11,250	0.62	39
18,000	11,250	0.42	28
18,500	11,250	0.21	15
19,000	11,250	0.00	0
19,500	11,250	0.00	0
20,000	11,250	0.00	0

Optimal Bid Price

Unit: THB

* $\mu_{125} = 0.4$, $\gamma_{125} = 0.231$, $n = 4$, $s = 10.8$.

Table 4.23: Simulated Bids of Bidder for Package 26 (Example 2)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	9,800	8,520	0.84	11
	10,000	8,520	0.84	12
	10,200	8,520	0.84	14
	10,400	8,520	0.84	16
	10,600	8,520	0.84	17
	10,800	8,520	0.63	14
	11,300	8,520	0.63	17
Average Market Price	11,653	8,520	0.63	20
	11,800	8,520	0.63	21
	12,300	8,520	0.63	24
	12,800	8,520	0.63	27
	13,300	8,520	0.63	30
	13,400	8,520	0.63	30.5
	13,500	8,520	0.63	31.1
	13,550	8,520	0.63	31.4
Optimal Bid Price	13,600	8,520	0.63	31.8
	13,650	8,520	0.42	21.4
	13,700	8,520	0.42	22
	13,800	8,520	0.42	22.0
	13,900	8,520	0.42	22.4
	9,800	8,520	0.84	11
	10,000	8,520	0.84	12
	10,200	8,520	0.84	14
	10,400	8,520	0.84	16
	10,600	8,520	0.84	17

Unit: THB

* $\mu_{126} = 0.507$, $\gamma_{126} = 0.2769$, $n = 4$, $s = 8.533$.

Table 4.24: Simulated Bids of Bidder for Package 27 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
12,500	10,320	0.2	5
12,600	10,320	0.2	5
12,700	10,320	0.2	5
12,800	10,320	0.2	5
12,900	10,320	0.2	5
13,000	10,320	0.2	6
13,100	10,320	0.2	6
13,200	10,320	0.2	6
13,300	10,320	0.2	6
13,400	10,320	0.2	6
13,500	10,320	0.2	7
13,600	10,320	0.2	7
13,700	10,320	0.2	7
13,800	10,320	0.2	7
13,829*	10,320	0.2	7
13,900	10,320	0.2	7
14,000	10,320	0.2	8
14,100	10,320	0.2	8
14,200	10,320	0.2	8
14,300	10,320	0.2	8
14,400	10,320	0.2	9
14,500	10,320	0.2	9
15,000	10,320	0.2	10
15,500	10,320	0.2	11
15,600	10,320	0.2	11
15,700	10,320	0.2	11

Average Market Price

Unit: THB

Table 4.24: Simulated Bids of Bidder for Package 27 (Example 2 - Continued)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	15,800	10,320	0.2	11
	15,900	10,320	0.2	11.6
	16,000	10,320	0.2	11.9
	16,100	10,320	0.2	12.1
	16,150	10,320	0.2	12.2
	16,200	10,320	0.2	12.3
Optimal Bid Price	16,250	10,320	0.2	12.4
	16,300	10,320	0.0	0
	16,400	10,320	0.0	0
	16,500	10,320	0.0	0

Unit: THB

* $\mu_{127} = 0.428$, $\gamma_{127} = 0.277$, $n = 4$, $s = 10.133$.

Table 4.25: Simulated Bids of Bidder for Package 30 (Example 2)

Bidding Price	MC	Probability of Winning (%)	Expected Profit
6,700	6,675	43.6	11
6,800	6,675	39.7	50
6,900	6,675	35.6	80
7,000	6,675	33.0	107
7,100	6,675	30.1	128
7,200	6,675	26.9	141
7,300	6,675	23.3	146
7,400	6,675	21.1	153
7,500	6,675	19.1	158
7,550	6,675	18.7	164
7,600	6,675	17.8	165
7,650	6,675	16.8	164
7,700	6,675	15.5	159
7,800	6,675	13.3	150
7,900	6,675	11.8	144
8,000	6,675	10.4	137
8,100	6,675	9.9	141
8,200	6,675	8.1	124
8,300	6,675	7.9	129
8,400	6,675	6.7	115
8,500	6,675	5.6	103
8,600	6,675	5.0	96
8,700	6,675	4.2	84
8,800	6,675	4.2	89
8,900	6,675	2.9	65
9,000	6,675	2.7	63

Optimal Bid Price

Unit: THB

Table 4.25: Simulated Bids of Bidder for Package 30 (Example 2 - Continued)

	Bidding Price	MC	Probability of Winning (%)	Expected Profit
	9,100	6,675	2.3	55
	9,200	6,675	2.3	58
	9,300	6,675	2.3	60
	9,400	6,675	2.1	57
	9,500	6,675	1.9	53
	9,600	6,675	1.9	55
	9,700	6,675	1.7	50
	9,800	6,675	1.7	52
	9,900	6,675	1.5	47
Average Market Price	9,909*	6,675	1.5	47
	10,000	6,675	1.2	41
	10,100	6,675	1.0	36
	10,200	6,675	1.0	37
	10,300	6,675	1.0	38
	10,400	6,675	1.0	39

Unit: THB

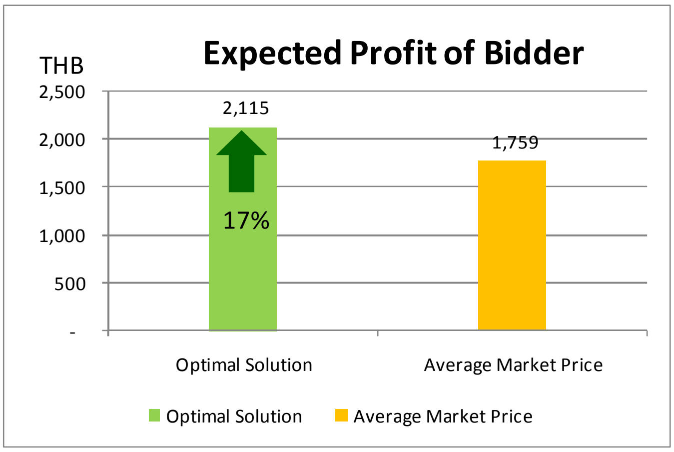
* μ_{130} = 0.52, γ_{130} = 0.692, n = 4, s = 8.33.

Table 4.26: Result of Bidding Simulation (Example 2)

Situation	Bid Price	Package	All Packages			
			MC	POW(%)	Expected Profit	Cost of Shipper
Optimal Solution	4,100	2	3,225	2.8	24	
	3,200	8	975	49.8	1,108	
	12,400	15	7,320	0.8	43	
	5,400	19	3,975	46.8	667	
	4,750	21	3,675	24.8	266	
	10,050	22	9,225		-	
	12,400	23	11,025	0.2	3	
	16,750	25	11,250		-	
	16,250	27	10,320		-	
	7,600	30	6,675	0.4	4	
Total	92,900		67,665		2,115 **(16.8%)**	20,525 **(-2.2%)**
Average Market Price	5,035	2	3,225	2.0	37	
	3,221	8	975	66.2	1,486	
	10,187	15	7,320	1.0	29	
	6,971	19	3,975	4.7	140	
	6,204	21	3,675	2.7	67	
	11,550	22	9,225	-	-	
	13,715	23	11,025	-	-	
	14,891	25	11,250	-	-	
	13,829	27	10,320	-	-	
	9,909	30	6,675	-	-	
Total	95,512		67,665		1,759	20,974

Unit: THB

For simulated bid of each package, the optimal bid price of them can be summarized in Table 4.26. We then submit all optimal bid prices received by our simulation model in the combinatorial auction. Thus bidder can obtain the expected profit with optimal solution at 2,115 baht. The results show that the optimal bid price can enhance the expected profit comparing with average market price at 16.8%. While in turn, the outcome of simulation also presents that the expected cost of transport service procurement with optimal solution of this study has been decreased comparing with the pricing of transport service market. The optimal solution of bidder helps shipper gain benefit by reducing cost of transportation service around 2.2% interestingly. In addition, the mutual benefit both carrier and shipper mentioned previously could be shown in Figure 4.12.



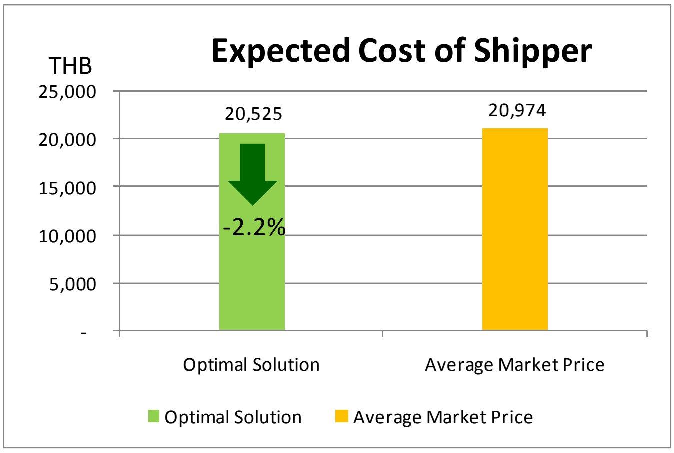


Figure 4.12: Mutual Benefit (Example 2)

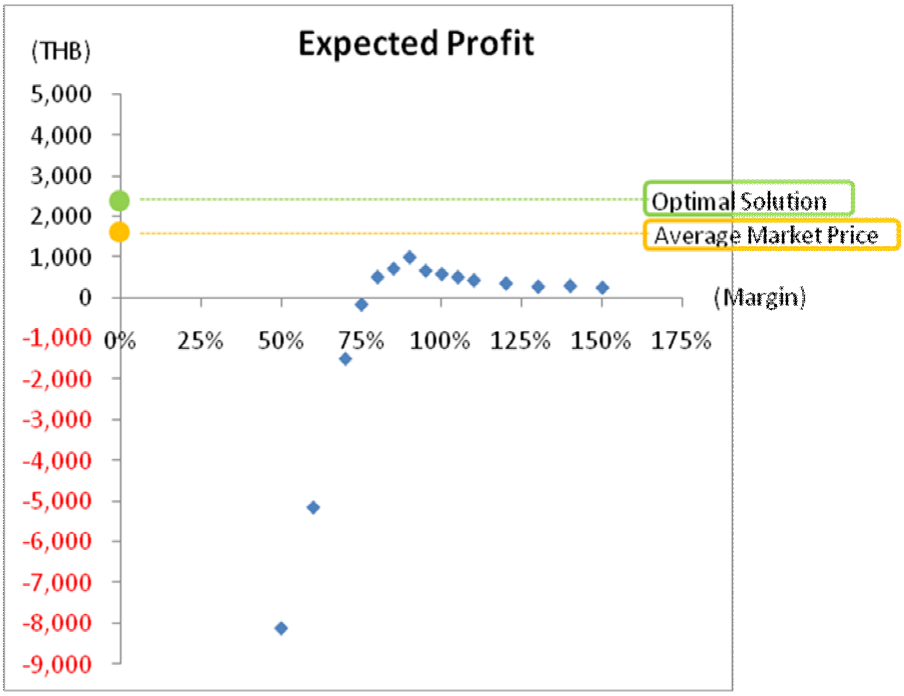


Figure 4.13: Expected Profit with Optimal Solution of Simulation (Example 2)

Table 4.27: Validation of Bidding Simulation (Example 2)

Scenario	Package										Total Expected Profit	Total Cost of Shipper	Expected Profit
	2	8	15	19	21	22	23	25	27	30			%
Optimal Solution	4,100	3,200	12,400	5,400	4,750	10,050	12,400	16,750	16,250	7,600	2,115	20,525	
Average Market Price	5,035	3,221	10,187	6,971	6,204	11,550	13,715	14,891	13,829	9,909	1,759	20,974	16.8%
50.00%	2,063	2,438	4,200	3,938	3,188	4,613	5,513	6,075	5,700	4,688	-8,132	15,444	484.4%
60.00%	2,475	2,925	5,040	4,725	3,825	5,535	6,615	7,290	6,840	5,625	-5,159	17,761	343.9%
70.00%	2,888	3,413	5,880	5,513	4,463	6,458	7,718	8,505	7,980	6,563	-1,489	19,831	170.4%
75.00%	3,094	3,656	6,300	5,906	4,781	6,919	8,269	9,113	8,550	7,031	-158	20,451	107.5%
80.00%	3,300	3,900	6,720	6,300	5,100	7,380	8,820	9,720	9,120	7,500	515	20,825	75.6%
85.00%	3,506	4,144	7,140	6,694	5,419	7,841	9,371	10,328	9,690	7,969	725	21,051	65.7%
90.00%	3,713	4,388	7,560	7,088	5,738	8,303	9,923	10,935	10,260	8,438	1,006	21,167	52.4%
95.00%	3,919	4,631	7,980	7,481	6,056	8,764	10,474	11,543	10,830	8,906	673	21,340	68.2%
100.00%	4,125	4,875	8,400	7,875	6,375	9,225	11,025	12,150	11,400	9,375	591	21,406	72.1%
105.00%	4,331	5,119	8,820	8,269	6,694	9,686	11,576	12,758	11,970	9,844	513	21,468	75.7%
110.00%	4,538	5,363	9,240	8,663	7,013	10,148	12,128	13,365	12,540	10,313	437	21,515	79.3%
120.00%	4,950	5,850	10,080	9,450	7,650	11,070	13,230	14,580	13,680	11,250	361	21,600	82.9%
130.00%	5,363	6,338	10,920	10,238	8,288	11,993	14,333	15,795	14,820	12,188	283	21,652	86.6%
140.00%	5,775	6,825	11,760	11,025	8,925	12,915	15,435	17,010	15,960	13,125	302	21,689	85.7%
150.00%	6,188	7,313	12,600	11,813	9,563	13,838	16,538	18,225	17,100	14,063	258	21,706	87.8%
OC	4,125	4,875	8,400	7,875	6,375	9,225	11,025	12,150	11,400	9,375			
MC	3,225	975	7,320	3,975	3,675	9,225	11,025	11,250	10,320	6,675			

Unit: THB

In Table 4.27, it shows the result of validation for combinatorial auction in Example 2. It has been tested the outcome of bidder by comparing the expected profit with optimal solution against fixed margin in various values during 50% - 150% of operating cost. The testing result confirms that the expected profit with optimal bid price for all interested packages is higher than the expected profit with all various fixed margins clearly. In addition, the all data in Table 4.27 could be presented in Figure 4.13 to prove that the expected profit with optimal solution is the best solution for bidder to submit these bid price into the combinatorial auction inevitably.

Chapter 5

Conclusion

The combinatorial auction has been applied in many businesses so that bidder is able to submit multiple bids in the auction. For truckload industry, it is used practically to solve the empty backhaul problem regarding economies of scope. Shipper in USA could reduce cost of transportation service procurement by using combinatorial auction while carriers also could reduce the empty backhaul.

The statistical data revealed that most carriers in Thailand suffer the problem of empty backhaul. The lane transport by truck had the empty backhaul at 46% of total shipments. It has consumed the energy uselessly around 22.5 billion baht per year in which is the critical economic issue. Thus, the combinatorial auction has been considered in this study in order to solve the problem of empty backhaul in Thailand. However, the number of packages for carrier to submit bids in the auction has been increased exponentially when the number of lanes increases. By this reason, the carrier faces the hard valuation problem to evaluate the bidding price of interested package. In addition, the study on bidding price for carrier to submit bid in combinatorial auction has less attention so far.

In this dissertation, thus, the author has presented the new simulation methodology to find out the optimal bid price of carrier for interested package in the auction. This is to obtain the maximum expected profit with optimal solution in the combinatorial transport auction. The research methodology with simulation technique captures Monte-Carlo simulation, Regression Model, Winner Determination Problem, and Stochastic Optimization Model in our simulation method.

To find the possible transportation network of competitor, we adopt Monte-Carlo technique to randomize the two factor both μ and γ of competitors. With independent factors in regression model, then we could find the bid-to-cost ratio of competitor as dependent variable accordingly. For regression model, the author has collected data by having depth-interviewed with truck carriers in Thailand who provide usually transportation service to shippers in various industries.

Therefore, the possible bidding prices of competitor randomized for interested packages in combinatorial transport auction would obtain in that order. Next, we enter all randomized bidding price of competitor against bidding price of bidder in the combinatorial auction with *m* number of iterations. To award bids to the winners in the auction, the researcher employs the Winner Determination Problem with Set Partitioning Formulation to execute the results. With all number of iterations (*m*) for each bidding price of bidder increased by step size (α) with *k* number, then we could receive the probability of winning of each bidding price of bidder evidently.

To acquire the optimal bid price of bidder for interested package, subsequently we employ the stochastic optimization model by which includes bidding price, marginal cost and probability of winning to obtain the maximum expected profit. Finally, this simulation technique could provide the optimal solution for bidder to gain the maximum benefit of interested package in combinatorial transport auction accordingly.

To determine the behavior of bidding for truckload carriers in the combinatorial transport auction, the author applies the regression model to represent their performance. A bid-to-cost ratio is specified as dependent variable, whereas the independent variables include with number of competitor, size of package, the decrease ratio of empty backhaul, the pre-empty backhaul over new lane distance, the product between the decrease ratio of empty backhaul and the pre-empty backhaul over new lane distance (transportation pattern), and the product between the pre-empty backhaul over new lane distance and number of competitor.

The statistical analysis of all hypotheses in regression model expresses that number of competitor, transportation pattern, the decrease ratio of empty backhaul, the product between the pre-empty backhaul over new lane distance and number of competitor have impacted to a bid-to-cost ratio of truck carrier in Thailand significantly. A bid-to-cost ratio of carrier in the transport market has been decreased significantly when a value of pattern of transport service ($\mu\gamma$) increases.

In addition, the result analysis can present the transportation efficiency zone where a bid-to-cost ratio of carrier lowers or equals 1.00 in the transport market. This could make the carriers realize the benefit of combinatorial transport auction by using the existing transportation network with new lane or new package regarding economies of scope very well.

For bidding simulation of combinatorial transport auction, the results of simulations find out that all optimal bid prices of bidder for interested packages received by our simulation methodology could provide the expected profit more than the average market price. On the other hand the results in this study express that the shipper gain benefit also from optimal solution of this model. The cost of transportation service procurement in combinatorial auction of shipper has been potentially decreased considerably. Therefore, the carrier and shipper achieve the mutual benefit from our simulation model to gain higher expected profit and to decrease cost of transport service procurement respectively.

In addition, the result of bidding simulation with the optimal solution for bidder in combinatorial auction has been studied by varying in range of competitors' γ considerably. The result of bidding simulation shows that when the value of minimum γ of competitors increases, the optimal bid price of bidder will be decreased. The expected profit with optimal solution of bidder has also been decreased. This is because when γ increases it can express the competitors have competitive advantage to compete with players in the auction. Due to low marginal cost, they can use the benefit of existing transportation network regarding economies of scope to provide the new transportation service with lower bidding price. Thus, the range of competitors' γ randomized uniformly is the critical factor to the optimal bid price of bidder in the combinatorial transportation auction.

For implication in this study, carriers can apply our simulation model to decide which package should be bided for and how much for interested packages to submit bids in the combinatorial auctions. Therefore, the hard valuation problem of carriers facing can be solved with our simulation model. Besides, the simulation model can present the probability of winning with bid price of bidder submitted for interested packages in the auction. By this knowledge, bidder could estimate the situation of winning or losing in the auction with bid prices including expected profit. Moreover, the bidding price generation model in combinatorial auction could make carriers in Thailand realize the benefit of economies of scope as well as support them to reduce the empty backhaul problem in their transportation network.

In this study, however, we assume that behavior of carrier for bidding in the combinatorial auction is homogenous. Each carrier has the same behavior to bid in the bidding game as risk neutral. Whereas, behavior of carrier for bidding in another combinatorial auction may be as risk-averse or risk-lover, moreover, the volume of freight to transport among truckload carriers in the bidding simulation has been assumed to be not different. Therefore, we suggest the researcher who is interested in bidding price of carriers in combinatorial transportation auction to study more on different behavior of carriers and volume of freight to bidding price in the combinatorial auction and discover the optimal solution in simulation bidding for further research.

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Appendices

Appendix A Questionnaire

วันที่___	เดือน______	2554

A

แบบสอบถาม
เรื่อง
การศึกษาพฤติกรรมการประมูลงานรถวิ่งเต็มคันของผู้ประกอบการขนส่ง ในการประมูลเป็นกลุ่มเส้นทาง

<u>คำชี้แจง:</u> แบบสอบถามชุดนี้เป็นส่วนหนึ่งของการวิจัยทางสถิติเพื่อการศึกษาของนายพิทวัส เอื้อสังคมเศรษฐ์ นิสิตบัณฑิตวิทยาลัย สหสาขาวิชา การจัดการด้านโลจิสติกส์ จุฬาลงกรณ์มหาวิทยาลัย

<u>ตอนที่ 1: ข้อมูลผู้ประกอบการขนส่งด้วยรถบรรทุก</u>

<u>คำแนะนำ:</u> โปรดใส่เครื่องหมาย X ลงในช่อง ☐ ที่กำหนดและเติมข้อความลงในช่องว่าง

1. ชื่อบริษัท/หจก. ____________________
2. ตำแหน่งของท่าน ____________________
3. เบอร์โทรศัพท์ ____________________
4. ประเภทสินค้าที่ให้บริการขนส่งด้วยรถบรรทุก (ตอบได้มากกว่า 1 ข้อ)
   - ☐ ผลิตภัณฑ์เกษตรกรรม
   - ☐ อุปกรณ์และวัสดุก่อสร้าง
   - ☐ พลังงาน
   - ☐ สินค้าอุปโภคบริโภค
   - ☐ ชิ้นส่วนและอุปกรณ์อิเล็กทรอนิกส์
   - ☐ ตู้คอนเทนเนอร์
   - ☐ อื่นๆ________________
5. ผลประกอบการรายได้(โดยประมาณ) _____ล้านบาท<u>ต่อปี</u>
6. จำนวนและประเภทรถบรรทุกที่ผู้ประกอบการขนส่งเป็นเจ้าของ (กรุณาใส่ตัวเลขโดยประมาณ)

ประเภทรถบรรทุก	จำนวน(คัน)	ประเภทรถบรรทุก	จำนวน(คัน)
รถ 4 ล้อ	_____	รถพ่วง 18 ล้อ	_____
รถ 6 ล้อ	_____	รถพ่วง 20 ล้อ	_____
รถ 10 ล้อ	_____	รถพ่วง 22 ล้อ	_____
รถกึ่งพ่วง 18 ล้อ	_____	รถพ่วง 24 ล้อ	_____
รถกึ่งพ่วง 22 ล้อ	_____	อื่นๆ1._____	_____
รถกึ่งพ่วง 24 ล้อ	_____	2._____	_____

7. ระยะทางวิ่งเที่ยวเปล่าทั้งหมด / ระยะทางวิ่งทั้งหมด (เที่ยวเปล่าและเที่ยวหนัก) = _____% (โดยประมาณ)
8. ท่านคิดว่าสถานการณ์การแข่งขันของตลาดการให้บริการขนส่งสินค้าวิ่งเต็มคันระหว่างผู้ประกอบการเป็นอย่างไร
   ☐ แข่งขันมากที่สุด ☐ แข่งขันมาก ☐ แข่งขันปานกลาง ☐ แข่งขันน้อย ☐ แข่งขันน้อยที่สุด
   เพราะเหตุใด ____________________
9. ท่านมีความคิดเห็นอย่างไรต่อตลาดการประมูลงานขนส่งสินค้าด้วยรถบรรทุกวิ่งเต็มคันในประเทศไทย ณ ปัจจุบัน
   ____
10. ผู้ประกอบการขนส่งเคยเข้าร่วมการประมูลงานบริการขนส่งจากผู้ว่าจ้างหรือไม่
   ☐ เคย โดยเป็นการประมูลแบบใด (ตอบได้มากกว่า 1 ข้อ) ☐ ไม่เคย

- [ ] ประมูลเป็นรายเส้นทาง หรือ เลน เช่น กรุงเทพฯ-อุดรธานี
- [ ] ประมูลเป็นพื้นที่ให้บริการ เหมาทั้งพื้นที่ เช่น พื้นที่ภาคอีสานตอนใต้
- [ ] ประมูลเป็น "กลุ่มเส้นทาง" คือ ยื่นราคาประมูลเป็นกลุ่มสำหรับ 2 เส้นทางหรือมากกว่า พร้อมๆกัน เช่น 2 เส้นทาง คือ กรุงเทพฯ-อุดรธานี และ หนองคาย-กรุงเทพฯ <u>พร้อมกัน</u>
- [ ] อื่นๆ ________________________________

11. ท่านคิดว่าการประมูลเป็นกลุ่มเส้นทางจะสามารถแก้ปัญหาเรื่องรถวิ่งกลับเที่ยวเปล่าได้หรือไม่

☐ ได้ทั้งหมด ☐ ได้บางส่วน ☐ ไม่ได้

เพราะเหตุใด ____

____

12. ความคิดเห็นและข้อเสนอแนะของท่านต่อการแก้ปัญหารถวิ่งกลับเที่ยวเปล่า

____

____

<u>**ตอนที่ 2: พฤติกรรมการประมูลงานรถวิ่งเที่ยวหนักของผู้ประกอบการขนส่ง**</u>

<u>**คำอธิบาย**</u>:

ก ข ค หมายถึง ตำแหน่งที่ตั้งของโรงงาน ก, ข, ค ตามลำดับ

→ หมายถึง <u>เส้นทางวิ่งเที่ยวหนักปัจจุบัน</u>ที่ผู้ประกอบการขนส่ง<u>กำลังให้บริการอยู่</u>

⇢ หมายถึง <u>เส้นทางวิ่งกลับเที่ยวเปล่าปัจจุบัน</u>ที่ผู้ประกอบการขนส่ง<u>ประสบปัญหาอยู่</u>

→ หมายถึง <u>เส้นทางวิ่งเที่ยวหนักใหม่</u>ที่ผู้ประกอบการขนส่งสนใจเข้าร่วมประมูล

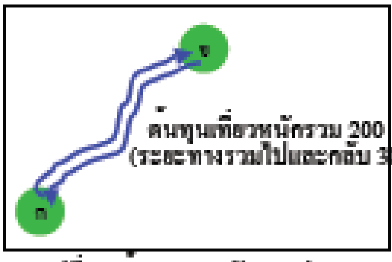
<u>**แบบจำลอง:**</u> ผู้ผลิตสินค้าชนิดหนึ่งมีความต้องการว่าจ้างงานบริการขนส่งสินค้าเต็มคันด้วยรถบรรทุก10 ล้อ จาก<u>ผู้ประกอบการขนส่ง ซึ่งมีความสามารถในการแข่งขันเท่าเทียมกัน</u> (วิ่งทุกวัน วันละ 1 เที่ยว บนเส้นทางปกติ) โดยกำหนดว่าผู้ชนะการประมูลจะต้องเป็นผู้เสนอราคาค่าบริการขนส่ง ในราคาที่ต่ำที่สุด

<u>**คำแนะนำ:**</u> โปรดระบุตัวเลขราคาประมูลว่าเป็นกี่เปอร์เซ็นต์หรือกี่บาทจากต้นทุน (ระบุอย่างใดอย่างหนึ่งเท่านั้น) ลงในตารางตามรายละเอียดที่กำหนด

---

1. เส้นทางวิ่งเที่ยวหนักใหม่ของงานประมูลวิ่งทั้งขาไปและขากลับ

- หากมีงานประมูลรถวิ่งเต็มคัน ทั้งขาไปและขากลับ (ดังรูปที่ 1)
- ท่านจะประมูลงานดังกล่าวด้วย<u>ราคาประมูลเป็นกี่เปอร์เซ็นต์หรือกี่บาทจากต้นทุนที่กำหนด</u> เพื่อชนะการประมูล



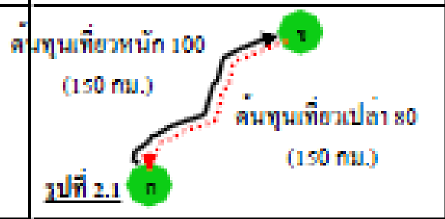
<u>รูปที่ 1: เส้นทางสำหรับงานประมูล</u>

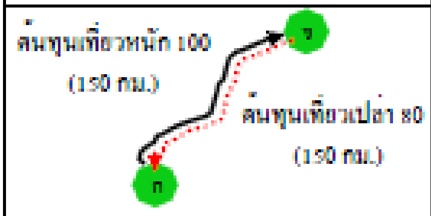
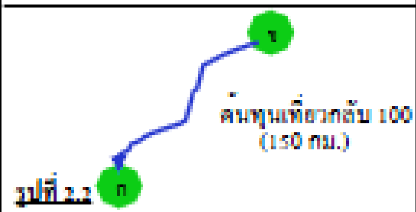
จำนวนคู่แข่ง		
1 ราย	3 ราย	5 ราย
ราคาประมูลจากต้นทุนรวม 200		
_____%	_____%	_____%
_____บาท	_____บาท	_____บาท

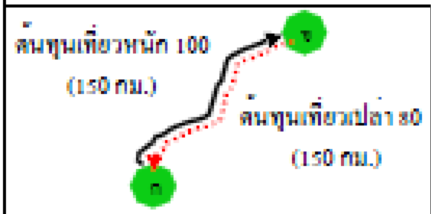
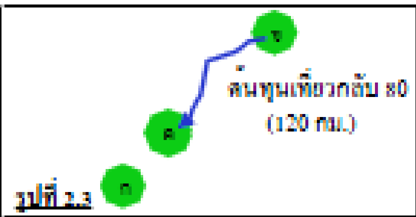
-ถ้า<u>ขนาดของระยะทางงานประมูลรูปที่ 1 เพิ่มขึ้น 5 เท่า</u> ราคาประมูลจะเปลี่ยนแปลงจากเดิม = _____%

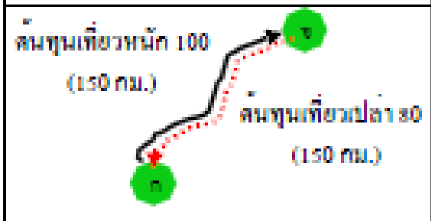
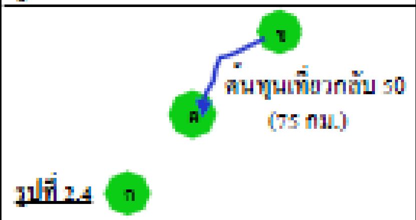
2. เส้นทางวิ่งเที่ยวหนักใหม่ของงานประมูลวิ่งตรงหรือวิ่งทดแทนกับเส้นทางวิ่งกลับเที่ยวเปล่าปัจจุบัน

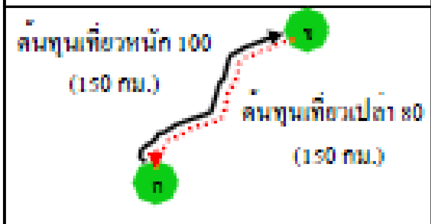
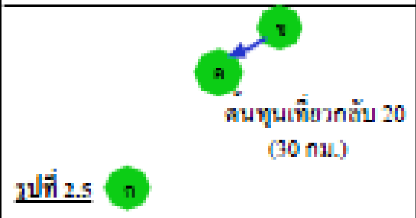
- เดิมท่านขนส่งสินค้าที่วิ่งเริ่มต้นจาก โรงงาน ก -> โรงงาน ข แต่ประสบปัญหารถวิ่งกลับเที่ยวเปล่า (ดังรูปที่ 2.1)
- หากมีงานประมูลรถวิ่งเริ่มต้นเส้นทางใหม่ที่วิ่ง (ดังรูปที่ 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8)
- ท่านจะประมูลงานดังกล่าวด้วย<u>ราคาประมูลเป็นกี่เปอร์เซ็นต์หรือกี่บาทจากต้นทุนที่กำหนด</u> เพื่อชนะการประมูล

<table>
<tr><th colspan="2">รูปภาพเส้นทางการให้บริการขนส่งสินค้าเต็มคัน</th><th colspan="3">จำนวนคู่แข่ง</th></tr>
<tr><th>เส้นทางการขนส่งปัจจุบัน</th><th>เส้นทางสำหรับงานประมูล</th><th>1 ราย</th><th>3 ราย</th><th>5 ราย</th></tr>
<tr><td rowspan="2"></td><td rowspan="2">

รูปที่ 2.1</td><td colspan="3">ราคาประมูลจากต้นทุนรวม 180</td></tr>
<tr><td>____% ____บาท</td><td>____% ____บาท</td><td>____% ____บาท</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

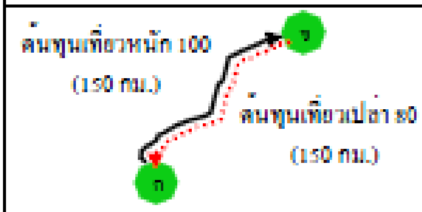
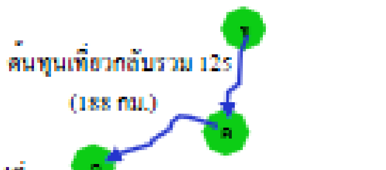
รูปที่ 2.2</td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 100 (ต้นทุนเพิ่ม 20)</td></tr>
<tr><td>____% ____บาท</td><td>____% ____บาท</td><td>____% ____บาท</td></tr>
<tr><td colspan="5">-<u>ถ้าขนาดของระยะทางงานประมูลรูปที่ 2.2 เพิ่มขึ้น 5 เท่า</u> ราคาประมูลจะเปลี่ยนแปลงจากเดิม = ______%</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

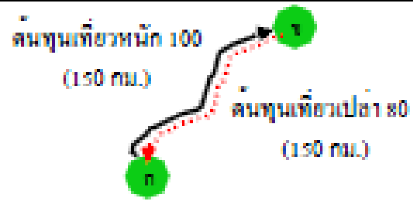
รูปที่ 2.3</td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 80 (ต้นทุนเพิ่ม 16)</td></tr>
<tr><td>____% ____บาท</td><td>____% ____บาท</td><td>____% ____บาท</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

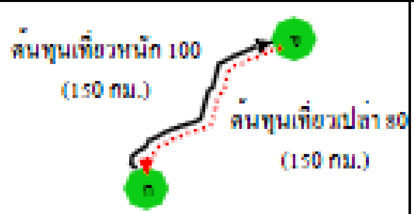
รูปที่ 2.4</td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 50 (ต้นทุนเพิ่ม 10)</td></tr>
<tr><td>____% ____บาท</td><td>____% ____บาท</td><td>____% ____บาท</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

รูปที่ 2.5</td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 20 (ต้นทุนเพิ่ม 4)</td></tr>
<tr><td>____% ____บาท</td><td>____% ____บาท</td><td>____% ____บาท</td></tr>
<tr><td colspan="5">-<u>ถ้าขนาดของระยะทางงานประมูลรูปที่ 2.3-2.5 เพิ่มขึ้น 5 เท่า</u> ราคาประมูลจะเปลี่ยนแปลงจากเดิม = _____%</td></tr>
</table>

* ต้นทุนเที่ยวหนักมากกว่าต้นทุนเที่ยวเปล่าประมาณ 20%จากต้นทุนเที่ยวหนัก

<table>
<tr><th colspan="2"><u>รูปภาพเส้นทางการให้บริการขนส่งสินค้าเริ่มต้น</u></th><th colspan="3">จำนวนคู่แข่ง</th></tr>
<tr><th><u>เส้นทางการขนส่งปัจจุบัน</u></th><th><u>เส้นทางสำหรับงานประมูล</u></th><th>1 ราย</th><th>3 ราย</th><th>5 ราย</th></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

<u>รูปที่ 2.6</u></td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 125 (ต้นทุนเพิ่ม 45)</td></tr>
<tr><td>____%
____บาท</td><td>____%
____บาท</td><td>____%
____บาท</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

<u>รูปที่ 2.7</u></td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 200 (ต้นทุนเพิ่ม 120)</td></tr>
<tr><td>____%
____บาท</td><td>____%
____บาท</td><td>____%
____บาท</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">

<u>รูปที่ 2.8</u></td><td colspan="3">ราคาประมูลจากต้นทุนเสมือน 500 (ต้นทุนเพิ่ม 420)</td></tr>
<tr><td>____%
____บาท</td><td>____%
____บาท</td><td>____%
____บาท</td></tr>
<tr><td colspan="5"><u>-ถ้าขนาดของระยะทางงานประมูลรูปที่ 2.6-2.8 เพิ่มขึ้น 5 เท่า</u> ราคาประมูลจะเปลี่ยนแปลงจากเดิม = ____%</td></tr>
</table>

Appendix B Surveyed Data

No.	5 times	Picture 1 (μ=0, γ=0)			Picture 2.1 (Existing Service)			5 times	Picture 2.2 (μ=1, γ=1)			5 times	Picture 2.3 (μ=1.25, γ=.8)			Picture 2.4 (μ=2,γ=.5)			Picture 2.5 (μ=5,γ=.2)			5 times	Picture 2.6 (μ=0.8,γ=1)			Picture 2.7 (μ=0.5,γ=1)			Picture 2.8 (μ=0.2,γ=1)		
		No.of competitors			No.of competitors				No.of competitors				No.of competitors			No.of competitors			No.of competitors				No.of competitors			No.of competitors			No.of competitors		
		1	3	5	1	3	5		1	3	5		1	3	5	1	3	5	1	3	5		1	3	5	1	3	5	1	3	5
1	-5%	150%	145%	140%	122%	120%	118%	-5%	50.0%	40.0%	30.0%	-5%	55%	55%	55%	63%	63%	63%	70%	70%	70%	-5%	55%	50%	45%	88%	83%	78%	120%	115%	110%
2	2.5%	115%	112%	110%	115%	112%	110%	0%	23.0%	22.4%	22.0%	5%	52%	50%	50%	69%	67%	66%	138%	134%	132%	5%	60%	58%	57%	81%	78%	77%	105%	103%	101%
3	5%	115%	110%	105%	120%	115%	110%	5%	23.0%	22.0%	21.0%	10%	23%	22%	21%	26%	25%	24%	27%	26%	25%	10%	41%	40%	38%	72%	69%	66%	109%	105%	101%
4	-10%	140%	135%	130%	140%	135%	130%	-5%	50.0%	45.0%	40.0%	-4%	70%	65%	60%	80%	75%	70%	100%	95%	90%	-2%	70%	65%	60%	90%	85%	80%	100%	95%	90%
5	-10%	140%	130%	120%	140%	130%	120%	-10%	60%	50%	40%	-10%	70%	60%	50%	75%	65%	55%	80%	70%	60%	-10%	70%	60%	50%	90%	80%	70%	120%	110%	100%
6	10%	130%	125%	120%	130%	125%	120%	0%	100%	95%	90%	0%	100%	94%	88%	120%	110%	100%	200%	175%	150%	0%	130%	125%	120%	130%	125%	120%	130%	125%	120%
7	-3%	120%	115%	110%	120%	115%	110%	-5%	60%	50%	45%	-5%	60%	50%	45%	70%	60%	50%	75%	65%	55%	-5%	60%	52%	44%	85%	80%	75%	105%	100%	95%
8	0%	120%	115%	115%	120%	115%	115%	0%	70%	60%	50%	0%	85%	75%	65%	85%	75%	65%	90%	85%	85%	0%	64%	56%	56%	100%	95%	90%	110%	106%	104%
9	0%	120%	115%	110%	130%	125%	120%	0%	80%	70%	60%	0%	100%	88%	75%	100%	80%	60%	100%	75%	75%	0%	72%	64%	56%	100%	90%	75%	106%	96%	94%
10	-15%	130%	130%	130%	130%	130%	130%	0%	50%	50%	50%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	0%	130%	130%	130%	130%	130%	130%	130%	130%	130%
11	0%	150%	130%	120%	150%	130%	120%	0%	100%	80%	80%	0%	125%	100%	100%	125%	100%	100%	125%	100%	100%	0%	120%	104%	104%	150%	140%	140%	120%	116%	116%
12	-2%	118%	117%	116%	118%	117%	116%	-10%	60%	50%	50%	0%	60%	50%	50%	60%	50%	50%	60%	50%	50%	-5%	52%	52%	52%	70%	70%	70%	90%	90%	90%
13	0%	200%	200%	200%	166%	166%	166%	0%	80%	80%	80%	0%	100%	100%	100%	130%	130%	130%	200%	200%	200%	0%	120%	120%	120%	125%	125%	125%	130%	130%	130%
14	0%	120%	110%	110%	120%	110%	110%	0%	60%	50%	50%	0%	60%	50%	50%	60%	50%	50%	60%	50%	50%	0%	75%	60%	60%	85%	70%	70%	120%	110%	110%
15	0%	156%	156%	156%	143%	143%	143%	0%	100%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	130%	130%	130%	144%	144%	144%			
16	-10%	120%	120%	120%	110%	110%	110%	0%	50%	50%	50%	0%	50%	50%	50%	70%	70%	70%	100%	100%	100%	-5%	50%	50%	50%	75%	75%	75%	95%	95%	95%
17	10%	120%	120%	120%	115%	115%	115%	0%	70%	50%	50%	0%	88%	63%	63%	80%	60%	60%	150%	125%	125%	10%	120%	120%	120%	120%	120%	120%	120%	120%	120%
18	-20%	150%	125%	115%	128%	115%	115%	-10%	88%	79%	79%	-5%	88%	79%	79%	88%	79%	79%	88%	79%	79%	-5%	128%	107%	98%	128%	107%	98%	128%	107%	98%
19	0%	120%	110%	110%	120%	110%	110%	-10%	110%	95%	90%	0%	125%	113%	100%	180%	160%	140%	250%	150%	100%	-5%	110%	95%	90%	115%	110%	105%	120%	110%	110%
20	-10%	150%	135%	120%	133%	125%	120%	-20%	100%	90%	80%	-10%	100%	88%	75%	100%	80%	75%	175%	150%	125%	-10%	88%	80%	72%	100%	95%	90%	130%	120%	120%
21	5%	140%	140%	140%	120%	120%	120%	0%	60%	50%	50%	0%	63%	63%	63%	100%	100%	100%	150%	150%	150%	0%	70%	70%	70%	80%	80%	80%	110%	110%	110%
22	-10%	140%	120%	110%	130%	115%	105%	-4%	60%	50%	40%	-4%	63%	50%	38%	80%	60%	40%	150%	100%	50%	-10%	80%	70%	70%	110%	100%	90%	130%	115%	105%
23	-5%	120%	118%	115%	120%	118%	115%	5%	50%	50%	50%	0%	63%	63%	63%	80%	80%	80%	200%	200%	200%	-5%	60%	60%	60%	120%	118%	115%	120%	118%	115%
24	-25%	150%	140%	130%	140%	130%	120%	-10%	70%	70%	70%	0%	88%	88%	88%	120%	120%	120%	250%	250%	250%	-5%	80%	75%	70%	105%	100%	95%	140%	130%	120%
25	5%	105%	104%	104%	105%	104%	104%	0%	80%	50%	40%	0%	75%	50%	38%	120%	80%	60%	250%	200%	200%	0%	80%	72%	64%	105%	104%	103%	105%	104%	103%

No.	5 times	Picture 1 (μ=0, γ=0)			Picture 2.1 (Existing Service)			5 times	Picture 2.2 (μ=1, γ=1)			5 times	Picture 2.3 (μ=1.25, γ=.8)			Picture 2.4 (μ=2,γ=.5)			Picture 2.5 (μ=5,γ=.2)			5 times	Picture 2.6 (μ=0.8,γ=1)			Picture 2.7 (μ=0.5,γ=1)			Picture 2.8 (μ=0.2,γ=1)		
		No.of competitors			No.of competitors				No.of competitors				No.of competitors			No.of competitors			No.of competitors				No.of competitors			No.of competitors			No.of competitors		
		1	3	5	1	3	5		1	3	5		1	3	5	1	3	5	1	3	5		1	3	5	1	3	5	1	3	5
26	-5%	150%	150%	150%	150%	150%	150%	-5%	120%	120%	120%	-5%	138%	138%	138%	140%	140%	140%	150%	150%	150%	-5%	104%	104%	104%	90%	90%	90%	110%	110%	110%
27	-5%	135%	133%	130%	135%	133%	130%	0%	70%	70%	70%	0%	88%	88%	88%	100%	100%	100%	250%	250%	250%	0%	80%	80%	80%	130%	130%	130%	135%	135%	135%
28	5%	130%	125%	120%	125%	123%	120%	5%	70%	65%	60%	0%	88%	83%	78%	100%	95%	90%	200%	190%	190%	0%	125%	125%	125%	125%	125%	125%	125%	125%	125%
29	-5%	170%	165%	165%	170%	165%	160%	-5%	60%	55%	50%	-5%	70%	65%	60%	80%	75%	70%	90%	85%	80%	-5%	154%	150%	150%	160%	155%	155%	150%	145%	145%
30	5%	160%	160%	160%	160%	160%	160%	0%	50%	50%	50%	0%	50%	50%	50%	50%	50%	50%	100%	100%	100%	0%	50%	50%	50%	80%	80%	80%	90%	90%	90%
31	-5%	155%	155%	155%	155%	155%	155%	-5%	55%	55%	55%	-5%	60%	60%	60%	54%	54%	54%	49%	49%	49%	-5%	57%	57%	57%	97%	97%	97%	159%	159%	159%
32	-5%	130%	128%	125%	130%	128%	125%	-5%	45%	43%	40%	-5%	38%	35%	33%	50%	46%	40%	100%	90%	80%	-5%	39%	39%	39%	78%	75%	75%	126%	122%	118%
33	0%	150%	140%	135%	150%	140%	135%	0%	40%	30%	25%	0%	50%	40%	35%	50%	40%	35%	50%	40%	35%	0%	54%	50%	49%	96%	93%	90%	139%	134%	130%
34	10%	130%	125%	125%	130%	125%	125%	10%	30%	25%	25%	10%	25%	25%	25%	30%	30%	30%	50%	50%	50%	10%	55%	55%	55%	99%	99%	99%	150%	150%	150%
35	0%	150%	130%	120%	133%	125%	120%	0%	100%	90%	80%	0%	100%	88%	75%	100%	80%	60%	175%	150%	125%	0%	88%	80%	72%	100%	95%	90%	130%	120%	110%
36	10%	140%	130%	120%	150%	140%	130%	28%	70%	70%	70%	-5%	88%	88%	88%	112%	112%	112%	210%	210%	210%	10%	67%	67%	67%	140%	130%	120%	150%	140%	130%
37	0%	130%	125%	110%	130%	125%	110%	0%	100%	100%	100%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	0%	130%	125%	110%	130%	125%	110%	130%	125%	110%
38	-10%	140%	130%	120%	140%	130%	120%	-10%	80%	60%	50%	-5%	100%	75%	63%	100%	80%	60%	150%	100%	75%	-5%	90%	70%	60%	100%	80%	75%	140%	130%	120%
39	-20%	170%	150%	150%	140%	130%	130%	-10%	100%	80%	80%	-5%	75%	50%	50%	100%	60%	60%	100%	50%	50%	-5%	96%	80%	80%	100%	90%	90%	140%	130%	130%
40	-10%	150%	130%	120%	150%	130%	120%	-10%	80%	60%	50%	-10%	88%	63%	50%	120%	80%	60%	250%	150%	100%	-10%	72%	56%	48%	140%	130%	120%	150%	130%	120%
41	-10%	150%	140%	130%	130%	125%	120%	-10%	50%	50%	50%	-5%	50%	50%	50%	60%	60%	60%	100%	100%	100%	-10%	60%	60%	60%	130%	130%	130%	130%	130%	130%
42	0%	150%	130%	120%	150%	130%	120%	0%	120%	100%	90%	0%	120%	100%	90%	120%	100%	90%	120%	100%	90%	0%	120%	100%	90%	130%	110%	100%	150%	130%	120%
43	-5%	140%	135%	130%	140%	135%	130%	-5%	112%	105%	100%	-5%	112%	105%	100%	112%	105%	100%	126%	118%	110%	-5%	112%	105%	100%	140%	135%	130%	140%	135%	130%
44	-5%	140%	135%	130%	140%	135%	130%	-5%	112%	105%	100%	-5%	112%	105%	100%	112%	105%	100%	126%	118%	110%	-5%	112%	105%	100%	140%	135%	130%	140%	135%	130%
45	5%	130%	120%	120%	130%	120%	120%	0%	85%	60%	60%	0%	106%	75%	75%	130%	104%	104%	195%	130%	130%	5%	83%	73%	73%	98%	85%	85%	130%	120%	120%
46	0%	140%	130%	120%	140%	130%	120%	0%	96%	88%	72%	0%	100%	90%	80%	110%	100%	90%	120%	110%	100%	0%	130%	110%	100%	135%	115%	105%	140%	120%	110%
47		115%	110%	107%	115%	110%	110%	-3%	81%	77%	77%	-3%	105%	98%	98%	120%	113%	113%	135%	128%	128%	-3%	80%	77%	77%	92%	89%	89%	92%	89%	89%
48	0%	130%	125%	120%	120%	110%	107%	0%	96%	90%	80%	0%	105%	95%	85%	168%	150%	130%	180%	160%	140%	0%	76%	65%	50%	110%	100%	85%	120%	110%	107%
49	0%	120%	115%	110%	120%	115%	110%	0%	110%	110%	110%	0%	113%	113%	113%	160%	160%	160%	250%	250%	250%	0%	120%	115%	110%	120%	115%	110%	120%	115%	110%
50	0%	110%	107%	105%	110%	107%	105%	0%	77%	60%	50%	0%	77%	60%	50%	77%	60%	50%	77%	60%	50%	0%	88%	85%	83%	110%	107%	105%	110%	107%	105%
Mean		137%	130%	125%	133%	127%	123%	-2%	74%	66%	62%	-2%	81%	73%	69%	94%	84%	78%	134%	118%	110%	-2%	87%	81%	77%	109%	104%	100%	124%	118%	115%
STD		0.17998	0.174	0.183	0.1481	0.145	0.1462	0.068	0.2513	0.2408	0.24063	0.039	0.266	0.251	0.25	0.334	0.314	0.313	0.632	0.573	0.578	0.05	0.295	0.283	0.283	0.228	0.224	0.226	0.1713	0.1582	0.158

Biography

Mr. Pittawat Ueasangkomsate was born in September, 1979 in Bangkok, Thailand. He graduated from the Faculty of Engineering in Electrical Engineering, Kasetsart University in 2002 with Scholarship of Kasetsart University and Isuzu Foundation. He then earned a Master of Science in Logistics Management from Chulalongkorn University in 2006. Next, he joined the Doctor of Philosophy in Logistics Management at Chulalongkorn University in 2009. During this program in 2011, he got JASSO Scholarship to do research at Tokyo Institute of Technology in Japan. For his work experience, he has worked for more than 10 years since graduation in many leading companies.