COMBINATORIAL AUCTIONS
FOR LOGISTICS VILLAGES

TUĞÇE ÇEVİK

MASTER'S THESIS

IZMIR UNIVERSITY OF ECONOMICS

İZMİR 2013

COMBINATORIAL AUCTIONS FOR LOGISTICS VILLAGES

TUĞÇE ÇEVİK

AUGUST 2013

COMBINATORIAL AUCTIONS FOR LOGISTICS VILLAGES

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

OF

IZMIR UNIVERSITY OF ECONOMICS

BY

TUĞÇE ÇEVİK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF ARTS

IN

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

AUGUST 2013

Approval of the Graduate School of Social Sciences

Prof. Dr. CENGİZ EROL
Director

I certify that thesis satisfies all the requirements as a thesis for the degree of Master of Arts.

Assoc. Prof. Dr. ÖZNUR YURT
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts.

Asst. Prof. Dr. AHMET CAMCI
Supervisor

Examining Committee Members

Asst. Prof. Dr. AHMET CAMCI

Assoc. Prof. Dr. ALİ DEVECİ

Asst. Prof .Dr. MUHİTTİN HAKAN DEMİR

ABSTRACT

COMBINATORIAL AUCTIONS FOR LOGISTICS VILLAGES

Tuğçe ÇEVİK

Master of Logistics Management, Institute of Social Sciences

Supervisor: Asst. Prof. Dr. Ahmet CAMCI

August 2013, 67 pages

With the growth in international trade and continuous developing economic and technological factors intermodal transportation and logistics villages have been among the immensely studied topics in logistics in the last two decades. In the studies on the establishment and evaluation of logistics villages, public private partnership during the construction phase has been one of the most important issues. Main problem from the public side is the excess amount of capital required to construct logistics villages. However, from the private firms' perspective rate of return of the investment is another critical factor in addition to the size of the capital required. In this thesis we demonstrate combinatorial auctions for logistics villages which encourage the private logistics firms to invest greater amounts to take part in logistics villages. The main motivation comes from the complementariness phenomenon of the

combinatorial auctions context. We derive a mathematical model for the combinatorial auctions for logistics villages. Our numerical experiments show that combinatorial auctions including several logistics villages simultaneously yield greater private sector investment compared to the regular auctions case.

Keywords: *Logistics Centers, Auctions, Combinatorial Auctions*

ÖZET

LOJİSTİK KÖYLERDE KOMBİNATORYAL İHALELER

Tuğçe ÇEVİK

Lojistik Yönetimi Yüksek Lisansı, Sosyal Bilimler Enstitüsü

Tez Yöneticisi: Yrd.Doç.Dr. Ahmet CAMCI

Ağustos 2013, 67 sayfa

Uluslararası ticaretin artışı ve sürekli gelişen ekonomik ve teknolojik faktörler ile birlikte intermodal taşımacılık ve lojistik köy kavramları son yıllarda lojistik alanında sıklıkla çalışılan konular arasında yer almıştır. Lojistik köylerin kuruluşu ve değerlendirilmesiyle ilgili yapılan çalışmalarda lojistik köylerin kurulumu aşamasındaki kamu ve özel sektör ortaklığının önemli konular arasında olduğu görülmektedir. Kamu tarafında en önemli sorun lojistik köylerin kurulması için büyük miktarda kapital gerekmesidir. Bunun yanında özel sektör firmaları açısından yatırımın getiri oranı da önemli konular arasındadır. Bu tez çalışmasında lojistik köylere özel sektör yatırımını artıracak olan kombinatoryal ihaleler

üzerine çalışılmıştır. Burada ana fikir kombinatoryal ihaleler konusunun kritik noktalarından olan tamamlayıcılıktır. Kombinatoryal lojistik köy ihaleleri için bir matematiksel model geliştirilmiştir. Sayısal deneylerimiz birden fazla lojistik köyü içeren kombinatoryal ihalelerin getirisinin lojistik köylerde ayrı ayrı ihaleler yapıldığı duruma göre daha fazla olduğunu göstermektedir.

Anahtar Kelimeler: *Lojistik Köyleri, İhaleler, Kombinatoryal İhaleler*

To my family

Acknowledgement

Firstly I would like to thank to my advisor, Asst. Prof. Dr. Ahmet CAMCI for his guidance and priceless support throughout my thesis. I would not have done this thesis without his endless support and academic knowledge.

I owe lots of things to Asst. Prof. Dr. Muhittin Hakan Demir and Assoc. Prof. Dr. Ali Deveci for their guidance and participation in my thesis committee

Also I would like to send my best regards to the lecturers in Department of Logistics Management for their suggestions and supports during the preparation of this thesis.

Finally I really appreciate encouragement and moral support of my family.

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CHAPTER 1

INTRODUCTION

In the last few decades globalization in production and liberalization in international trade has caused the demand to grow sharply. To satisfy demand there must be significant changes in supply chains and distribution channels. With this change, efficiency has become more and more important in supply chain management. The needs of efficiency in cost and transit time, quality, the legislations and shifts in economical environments stimulate new trends in designing the distribution networks and intermodal freight transportation. The efforts in finding new trends led the idea of logistics centers. There are varieties in concepts of logistics centers according to the differences in services, location and freight modal used.

Mainly the logistics centers aim at supporting seamless integrated transport network that can increase the attractiveness of the market and competitiveness of the companies, as well as establishing a good reputation through improvement. The logistics centers services can be categorized as basic services, ancillary services, and value-added services. There are also supporting activities that enable logistics centers services. The infrastructure includes both hardware aspects (e.g. facilities and equipment) and software aspects (e.g. information communication technology).

The definition of freight village indicates that it is a more comprehensive logistics center with the strengths in geographic coverage and transport modes. However the terms logistics center and freight village are to great extent interchangeable.

Planning to dedicate a location as a logistics center, deciding on the layout of the logistics center, quality in transportation and improvement in intermodality generate the logistics centers' concepts. Allocation of an area for logistics center needs to optimize land utilization, figure out the traffic congestion according to the operations and freight modes that will be used. In order to be more efficient in logistics, optimization in utilization of transportation, warehouse and labor force play a key role.

Another key issue for the idea of logistics centers is the development in intermodal transportation. Logistics centers generally give intermodality solutions, especially with sea and land transportations. With this transportation volume in goods and quality in transportation increase and the costs reduce. Forwarders working in logistics centers make a big impact and increase adaptability to the changes in supply chains.

With the globalization information technologies have developed and the firms have started to use IT solutions in logistics. On the other hand because of the low volume of transportationand high costs prevent the small firms to use IT in their whole system. Being a part of logistics centers as small firms consolidation in IT solutions makes their operations more efficient.

Variety in transportation flow and flexibility in warehouse capacity have a positive impact on transportation goods volume. With the cooperation and collaboration in

logistics firms and integrated services result in improvement of the whole supply chain system. With the additional services offered in logistics centers like banking, renting offices, custom clearance contribute the new investments and become important effect in economy and manpower industry. Sharing integrated services, IT systems and know-how provide cost-sharing and reduction in costs. Besides, hub and spoke networks in freight transportation and cooperation with other logistics centers produce economies of scale.

The obstacles in establishment of a logistics centers basically are constraints at the planning duration, different aim to land use and bureaucracy. When the planning procedure postpones or extent, capital budget could be needed to increase. Therefore there could be lack of motivation from the view of investors and the investors may lose money because of unestimated expenses. Establishing logistics centers involves long term investment. Especially plans of local authority about land use should be in line with the investors' plans. Besides the different plans to use long and heavy procedures cause the plans to be postponed.

Financial base of logistics centers is composed with selection of location and traffic forecast, services provided, estimation and assessment of costs and investment. There are uncertain circumstances in variables like expenses, revenues at establishing period. Herewith this infrastructure needs not only private investment but also need public support in establishing and operating infrastructure.

The private and public partnership should share the responsibility, risks and expenses and revenues. The private sector aims profit at the maximum level and public funds' purpose is to keep risks at the minimum level. Private investments and public funds should combine due to the preference of location, services preferred, estimation investment and evaluation investment. It shows that the combination is needed and the private sector couldn't succeed without public support because of the uncertainty in economic environment

Auctions have a long history for years and studies based on theory started with 1960s, but it has become a current issue since the early 2000s with the sales on internet. They basically help to elicit information from the customers and set a reasonable price for the item.

Auctions have many reasons to be improved. Firstly with the globalization quantity of services and goods has been increasing and many markets need new auction design. Secondly auctions help the economy theory provide and avoid especially the lack of information about the market. Thirdly auctions develop to perceive market behavior about the price determination.

Basic auctions types are the ascending-bid auction, the descending-bid auction, the first price sealed-bid auction, and the second-bid sealed auction. In the ascending-bid auctions, the seller proclaims the price of the object and the bid is increased by the bidder until the demand matches the stable price. The ascending-bid auction is also called English auction.

In the descending auction, the seller announces the highest bid and the bid is decreased until the demand matches the stable price. It is also called Dutch auction. In the first price sealed bid auction, the bidder offers a written bid in unaware of the other bidders. Highest bidder wins the object and pays the price.

First-price sealed-bid auction is also known as discriminatory auction with multiple objects. In the second price sealed-bid auction, the bidder offers a written bid in unaware of the other bidders. Highest bidder wins the object and pays the second highest price. It is also common with the name of uniform price auction (Vickrey auction) with the multiple objects.

Combinatorial auction in which multiple items are for sale has the problem of complexity in analyzing optimum strategy. Combinations of objects should be more valuable than the other combinations and the combination that the bidder values should be greater than total value for the individual item in the combination.

Combinatorial auctions have main figures as bidding, allocation, payment and strategy. Every bidder has a value for each combination of items. By expressing the bids auctioneers can be informed about how efficient the bids are. Allocation will be optimized due to economical environment, but the optimized solution changes due to every auction. The payment policy ascertains the bidders strategy and auctioneer's revenue.

The goals desired to achieve in auction designs are allocative efficiency, revenue maximization/cost minimization, low transaction cost and transparency. The allocative efficiency is to maximize the total value by the one bid in auction with the economic efficiency. The economic efficiency is affected negatively from inefficient taxes or other cost. Companies –the bidders- desire the cost minimization, on contrary to the auctioneers-generally the government- aim to maximize the revenue. To achieve this, both sides face the difficulty about estimating the bidders' strategies.

Sometimes the auctions take time to terminate and it causes the postponement in results. This kind of postponement is called transaction cost and is undesired situation, the auction speed should be as high as possible. Fairness is essential in auctions. The auction rules should be well-defined and well-announced. The auctioneers don't let the bidders' willingness to reduce and the auctioneers prevent the bidders from failure because of the unannounced auction rules. The final goal is transparency. Transparency helps the bidders to understand and handle the issue and enhance their willingness.

In contrary to simple auctions combinational auctions provide the bidders behave independently on the combinations of items for sale and at the same time by gathering information the auctioneers generate the optimized and common value for the combinations and decide which combinations contribute.

The aim to design combinatorial auction for logistics villages is basically complementary logistics villages –i.e. operating in several logistics villages

simultaneously- provide reduction in costs and contribute to the economies of scale. In addition the bidders could consider the combinational logistics villages as substitutes. To bid on complementary logistics villages the bidder should have enough resource and capacity.

In studies focused on logistics villages, we have seen that private sector has an important place in financing logistics villages. Our goals in this thesis are to show combinatorial auctions for logistics villages which encourage the private logistics firms to invest greater amounts to participate in logistics villages. Combinatorial auctions contain phenomenon of complementariness. We constitute a mathematical model for the combinatorial auctions for logistics villages. Our numerical scenarios show that combinatorial auctions involve various logistics villages carry interest from private sector in comparison to the regular auctions case.

The outline of this thesis is as follows: in chapter 2 we review the literature about logistics villages and auctions. In chapter 3 we inform generally about the logistics villages and auctions. In chapter 4 we demonstrate our mathematical model about the combinatorial auctions for logistics villages. In chapter 5 we exhibit our numerical experiments' results. Finally, in chapter 6we conclude after a brief discussion.

CHAPTER 2

LITERATURE REVIEW

In this chapter, we review the literature involving 2 main topics: logistic villages and auction design. Firstly we discuss the definition and design of logistics village. We present some of studies on creation of logistics villages using different methods and financial evaluation with public and private partnership. Then, we concentrate on studies about definition and types of auction design. In this field, furthermore, we argue the policies in auction design. Finally we investigate the studies on theory and practice of combinatorial auction in different fields. By the studies of theory and practice of logistics villages and types of auction design. We try to determine how to adapt combinatorial auction design in logistics villages.

2.1 Logistics Villages

The review of literature in logistic villages determines the reason in creation of logistics villages; and general framework of establishment logistics villages under uncertainty with economical evaluation.

Ieva Meidute (2007) points out that international trade occupies a place in the world quickly with the globalization spreading rapidly. And the transport sector and transportation framework need an implementation to this process. Logistics centers gain importance with the economic, political and social changes in transportation

sector. In his article it is stated that with this global trend 57 transport and logistics centers are located in Italy, Spain, Germany, Denmark, Portugal, Luxemburg, Greece and France.

Tsamboulas (2002) states that intermodal transportation needs to carry out at least two tasks:

- At least two transport modes are used
- The same transport load carries on in whole transition by changing the transportation modes

In RTD Programme ‘FV 2000’- Quality of Freight Villages Structure and Operations it is argued that to appeal to multimodal transportation different modes must be served for and all the services that are given should be used equally by all companies in logistics villages. This structure could be managed by the tenants or owners of building. But logistics centers need the supports from both public and private sectors.

Potential customers of logistics village have expectations about integrated transport chain as follows:

- Cost-savings,
- Reliability,
- Reduction in transit times,
- Increasing in quality

Tsamboulas and Kapros (2003) advocate that joint venture and concession are the most favorable options in public private partnerships. In joint venture public and private parties share the responsibility, risks, profits and losses equally and each one takes part in field where they are more experienced. In concessions generally government give a concession to one or more private firms and the firms are responsible for operation, construction and financing. During the concession the firm is the owner of the facility and operates the process and gets the revenues to repay its part. The types of concessions are;

- BOO (build-own-operate),
- DBOT (design-build-operate-transfer),
- BOOS (build-own-operate-transfer),
- BOOT (build-own-operate-transfer),
- BOTT (build-operate-training-transfer) .

Investment decisions about freight village establishment are made by public sector according to the socio-economic evaluation. And in public private partnerships financial evaluations are made with calculating the risks and uncertainties in economy. There are too many methods to be used while evaluating both, but especially Monte Carlo simulation is a technique that creates scenarios with using probability statistics to figure out the expected values. In the simulation scenarios created repeat many times to give possible solutions. The scenarios are created with the four phases as follows; traffic forecasts, services offered estimation of investment and operation costs, evaluation of investments. So the corresponding method changes

according to the needs, especially to the transportation infrastructure of freight village,

Afandizadeh and Moayedfar (2010) discusses that a freight village as a terminal is an important link in transportation chain by serving multimodal transportation. Main models that are the most common used: the Urban model (that has transportation activities around the big cities and using generally trucks and smaller vehicles), Italian model (using the multimodal terminal of the Italian railway transportation); the combined port cargo transportation model (combining with other port zones); the simultaneous impressionability model (impressing all parameters by the creation type).

In the studies on creation of freight village in Hormozgan province, parameters like dock length, terminal area and average services time per ship affect considerably on changing the total turnover of Shahid Rajaie port, but progress at the same time in these parameters would affect more considerable. For example % 20 increases in the dock length and decrease in the service time would provide %52 increase in the total turnover in general cargo. Without increasing the loading and unloading facilities decrease only the cargo average waiting time in storage. Also increasing loading and unloading facilities results with increasing the average waiting time of the cargo in the storage.

Meidute (2010) claims that a financial evaluation model optimizes the possible funding scenarios for the private sector. The model shows the total investment

needed and allows maximizing the return on investment. Also the evaluation model provide to minimize the data needed.

Ballis and Mavrotas (2007) state that the current market status and trends affect the making decision on location selection of freight villages. Site selection problem will be solved by using some objectives as follows: cost objectives, demand-oriented objectives, profit objectives and environmental objectives. Like minimization of travel distance, accessibility, maximization the market share and minimization population at risk can change the optimization of freight village location selection. In their study, they consider about the factors as utilization of space for the building, warehouse sizes, transshipment option, number of rail-road crossings, traffic density in the internal traffic network. There are 3 alternative design with determining major characteristics and measurable 15 criteria. The multicriteria method is helpful for investigation of the most favorable design that decision makers prefer for the freight village structure.

Jarzemskis (2006) claims that framework of the logistics centers consist in 3 factors as follows:

- Systematization in establishment planning
- Quality in transportation
- Evolution in intermodal transportation

Logistics center establishment starts with selection of a definite area to regulate transportation and distribution traffic, building infrastructures for using operational services without harming the environment. Transport quality develops with optimization in logistics chain. Optimization in logistics chain carries with optimization in usage warehouse and employment. It provides decrease in transportation cost, industrial cost and personnel cost. One of the goals of logistics village establishment is to provide augmentation of intermodal transportation. Reasons in preference of railway, sea shipping and road transportation changes in comparison with the fault tolerance, weather ability quantity of the goods.

Logistics villages provide solutions with the multimodality utilization. With using at least 2 different transportation modes, volume of transported goods and frequency of the transportation increase. Forwarders become part of logistics villages and synergy in logistics chain and transportation performance increase. Small warehouse and transportation firms can gain favor from bigger companies that have IT solutions for operational services. With the economies of scale, small companies can learn operational management like planning, executing and control of the transportation process. Warehousing capacity and modern operation services have an important impact for new goods flow. Insurance companies, freight forwarders and the operation services attracts the new ones, new companies want a part of the system and flow of the goods increase, domestic transportation reactivates. Additional services like banks, washing facilities, filling stations, custom clearance occur a synergy and centralized electric and telecommunications supply reduce the firms' cost and attract new entrepreneurs. IT solutions, centralized services and knowledge

provide small firms higher profits and bigger firms reduce the cost with cost sharing. Co-operation with the firms increase the economy of scale and firms get advantages. Logistics centers generate a quality standard and small companies can use bigger companies know-how and knowledge and with the co-operation create joint marketing.

Planning of logistics villages is an important process. And the duration of the planning process could take too long and it could cause the investors lose money. Planning starts with the selection location. Investors need to research government's development plans for the location. Difference between government's development plan for the location and the investor's plan of logistics village cause conflict in the system. The conflict generates money and time loss. Besides, there could be different aim about use of the land which is selected for the logistics village. Settlement or nature conservation area that is near to logistics center causes some problems, too.

Another obstacle for establishment of the logistics villages is legislation and bureaucracy. Establishment of logistics villages takes a long process. Changing in legislation and bureaucratic procedure could procure delay in the logistics village plan. Establishment logistics center by private public partnership faces problems like lack of regulation about PPP experience or public sector's expectations interferences with private sector's aim. Private sector always wants quick and hassle-free earnings, but public sector should take benefits of society into consideration. In PPP investment could have a handicap in financial and economic regulation. Both public

and private sector could have lack of information about which role they should take. Public and private sector should be together from the planning to the establishment of the logistics village.

2.2 Auction Design

Governments have liberalized their infrastructure services such as energy, transportation and telecommunications by direct selling or awarding concessions. For both direct selling and awarding concessions governments need to manage their competition policies. (Emek,2002)

Nowadays concessions can be seen equal with the standard equipment procurements with using the similar auction rules, but concessions need to develop effective long-term contractual relations between parties. Auction rules should provide getting the best possible deal with setting up clear bidding rules and prevent collusive, predatory, and entry-deterring behavior. Also the rules establish procedural safeguards. These safeguards aim at ensuring the process is fair and transparent.

In awarding concessions the value of concession and expected return of it are needed to calculate. In the calculation, economic, technical and financial capacity of the bidders limits the scope of the value and the expected return.

An auction design concept should be designed according to the entities who use it mostly. Optimal conditions that the firms and the government are under must be

considered while designing. And also aims of an auction design must be supporting the public finance and maximizing the profit with realizing the economic value to the consumers and industry.

Competition between bidders should be non-discriminatory and address former aim. With the maximizing profit, efficiency must be understood for both bidders' business plan and future positioning in industry.

There are many successful auction markets. With the variety in economic circumstances auction design changes according to the context. So the auction design is not *'one size fits all'*. Every auction design could need to be tailored according to the requirements. Auction design should encourage the entry and discourage the collusion. Also auction designers should be sensitive to the harmful pressure of political and administrative pressure.(Klemperer,2003)

There are four basic types of auctions are used as follows:

Table 1. Types of auctions

TYPES	RULES
Ascending-Price, open-bid auction or English	Seller declares the first low bid and the bid increases until demand match the fixed amount at auction
Descending-Price, open-bid auction or Dutch	Sellers declares the first high bid and the bid lowers until demand rises to match the fixed amount at auction
First-Price Sealed-Bid Auction or With Multiple Objects, Discriminatory Auction	Bidders present written bids, no bidders have information about the written bids. And highest bidder wins the auction and pays the amount bid.
Second-price Sealed-Bid Auction or With Multiple Objects, Uniform Price Auction (Vickrey Auction)	Bidders present written bids, no bidders have information about the written bids. And highest bidder wins the auction and pays the amount of the second highest bid.

Klemperer (2002) collects competition policies oriented pitfalls in auction design in four groups:

- Collusion
- Entry deterrence
- Predatory pricing
- Winner's curse

Collusion, especially tacit collusion, is quiet common in ascending and second-price sealed bid auctions. Collusion agreement can be made explicitly by putting limit on number of rivals and also collusion agreement can be made implicitly by putting limit on price during auction process.

In ascending auction, rivals' bids are noticeable and during the process a cartel member pass over the collusion price that is determined before, other members response with increasing the bids. So breaking up co-operation agreement between cartel members is not possible.

In second-price bid auction, the bidder who has the highest evaluation present his bid and pays next highest bid, behaves unsuitable with the cartel agreement and exceed the pre-determined low cartel price are not advantageous to any cartel member.

With insufficient number of members an auction cannot use its potential efficiency. In auction design attracting the bidders and providing them to attend the auction increase the efficiency.

Some dominant firms set very low prices or selling below the firms' marginal costs of producing the output. It is an adopted strategy called predatory pricing. Predators drive out rivals and discourage entry of small or new firms; they can increase the prices and get more profit.

Inadequate reserve prices cause the incensement for predation and encourage collusion. In ascending auction a strong bidder can have the chance for collusion at low price or forcing the price up to drive out weaker bidders to end the auction quickly. The lower reserve price can be thought more attractive at first sight, but it could be end up with disasters.

Some reserve prices are opposed by industry but also by the government officials when the object is not sold and the reserve price is not met. Especially in first-price bid auctions in which the bidders make the best and final offers, the winner pays the price of the bid. For example in an auction of a privatized bank in Brazil, the bids are opened and the bank managers learn that their bid of over 7 billion reals ($3.6billion) is more than is needed to win. In some other auctions, the losers who underbid the winners find it equally hard to explain themselves to their managers. For this reason first price auction are opposed by many firms and their managers. In a second price sealed bid auctions in which the winners pay the runner-up's bid can be

uncomfortable for the auctioneer if the auction design is efficient and is maximized the expected revenue.

In some cases the auction rules can allow loopholes for behavior to game the auction. For example if defaults costs are small, the bidders bid for options on prices rather than the prices themselves. If smaller, underfinanced firms can keep away from commitments

When all bidders have the common information about the auction, they usually give the similar value on it. But if a bidder's information about the auctioned item differs from the other bidders, winner's curse occurs. And the bidders try to preserve themselves from temperately.

The aim of auction design to sell item is to create a value using the consideration between sellers and buyers and on the other hand consideration between the rivals.

Creating value in auction design can be managed by attracting bidders and causing the competition. Announcement the available information provides increasing the revenue of the auction. On the other hand if seller doubts about the collusion, the bids are pushed up. Notwithstanding attractiveness of the auction decreases and it causes the lack of new attendance.

2.2.1 Combinatorial Auction Design

Auctions have become known with liberalization and increase in use of internet. Variety of goods that are sold and variety of selling methods have increased dramatically. Auctions like Ebay.com have provided millions participate in internet auctions and this has made the auction daily application, but essentially auction has established a presence in B2B (business-to-business) application. Most of the large companies have started to use auctions for their procurement operations.(Pekec, Rothkopf, 2003)

Auction is an important entity on gaining information, especially about the bidders' valuation of an item that is not known. By gaining information about item's valuation, it helps to learn the fair price for the item. However there could be multiple items and the auction design could be more complex than it is thought. In that case new strategies should be developed. Strategies that are composed of a theory can limit, so strategies need to be put into practice to see how realizable it is.

Combinatorial auctions aren't just bids on combinations of items and as well combinatorial auctions shows whose valuation on combinations is superior than the valuation for the individual items in the combination. In combinatorial auctions complementaries, substitutes and synergies between the items come into view discernibly. In the meanwhile the companies' capacity and limits of procurement come to the light.

Description of combinatorial auction is that selling multiple items synchronously, and allows ‘all or nothing’ bids on combinations of these items.But in both combinatorial and noncombinatorial auctions state of equilibrium, efficiency and return expectations are difficulties encountered.

In noncombinatiorial auctions, the bidder who has the highest bid is the auction winner, but in combinatorial auctions, the highest bid does not guarantee to win. Nevertheless there is not concerted set of items in a combinatorial auction for all the bidders. A bidder benefits from a set of complementary items, the other prefers another combination.

It is an achievement when one maximizes the total valuation of the items being auctioned to the winners. Cost minimization or revenue maximization is mostly an initial aim for bidders. It is too difficult for combinatorial auction designers to design the favorable set of combination with aiming cost minimization for the bidders. Auction speed and cost for having a part in an auction are other expectations for the bidders. Fair platform should be part of an combinatorial auction and awareness of the rules in the auction needs to be augmented. Failure cannot be avoided completely but designers should minimize the risk of failure. Transparency is an important element in the auction for simplifying the bidders’ understandings and increasing the bidders’ trust for the auction.

There is not a guaranteed efficient algorithm copying with the computational disruption for winner determination. But auction designers study on the algorithm

closer to the optimality. In despite of protecting bidders' information is important, auction designers, the auction designers need to hire whoever find out the best solution for computational complexity. On the other hand, a chance could be given to the bidders to find their optimal solution for the winner determination. In the meantime fairness in the auction should be protected and maintained.

Park and Rothkopf (2001) offer to limit the biddable combinations to express bidders values perfectly, but it is figured out that individual items limit what is biddable. It is understood that no auction can be totally ineffective and auction designers should take computational complexity into consideration. And limiting the use of combinatorial bids could be an alternative.

Basic combinatorial auction mechanisms are as follows:

- Sealed Bid First-Price Combinatorial Auctions
- Vickrey-Clarke-Groves Mechanisms
- Uniform Price Mechanisms

In sealed bid first-price combinatorial auctions, all bids are presented before a deadline. After the winner determination solution, items go to the revenue – maximizing combination of bids and the winner pays the amount of the bid. The winner determination solution is an important barrier to carry out this kind of auctions. This kind of auctions resist to the collusive conspiracies by bidders. Sealed bid auctions canalizes to participation in comparison with tacit collusion. Bidders should not just value on their information, because sealed bid auctions including

combinatorial ones are quiet open to competitive information. However sharing the information prevent the winner's curse, too.

In a combinatorial auction Vickrey-Clarke-Groves mechanisms build a strategy that bidders bid their true value for every combination of items. VCG mechanism builds this strategy by returning to the bidders the gain in value that bidders cause. This return is called vickrey payment. VCG mechanisms are rarely used, because vickrey payment causes the missing revenue and this system makes cheating possible.

In uniform price mechanism, some bids are proposals for selling, others are proposals for buying. When the highest proposal to buy meets the lowest proposal to sell, and next highest and next lowest meets and etc. until the price of the sell is superior to the price of the buy. Every meeting of lowest price to buy and highest price to sell is priced.

Bikhchandani and Ostroy (2002) claim that each bidder maximizes its profit in the revenue-maximizing and it is not a little. At the same time this market-clearing price is not additional contribution.

CHAPTER 3

PROBLEM DEFINITION

3.1 Logistics Villages

Globalized market leads companies using logistics to consider cost-efficiency, transport time, quality and environmental factors while choosing location. On the other hand, like transport or logistics companies on the supply side endeavor to satisfy shareholders' demands. With developments in the market management at the government level makes an effort to attract investment, improve production and trade while regulations strive to improve land use, ease modal shift and reduce traffic congestions. In the meantime research and academic part contribute to develop logistics centers with knowledge and competence.

The aim of international logistics centers is to support seamless integrated transport network. It is not only to attract the market and competitiveness but also a good reputation with continuous development. Definition of international logistics centers has a lack of consensus but improved logistics centers generally involve actors who are in both private part like transport and logistics industry and public authority like government. Private and public parts make effort to collaborate with each other for promoting global trade. In this manner logistics infrastructure and supply chain conditions improve. It also develops cost-efficiency, quality and environmental aspects.

Supply chain includes all the features of manufacturing, procurement, transportation and other value adding services that begins from source of raw material and terminates with end user. Progress at supply chain management is seen as a competitive advantage along with the improvement at information communication technologies. Changes in supply chain management establish a relationship that is more valuable and less costly between supplier and customer. Growth in demand and complexity requires logistics centers to add new value adding services to ensure customer satisfaction.

Differentiation in production and storage cause update functions at logistics centers. With focusing on integrated services needs for third party logistics and outsourcing are emerged in framework of logistics centers. To meet the expectations of multinational companies logistics centers become larger with services for wider geographical coverage. Reduction in cost and improvement in quality become the main drivers behind this enlargement. Intermodal transportation brings with the bottlenecks in goods flow. The bottlenecks like lack of flexibility in goods flow result in specialization and deep integration with some of forwarders. So too deep integration in supply chain influence the effectiveness of logistics centers negatively.

Improvements in the basic logistics functions like transportation, goods handling or storage are not only attempt in logistics centers, but also like production or retailing segments of supply chain are strived at development.

The main criterion for the choice of the location for logistics centers is the transportation cost. However the effects of multinational collaborations and globalized market add other factors in decision of optimum location for logistics centers. Logistics users and government give importance on synergy effect, business attitudes, labor productiveness and environmental aspects while deciding on location. Aim cannot be seen only improve logistics activities, seamless supply chain should be the main driver. Effective supply chain includes both product flows and transaction flows which need to be coordinated. Transaction flow is to pass the ownership from seller to buyer. It involves marketing and promotion activities carried out by chamber of commerce research institutes, banks, insurers and customs.

International logistics centers focus on economic improvement and increment in business and trade alongside of goods flow. Focal points show that the infrastructure of international logistics centers creates value to resident of the logistics centers. Standards and quality performance that are specified should be compatible with the commercial and continuous intermodal transport solutions. Advantage in cost, environmental aspects, quality and integrability are stressed to succeed a competitive advantage in intermodal transportation.

Logistics centers establish an environment that is based on comparatively convenient transport infrastructure and cargo traffic. Companies that use transport and logistics service in the logistics centers take advantage of economies of scale.

The infrastructure involves hardware and software aspects. Hardware aspects are facilities and equipment, on the other hand software aspects includes an information platform to facilitate information flow related to transportation. Geographic information system for track and trace, computer-assisted terminal management system and global positioning system are examples for software aspects. A successful technology design for seamless logistics development is the aim of advanced logistics system.

The basic services involve storage, cargo handling, distribution, packing and multimodal transportation, etc. The ancillary services are public and commercial services. Value added services that add value directly to the goods are goods processing, inspection, packaging and bar coding, etc. In logistics centers enhancements in services cannot be seen only rise in numbers, it also involves improvement in functionality.

To attract cargo flows and investments as well as satisfy customer expectations logistics centers establish an effective and efficient network regarding to geographical, economic, political and social structure.

The level of internationalization of logistics centers is determined by using 8 basic figures as follows:

- geographical coverage,
- transport modes and corridor,
- third party logistics services,
- value added logistics services,
- commercial and public services,
- customs and administration,
- marketing
- horizontal collaboration and networks.(Berqvist, Du,2010)

Some logistics centers focus on regional or national distribution, but some of them operate in an international coverage. The transport mode is related to transport corridor with its size and geographical aspects. Logistics centers can facilitate to use all transport modes but they may not convenient for intermodal transportation. It means they could be multimodal but not be intermodal. Differentiation in services used in logistics centers show the level of internationalization. Third party logistics services give integrated transport and logistics solutions by using integrated relations to the business sector and deal with services including information, physical and administrative management like planning, allocating and controlling through the supply chain. Inventory management, goods processing, semi-manufacturing, reverse logistics and product customization are value added services. They are a combination of scale and scope.

Some logistics centers become more commercialized by developing diverse community related business. Commercial activities are restaurant, hotel, shopping mall and other services that can be used by communities. Public services are banks, post offices, truck stops, etc. The aim of public services indicating the community integrated level of logistics centers is to promote regional development. The commercialization is regarded as distinguishing factor that different from the core business of logistics centers. Custom clearance, document handling for import and export are the services that are needed to develop trade and business in international coverage. To reduce uncertainty that is caused by formalities and customs this services are needed. It is different from value adding services, because mostly logistics centers give importance on only custom clearance and do not have remarkable number of value added services. Marketing is a factor that affects recognition of logistics centers and provides regional development.

Strategic marketing is a competitive advantage in differentiation and increase the attractiveness. With nationalization network flow become larger and logistics centers need to establish a collaboration transport management system. Collaboration is divided into two groups. One is vertical collaboration that is occurred at an individual company's level. Horizontal collaboration is occurred with the other logistics centers. Aim of horizontal collaboration is to add value on products with generating new strategies, new synergy and consolidating the competence of network members. Combine with offered services collaboration between actors in logistics centers is a good indicator of the level of internationalization in logistics centers.

Differences in the purposes label the logistics centers in three basic clusters as follows:

- specialization in logistics and cargo handling,
- dedicated for production and trade development,
- comprehensive services in regards to business and logistics and/or community.

In cluster 1 the concept of logistics centers focus on cargo handling, distribution and multimodal transportation. The public and commercial services are involved in development. This concept is generally transshipment-oriented and transship large amount of goods through international transportation. In cluster 2 the concept focuses on regional economic growth. It is succeeded by not only logistics capabilities and also using beneficial policies. It depends on providing transportation, storage and also offered value-added services. In cluster 3 logistics centers have various services that handle international traffic. This type of logistics centers that is owned by private public partnership is a combination of cluster 1 and 2. Development of economic growth and facilitating a flow on supply chain with supporting services are aimed at cluster 3. Regional growth can be achieved by both logistics-using companies and other business such as banks, retail stores, etc. that serve the all community. Some of the logistics centers locate close to technology parks to attract investment and develop technology in logistics and transportation.

Behind the differences in the clusters of logistics centers, they have similar features. The target group of the logistics centers is the group of transportation and logistics users and forwarders (1). All the logistics centers have capabilities for logistics and transportation activities and also aim to create value using economies of scale (2). From a perspective that involves cost efficiency, quality and environmental the logistics centers intend to build up a platform to serve better for members of themselves those are related to logistics and transportation.

Logistics centers are classified in local, regional, national, international and continental. Domestic market is the focal point at local or regional level. At national level logistics centers have wider network that covers the country. International logistics centers have direct trade lanes with departure and destination points related to local, national and continental markets.

Logistics centers serve for different reasons like cargo shipment, production synchronization, facilitate business or strengthen the logistics capability to improve regional economic growth. Development of the logistics centers has 3 basic stages such as

- functionality ,
- value adding ,
- and comprehensiveness

Functionality stage which involves cargo handling, distribution and consolidation is seen at logistics centers which are in cluster 1. Value adding which have value adding services has similarities with cluster 2. The aim is development in regional growth. It may be possible while carrying out the activities with business friendly policies. Comprehensiveness is recognized multifunctional node for international trade by building up international transport services. The target for this stage is to promote supply chain flow with supporting services and environmental performance.

In the meantime activities in logistics centers are not limited with transportation solutions; the activities include other activities which are carried out by research institutes, financial institutions.

International logistics centers rely on private public collaboration and are managed by a neutral legal body with accessing third party logistics. Member of this type of logistics centers improve with better economical and productive performance. The standards in services should be harmonized standards with global market. Logistics centers which operate international goods flow share the characteristics of all the 3 clusters and evolve the specialization and diversification.

Establishment of logistics centers has 2 main effects such as public interest and private business interest. Logistics centers are established with acquirements of land, construction, operation and management. Negotiations with transportation companies are needed. There are two basic attitudes to evaluate the revenue of logistics centers. Firstly companies need to consider the area to locate and services to calculate the

fees gathered from each company. Secondly the total expected traffic flows should be estimated by the model of forecasting. The revenues depend on the transport units among the logistics centers' members.

Generally public sector decides on investment about infrastructure projects by using socio-economic evaluation. Nevertheless the projects owned by private public partnership decide by using financial evaluation with considering risks and uncertainties. In the financial evaluation construction costs, period for construction, traffic volumes, etc. are main parameters in the financial evaluation.

While evaluating a logistics center establishment site selection is done in two levels. First level called macro level is to choose a location with no specific borders. After traffic forecasting is done second level called micro level is completed. In evaluation services offered need to be identified to estimate the cost of services. Costs and revenues affect the size of logistics centers and attract the traffic. Estimation about daily traffic in tones, number of vehicles per goods type and loading transport units are used in the evaluation model.

Goods types' volume is attracted by services which the logistics center determines. The services can be warehousing, parking areas, medical services, security, etc. Evaluation model needs to combine of the forecasting traffic and necessary services. According to the results of this combination some costs of investment are needed to estimate. These cost are identified as fixed costs like land acquisition, total

construction and equipment acquisition costs. On the other hand operational expenses which depend on the volumes of services are called variable costs.

Evaluation involves socio economic and financial approaches. Private sectors and public authority have different expectations and need different benefits. Augmentation on revenue of an investment is the main aim of private sector, on the other hand augmentation on benefits of society and implementation a policy in wider area are the aims of public authority.

Ownership by private public partnership is advantageous when socio economic analysis and economic analysis are greater than the acceptable limit. Development in private public partnership depends on the features as follows: (1) combination of private investments, bank loans and public funds, (2) combination of private investments and bank loans, (3) fully private investments. To retrieve risks of private investment public funds are needed to minimize the risks.

3.2 Combinatorial Auction Design

Combinatorial auctions are the auctions which the bidders can set bids on combinations of items which are called packages. Combinatorial biddings are useful in operation research, especially in combinatorial optimization and mathematical programming. For optimization in combinatorial biddings computer science is in relation with expressiveness of bidding languages and algorithmic aspects. It is

obvious that the study of combinatorial auctions is based on conjunction of economics, operation research and computer science. (Nisan,2000)

In standard procedure of an auction, individual items are auctioned and finally bids for packages of items are accepted. If a package bid surpasses the sum of individual bids for the items in package, the items are sold as a package. (Cramton et al.,2006)

In recent years the examples of combinatorial auctions are seen in industry like auctions for truckload transportation, bus routes, and industrial procurement. To understand the role of combinatorial auctions, it is useful to think about the auctions generally. Combinatorial auctions can be used in many auction environments. Numbers of sellers and buyers, number of items being auctioned, preferences of the bidders and private information of participants about the preferences are determinants in auction environment.

There are basic issues that deal with combinatorial auctions as follows: bidding, allocation, payment and strategy. Bidders express a bid on combinations of items. Even if combinations of items vary, auction communication codes the information in a simple way. The auction protocol set down the way of communication is done efficiently. When the bids are all in, the items in combinations are allocated among the bidders. Optimization of auctioneer's revenue or total economic efficiency is attempted by the allocation. Auctioneer's revenue and the bidders' strategy are determined by the payment rules. The bidding strategy is chosen when the auction protocol, allocation and payment rules are determined.

The bidding language should be set out to let the bidders put their bids for each possible combination that they win. The basic bidding language includes expressiveness and simplicity. The bidding language let the bidders express any bids. In the bidding language expression of bid is needed to be short and it should make the bidders express their bids easily. In bidding language expression of the bids should be simple and the bidders need to understand mechanism of the bidding language without half trying.

The advantage of combinatorial auction is that let the bidders fully express his preferences. It is especially important when the combinations of items are complements. Expressing bidders' preferences fully leads to improve economic efficiency and increase the auction revenues. Combinatorial auctions give rise to host of new and interesting questions and challenges. The first question is what the language of bidding should be. The answer varies in expressiveness and simplicity. The suitable way to understand the preference is to get the bidder assign a monetary value to each suitable allocation. It helps the bidders express their preferences but it is not that much simple.

Combinatorial auctions have two characteristics that differentiate from other auctions: (1) complexity of winner determination and (2) a cooperative aspect. Determination of auction winner is an unimportant exercise in noncombinatorial auctions, because the bidder who gives the highest bid wins the auction. In combinatorial auctions the highest bid on a combination of items is not guaranteed to win. However there are different ways of separating combinations of items for sale

in feasible allocation, a bidder can benefit from bids on complementary items, the other bidder benefits from other combination.

Allocative efficiency is beneficial feature of an auction and it is demanding even in theoretical model. It will be succeeded when one maximizes the total value to the winners of the items that are auctioned. And also effect of auction revenue on economic efficiency is taken into account. On the other hand, an auction does not always increase the revenue, inefficient taxes can be replaced with money and affects economic efficiency. (Pekec,Rothkpf, 2003)

Revenue maximization or cost minimization is another goal in auctions. The government aims the revenue maximization and the companies aim the cost minimization. Predictions about bidding strategies and designing revenue-optimizing combinatorial auctions are not easy but the basic problem that auction designers face is determining the revenue maximizing or cost minimizing allocation for a given set of bids. Both bidders and bid takers consider about the costs in the auction that they participate. Delay in auction is also transaction cost. So high speed in auction is needed. Equal treatment of competitors is difficult to define but is a goal in auction. Fairness affects the bidders' willingness to participate in an auction. The auction rules that are preannounced should be evaluated the probability of failure. In combinatorial auctions importance of transparency is based some reasons as follows: it makes the bidders understand the situation and decide easier in auction. It also increases the trust in auction by enhancing the ability of bidders affirm the auction rules.

Combinatorial auctions have come out in literature about two decades ago and applicability to auction was thought to be complex. And combinatorial auctions are harder to study and analyze. The efforts to define enlargements of noncombinatorial auction models are arguable.

Combinatorial auction mechanisms are basically (1) single round (sealed bid) first-price combinatorial auctions, (2) vickrey-clarke-groves mechanisms, (3) uniform price mechanisms.

In single-round (sealed-bid) first-price combinatorial auctions all bids are presented before the deadline. The main barrier in implementation of such auctions is the complexity of the winner determination. Such auctions are robust to collusive conspiracies by bidders. Sealed bid auctions encourage participation. In developing auctions the bidder who knows other bidder gives higher value on an item or combination has no encouragement to bid on it. On the other hand in a sealed bid auction the bidder with the known higher value is uncertain about the best competitive bid. Bidders in sealed bid auctions are concerned about competitive information and information about competitors is worthful.

Like the single-item Vickrey auction, Vickrey Clarke Groves combinatorial auction is apparently captivating. In VCG mechanism a dominant strategy for bidders as bidders should bid their true values for every combination of items. The increase in value caused by their bids is refunded to the bidders. The refund is called vickrey payment. The bid taker achieve allocative efficiency with the bidders' true

evaluations. But VCG is rare in practice. Because the vickrey payment causes the lack of revenue. This kind of auction is also subject to be cheated and is sustainable in realistic dynamic environments in which the disclosure of bidders' values has some results beyond the auctions.

Market clearing price mechanisms have appeal when multiple items are being sold. In these kinds of mechanisms price ranks the bids and until supply is exhausted the highest bids are allocated. When some bids are offered to buy and some others are offered to sell, a version of uniform price mechanisms are used. The highest offer to buy a unit is matched with the lowest offer to sell, then the next highest with next lowest until the price of the sell offer exceeds the price of the buy offer. The idea of a market-clearing price auction may be used to sell nonidentical items when there are ways to account for the differences. Notwithstanding to define a uniform price for all winning bidders' bids is not easy in general sales of items which are heterogeneous where bidders' valuations of subsets are not additive.

Combinatorial auctions let the bidders to express their valuations of combinations of items for sale at the cost of creating considerable implementation complexities. Sometimes costs of combinatorial auction preponderate the benefits of combinatorial auction. It should be calculated by the auction designers. And also combinatorial auctions can require the solution of winner determination by using combinatorial techniques.

What is to be sold must be defined by the auction designers and this includes significant and subtile preferences. For so many reasons iterative formats are of interest rather than the other types of combinatorial auctions. It involves design that fail to address the unveiling and verge problem facing bidders could easily use up any benefits of combinatorial bidding.

Expressing the value on combinations of items by the bidders is valuable and is not ignorable for the auction designers.

3.3 Auction for Logistics Villages

Someone who has an object to sell and who does not know how much his expected buyers might be willing to pay for the object needs to find some auction procedure which can give him the highest expected revenue or utility between the different types of auctions that are known. A plan that is not elaborated to design an auction starts with describing the assumptions and notations of the auction design problem.

In an auction design for logistics villages the assumptions about the parameters that are used by the bidders to evaluate the valuation of logistics villages could be traffic forecast and definition of services offered. Traffic forecast can be detailed with using the estimations of daily freight transport traffic in tones, estimation of loading transport units, etc. Assumptions for services offered can be related to volume for each commodity type, accepted minimum capacity of storage for each good.

Second step in auction design is to characterize the set of feasible auction mechanisms and show how to formulate the auction design problem as a mathematical optimization problem. An auction mechanism is an auction game that includes a strategic plan which the bidders are expected to use in playing the game.

CHAPTER 4

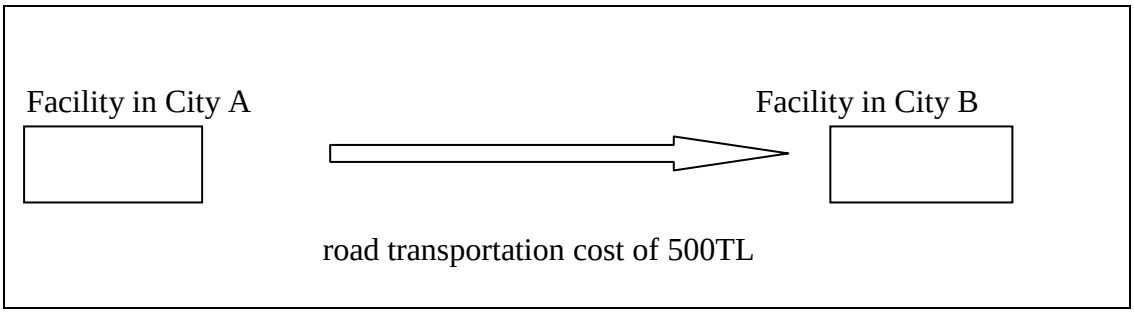
MATHEMATICAL MODEL

4.1 Complementariness of Logistics Centers

Valuation on logistics centers for companies in private sector could be different from each other. Differences in types of goods transported, volumes for each commodity type, variety in services required are some parameters to evaluate a logistics center for companies.

At this point, in order to demonstrate the complementariness idea we will illustrate an example. As an example a firm can transport the goods from city A to its facility in City B with using the road transportation with a cost of 500TL.

Figure 1: Tranportation cost without taking part in logistics center



In transportation modes rail transportation cost is lower than road transportation cost. And in the example to use rail transportation the goods needs to be handled in order to be brought to the logistics center in City A. The firm should use handling from the

point where the goods are stored in City A to logistics center in the same city (City A) and let us say this cost is 250TL. From logistics center in City A to logistics center in City B rail transportation cost is 300TL. And finally to arrive point where the facility in City B one more handling is needed and the cost is 250TL again.

If the firm has no facility in neither of the cities' logistics centers obviously road transportation is less costly with a cost of 500TL. Besides, the value of owning a place at the logistics center of city A without owning a place at logistics center of B is 0 for this single shipment. Because if the firm has a place at logistics center A the cost to transport to the facility at city B is 550TL (300+250) which is still not preferred to road transportation. However if the firm has places in both of the logistics centers the cost of transportation becomes 300Tl, thus creating a value of 200TL for having logistics centers at both cities for this shipment. In this example having individual logistics centers worth nothing while owning both is creating a value for the firm. This demonstrates the complementariness idea in our framework.

Figure 2: Handling cost and rail transportation cost with using logistics center

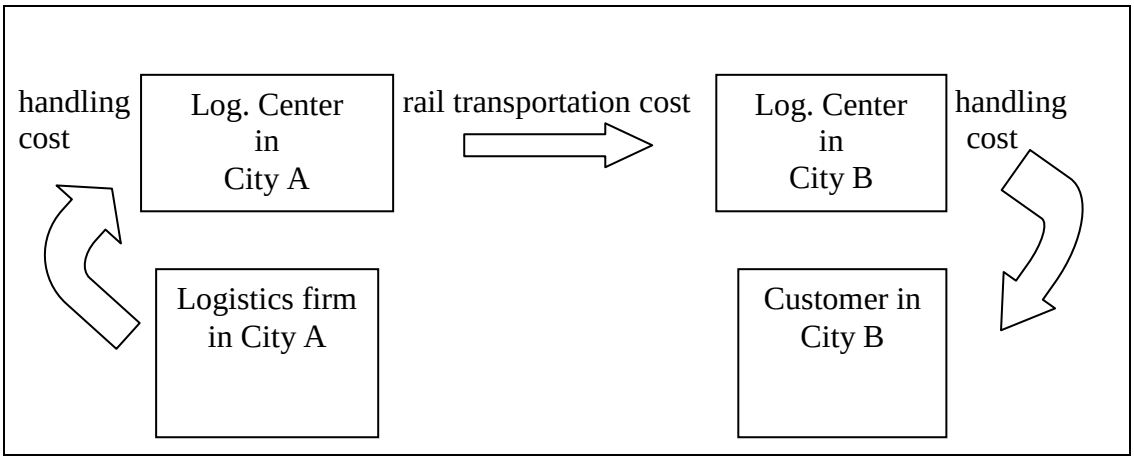
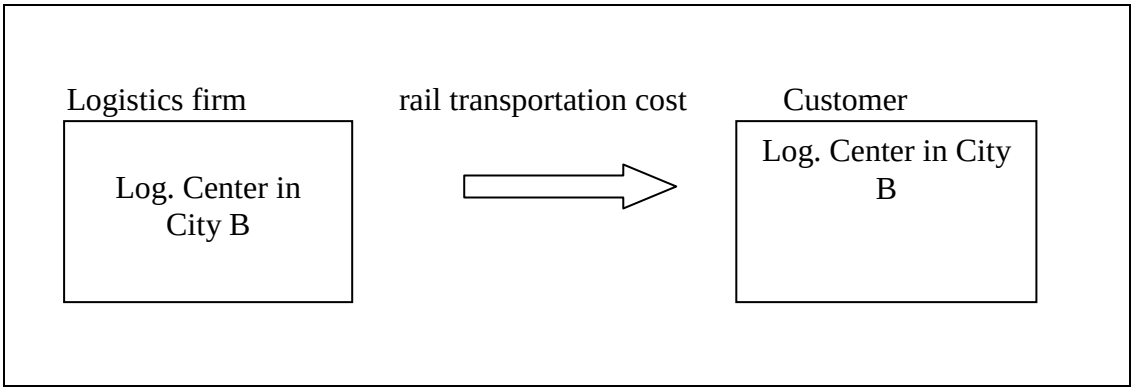


Figure 3: Rail transportation cost with taking part in both logistics centers



Although we illustrated the complementariness idea with a simple example based on transportation costs we believe there are other factors which make the value of taking place in several logistics centers greater than the sum of values of taking place in them individually. Taking place in several logistics centers enhances the rail transportation(or sea transportation) network resulting with lower operational costs.

Complementariness of logistics villages provides firms benefit from the economies of span, economies of scale and specialization. Economies of span refer to the efficient coordination or sequenced utilization of logistics villages and through the decreased transaction costs between the stages of production, the unit cost declines. Economies of scale are the cost advantages that enterprises obtain due to size, with cost per unit of output generally decreasing with increasing scale as fixed costs are spread out over more units of output.

4.2 Mathematical Model

In this chapter we try to show that expected gain on combined bids for logistics villages is higher than expected gain on sum of individual bids. In our mathematical model the objective function is to maximize the gain of the auction.

The model includes customers who attend the auction, cities where the logistics villages are established, slots which are the available facilities for the firms in logistics villages at the cities and the bids which the customers can possibly bid on combinations of items. Number of customers and cities can take any value. Numbers of slots should be less than or equal to number of firms since we assume that each firm can take only a single slot in each city. Some firms could bid on all slots but some of the firms prefer not to bid on some slots. Numbers of bids on combinatorial slots are calculated according to the numbers of slots and cities by taking bidding constraints into consideration. However, in our numerical examples we assume that any combination of slots in different cities is possible.

We add two parameters as (1) value of each customer for each bid and (2) each bid that involves each slot in each city. Each customer value on each slot at each city. Valuation on slots can change according to the firms. Valuations on a slot can vary. A firm sets a premium on a slot but another firm underrates the same slot. The reason about the changes on valuation of a same slot for the different firms is mainly due to the transportation volume of different firms. Each bid involves only one slot in a city. A firm cannot bid on more than one slot in a city. Decision variable is the bid of a

customer. The first constraint is that each slot at each city can be allocated to only one customer (firm). The second constraint is that each customer can bid on only one slot at each city simultaneously, i.e. a combinatorial bid cannot include multiple slots from same city. This assumption can be relaxed easily. A customer defines a specific value for each slot at each city. It cannot be the same value for the each firm. A slot could be the most valuable for a firm, but it may not be as valuable as for another firm. The reason of the differences in the valuation of the firms changes. A slot is valuable because of the capacity, closeness to the customer, closeness to the firm, etc.

Every firm cannot give the same importance on each slot because of this kind of reasons. A bid involves combinatorial slots. The gain from the combinatorial bid is higher than the gain from the sum of two slots. If a bid involves a slot from city A and a slot from city B, the combinatorial gain is higher than gain from the valuation of sum of these two slots. The gain ratio could changes and in this manner combinatorial gain changes, too.

Sets:

$I = set\ of\ customers\ attending\ the\ action$

$J = set\ of\ cities\ in\ which\ the\ logistics\ centers$

$involved\ \ in\ the\ auction\ will\ be\ built$

$K_j\ = set\ of\ sots\ at\ city\ j$

$B = set\ of\ all\ possible\ bids$

Parameters:

$V_{ib} \quad = value\ of\ customer\ i\ for\ bid\ b, \quad i \in I, \quad b \in B$

$q_{bjk} = \begin{cases} 1\ if\ slot\ k\ of\ city\ j\ is\ in\ bid\ b \\ 0 \qquad o.w \end{cases} \qquad b \in B, j \in J, k \in K_j$

Decision Variables:

$X_{ib} = \begin{cases} 1\ if\ bid\ b\ of\ customer\ is\ granted \\ 0 \qquad o.w \end{cases} \qquad i \in I, b \in B$

Mathematical Model:

$max \sum_{i \in \mathrm{I}} \quad \sum_{b \in B} (v_{ib}\ x_{ib})$

Subject To

$$\sum_{i \in \mathrm{I}} \quad \sum_{b \in B} x_{ib} = 1 \qquad \forall j \in J, k \in K_j$$

$$\sum_{k \in \mathrm{K}_j} \quad \sum_{\substack{b \in B: \\ q_{bjk}=1}} x_{ib} \leq 1 \qquad \forall i \in I, j \in J$$

$x_{ib} \in \{0,1\} \qquad \forall i \in I, \ b \in B$

CHAPTER 5

NUMERICAL RESULTS

5.1 Settings

In our mathematical model we try to prove that complementariness of logistics villages provide more gain to the firms. A firm evaluates first slot at second city and the value of the slot for the firm is 350 units. Same firm evaluates first slot at first city and the value of the slot is 300 units. The sum of value for two slot is 650 units. According to our model the value increases when the bid contains combinatorial slots. Therefore in combinatorial bid that involves first slot at second city and first slot at first city the value that comprises complementariness of logistics center could be 700 units. We use different gain ratios (0.01, 0.05, ..) for combinatorial bids in our experiments. Let us consider the following example to clarify the notion of gain ratio. Let the value of first slot at city A for firm 1 is 100 and that of third slot at city B is 200. Then the value of the combinatorial bid which includes these two slots is 1.01*(200+100) for firm 1 with a gain ratio of 0.01. For combinatorial bids which include more than two slots an additional factor is multiplied, i.e. for a combinatorial bid with 4 slots the value of the bid is: $(1.01)^3$*(sum of individual values).

Another issue for our numerical experiments is the best slot for each firm at each city. For each firm we randomly choose the best slot in each city and we randomly assign a value (uniform between 100 and 500) for this slot. The value of the other

slots at the city for the same firm decreases as they deviate from the best slot according to some factor.

The measure we use is percentage gain which is calculated using the following formula:

$$Percentage\ Gain = 100 * \frac{(Comb.Auct.Rev. - Sum\ of\ single\ \ auction\ revenues)}{(Sum\ of\ single\ \ auction\ revenues)}$$

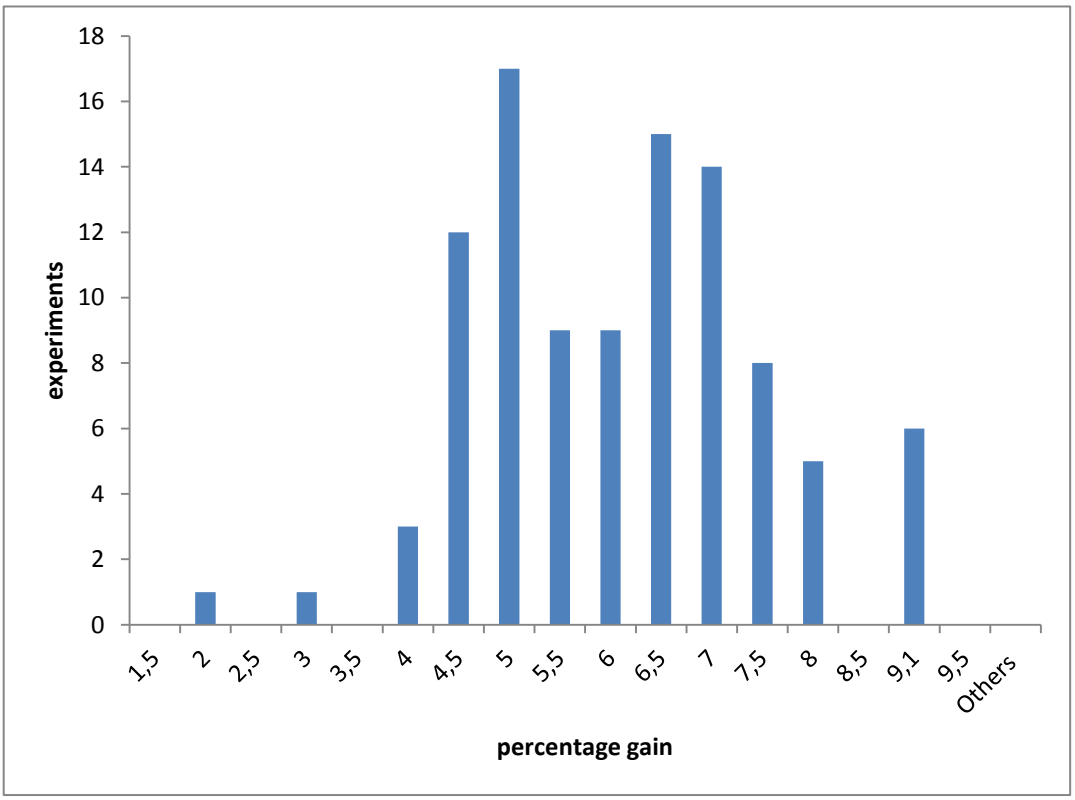
It measures the benefit of using combinatorial auctions instead of regular single (noncombinatorial) auctions.

5.2 Numerical Results

We have constructed a GAMS code and run our experiments using GAMS 23.3. Our initial basic model contains 7 firms, 4 slots at 2 cities with gain ratio 1,09 in 100 experiments. A histogram is constituted to understand the maximum gain, minimum gain, average gain and standard deviation. And also a histogram can be presented to see percentage in differences of gain.

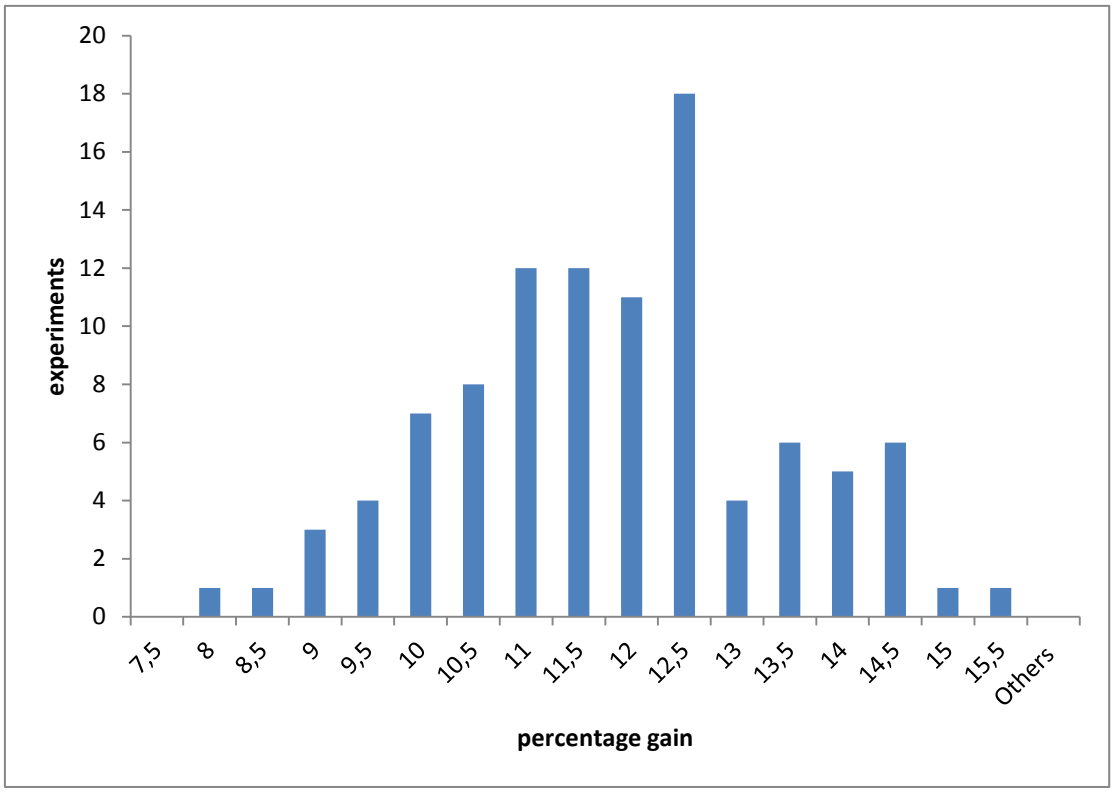
Percentage of maximum gain from combinatorial auction that involves 7 firms, 2 cities and 4 slots is % 9. Percentage of minimum gain is % 1,692627 and the percentage of gain on average is % 5,838609. Standard deviation is % 1,411349

Figure 4: Combinatorial auction with 7 firms for 4 slots at 2 cities



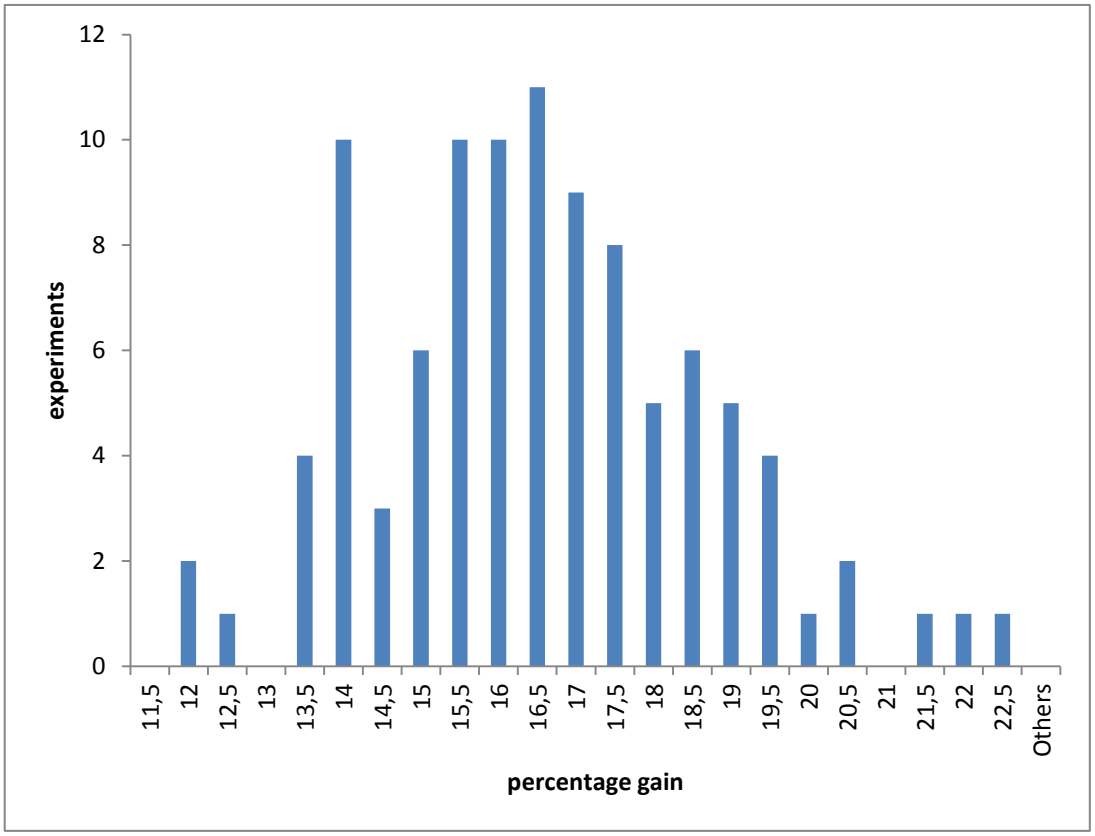
In another case we have 11 firms bids on 6 slots at 3 cities with gain ratio 1,09 in 100 experiments. In the related histogram it is seen that percentage of maximum gain from combinatorial auction that involves 11 firms,3 cities and 6 slots is % 15,10509. Percentage of minimum gain is % 7,849064 and the percentage of gain on average is % 11,61498. Standard deviatiaon is % 1,566554. Increase in number of firms, cities and slots affects the gain. In this model firms maximum gain become higher. Changes in experiments are diversified and distribution of the histogram become expanded.

Figure 5: Combinatorial auction with 11 firms for 6 slots at 3 cities



Below there is a histogram that is used 22 firms bids on 7 slots at 4 cities with gain ratio 1,1 in 100 experiments. It is observed that percentage of maximum gain from combinatorial auction is % 22,32437. Percentage of minimum gain is % 11,86941 and the percentage of gain on average is % 16,3092. Standard deviatiaon is % 2,10917. Changes in number of firms, slots and cities with increased gain ratio standard deviation increases and gain increases, too.

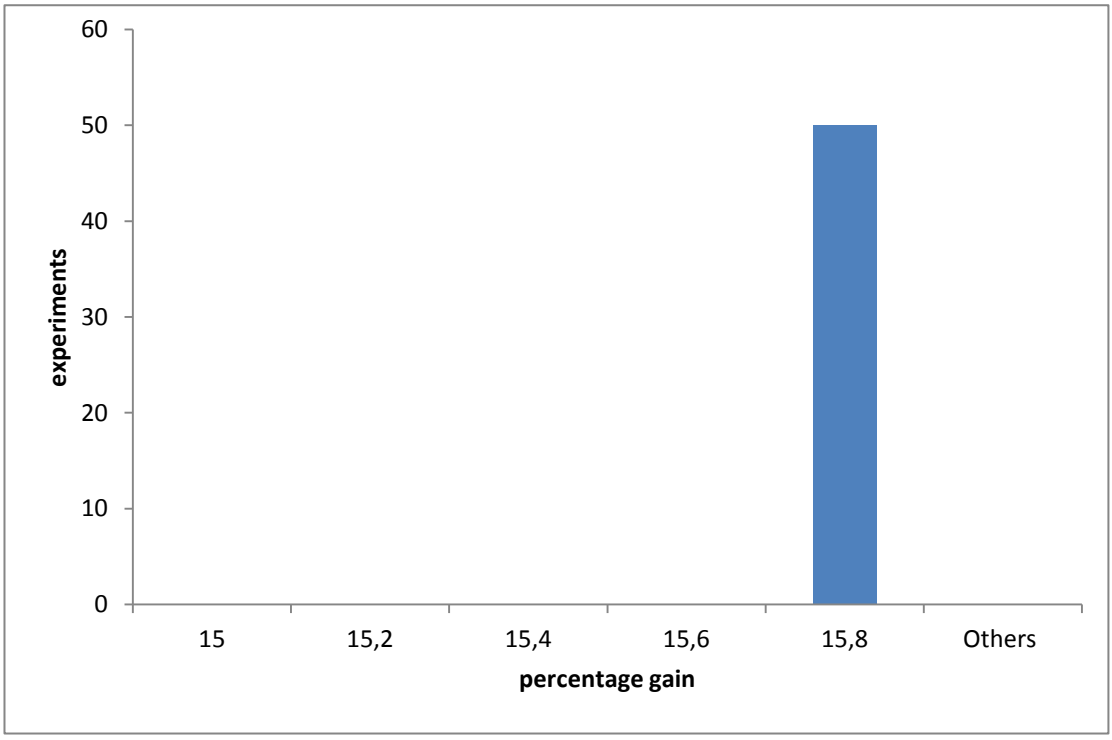
Figure 6: Combinatorial auction with 22 firms for 7 slots at 4 cities



As a final example we have 12 firms bids on 12 slots at 4 cities with gain ratio 1,05 in 50 experiments. In the related histogram it is seen that percentage of maximum gain from combinatorial auction that involves 12 firms,4 cities and 12 slots is % 15, 7625. Percentage of minimum gain is % 15,7625 and the percentage of gain on average is % 15,7625, too. Standard deviation is % 0. In the histogram it is understood that every firm gets its optimum gain from the auction and every firm gain more with combinatorial bids from the auction with % 15, 7625. The histogram shows that there is no diversity in the distribution of the combinatorial auction gains. This happens when we have same number of slots as number of firms

because of the constraint which forces a single slot to be allocated to each firm at each city.

Figure 7: Combinatorial auction with 12 firms for 12 slots at 4 cities



5.3 Analysis

We have seen that different cases have different results. Number of firms, slots and cities affect the results. However, increase in the number of experiments and changes in the gain ratio create change the results, too. As a first example in Table 2 we demonstrate the effect of number of the firms on the results. In the example only number of firms changes and all other sets are fixed. In the case number of experiments is 100 with gain ratio 1,05. With the increase in number of firms percentage of gain drops off and related to the changes in firm numbers standard

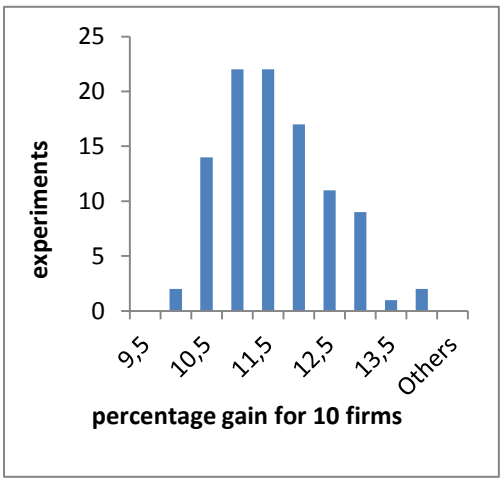
deviation increases. In a scenario 10 firms attend an auction for 7 slots at 4 cities, maximum gain is % 13,67813. On the other hand 25 firms participate in an auction for 7 slots at 4 cities, the maximum gain decreases to % 8,96801

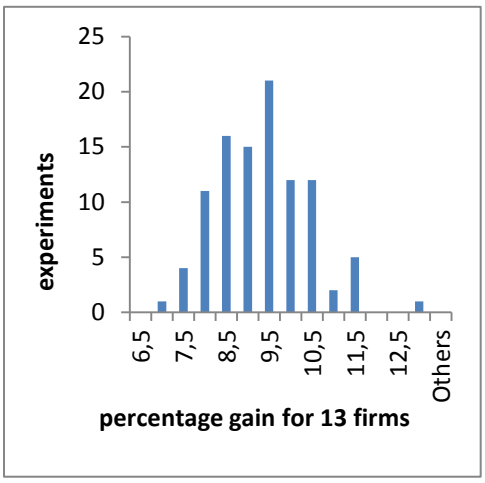
Table 2: Changes in number of firms

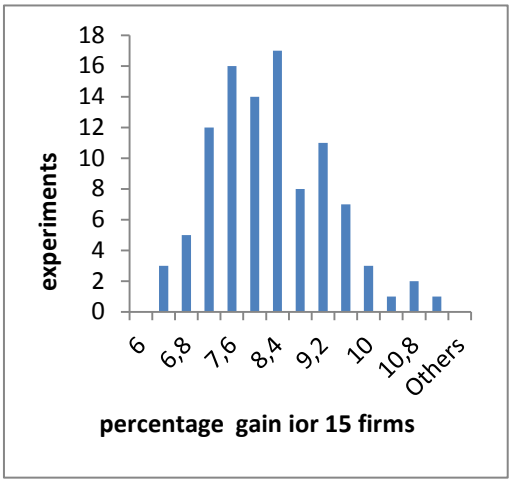
changes in number of firms								
					(%)			
number of firms	number of cities	number of slots	gain ratio	number of exp.	maximum gain	minimum gain	average gain	standard deviation
10	4	7	1,05	100	13,67813	9,76964	11,36983	0,860952
13	4	7	1,05	100	12,88294	6,871881	9,093883	1,074624
15	4	7	1,05	100	11,12825	6,308108	8,097412	1,00035
16	4	7	1,05	100	11,12825	5,465202	7,69301	1,006285
22	4	7	1,05	100	8,968017	3,925033	6,185768	1,009046
25	4	7	1,05	100	8,950458	3,160302	5,711259	1,065623

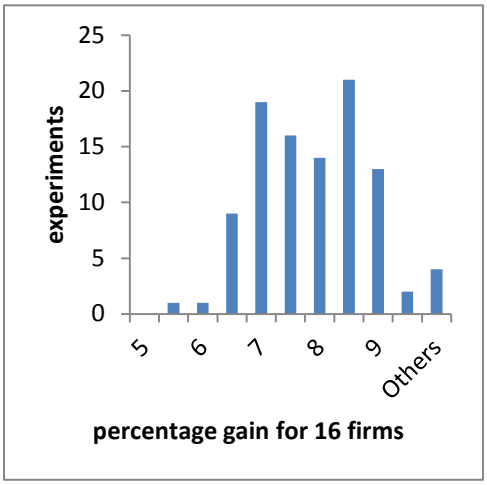
The histograms are presented as below:

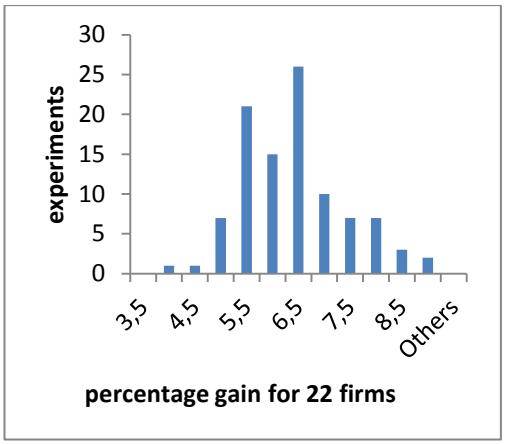
Figure 8: Changes in number of firms

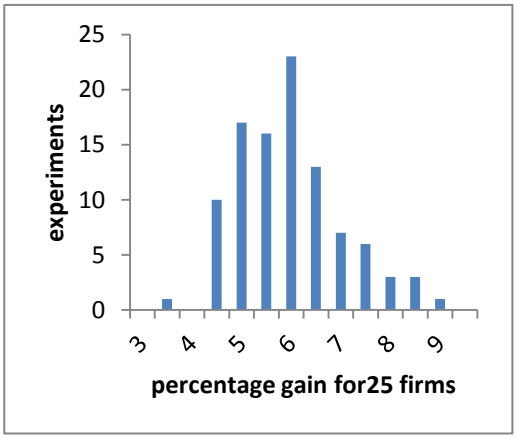






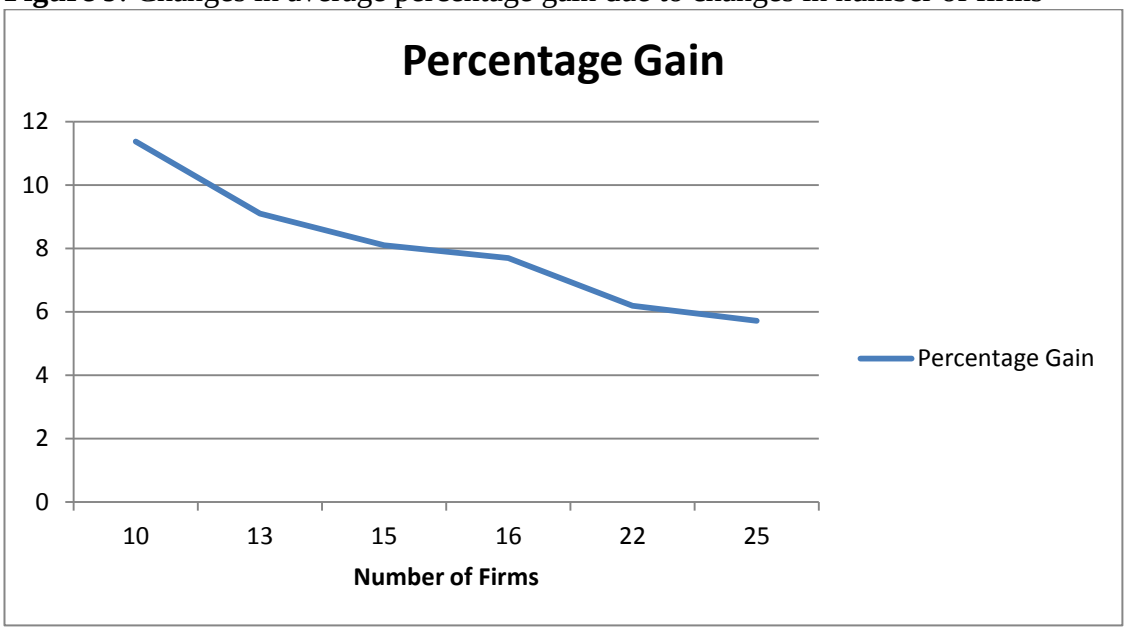






We observe that while number of firms increase, average gain from the combinatorial auction decreases. The lines cross on a point when the firms are between 10-13 and average gain is between 9-11. The reason behind this converse relation between the number of firms and percentage gain is as the number of firms attending the auction increases the number of allocated combinatorial bids decrease. We show the related figure below.

Figure 9: Changes in average percentage gain due to changes in number of firms



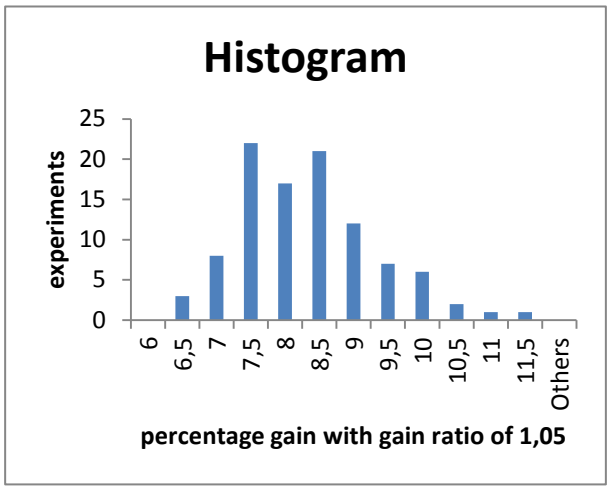
As a second example changes in gain ratio causes different results in the combinatorial auction for logistics centers. With using the gain ratio of 1,01 it makes the maximum gain % 3,175507, on the other hand when the gain ratio increases to the 1,1 the maximum gain increases to the % 16,87289. With using gain ratio of 1,1, standard deviation is % 1,238594, but although gain ratio of 1,01 makes the maximum gain % 3,175507, standard deviation at that gain ratio is % 0,202309. It is understood that increases in gain ratio causes increases in standard deviation.

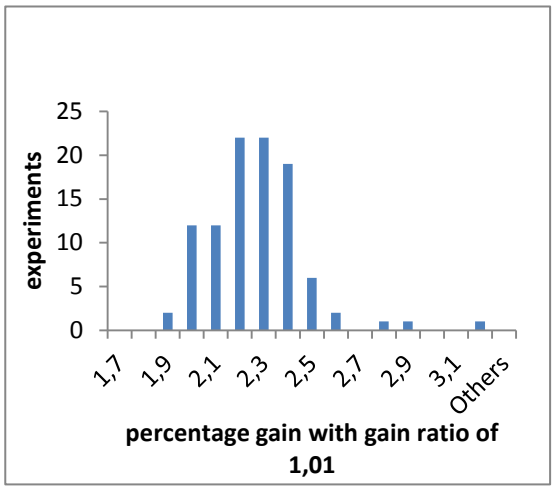
Table 3: Changes in gain ratio

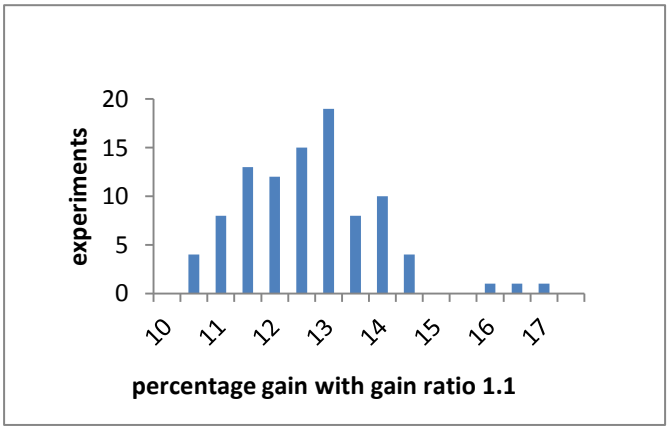
changes in gain ratio								
					%			
number of firms	number of cities	number of slots	gain ratio	number of experiments	maximum gain	minimum gain	average gain	standard deviation
11	5	6	1,01	100	3,175507	1,801044	2,215997	0,202309
11	5	6	1,05	100	11,12825	6,309108	8,097412	1,00035
11	5	6	1,1	100	16,87289	10,40501	12,37619	1,238594

The histograms are given below:

Figure 10: Changes in gain ratio







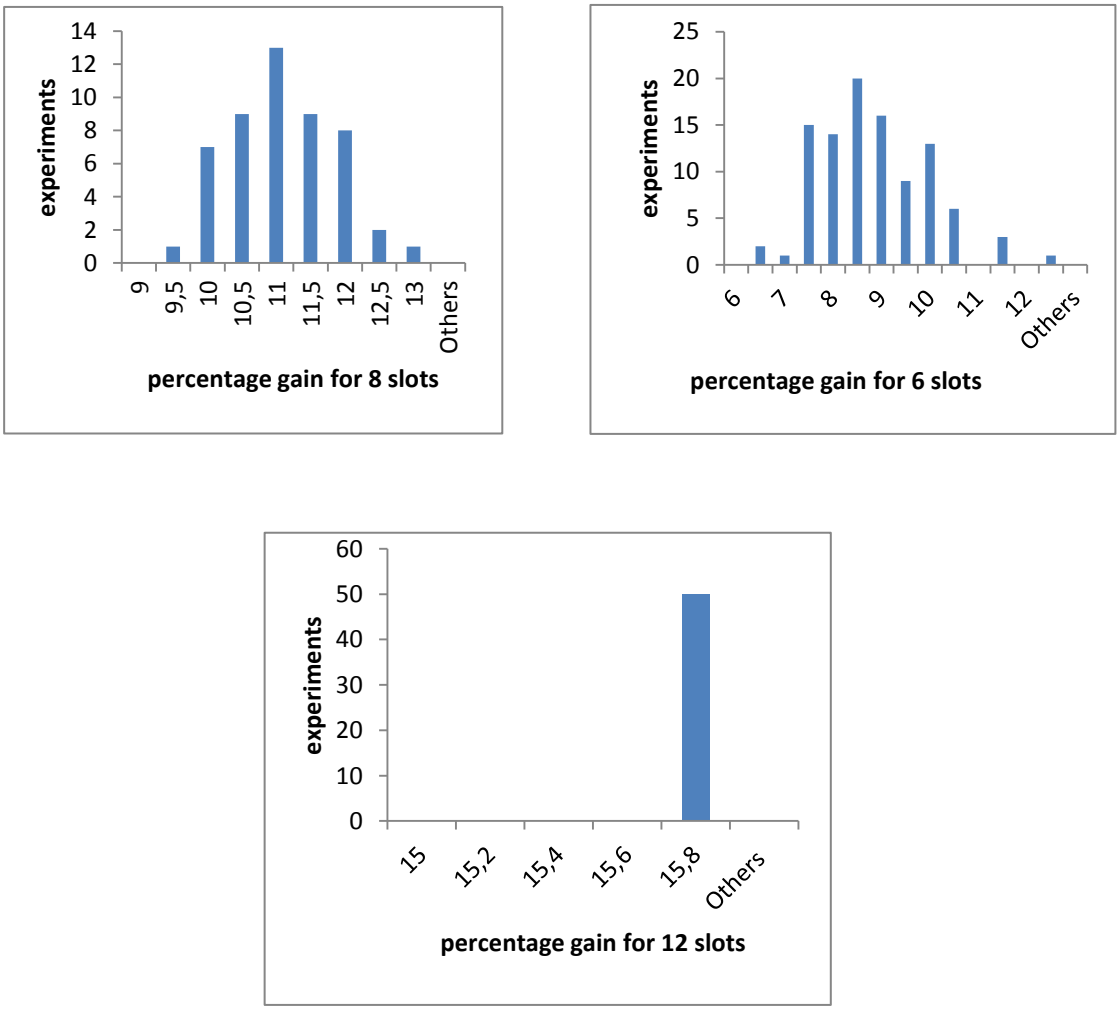
With using our model we try to see the changes in results when only number of slots are changed. Increase in number of slots maximize the gain from the combinatorial bid of logistics centers. With fixed gain ratio of 1,05 it is observed that while number of slots increase on the contrary standard deviation falls down. In a scenario 12 firms bid on 4 slots at 4 cities, the auction revenue get % 10, 04776 maximum percentage gain. If the number of slots increases up to 9, maximum gain becomes % 13,50327. It means that when 5 slots more add to auction, it makes the gain rise about %3,5. If the number of firms and number of slots are equal, percentage gain from the combinatorial bids become same for every firm which participates in the combinatorial auction

Table 4: Changes in number of slots

changes in slots								
					%			
number of firms	number of cities	number of slots	gain ratio	number of exp.	maximum gain	minimum gain	average gain	standard deviation
12	4	4	1,05	100	10,04776	4,224227	6,34494	1,290592
12	4	6	1,05	100	12,1975	6,276055	8,62055	1,094619
12	4	8	1,05	50	12,7623	9,105388	10,8292	0,793649
12	4	9	1,05	50	13,50327	11,03932	12,0463	0,571807
12	4	12	1,05	50	15,7625	15,7625	15,7625	1,28E-14

The related histograms are shown below:

Figure 11: Changes in number of slots



Finally we try to see the changes in the results when only number of cities are changed. With gain ratio of 1,05 increasing the number of slots maximizes the gain from the combinatorial bid. And also standard deviation decreases on contrary.

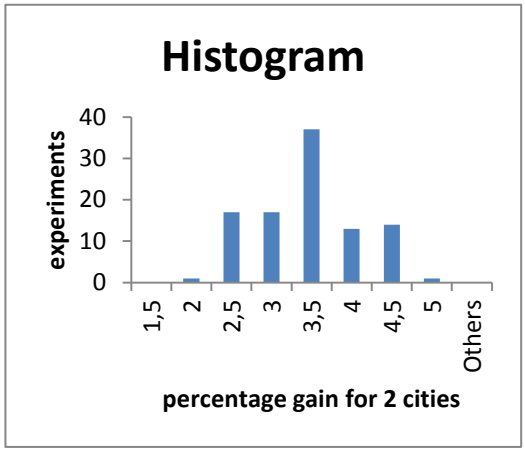
In a scenario that 10 firms take part in for 6 slots at 2 cities, the maximum gain become % 4, 952096. On the other hand when 10 firms bid on 6 slots at 5 cities maximum gain increases up to % 17,10491

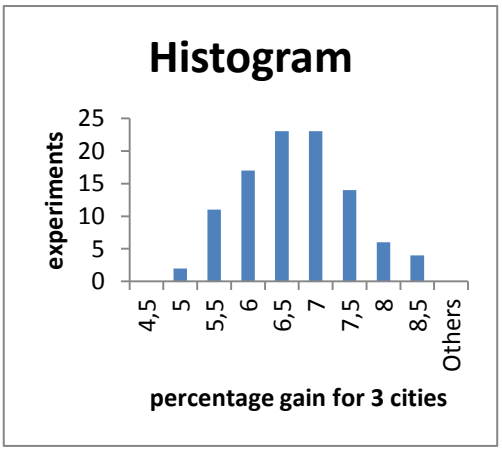
Table 5: Changes in number of cities

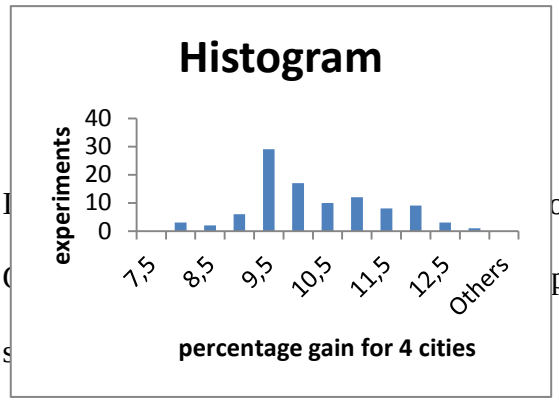
changes in number of cities								
					%			
number of firms	number of cities	number of slots	gain ratio	number of exp.	maximum gain	minimum gain	average gain	standard deviation
10	2	6	1,05	100	4,952096	1,805189	3,20392	0,631559
10	3	6	1,05	100	8,235316	4,831206	6,43038	0,797609
10	4	6	1,05	100	12,65261	7,588236	10,0089	1,094606
10	5	6	1,05	100	17,10491	10,92287	13,4468	1,162152

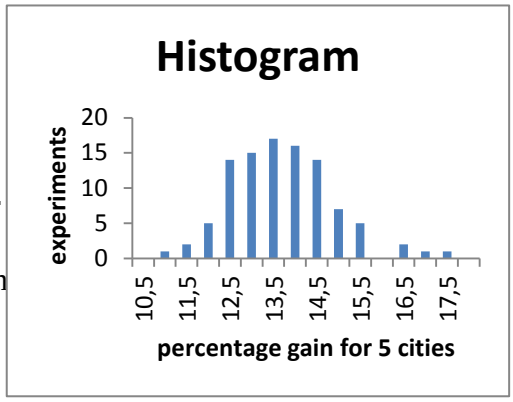
Related histograms are presented below:

Figure 12: Changes in number of cities









The results we present are mainly related with the basic parameters like value of the customer for a bid and bid on a slot at a city. With this idea in the mind, we are interested in researching generally that combinatorial bids for logistics villages provide the auctions more gain and therefore attracting the private sector interest in logistics centers investing in greater amounts.

While creating scenarios about combinatorial auctions for logistics centers it is realized that changes in numbers of firms, cities, slots or gain ratio affects the results and gain from the auction.

Increasing number of firms cause diminution in gain from the bids and increment in standard deviation. Besides that increasing gain ratio, numbers of slot and cities enhance the gain of the auction. Raise in gain ratio and number of cities is a factor that causes augmentation in standard deviation. But increment in numbers of slot makes reduction in standard deviation.

CHAPTER 6

DISCUSSION AND CONCLUSION

This thesis aims to prove that combinatorial auctions for logistics centers call the private sector attention to take part in. Bids on combinations of logistics centers are important to bidders whose value for combinations is greater than the sum of their values for the individual logistics centers in the combination. Such complementarities ascend from cost savings in procurement and synergies between firms and properties.

Complementariness is the main source of the motivation. Sometimes bidders take the offered logistics centers as substitutes. The second situation is observed when the firms have constraints about capacity or resource. As a matter of fact thought of multiple logistics centers where all bidders would value all combinations as the sum of individual items cannot be realistic.

However combinatorial auctions allow bidders to express interdependencies in their valuations of combinations of logistics centers for the sale. In combinatorial auctions the highest bid on a combination of items is not guaranteed to win, for this reason valuation of combination of logistics centers rises in importance.

While a firm evaluates a combination of logistics centers, cost savings and reduction in inefficient taxes could be the main points to be considered.

In some auctions there could be limits to use of combinatorial bids on combination of logistics center. At that point firms need to choose one of the two alternatives. Firstly bidders choose to find the intersecting structure of all biddable combinations without taking into account the combination size. Secondly firms can pay attention to number of combinations. Both of the alternatives may induce changes in logistics centers' value.

Services that logistics villages have can add value in auctions. In addition to main services having hotel, meeting rooms, restaurants and other similar services could be the features that firms can take into account while evaluating. Also services could be subsidiaries while firms create combinations of logistics centers.

In our study we try to find new ways to arouse the private sector's interest. Auction is an important mechanism in market. With the popularity there are various types of auctions. Especially because of the developing economy and privatization both government and private sector aim maximize the revenue or minimize the cost. To develop market mechanism and economic welfare concept of logistics centers should be understood and extended.

As a future work, we can add new parameters in this model and implement as a field study with acquired real data. In our study we assume that all the logistics centers have similar features and with only changing number of firms, city, slots or gain ratio we try to observe different results in various scenarios. In a future work features of logistics centers can be differentiated and observe that how experiments differ in results.

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