universität
wien

DIPLOMARBEIT

Titel der Diplomarbeit

„Outsourcing in Transportation"

Verfasserin

Katarzyna Prokopowicz

Angestrebter akademischer Grad

Magistra der Sozial- und Wirtschaftswissenschaften
(Mag. rer. soc. oec.)

Wien, im September 2010

Index of contents

Index of figures

Index of tables

1.   Introduction

Logistics is one of the main parts in almost every business type as well as every economy. It is a channel of supply chain and manages serving of goods in the correct quantity, in the right quality, at the right time, at the right place and at the appropriate cost. Recently, business is facing an increasing competition due to globalization what forces companies to be faster and more flexible even in a more and more uncertain environment. In order to operate successfully on the market firms more frequently decide to concentrate on core competencies and outsource most of the logistics functions to third-party logistics companies. Outsourcing can be defined as subcontracting logistics services to specialized external providers and may be seen as a growing alternative to traditionally, vertically integrated organization. An increasing number of third-party logistics providers and its professional concentration on core competencies led to lot of flexible partnerships between buyers and sellers of special services.

The most important advantages of outsourcing are cost saving, winning of competitive advantage and possibility to focus on the skills that are core for the concrete business entity. Depending on company's and market characteristics different contracts and forms of partnership are going to be applied. Beginning from outsourcing only transportation activities and ending with wide range of contracts related to warehousing, information technology, and distribution. Mentioned situation is known as Logistics Outsourcing or Contract Logistics. Business entity has to identify competencies which are not core for the company and decide to let them be done by a third- party which is specialized in some concrete logistics services.
Most popular and worldwide applied is outsourcing of transportation activities. However, the companies that are the most successful, gain competitive advantage and high return on investment generally decide to outsource other logistics functions as well.

Industry of third-party providers is definitely evolving and growing because of the globalization, expectation to reach customers worldwide, while shorten the lead times and reducing costs. The crucial task for the companies is to build a network that will make possible to reach every potential client on the globe, of course ensuring the same service level. The Third-Party provider's professionalism leads to developing a long term partnership between buyer and seller of logistics services.

The thesis is concentrated on outsourcing transportation functions and is structured as follows. First, I will present the theory on transportation, supply chain and new trend in logistics- outsourcing. This is followed by analysis of logistics service providers and transportation modes classification. Then I will describe different contract types. Continuously, I will introduce, as a main point, new phenomenon - auctions and electronic marketplaces of transportation services. The strategies for carriers and shippers to operate efficiently in the new online markets will be presented.

2. Outsourcing in transportation

Logistics is directly or indirectly affecting every field of human activity. It deals with distributing the right products at the right place at the right time in the right quantity and quality and of course at the right cost (Stock, Lambert, 2001). In order to correctly fulfil these requirements there exist departments inside logistics like warehousing, inventory management and transportation which are managing different zones of the process. In the thesis we will analyze especially transportation activities. Recently, the industrial development is still rapidly proceeding so there is a demand and necessity to offer an effective transportation system.

2.1 The role of Transportation in a Supply Chain

"Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right location, and at the right time, in order to minimize system wide costs while satisfying service level requirements" (Simch-Levi, Kaminsky, 2008). Clearly, one of the most important tasks to achieve success and profitability is to cooperate along the entire chain. Only in this situation information will be used efficiently and effectively. The aim is to create awareness that every entity in the network is responsible for the success or failure. Transportation is a crucial part of the supply chain and handles the movement of finish goods or raw materials to places where they are going to be consumed (Stock, Lambert, 2001). In that sense transportation creates firstly the place utility and secondly also the time utility because it influences how fast products will be moved from point A to point B and all decisions are made in short term so it belongs to operational planning.

Transportation is also closely connected with other supply chain areas such as planning, procurement, manufacturing and distribution. Additionally it affects also departments outside logistics like accounting (for example freight bills), engineering (packaging equipment), law (transportation contracts), marketing and sales (customer and service standards) (Stock,

Lambert, 2001). The bellowed table shows areas inside logistics with examples of activities and decisions influenced by transportation.

Planning	*Procurement*	*Manufacturing*	*Distribution*
-Network and asset rationalization -Lead times -Vendor sourcing -Economic Order Quantity	-Landed costs -Inbound in-transit inventory management -Reduced raw material and work-in-process inventories	-Interplant movements -JIT and other specialized services	-Load plans -Pick lists -Shipping documentation preparation - Dock scheduling -Outbound shipment management - Mode/carrier selection

Table 1 - Areas in the supply chain affected by transportation (Stock, Lambert 2001).

Transportation is playing an important role in many logistics systems because after liberalization of transportation law managers could achieve better service level at lower costs than before. Furthermore, since the strategy just-in-time became more popular, resulting in decrease in inventory levels, transportation was and is often used to compensate the potential bad impact on customer service level (Gourdin, 2001).

The results of not-in-time delivery may be poor service level, lost sales and customer dissatisfaction. It gives the first view of the company for the customer, if goods will be delivered on time firm seems to be reliable, so definitely transportation has one of the most significant impact on customer satisfaction throughout the entire supply chain. The service characteristics that affect client fulfilment are: consistency of service, time-in-transit, ability to offer door-to-door transport and flexibility (Stock, Lambert 2001).

Furthermore the highest costs in supply chain are caused by transportation so it is really very important to make the right decisions while planning it. As shown on the graph below in United States between 1984 and 2005 the biggest part of the total logistics costs was caused by transportation activities. From 1984 till 1990 inventory costs and transportation costs were nearly equal, afterwards both were growing but transportation costs definitely faster. In 2005

transportation costs were twice as high as inventory costs and from 1984 to 2005 grew about 4 times. Such rise was affected by, for example, not effective transportation.

Total U.S. logistics costs between 1984 and 2005
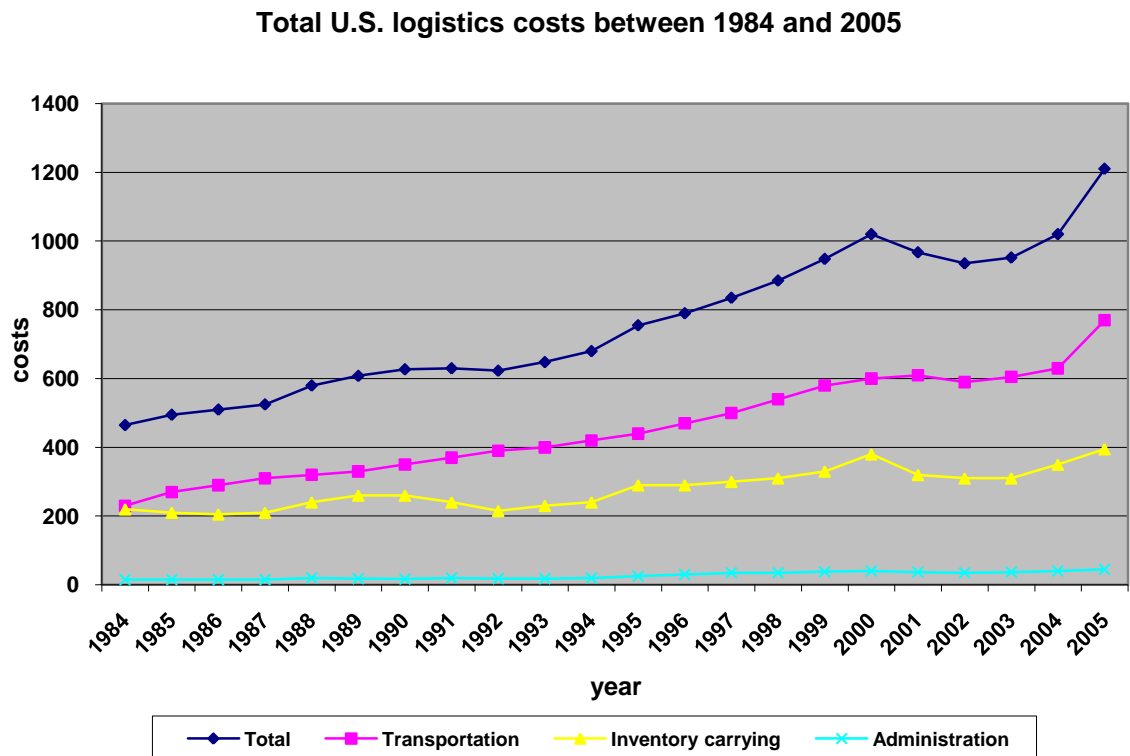
Figure 1 – Total U.S. logistics costs between 1984 and 2005 (Simch-Levi, Kaminsky, 2008)

The increase in transportation costs was due to fuel prices increase, cost of security, rail capacity shortages and outsourcing (Simch-Levi, Kaminsky, 2008).

2.2 Transportation modes classification

The main transportation modes are: air, see, land and rail. There is also a possibility to combine more than two modes which is then called intermodal. The decision which mode, in which situation to chose is the task of logistic manager. It is not always so simple because there are mostly trade-offs between, for example, price and delivery time, packaging cost and risk of damage, and so on. In reality it is not possible or not feasible to move goods only by a one transportation mode. Considering, for instance, airplane there has to be another mode, like

truck which will deliver the goods to the airport and pick them from the airport to the place of destination. Each transportation mode will be now described in details (Gourdin, 2001).

2.2.1 Air

Air transportation is mainly applied when transportation quantities and dimensions are small so that they can fit into limited containers. However, these goods are often of high importance, its delivery speed is crucial and they are moved for long, global distances. It's viewed as emergency shipments. Furthermore, air-freight's biggest aim is to move passengers from one point to other. It has not such significant meaning in case of moving goods on a large-scale. Another aspect is that air transportation is the most expensive transportation mode. Mainly the fixed costs are high and marginal costs are lower. There are also insurance and packaging costs. Since the costs are so high it is used mainly to move perishable and high value goods which require rapid delivered. Examples of such products are: medicines, seafood, spare parts and electronic equipment. Air-freight is very reliable and the risk of damage or products loss is low. Furthermore this transportation mode is strictly limited to places where airports are. Also important is the nearest infrastructure in order to have an easy access to the airport. Another limit is the necessity to bring the goods to the airport by another mode of transport and pick them up. Not without a meaning is the fact that air industry is rather young and rapidly growing, so maybe in the future the costs and transported volumes are going to change (Enarsson, 2006).

There are not many big air-freight agents so the competition between them is rather low. Moreover they cooperate often with each other. Most of the airlines are owned by governments of the countries but this structure is changing to private owners.

2.2.2 See

Using see transportation one can benefit from very low unit costs. On the other hand it is restricted to places that have access to sea so it requires bringing and picking up the goods from port. However the containers used in see transportation are big so that also high

dimension products fit into it and some of them are specially designed to transport, for example food. The conditions of the movement are very important because it takes long time to reach the delivery port. Sometimes it is even a month and of course depends on the distance. Sea transportation is moving goods on long distances, between different countries and continents. The advantages are for example stable tariffs and up-to-date equipment. This mode of transport is very traditional and one of the oldest one. Furthermore it is still the top one while moving high amount of goods over long distances. Air-freight can not be competitive because of its limited capacity and high price (Sadler, 2007).

Due to the fact that sea shipping requires large investment costs there are not so much companies in the business and all of them are big ones. Each company specializes in some segment like: car shipment, tank market or fresh or deep frozen food. Ships are specially designed to transport goods in containers. Containers as well as loading and unloading points have to be adapted to different conditions required by transported items. For very large ships there is only a limited number of harbours and ports where it can be loaded or unloaded. This makes the business restricted and dependent so the most powerful and competitive are international, large companies which have bought smaller ones. Sea transportation is best suited for mass products (Enarsson, 2006).

2.2.3 Land

Road transportation is the most common and flexible mode of transport. It offers service from door-to-door so company does not have to use additionally other mode like air or sea-freight. However it needs a good infrastructure and highway network to efficiently and effectively meet customers' needs. Furthermore the situation in European Union is convenient for road transportation because there are no boarders between countries as well as law and tax system are standardized what has created free market. From 1970 till 1995 usage of road transportation has increased by 150 percent and this growing trend still takes place but maybe slower than before. However, there are each year more and more vehicles on roads which make them crowdie and delivery delays are inevitable. Trucks are able to transport medium size products bigger than in aeroplane but smaller than in sea containers (Gourdin, 2001).

There are many players on the carriers' market so the business is facing a strong competition. Because of many private businessmen road transportation was decentralized and price has decreased. The market is divided into different segments. Some companies are small, some of them very big, they differ also in goods transported and travelled distance. Large logistics providers offer transportation services but also other ones like warehousing, inventory, and so on. Players who offer a wide range of services are called third-party logistics. Also the increased usage and development of information technology led to a situation where we have another player on the market called fourth-party logistics. He is working with information exchange and for example offers carrier some load to be picked up while returning after delivery, so with nothing in a truck. Carrier accepts this load also at low price because otherwise it would have to go back with empty vehicle while if he takes these goods he will at least gain some money (Enarsson, 2006).

Road transportation brings cost and time advantages when used in short distances. It has also flexible timetables. Lorries can pick up the goods at any time, not like rail or air at specific hours. However it is closely dependent on weather conditions and can cause delays because of traffic jams.

2.2.4 Rail

Railway is an old transportation mode. It is a good choice while having large quantities to ship over long distances. This mode seems to be reliable. In different countries railways are mainly government owned, but it also slowly goes into private hands. If a state owns some business, nearly without competition it will not be effectively managed and so its chance to develop and expand is rather low. Furthermore, this transportation mode is not so reactive to customer needs like road transportation and does not offer service from door-to-door. Almost always there is a necessity to bring the goods to the station and pick them up by another transportation mode, like truck for example. Moreover products have to be packaged in containers. Also the infrastructure is not so fast developed like roads what makes railway inflexible and companies' dependent on the access to existing network (Sadler, 2007).

Although rail is quite slow, it is for sure a cost effective and energy efficient mode as well as it has a low impact on the natural environment. Traditional good which is mass-transported since a very long time using rail is coal. The reason for such situation is that it is heavy and many coal mines have in close neighbourhood railway stations. Considering international transportation there may be a problem if countries do not have the same gauges and voltages, also very often locomotive has to be changed. Sometimes goods have to be moved from one train to another on the border. Such multiple handling is costly and lengthens the transport time. Furthermore railway is still not de-regulated and not harmonised. Due to the fact that railway in almost every country is monopolistic, there is rather a competition between rail and other transportation modes than between companies from the same sector. Another aspect not without a meaning is that rail can use only specified, limited network to deliver goods and has exact time schedules (Enarsson, 2006).

2.2.5 Intermodal

Intermodal, as mention before is a situation when we use more than just one transportation mode. Goods need to be unloaded and loaded on another mode. Of course such situation increases risk of loss or damage and is time consuming. Main challenge is to minimize the transit time. Company benefits from transportation cost advantages but have to deal with increasing handling costs. However, newest technology is being introduced to standardize transportation, for example the usage of the same containers in order to minimize waiting time. Additionally firms want to initiate systematic transfer and use trailer to move the goods, for example from a truck to the train, fast and safety. Mentioned containers are a good way to secure products but they are often too heavy to be transported by a vehicle. Less heavy than sea containers are rail containers and this is most often combined with road transportation. Carriers use then trailers to improve the transfer between modes. Sometimes also whole trucks are loaded into a train (Gourdin, 2001).

2.3 Outsourcing – a growing trend in logistics

For a business entity there are two options to organize its logistics process to either do everything by themselves or to delegate some or all activities to external companies. Nowadays more and more companies decide to concentrate on their core competencies and to outsource activities in which they are not experts. Recently this new logistics trend has been expanding and outsourcing is now a very common practice in supply chain business. In the following chapter I will concentrate on this phenomenon.

2.3.1 The definition of outsourcing

"Outsourcing means using a contract with outside parties for services such as transportation, warehousing and other distribution functions" (Sadler, 2007). For a company it is like a make or buy decision. Over the last years outsourcing trend has been continuously growing. It reflects the changes in logistics like rising requirements as well as widen of activities belonging to the supply network. Another important aspect is the increasing globalization of the business. Market is being more global rather than concentrated locally what expects to make the right transportation decisions to reach every region on the world. These changes influenced supply chain making it more complex than before. Logistics demand has increased because many firms are willing to source materials and products from others, many times far away situated countries (Deepen, 2007). Factors that convince need to outsource are for example lack of specific knowledge about foreign markets and not possessing infrastructure in them. Outsourcing gives a company the possibility to concentrate its resources on core activities and to delegate rest to logistics service providers.

Third party can provide reduction of logistics costs while increasing the service quality. This occurs since transportation is a core competency for it and so processes can be made more effectively and efficiently, what gives a source of competitive advantage for the company. Today, outsourcing of some special logistics functions is an integral part of corporate strategy (Lankford, Parsa, 1999).

However before making such a strategic choice each firm should answer two questions at the beginning. First is what functions do we want to outsource? Second is which logistics service provider should we invite to cooperation? (Deepen, 2007). Other important questions are listed on the figure below. As cost and service is very crucial company can not forget about other aspects that can influence the decision. Only after answering all the bellowed questions and finding a best balance between costs and service level firm can make a decision which activities to outsource and which to do further itself (Sadler, 2007).

Figure 2 - The strategic dimension of outsourcing (Sadler, 2007).

Important is also to see the difference between outsourcing and off shoring. Some people are mixing the both terms but in reality there are not one ant the same thing. Not all off shoring include outsourcing. Below, on the figure there are four possible situations presented.

Sourcing = who?

	In-source (Captive)	*Outsource*
Domestic	Wholly owned domestic operation	Domestic operation owned by third party
Off shore	Wholly owned foreign operation	Foreign operation owned by third party

Location =where?

Figure 3 - Difference between off shoring and outsourcing (Van Mieghem, 2008).

The rows precise location, so where operation is performed whereas columns present sourcing, so who owns the operation (Van Mieghem, 2008).

2.3.2 Reasons for outsourcing

Recently outsourcing has become more a necessity than only an option. Main indicators that drive the companies to concentrate on their core competencies and to outsource rest are:

- strong competition
- globalisation
- extension of information technology
- increase of mass customization
- necessity to reduce costs
- more complex products (Sangam, 2009).

There exist various explanations why outsourcing is so widely applied. As so far mentioned, first reason is to concentrate on functions which are core for the company. This helps to achieve competitive advantage and to win market share because firm can focus on

improving the product differentiation and to induct new innovations. Outsourcing can also be helpful to reduce the lead-times (Van Mieghem, 2008). Furthermore many entities decided to delegate some activities to third-party as a good way to re-organize and re-engineer their logistics networks to be able to react quickly if market requirements or customer needs are changing (Sangam, 2009).

Until now, there are no so clear reasons for outsourcing that would match every business type and every economic situation. However ones that are mainly mentioned are listed below:

- concentrate on core competencies
- gain from special knowledge of third-party
- costs reduction
- support innovation
- increase variability in cost structure
- build a flexible supply chain
- improve service level
- increase responsiveness
- assist expansion (Sangam, 2009).

Of course outsourcing indicators differ also from country to country. In China the most important reason is to decrease logistics costs. Also often mentioned are concentration on core activities, higher service level, flexible logistics network and simplification of complex transactions. Other aspects drive companies in Australia to outsource. And so on the first place is customer satisfaction as well as flexibility. Less important are use of newest techniques, cost reduction, productivity improvement and focus on core functions. Whereas in New Zeland the key factor to outsource is the focus on core business. The remaining indicators are decrease investment in inventory, flexibility, quick respond to changes on the market, use of newest technologies (Sangam, 2009).

The Capgemini report about outsourcing trend give following reasons why firms decide to delegate logistics activities, necessity to save costs, to improve customer service level, to organize more effectively supply chain, globalization, upgrading new information technologies, frequent and quick new product introductions (Capgemini 2006).

Concluding, there are many indicators that force companies to outsource logistics functions and they differ between countries, depend on firm situation and market size.

2.3.3 Outsourcing's potential profits and risks

If outsourcing will be led cleverly and properly it will for sure bring many advantages. Firstly, it allows a company to concentrate on competencies which are core for it what helps to achieve a success on the market. The strengths of a company such as knowledge, skills and talent differentiate it from competitors. Furthermore third-party has more economies of scale and economies of scope what can reduce the firm's logistics costs in a comparison with doing everything by themselves. Additionally some risks may be limited and distributed between business partners. Third-party collects demand from many firms and so it is able to reduce uncertainty through risk pooling. Subsequently, company gains operational and financial flexibility and high infrastructure investments can be avoided. Thanks to this flexibility risk of demand fluctuation is reduced. Another aspect is the possibility to use the newest technology and participation in innovations creation and introduction. Because of outsourcing companies gain the resources to be updated with newest methods and tools. They can also decrease the inventory level and at the same time increase service level (Van Mieghem, 2008). Summarizing this all advantages it is clear that they help company to be competitive on the marketplace.

However there are also some risks related with outsourcing. Managers can not only follow the trend but have to choose the strategy that matches best firm's requirements. First is that a company may loose control over some functions delegated to logistics provider and begins to be dependent. Once the activities are no longer done by the company members, they have lower ability to influence the decisions and processes. Additionally buyers and sellers of logistics services may have sometimes conflicting objectives. For example cost reduction is not always in line with increase of flexibility and responsiveness to market changes. Furthermore company can loose some of its skills what is obvious when provider will do some tasks, but if it happens that outsourcing project fails company will have to do it in-house again. Then it will be costly and time consuming to gain this knowledge once more. Another example of risk could be when a company delegates functions that are core and special for

them. In extreme case this can led even to bankruptcy, that is why it is so important to identify clearly core competences at the beginning of the decision making process (Enarsson, 2006).

Decision to outsourcing can also influence the motivation of employees. Some of them may be afraid that they will be dismissed and others that they do not do their job appropriate and because of this, company has decided to delegate some activities to third-party. In both cases the motivation of employees will probably decrease. Often managers want to ensure in a contract that logistics provider will engage employees who were dedicated to activities that will no longer be performed in-house. Such situation is also beneficial for logistic partner since he can gain from the people's knowledge (Enarsson, 2006).

Another drawback could be for example necessity to control, monitor and evaluate processes and results. It can happen that cooperation will not be satisfactory and partnership will cause company transparency (Juscinski, Piekarski, 2009).

Further aspect is that outsourcing not necessarily means costs reduction. Many companies deciding to do it mainly because of savings may be disappointed. The reason for such problem is for example dual marginalization and transaction costs. Additionally business entity gains no knowledge by doing the activities that are outsourced (Lankford, Parsa, 1999).

3. Logistics Service Providers and Contract Logistics

Because of the growth of outsourcing third-party business is increasing and becoming more and more popular. This happened because demand for advanced, specialized logistics functions raised. Many companies that were before operating in other sectors have recognized the trend and enter logistics service provider field. Many studies and researches are dedicated to this recent phenomenon. According to (Marasco, 2008) third-party "involves the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third-party can encompass the entire logistics process or selected activities within that process". Growing internationalization, reduction of lead times, customer orientation as well as outsourcing are main indicators for a company to use third-party. However, logistics service provider has to find a balance between adaptation to an individual customer and serving a greater amount of them having different needs and requirements (Hertz, 2003).

3.1 Main characteristics of the Logistics Service Providers

Logistics service providers are entering into cooperation with business entities wanting to delegate some or all its logistics functions. The aim is mainly to build a long partnership that will be beneficial for both contract sites. The relationship may be formal or informal. In the most cases companies outsource transportation and warehousing activities (Hertz, 2003).

In the logistics network we have the first-party who is the supplier and the second-party who is the buyer. Between them there is the third-party who is an intermediary and does the transportation or other functions for the supplier. He is taking care of the logistics activities and does not have a title to the goods produced. In order to guarantee special service level partners are connected by a contract .Typically functions delegated to third-party are:

- transportation
- warehousing
- inventory

- information technology
- reengineering of the supply network (Hertz, 2003).

At the beginning of the industry there were mainly transportation firms, then in 1990's companies like DHL, FedEx, TNT joined the business and now new comers are generally consulting firms like for example GE capital and Anderson Consulting, which is now Accenture. The latter one is an example of fourth-party logistics provider. What distinguish it from third-party is that it concentrates not only on functions but on managing whole processes. Definitely over last years logistics providers have widen their service offers. The most important for the development of all third-party logistics providers is the ability to solve problems and also ability to adapt to customers (Chopra, Meindl, 2007).

	High	**Service developer** Example: An advanced modular system of a large variety of services and a common IT-system used for all customers.	**Customer developer** Example: The firm develops advanced customer solutions for each customer.
Problem solving general ability	*Relatively high*	**Standard provider** Example: A high standardized modular system where customers are offered their own, relatively simple combination of standardized services	**Customer adapter** Example: Totally dedicated solutions involving the basic services for each customer. Firm is seen as a part of the customer organisation.
		Relatively high	*High*

Customer adaptation

Figure 4 - Firms classification according to abilities of problem solving and customer adaptation (Hertz, 2003).

So as can be observed on the figure above we can divide logistics service providers into standard provider, service developer, customer developer and customer adapter. The standard provider offers mainly traditional functions like transportation and warehousing. On the other hand the service developer is concentrated on some advanced and special activities which provide more economies of scale and scope. Then, the customer adapter is taking care of some standard functions but is trying to slightly improve the efficiency of the processes. The most professional and advanced type is the customer developer. Generally it controls the whole logistics flow and is highly integrated with customers (Hertz, 2003).

3.2 Selection of Third-Party Logistics Providers

Third-party logistics provider is going to be a firm's close partner so decision which one to choose is very crucial. One of the main important factor is value-added service, so the specialization level and ability to perform logistics processes efficiently. Next one is of course price, in order not to loose competitive advantage and do not increase product price on the market. However it happens that these both criterions are often conflicting. When a price is low, offered service may be not so professional and vice versa. Furthermore, what companies wanting to outsource some logistics activities value is the experience of the logistics firm as well as internationalization like a global network build or used by them. Additionally information technology system is not without importance. It is good when systems of partners are compatible. Other characteristics important in choosing the third-party logistics provider are for example reliability, knowledge of the company and the business, good reputation on the market and flexibility. The last one is extremely essential in situations where demand, market and customers needs are fluctuating and business entities must be able to react quickly to these changes in order not to lose the market share. Logistics providers have to meet company's requirements or even exceed them and offer services of very good quality. They also should be in a stable financial situation as well as own some assets and quality certifications (Sangam, 2009).

An interesting method to select a third-party was described in (Jharkharia, Shankar, 2007). It is an analytical network process and it "captures interdependencies among the decision attributes and allows a more systematic analysis". The method was tested with good results in

energy policy planning and product design. It is a general method and can be applied in a decision making process. The two steps in this approach are: initial screening and final selection of a provider. For more details please see (Jharkharia, Shankar, 2007).

Once a decision which third-party to choose was made a company needs to monitor and evaluate processes that are outsourced to maintain the service level and not to lose control over these functions.

3.3 Managing relationship with Third-Party Logistics Providers

Suppliers and buyers of logistics services are all connected what results in creating a whole network of many players. There are not only them but also some business partners, customer's customers and others. Between them there is a physical and information flow but as well for example economic, legal and social exchanges. However, the most important in a chain is communication between partners and trust that they want to achieve the same goals (Hertz, 2003).

Relationships are build thinking rather for a long cooperation. The partners need some resources, time and cost to adapt to each other so they prefer a long-term partnership due to these investments. Additionally integration takes some time and may be risky. Over time the number of outsourced functions is increasing so for a third-party it is beneficial to build a good relationship with its customers because maybe one day they will decide to delegate some more functions to his company. In such situation logistics provider's business increases and they tighten the relations with the customer. For sure they prefer to take some more activities from an old partner than from a new one because they have invested in the relationship and they know him so far. It is then less time consuming as well as less expensive (Hertz, 2003).

Third-party logistics providers help also companies to develop. For example because of the outsourcing firms may have the opportunity to become more international what is especially important in today's global world. Logistics providers make possible to reach customers and regions that were unexpected to serve because of distance and insufficient

resources. However, third-party has to work continuously on improving its services, resources and global network. It is so crucial since customer's requirements are of course changing over time and become more and more demanding. Furthermore, recent studies emphasis that the relationships are based on long-term cooperation and they continuously increase in scope and integration. For all the players in a network it is important that everyone will work on its development over time. The best situation is where all members, suppliers, buyers customers, third-party are equally well-developed, because they have an impact on each other (Hertz, 2003).

3.4 Contracts with Third-Party Logistics Providers

In order to create and develop outsourcing relations, which can be formal or informal, companies decide to sign contracts. The documents assure cooperation rules and define each site rights and obligations, to guarantee the service level, quality and on time deliveries. Transportation contracts are very important and powerful. Depending on the initial negotiations, content and conditions are chosen and accepted. Furthermore, partnership length is defined (Simchi-Levi, Kaminsky, 2008). Subsequently contracts with logistics providers are going to be described.

Outsourcing transportation services is mainly done by using contracts. Before it was more like series of transactions. Formalizing long-term partnership is possible only if there is a limited number of a provider. The relationships are then tighter and companies adapt to each other. Furthermore if the required services need high involvement and know-how, short-term relations are not possible and do not pay off. Tasks are often too complicated to hire provider only for one time. Long-term partnerships have usually the advantage that they continuously improve quality of service and performance. The five factors that influence the cooperation success are:

- Selective matching – entities have similar values and cultures
- Information sharing – partners exchange information
- Role specification – each player receives its unique role in cooperation
- Ground rules – rules and conditions of partnership are clear and known for everybody

Exit provisions – the way of ending the cooperation is specified (Brewer, Button, Hensher, 2001).

Logistics partnerships exist in order to build competitive advantage on the market. Except from performing the services, business partners work to create and continuously improve logistics systems. Close collaboration, information and know-how sharing bring advantages for both parties. These can be, for example: reliability, reduced inventory levels, on time deliveries, quality improvements and high customer service (Brewer, Button, Hensher, 2001).

For sure there is a trend in today's outsourcing relationships to formalize partnership between manufacturer and carrier. Written contracts are without a doubt a good way to do it. According to (Laarhoven, Berglund, Peters, 2000) only the half of the companies specifies details of the cooperation and targets to achieve. Before the percentage was higher, but now it means that logistics providers have more flexibility, are able to show their invention and can more frequently work on their own rather than simply copying the activities which were previously done in-house. It gives the providers also chance to show its creativeness. Furthermore, a tool to motivate partner is a penalty provision if the established goals are not going to be met. However, the conditions of payment, invoices, service level are generally specified in details. The rest fields can be modified and improved. Furthermore if the carrier achieves targets in a shorter period of time or if he exceeds aims from the contract he can get additional provision but if he won't succeed he will be penalized. In order to check the performance of the logistics provider manufacturer has to do, for example, monthly service level reports. While the partnership is improving the business results also the whole supply chain benefits from it.

3.5 Contract types

Traditional logistics services, which generally are not so complicated, will be delegated for a long period of time. In such situations targets and requirements do not change so often. Talking about basic services we can assume that they do not differ much from one company to other. It may be stated that they are standard for the business. However, basic functions can be outsourced for a short period of time. As can be observed on the figure below such

situation is called freight exchanges. It benefits from the increasing importance and popularity of internet based services. An example can be freight exchanges. The higher the complexity and the longer the contract period is the more advanced the outsourcing situation will be (Andersson, Norrman, 2002).
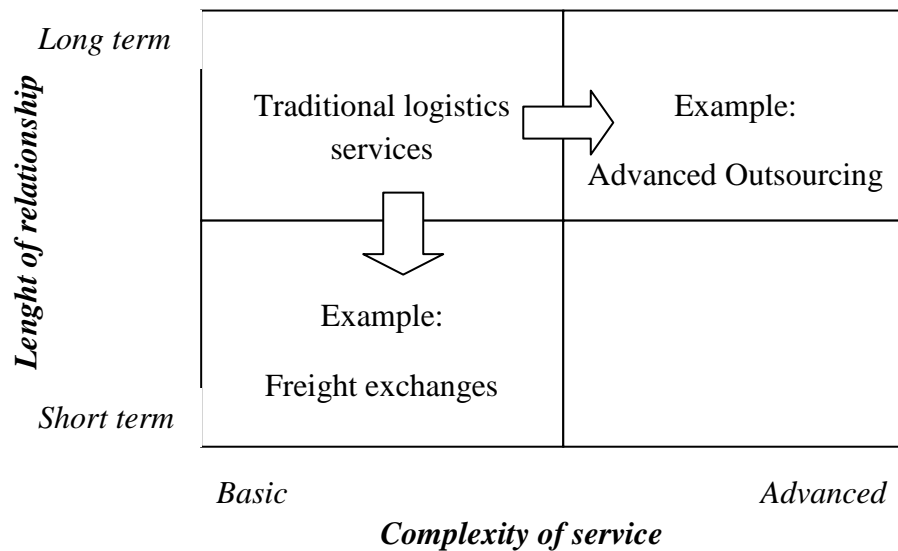
Figure 5 - The two phenomena studied compared to purchase of traditional logistics services (Andersson, Norrman, 2002).

	Define/ specify the service	Understand currently bought (vol & delimits)	Simplify/ standardise	Market survey	RfI	RfP	Negotiations	Contracting
Advanced outsourcing	Difficult as service often new for both shipper and provider + it is complex	New service not bought before and changed context	Standard operating procedures and IT interfaces to be developed	Few providers available – must find "potential" to develop or new entrants	Difficult to communicate the scope and nature the of service	Complex to answer and analyse. Not directly compareble answers	Long time due to new type of negotiations and requirements and complex service	Detailed due to uncertainties and complexity
Freight exchanges	Simple service – from A to B	Not necessaray as spot buy	Exchanges bidding format is standard	Exchange is the market	Not applicable	"Direct order" on the exchange	Short and directly on the web	Direct buy - Exchange "market maker" and handles deal

Figure 6 - Differences in the purchasing processes for basic and advanced logistics services (Andersson, Norrman, 2002).

The contract is generally created during negotiations phase. It is the last step in the purchasing process, as shown on the figure 6. Written contract is not always a part of the transportation services outsourcing. For example in case of freight exchange there is no formal, written agreement. It is just a direct buy in the market. However, the more complex the provided logistics services have to be, the more often written contract describing all details and requirements is needed. Apart from, many times complicated procedures there is also growing risk of uncertainty (Andersson, Norrman, 2002).

The content of contracts will differ from the time period. In case of short-term agreements the most important points to specify will be function and activity describing. The function to be performed has to be defined as well as activities, since the customer should know in details how services are executed. Continuously, also tangibles and intangibles factors should be defined. These ones show the nature of the activity. Tangible factors are for example possessed equipment like types and quantity of vehicles, warehouses, further activities like loading or unloading a truck ought to have instructions. Although tangible factors are easy to define and measure intangible factors are more difficult to evaluate and compare. These are, for example, knowledge, creativity, competences and for sure need some time to show its value so they bring advantages in a long-term relationship. In a short-term the most important for the customers are factors that can be measured and offer fast benefits, like low cost, fast delivery. However taking into account longer partnership also other aspects are valuable. These can not be so easily measured but help to achieve unique position and gain competitive advantage.

For example in the rail industry 80% of the contracts are short-term, usually less than one year. Short-term contracts mean that the provider has not yet achieved unique, important position in the relationship with manufacturer. It can also happen that the carrier will be replaced by another when the agreement goes out. On the other hand in road transportation a half of the contracts are longer than one year (Beier, 1989).

There exist different views on the contract. Some see the contract as an important part of the relationship and others argue that a lack of contract favors strong partnership. According to (Andersson, Norrman, 2002) more than a half of the contracts with logistics providers in Europe is detailed and contains aims and targets to be achieved. Furthermore they confirm

that less than a half of the agreements include penalty clauses if the partner will not achieve specified targets. This aspect will have a growing importance while the responsibilities of third-party are continuously increasing. The liability of the logistics failure will in the future lay more in the field of provider than manufacturer. The third-party has to carry out also potential risks and problems and successfully deal with them. Sometimes it means that huge amounts of money have to be paid.

Contract may have an important meaning in case of support and safety issues. It can be applied to protect ones interest and minimize risks. Another aspect is that contracts can be used in order to assist logistics operations, for example it includes instructions and definitions of processes, activities, roles to be performed. The more complex and difficult the logistics systems to be outsourced are, the more detailed the contract is. Furthermore some predictions and assumptions about unknown future and risks and how to deal with such ones ought to be included in the agreement. Additionally contract has an aim to secure long, continuously improved and developed relationship and good performance (Andersson, Norrman, 2002).

The shorter the time period the frequently price and conditions can be changed. However if high investments are involved, like equipment, vehicles, longer contract will be preferred. The contract should for sure include:

- Specific targets
- Description of the outsourced area
- The size of activities and processes
- The goals should be feasible to achieve, measure and evaluate (Hensher, Gwilliam, Burton, Smith, Velde, Fridstrom, 2008).

Concluding in short term contracts there are possibilities to negotiate and compete in terms of price. Additionally there is a wide range of potential providers to choose. On the other hand long term contracts require high adaptation costs, significant investment what guarantees that in case of changing a carrier the switching costs will not be low. In long partnership there occur also learning effects.

4. Auctions

Auctions were used since ages to sale different objects. Still now the best and most popular art objects are being sold during auctions. However the meaning of bidding and the percentage of its usage to sale many diverse goods and services is continuously growing. Also privatization in various countries is carried out utilizing bidding processes. Furthermore individuals take advantage from selling items on auction portals too. The number of such websites grows and each is dedicated for selling different goods and service types.

In the twentieth and especially in the twenty-first century information technology has dramatically changed many aspects in business. Lately during the expansion of outsourcing also electronic tools supporting these activities benefit from this growing trend. The main role plays internet and online marketplaces. Traditional ways to match shipments with capacity are replaced by dynamic processes on a virtual market. The reasons why the online auctions are so popular are: simplicity of the product description, common standards and access to many different suppliers. The benefits of using internet based marketplaces can be for example: transaction cost, time and effort reduction, exploring new markets and combining buyers and sellers of logistics services in ways that were previously not possible (Figliozzi, Mahmassani, Jaillet, 2003).

4.1 Definition of an auction marketplace

Internet sites that are acting as marketplaces offer a wide range of services. For transportation auctions the most important is the sale of cargo capacity. Manufacturers have some load to ship and logistics providers offer capacity on their transportation modes. Carriers bid in an auction to win the shipment. They compete mainly in terms of price but of course basic service requirements and customer service level has to be satisfied. According to (Figliozzi, Mahmassani, Jaillet, 2003) "auctions are market institutions with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants". Auctions help to effectively allocate resources through matching demand with supply.

Fast development and rapid changes are characteristics of transportation marketplaces and auctions. This recent phenomenon is still in its starting, growing phase. Auctions function in real time and in a many-to-many market. Such situation where many customers and many buyers of specific services meet in order to fulfil their requirements and targets is called marketplace. It graphically looks as shown on the figure below.
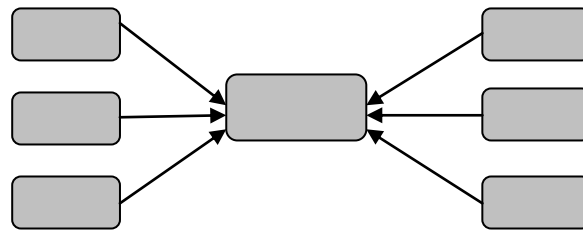
Figure 7 - n:m relationship

Furthermore auction provides useful structure to get information about the factors influencing the price, to understand and evolve management strategies. (Figliozzi, Mahmassani, Jaillet, 2003).

Auctions are generally then applied, when the product or service does not have standard and fix value. However, at least lower and upper bound ought to be specified in order to know the reasonable values for the price and not to make loss. The upper bound is the price that shipper would pay on the regular market to the carrier less the auction fees and provisions. On the other hand the lower bound is the cost for the vehicle, driver, loading and unloading time. For sure things can change because of the factors that influence the bounds. These are affected by the unique specifications of the transportation marketplace like:

- Entity for sale is service
- Transportation is a perishable service and can not be stored
- Demand and supply are placed far away from each other
- Penalties for late delivery may be higher than the transportation cost paid for the service
- Demand and supply are many times not exactly known and uncertain
- Group effect: the value of the shipment can be dependent for example on the other shipments

- Network effect: the value of the shipment may be counted according to the usage of the fleet
- There may be substitution or complementarity depending on the fleet status and shipment specifications (Figliozzi, Mahmassani, Jaillet, 2003).

Characteristics of transportation marketplaces like connecting shippers and carriers worldwide in a real time, increasing size and scope of the market are moving it towards an ideal, perfect market. At the same time cooperation between shippers and carriers can expand what results in extended service offers as well as cost savings. Wide users group gives internet auctions many advantages and very important role in the growing global economy. However, as always, there are some risks. One example can be that in case of similar, repeated auction types, buyers and sellers may start to behave collusively (Figliozzi, Mahmassani, Jaillet, 2003).

In situation where there are many buyers of transportation services and just few suppliers we speak about oligopoly. Seller's behaviour has then enormous impact on the market conditions and rules and also on the competitors' actions. Buyers do not have a wide choice of suppliers so they have to take the conditions as given. An oligopolist faces difficult and complicated decision making problem because of the strategic interdependencies between competitors. For such problems game theory is searching for a good solution (Figliozzi, Mahmassani, Jaillet, 2003).

4.2 Structure of auctions

The first step is that all suppliers register on a specific portal offering transportation auctions. Only selected bidders can participate in bidding processes. Continuously players should determine their needs and related features like in this situation lead time, quality, price and warranties. Furthermore details need to be planned and afterwards auction will be publicised. It can be open or closed. Bidding mechanism can be also open or sealed-bid. If there are price bounds these also have to be identified and calculated as well as time required for solving an auction. Whenever all points are fixed bidding phase starts and finally winner is determined (Figliozzi, Mahmassani, Jaillet, 2003).

There are two types of assets in transportation marketplaces. One is load that will be sold to the lowest bidder. The load can be seen as shipper's demand. In this situation the bidder is the carrier or third-party. The other asset is capacity that will be sold to the highest bidder. Capacity is the possibility to transport goods from the point of origin to the point of destination by a given mode and satisfying the requirements. Here, the bidder would be for example shipper willing to move some goods, carrier who needs additional transportation capacity or maybe third-party who wants to gain money be reselling the capacity (Figliozzi, Mahmassani, Jaillet, 2003).

The profits depend on a bidding strategy and quality. Bidding models in transportation auctions are mainly for one period, involving only few carriers with different fleet sizes which are individually assigned. This process is characteristic and unique for each logistics provider. They continuously meet and set their strategies to extensively take advantage from market opportunities (Figliozzi, Mahmassani, Jaillet, 2003).

The repeated cooperation between carriers enables learning by doing, collecting more information about competitors their strategies and environment. The realistic assumption enables the possibility for carriers to study and analyze history of bidding process and therefore forecast the future results for current actions. This is the reason why during modelling shippers and carriers should be treated like intelligent entities taking advantage from previous plays, experience and their knowledge about strategies, competitors and environment. However the market settings are the elements that shape the bidder's strategy the most. Not only playing process is affected but also fleet assignment process. For a carrier the decision whether to bid, assigning vehicle to load or for example to buy space on a competitor's truck at lower costs has to be combined in a real-time decision process for fleet allocation. The more information about conditions and demand is known the better and the closer to optimality the results of assignment are. Furthermore the profit and revenue depends closely from availability of vehicles at time when load needs to be moved from origin to destination. Then different models to solve the dynamic vehicle routing problem are applied. Examples are stochastic programming, probabilistic travelling salesman problem or heuristics for real time applications (Figliozzi, Mahmassani, Jaillet, 2003).

Below the auction overview taken from (Figliozzi, Mahmassani, Jaillet, 2003) is shown. At the beginning we have real-time data like available fleet, vehicle positions and other attributes. Shippers place new demand also with unique features like location, dimension, maybe some time window for service or special equipment required. On a marketplace, aspects like auction type, competitors and information available are decided. Additionally also carriers need to specify their bounds for price and estimate competitors bidding strategy. Afterwards bidding process starts and when results are known previous convictions have to be updated. The last step is fleet assignment and continuously fleet status changes.
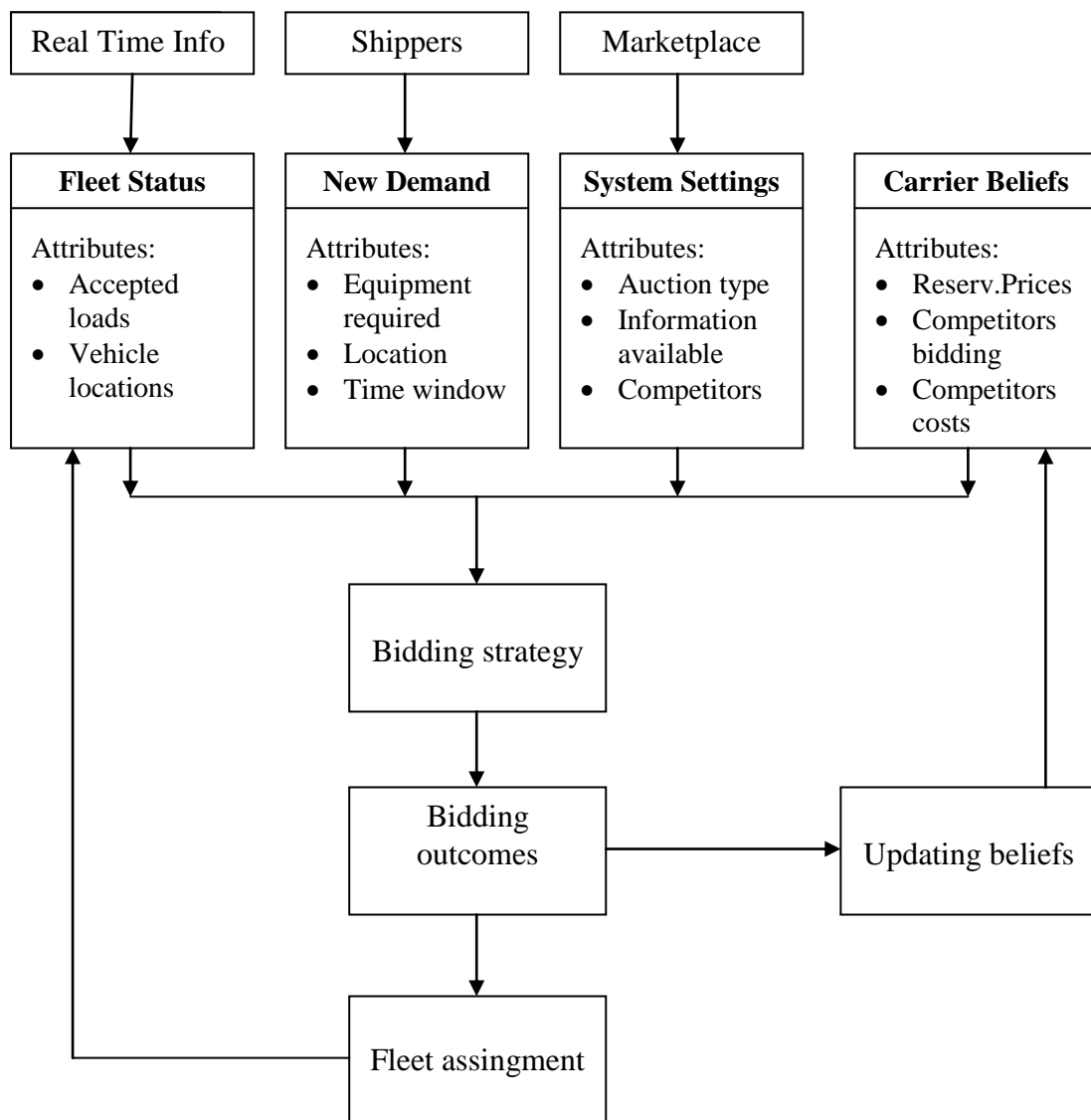
Figure 8 - Overview of an auction marketplace (Figliozzi, Mahmassani, Jaillet, 2003).

4.3 Auction types

Considering auction format and types we first need to define corresponding problem model. In an auction there is a fixed object or service to sale, in transportation case it is the load to be moved using free capacity. N potential buyers, precisely carriers compete in bidding process to win the auction. Each bidder i evaluates the value of service u_i for him. This value is the carrier's lower bound so the minimum amount he wants to get for performing the service. Each u_i is identically and independently distributed on some interval $[0,\infty]$. Bidder knows only his value and price bounds for winning the service, others bid accordingly to their perceptions (Krishna, 2002).

$$u_i = \theta_i * x_i - t_i$$

θ_i is the value which has the service for bidder i, based on his private information and beliefs.

x_i is the allocation rule

t_i - transfers

Other variables and conditions are known for every auctioneer. Each auction participant is risk-neutral so their objective is to maximize own expected profit. An obvious condition is not only good will to move the load at lowest price but also ability and feasibility to do it at such low costs. Bidder should create a strategy of bidding process like for example a function which defines the next bid in respond to any value. Another assumption is that all bidders are symmetric so also the attention will be focused on symmetric equilibrium (Krishna, 2002). There are different auction types which will be now described in details.

4.3.1 First-Price Auction

The winning bidder gets the service to realize and receives the amount he bid, so the lowest price proposed in an auction. In case there are more carriers which has bid the same

price the service will be fulfilled with equal probability by each of them. Bidding is closed (Krishna, 2002).

The bidder has of course interest in offering higher price for the service than his lowest value because he wants to gain profit. During auction each participant faces trade-off because if he will submit lower price he would have more chances to win but on the other hand he will get less provision and less expected profit. Which strategy to choose is up to every one carrier (Krishna, 2002).

The allocation rule x_i and transfers according to (Krishna, 2002) for the first price auction look as follows:

$$x_i = \begin{cases} 1 & if\ b_i < b_j \quad for\ all\ j \neq i \\ 0 & else \end{cases}$$

$$t_i = \begin{cases} b_i & if\ b_i < b_j \quad for\ all\ j \neq i \\ 0 & else \end{cases}$$

To simplify these rules we expect that no one will win until there are at least two equally low bids in case of transportation auctions. On the other hand in opposite auctions, so where the highest bid wins nobody gets the good when there are two or more highest bids.

To study the balance of symmetric equilibrium strategies heuristic derivations can be used. As stated before there is a trade off for the bidder. The effects he is facing during auction are:

- The lower the bid price the higher the possibility to win the auction
- However the lower the bid the less carrier will be paid for providing the service if he wins

The overall rule for the bidder should be to play as long as the valuation of the service is lower than current best bid but to stop when the bid price is lower than his marginal cost to serve the load. In a formal way we can express equilibrium as a Bayesian Equilibrium, where the strategy for every player can be written as follows (Krishna, 2002):

$$b_i(\theta_i) = a * \theta_i + c$$

For simplification we assume that θ_i is uniformly distributed on [0,1] for every i.

4.3.2 Second-Price Auction

Second price auction is similar like first price auction but the winning carrier is paid the second lowest bid.

The allocation rule x_i and transfers according to (Krishna, 2002) for the second price auction look as follows:

$$x_i = \begin{cases} 1 & if\ b_i\ <\ b_j \quad for\ all\ j \neq i \\ 0 & else \end{cases}$$

$$t_i = \begin{cases} second\ lowest\ bid & if\ b_i\ <\ b_j \quad for\ all\ j \neq i \\ 0 & else \end{cases}$$

The allocation rule is the same like in first price auction

It is principal for each bidder to bid so the Bayesian Equilibrium in case of second price auction can be formally written like this:

$$b_i(\theta_i) = \theta_i$$

4.3.3 English Auction

The English auction is probably the oldest one. Price increases continuously, for example one type of this auction is lead by an auctioneer who offers growing price as long as there are at least two bidders interested. Bids are known and the winning player is who offers the highest bid and no one else wants to give higher price for the object. Formally it looks like this that price rises continuously and when game participant is interested in buying at given price he raises his hand. It is visible to everyone. However when the player is no longer interested, because the price is higher than his valuation for the good he is not showing his

hand. The winning bidder receives the object and pays an amount equal to the price at which second bidder lost his interest in bidding further (Krishna, 2002).

4.3.4 Dutch Auction

Dutch auction can be seen as an opposite situation to English auction. At the beginning auctioneer offers high price at which no one is interested in purchasing the product. Price decreases continuously until a bidder will show his interest in buying at such price level. So the first bid wins and the player pays given price for the object. Dutch auction can be described as a reverse auction type (Krishna, 2002).

Dutch and English are open auctions and the two others, first price and second price are sealed-bid auctions. They differ in the implementation in the real situations. First two auction forms require that the bidders meet at the same place and start play whereas in first and second price auction participants can submit their bids by an e-mail or on the web portal (Krishna, 2002).

It may be observed that Dutch auction is strategically similar to first price auction. In a first price auction the value and private information of the bidder is converted into bid strategy. In a Dutch auction despite it is open, bidder can not benefit from having more information. He knows only that someone has accepted proposed price and he won the object, what ends the auction process. When a player bids certain price in a first price auction it can be seen as an equivalent action to offering to buy the object at that amount in a Dutch auction. It can be assumed that for each bidding strategy in a first price auction there is a corresponding strategy in a Dutch auction (Krishna, 2002).

In case values are private, English auction is comparable with second price auction format. However, this similarity is weaker than previous one with Dutch and first price variants. The English auction provides information at which price level other bidders resign from further play and this provides possibility for others to estimate their private information. The private value can also be estimated after bidder drops out because it means that price level has exceeded his value for the object. The simple rule is that participant stays in a game

as long as bids are below his price upper bound, because there is still a chance to benefit from the transaction. However when the price level exceeds the private value bidder should stop playing otherwise he will make loss. Equivalently, in second price auction it is the best to bid the value. Concluding, in case of private value it is optimal to bid up to this value and to stay in a game until the value is reached (Krishna, 2002).

Open Format **Sealed-Bid Format**

Dutch Descending Price	*Strong* ⟷	First-Price

English Ascending Price	*Weak* ⟷	Second-Price

Private values
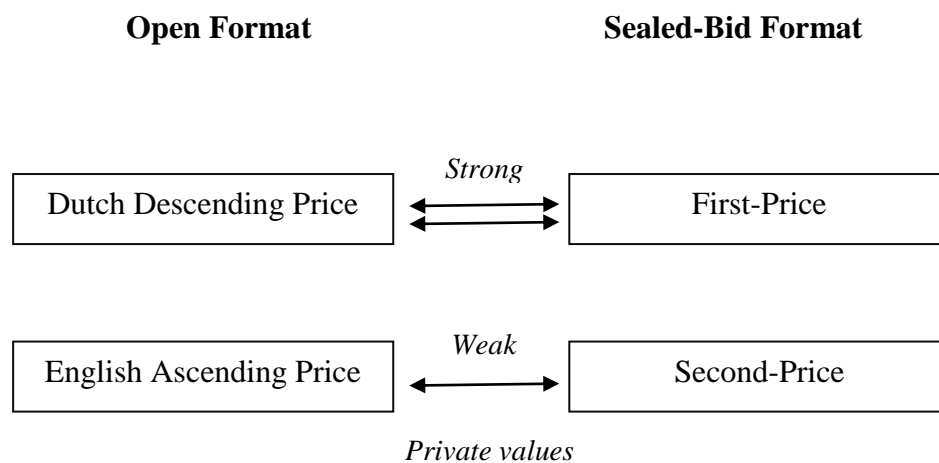
Figure 9 - Equivalence of Open and Sealed-Bid Formats (Krishna, 2002).

Figure above shows graphically the equivalency between the four described auction types. The similarity between English and second price auction is weak in the sense that strategy in both variants is not equivalent. Furthermore ideal strategies are only then the same in both auction types when the values are private. The opposite situation is when the values are interdependent. The participants use information from others and also their behaviour to change or update their value and corresponding bidding strategy. When one bidder decides to end his play it is an indicator for the rest to think if the object is really worth the value they have estimated. In such cases the two auction formats are not equivalent (Krishna, 2002).

4.4 Complexity of an auction

On the one hand auctions enable more efficiency in transportation tasks but on the other hand they require much attention and are a kind of challenge for each player on the

marketplace. There is of course more information and possibilities available but the difficulty of tasks increases substantially. Shippers and carriers have to be aware of their fixed costs and estimate their desired profit. Auctions in a real time are NP hard problems to solve, so every information we would like to have is very difficult to extract. NP hard problem is the one where time needed to find an optimal solution grows exponentially while size of the problem grows linearly. The reasons for this complexity are:

- Many cooperating agents having conflicting objectives
- Uncertain variables like: value of the shipment, price bounds for the shippers and for the carriers
- Fleet assignments, constructing efficient routes and sometimes also with time windows or maybe some penalties, it is proven that problems like vehicle routing problem with additional constraints can not be solved optimally
- Information must be updated as soon as possible to guarantee real-time information
- Responses to requests and changes must be very fast
- Demand is many times temporal, not regular
- In case combinatorial bidding is allowed problem becomes even more complex (Figliozzi, Mahmassani, Jaillet, 2003).

The new tool namely online transportation auctions offer for sure many new possibilities and chances to expand the business for both carriers and shippers but the mentioned sources of complexity make it anyway quite difficult to use. However there are continuously studies and researches done to overcome these problems (Figliozzi, Mahmassani, Jaillet, 2003).

5. Efficient bid strategies

The demand to move goods from origin to destination is generated by the shippers. These manufacturers and retailers hire logistics provider to perform the dedicated transportation. Carriers bid on individual lanes, so the origin destination pair for freight movement, which seems to be the most profitable for them. On the other site shippers choose the one bidder which offers the most attractive price, so the lowest one. However, there are many strategies to obtain the most effective solution for both parties. These ones depend also on many external indicators and on auction environment. In the following a couple of different strategies for some particular situations will be presented.

5.1 Carrier's optimal bid policy in combinatorial auctions

Carrier will generally bid on lanes which together minimize empty movements. The main cost ineffectiveness occurs when truck after performing the movement has to go back to depot without any load. In such case transportation companies offer service on particular repositioning tour at very low cost in order not to make loss. This is the reason why, while bidding carrier will always take into account cost of way back from the last destination to the depot. Although third party will bid on a set of lanes which is the best cost efficient solution for him, it may happen that he will not win all the individual tours. Then the incomplete set is not much worth for the carrier and it will for sue not maximize his profit as it would be in the situation he would won all the jobs. To overcome such problems and to guarantee the winning of a set of lanes combinatorial auctions are used. Such auction form allows placing a single bid on a set of tours. When the carrier wins, he gets all of the lanes from his set and if he loses he gets nothing. It can cause more aggressive bidding process since the players will not be afraid they will receive only a subset of desired lanes (Lee, Kwon, Ma, 2007).

It has to be mentioned that until now, we have assumed the carriers know the perfect set of lanes for them. However, in reality it is not very often that a third party can estimate which tours from the set of possibilities will maximize his profit. Having exponential number of

possibilities the problem will not be easy to solve. Carriers can apply models known from the vehicle routing problem. Most of them consist of two phases. First one is to generate some feasible routes and the second step is to perform improvements by exchanging nodes or removing and reinserting (Lee, Kwon, Ma, 2007).

The carriers optimal bid strategy consists of generation and selection of routes. The objective for the carrier is to maximize utility in the sense of expected revenue minus expected transportation costs. The model will search for solutions that generate the highest profit for the third party. It is an integer program (Lee, Kwon, Ma, 2007).

5.1.1 Auction environment

The shipper decides which lanes to offer for bidders and carrier decides which set of lanes are of his interest. The shipper solves an optimization problem in order to decide which package of lanes to allocate. This problem is called winner determination problem and it is a very hard combinatorial optimization problem to solve. In case there is only a single round auction, after winner determination no more bids are allowed. On the other hand, when the auction is said to be multi round after determining a winner, carriers can once again submit bids for the same, like in round before or totally different set of lanes. The use of single or multiple round auctions depends on the auction environment. Both types have some advantages as well as disadvantages. On the figure below there are different stopping rules presented (Lee, Kwon, Ma, 2007).

Provisional allocation
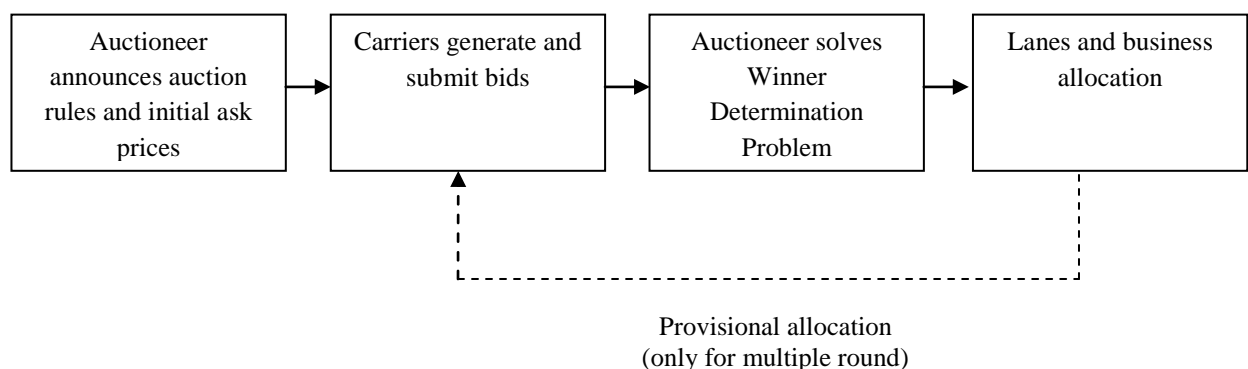(only for multiple round)

Figure 10 – The structure of single round and multi round auctions (Lee, Kwon, Ma, 2007).

In a multiple round it is possible to construct new bid which will reflect current allocation. Each participant knows that he will have chance to bid in the future maybe for other packages of lanes in next round. He is not scared that when his bid will not be perfect at the moment, he loses everything. He may change the behaviour in the next allocation. The iterative auction that is considered will end only when the carriers will have no more utility maximizing set of tours. So the rounds continue until the bidder has positive utility in staying in the game. Multiple round auctions are more optimal than single round in case bidders have hard computational requirements to estimate the value of items. Bidder can also react in next round to price changes. Taking into consideration prices for individual lanes which enable to estimate expected revenue when servicing these lanes, carriers can transform this information into objective function of his bid generation optimization. In such way the best package of items for a specific bidder can be identified. Of course in each round when price is changing also the best package of lanes will be updated (Lee, Kwon, Ma, 2007).

In order to describe the model more formally some notations, definitions and assumptions have to be presented. Suppose there exist a transportation network, which is a graph $G=(V,E)$ where $V=\{1,2,3,...,n\}$ is the set of nodes, for example cities and E is the set of edges, actually directed arcs between each pair of nodes. Carrier owns a limited number of trucks. A depot is a place where all the trucks begin and end their service. All the vehicles are hold in the depot. A carrier has so far some confirmed lanes to serve in his transportation network but hopes to win with the new business more routes to add. Carrier will only want to add lanes which will fit the existing set of promised routes and maximize expected profit as well as minimize operational costs and repositioning costs (Lee, Kwon, Ma, 2007).

One assumption is that price for particular lane is constant during one round. The lane price is approximate marginal value, not exact value because of the non-convexity of winner determination problem. The carrier solves optimization problem to decide which set of lanes is the most profitable, estimating sum of the revenues minus associated costs. Not without a meaning is the fact, that a cost or a revenue from servicing particular lane may depend on the whole package of tours which carrier has decided to perform, in one route one lane may have higher cost than the same lane in another route. However, we will concentrate on the cost of

servicing whole package which carrier has chosen rather than single lanes (Lee, Kwon, Ma, 2007).

Notation:

- V – the set of all nodes (cities), $V=\{1,2,3,...,n\}$,
- S – one subset of all nodes V,
- Γ – the set of all lanes,
- d_{jk} – the shortest distance between node j and node k,
- f_{jk} – the existing flow volume between node j and node k,
- q_{jk} – the new flow volume available for bidding between node j and node k,
- p_{jk} – the ask price for the new flow volume q_{jk},
- R_{jk} – the revenue from the existing business f_{jk},
- L_i – the total length of the tour i,
- ω – the given maximum length allowed for a tour,
- T – the capacity or the number of trucks the carrier has ($T \geq 1$),
- υ – the cost of travelling a unit distance for a truck (Lee, Kwon, Ma, 2007).

Furthermore there are also assumptions authors have made in their article, (Lee, Kwon, Ma, 2007). The nodes and lanes in a transportation network form a complete graph. Node which is denoted as the first one is a depot where all tours start and end. The capacity of all trucks is the same. Continuously each load has one unit capacity and there are integral unit demands on each lane. For each node inequality $j, d_{1j} \leq \frac{\omega}{2}$ holds as well as triangle inequality is valid ($d_{jk} + d_{kl} \geq d_{jl}$ for $j,k,l \in V$ and $j \neq l$. Each carrier decides which package of lanes, S is the most profitable for him and submits it to the auctioneer. The last point is that carrier will choose the package where lanes have multi unit demand, despite that, truckload units may be split between different tours (Lee, Kwon, Ma, 2007).

5.1.2 Problem description and the model

Transportation problems have specific characteristic because empty trucks have to be repositioned to the depot. To look closer at this constraint first we identify three types of flow scenarios for each lane:

- the lane has f_{jk} units of flow volume due to existing business,
- the lane has q_{jk} units of flow volume due to new business,
- the lane has zero unit of flow volume, for example repositioning to the depot.

Carrier's optimal bid generation model can be presented as follows (Lee, Kwon, Ma, 2007) :

max Total utility

constraints: on each lane with existing business truck can travel only once

on each lane with new business truck can travel at most once

total transportation capacity can not exceed vehicles capacity

all vehicles must be returned to the depot

Decision variables are:

y_i = the number of times tour i is included in the submitted packages,

$$z_{jk} = \begin{cases} 1 & \text{if the lane from } j \text{ to } k \text{ is carrying new business flow } q_{jk} \text{ in the bid,} \\ 0 & \text{otherwise} \end{cases}$$

$$x_{jk}^{i\alpha} = \begin{cases} 1 & \text{if lane } j \text{ to } k \text{ with business of type } \alpha \text{ is in tour } i, \\ 0 & \text{otherwise} \end{cases}$$

$$z_j^i = \begin{cases} 1 & \text{if node } j \text{ is in tour } i, \\ 0 & \text{otherwise} \end{cases}$$

Now we can write mathematical model of carrier's optimal bid generation (Lee, Kwon, Ma, 2007):

$$max \sum_j \sum_k p_{jk} * z_{jk} - \sum_i \sum_j \sum_k \sum_\alpha v * d_{jk} * x_{jk}^{i\alpha} * y_i$$

under constraints:

$$\sum_i y_i \leq T$$

$$\sum_i y_i * x_{jk}^{i0} = f_{jk} \quad \forall j,k$$

$$\sum_i y_i * x_{jk}^{i1} = z_{jk} * q_{jk} \quad \forall j,k$$

$$\sum_\alpha \sum_k x_{jk}^{i\alpha} = \sum_\alpha \sum_k x_{kj}^{i\alpha} \quad \forall i,j$$

$$\sum_\alpha x_{jk}^{i\alpha} \leq z_k^i \quad \forall i,j,k$$

$$\sum_\alpha x_{jk}^{i\alpha} \leq z_j^i \quad \forall i,j,k$$

$$\sum_\alpha \sum_k x_{1k}^{i\alpha} \geq 1 \quad \forall i$$

$$\sum_j \sum_k \sum_\alpha d_{jk} * x_{jk}^{i\alpha} \leq \omega \quad \forall i$$

$$\sum_\alpha \sum_{j \in S} \sum_{k \in V \backslash S} x_{jk}^{i\alpha} \geq z_l^i , \quad S \subset V, \quad 1 \in S, \quad l \in V \backslash S \quad \forall i$$

$$x_{jk}^{i\alpha} \in \{0,1\} \quad \forall i,j,k,\alpha, z_j^i \in \{0,1\} \quad \forall i,j$$

$$y_i \geq 0 \text{ and integer}, \quad \forall i, z_{jk} \in \{0,1\}, \quad \forall j,k, b_n \in \{0,1\} \quad \forall n$$

In the objective function the first part reflects total revenue from bidding on a package of lanes and from this value we substract a sum of travelling cost. The aim is to maximize the result. The constraints are: the number of trucks needed for a service can not exceed total number of vehicles carrier owns, next one ensures that the existing flow volume must be covered once in all sets of lanes, further new flow volume can be covered at most once in all sets, the fourth equality exist to allow only pure cycles or cycles with subtours, two next inequalities ensure that if one lane from node j to k is a part of optimal route, both nodes have to be selected, this must be valid since each lane has at most one unit of flow volume, the seventh constraint requires that each tour includes the depot or that one truck must visit the depot at least once in each route, next one enforces that each route satisfies the total length limitation, further all connected subtours are feasible in this model, the last two stand for integral or binary variables (Lee, Kwon, Ma, 2007).

The carrier's optimal bid generation model is NP-hard problem, where objective function as well as constraints are quadratic. It is very difficult to solve such problem, also because the number of constraints is exponential. In the paper (Lee, Kwon, Ma, 2007) authors proposed to divide the problem into two smaller problems. The first one is a master problem and the second a subproblem. In order to get exact solution for the master problem branch and bound method is used. On the other hand the result of the subproblem are feasible tours that maximize the utility for master problem and is solved by heuristic since it is also NP-hard problem. If the solution generated by heuristic is feasible and brings cost reduction, then the solution will be added to the master problem, otherwise it will be solved exactly by CPLEX.

In the master problem there are two decision variables: y_i, z_{jk}. For the subproblem there is another decision variable : $x_{jk}^{i\alpha}$. It is a decision variable only for the subproblem because in the master problem it is constant. So, the master problem looks as follows (Lee, Kwon, Ma, 2007):

Objective function

$$max \sum_j \sum_k p_{jk} * z_{jk} - \sum_i \sum_j \sum_k \sum_\alpha v * d_{jk} * x_{jk}^{i\alpha} * y_i$$

Constraints

$$\sum_i y_i \leq T \qquad (\sigma)$$

$$\sum_i y_i * x_{jk}^{i0} = f_{jk} \quad \forall j, k \qquad (\theta_{jk})$$

$$\sum_i y_i * x_{jk}^{i1} = z_{jk} * q_{jk} \quad \forall j, k \qquad (\lambda_{jk})$$

$$y_i \geq 0 \ and \ integer, \quad \forall i, z_{jk} \in \{0,1\}, \ \forall j, k$$

The master problem is an integer program so it is NP-hard problem.

In the subproblem we will need another decision variable:

$$z_j = \begin{cases} 1 & \text{if node } j \text{ is in the tour} \\ 0 & \text{otherwise} \end{cases}$$

Then the subproblem looks as follows (Lee, Kwon, Ma, 2007):

$$-\upsilon * \sum_j \sum_k \sum_\alpha d_{jk} * x_{jk}^\alpha - \sigma - \sum_j \sum_k x_{jk}^0 * \theta_{jk} - \sum_j \sum_k x_{jk}^1 * \lambda_{jk}$$

Under constraints:

$$\sum_\alpha \sum_k x_{jk}^\alpha = \sum_\alpha \sum_k x_{kj}^\alpha \quad \forall j$$

$$\sum_\alpha x_{jk}^\alpha \leq z_k \quad \forall j, k$$

$$\sum_\alpha x_{jk}^\alpha \leq z_j \quad \forall j, k$$

$$\sum_\alpha \sum_k x_{1k}^\alpha \geq 1$$

$$\sum_j \sum_k \sum_\alpha d_{jk} * x_{jk}^\alpha \leq \omega$$

$$\sum_\alpha \sum_{j \in S} \sum_{k \in V \setminus S} x_{jk}^\alpha \geq z_l, \quad S \subset V, \quad 1 \in S, \quad l \in V \setminus S$$

$$x_{jk}^\alpha \in \{0,1\} \quad \forall j, k, \alpha$$

$$z_j \in \{0,1\}, \quad \forall j$$

The objective function is the cost reduction for the generated tour. Subproblem is as well as master problem NP-hard.

The procedure how to solve master problem and subproblem is given on the next figure (Lee, Kwon, Ma, 2007). At the beginning initial feasible solutions satisfying all existing business are generated. Afterwards, relaxation of the master problem on current routes needs to be solved, when the solution is an integer it is a lower bound. Further, basing on the dual information of the master problem, we build a subproblem and solve it using greedy heuristic

or neighbourhood search. If the found solution brings cost reduction go back by one step. Next, optimally solve the subproblem and when the result is positive add it as a new column to master problem and return to step 2. Look for better lower bound by applying simplified branch and bound method. Choose a lane using branching rule, however when there is no node to branch out take the current solution as optimal and stop.

Notes:

1. PRC: positive reduced cost
2. SBNB: Simplified branch and bound method
2. B & B: branch and bound method
3. If find any feasible integer solution better than the current best solution,
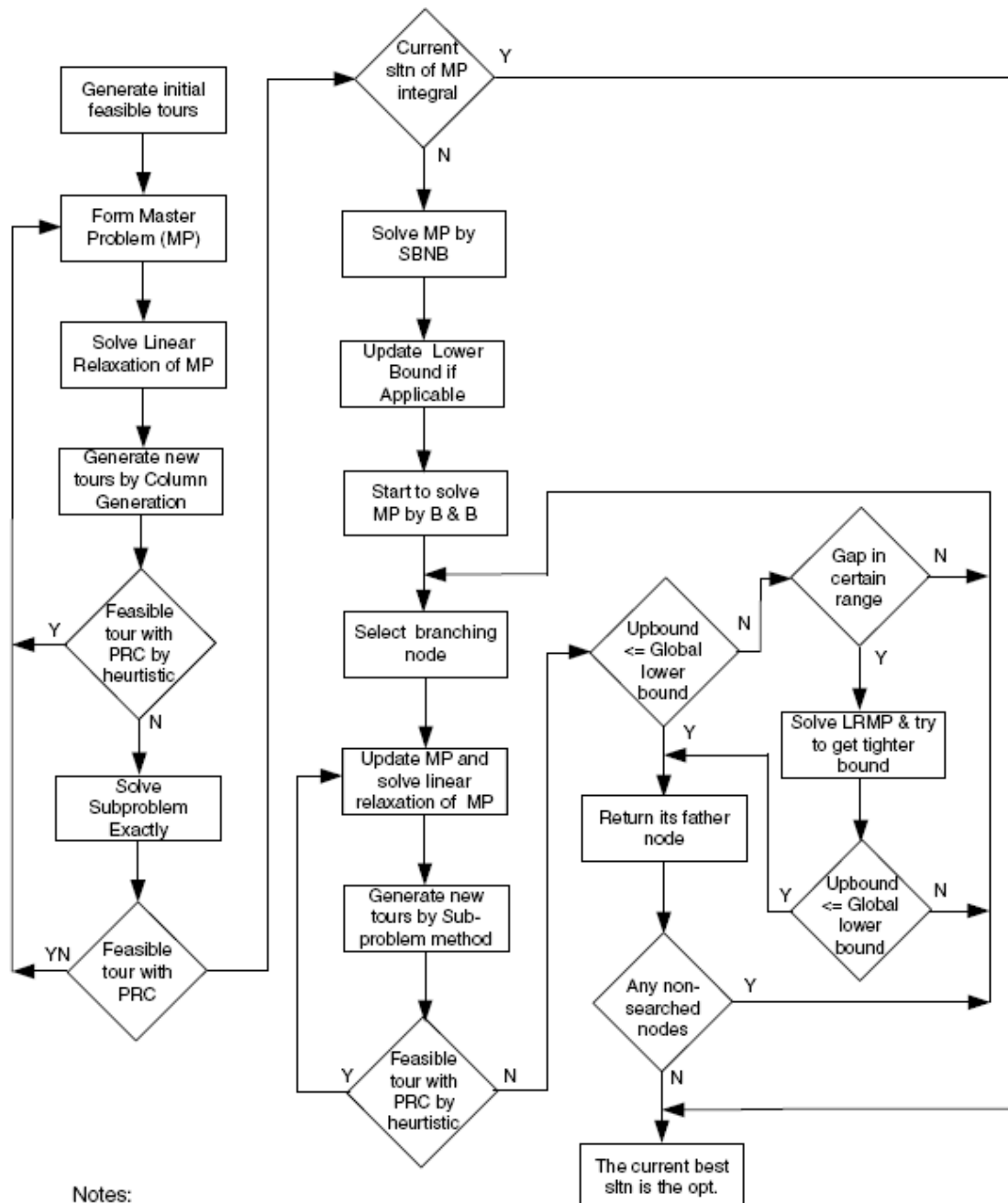   update it as the current best solution.

Figure 11 – The flow chart of the algorithm (Lee, Kwon, Ma, 2007).

For the master problem solve the linear relaxation and if the result is integer and better than the current best solution, update the lower bound. If the solution is less than current lower bound, go back to its parent node and if not then start from picking a lane for another node. After, start the depth-first branch and bound technique. Choose a lane using branching rule, however, when there is no node to branch into take the current solution as optimal and stop. For the master problem solve the linear relaxation and if the result is integer and better than the current best solution, update the lower bound. If the solution is less than current lower bound, go back to its parent node. If the difference between lower and upper bound is smaller than 5% of the current lower bound Lagrangian relaxation should be solved and if the bound is less than the current lower bound go back to its parent node. When we find, using heuristic, a column with cost savings we go back to step in which linear relaxation is solved. Afterwards, subproblem is exactly solved and when a column with positive cost reduction is found we return to step with the linear relaxation and if not, we start again by picking a lane for a next node (Lee, Kwon, Ma, 2007).

There are strong relations between master problem and subproblem. It may be useful to solve first subproblem and get as a result some feasible tours that will tighten the limit of the objective function. However, carrier may also use information from the master problem's linear relaxation in order to get tours with positive cost savings. To generate starting initial solutions we can use heuristics. One of the possibilities is to try greedy algorithm (Lee, Kwon, Ma, 2007). The most important solutions are these ones which serve the highest improvement in cost savings. Greedy looks for the best solution in the neighbourhood at each step of the algorithm hoping to find global optimum. For example in transportation problem it searches for the closest node to the depot and then the closest to the one so far selected. Each solution founded in this process is a feasible one for the master problem. Another heuristic that can be used is neighbourhood search. It is a special case of greedy algorithm. We pick the lane from the current's node neighbourhood that serves the highest cost reduction. We follow this procedure till we reach depot again. When the created tour brings positive cost reduction it will be added as a new column for the master problem.

The quality of the lower bound is very important since any feasible solution with highest found cost reductions is a lower bound for the master problem. Heuristic that helps to find the lower limit is called simplified branch and bound method. At the basis node of branch and

bound technique columns are generated and in this way feasible solutions found. Further during whole branch and bound method the same initial tours stay in order to find very good result for the master problem. Column generating process is not implemented at each branching step that is why the procedure is called simplified branch and bound (Lee, Kwon, Ma, 2007). Its advantages are the ability to find quite fast and in big problem instances good and feasible solutions.

To get upper limit we can apply for example lagrangian bound which seems to offer reasonable improvements over other procedures. First constraints are relaxed and so lagrangian relaxation of the master problem is achieved. Afterwards, subgradient optimization method is engaged. For more details please see (Lee, Kwon, Ma, 2007).

5.1.3 Computational results

Problem, on which model was tested was based on the distances between major north American cities (Lee, Kwon, Ma, 2007). The existing and new flow volume was randomly generated, its minimum was 0 and maximum 60. There were 7 problem instances, for 6, 8, 10, 12, 15, 17 and 20 nodes. The truck capacity was also randomly generated in range from 50 % to 100% of existing flow volume. There was also a limit of the total length implemented which is equal to product of number of working hours times average travelling speed.

The results of tests made by authors (Lee, Kwon, Ma, 2007) show that model without simplified branch and bound method seems to work well in small problem instances, which is where number of nodes does not exceed 10. However, when using this method for relatively larger instances, one will notice that it is able to find optimal solutions quite fast. Problems with high existing flows and large truck capacities surprisingly need less computational time to find a solution than problems with small flows and small capacity. Furthermore the linear relaxation of the master problem at the root node in branch and bound tree helps to find integer solutions. Additionally, it was shown, that the best results give lagrangian relaxation of the constraints for the existing business.

For large instances where it is very hard to solve the problem optimally, authors (Lee, Kwon, Ma, 2007) proposed to set a special time limit, for example 2 hours, and take the best solution found within this time as a final one.

Concluding, the aim of this model is to simultaneously integrate generation and selection of the route. The model is an utility maximizing decision problem. Each carrier can use this method to decide about its strategy to bid for the best suited package of lanes in a combinatorial auction. The model takes into account profit resulting from servicing the route as well as repositioning costs.

5.2 Collaborative carrier network

The method of collaborative carrier network was proposed by (Song, Regan, 2003). The small and medium sized trucking companies were studied in order to increase their operational efficiency by building cooperation networks. Such systems may bring many benefits since the trucking industry is a very competitive market with low profit margins. Innovative solutions are very welcome. The areas where improvements are needed are operational costs and information exchange. On the other hand solutions and new technologies can not be expensive because small and medium companies will not be able to afford such expenses. The paper by (Song, Regan, 2003) proposes a model for an auction based collaborative carrier network. It is dedicated for small and medium trucking companies.

5.2.1 Trucking industry situation

In the last years manufacturers, who want to move their goods from origin to destination increase successively their requirements at the same time waiting for price decrease and service level increase. The market became very competitive and now only innovative, well managed carrier companies are able to survive and expand their activities. However, as shippers expect less and less expensive service, the operating costs such as labour and gasoline continuously increase, we can confirm that this industry is a quite low profit sector (Song, Regan, 2003). The main aim of the carriers is to benefit from new routing and

scheduling tools, increasing e-commerce, information exchange improvement. The listed technologies improve the efficiency of fleet utility. Right information at the right time can ensure the efficient service. Each day on the spot market there are more, both shippers and carriers, offering their services and business to perform. In order to exchange information in more sophisticated way, spot markets have moved online in the last time. Such situation enables operators from the entire globe to meet at one, online place and bid for the service. The examples of advanced online servers where shippers offer load to move and carriers bid for this load and the system is able to match the demand and supply are: Transcore Commercial Services, NTE and Transplace. Both shippers and carriers benefit from lower search and operational cost and access to bigger, world markets (Song, Regan, 2003).

Online auctions despite many advantages for all size carriers benefit mainly large ones. For example, large companies have more possibilities to invest in latest technologies and tools so they have more chances to bid efficiently and win the service. Furthermore they are able to minimize empty movements much more often than small carriers. The bigger ones have also wide and stable customer base. However, the trucking industry has a couple of large carriers and many small ones. The second type companies compete mainly in terms of price and are able to serve solely small shippers. They also accept to serve routes offered them by larger carriers. Fluctuating demand is very scary for the small operators and leads them to lose and much more empty lanes than in case of large providers (Song, Regan, 2003).

The method proposed by (Song, Regan, 2003), namely collaborative carrier network is designed for small and medium sized carriers in order to help them to operate more efficiently, improve their profit and competitiveness. At the same time this framework requires low costs so small companies don't have problem with high investment.

5.2.2 The model of a collaborative network

Of particular interest is the group of small and medium sized carrier companies. We assume that each one offers services locally and with equivalent quality level (Song, Regan, 2003). At the moment when new demand appears on the spot market or is offered in terms of subcontracting from large providers, small carriers have to decide how to assign new loads to

the current job routes. Of course there are also situations where it is impossible to assign load efficiently, so carrier should not consider bidding for this service. A new, possible option for small providers is to build a network and collaborate with other partners in order to integrate ineffective route which can be effective when combining with other carrier's lanes.

An auction based collaborative carrier network proposed by (Song, Regan, 2003), has as its first aim improvement of operational efficiency and is based on a mutual agreement between a group of small and medium carriers. The contract specifies payment and performance conditions. Logistics providers collaborate by a central portal or just by a direct communication between them. Each time a new load appears, carrier starts his specific optimization process in order to decide whether this particular route is of interest for him. This means whether the new load is efficient or inefficient. When the carrier determines that this new service is not best suited for him he calculates the reservation price and looks for his partner carriers in the network with an aim to subcontract. The other logistics providers start the same optimization process to decide whether the new service will fit their existing routes. As soon as there is one or more partner interested for the load which will gain profit for them, they submit bids. The carrier who initiated the auction compares his reservation price with the submitted bids and subcontracts the load to the lowest bidder. This process does not cause significant transaction or negotiation cost, it may be led in an electronic environment. In the last time Internet is such a global tool, that also small carriers have access to it and are able to operate in the virtual world. Internet brings many advantages, based mainly on cost reduction like transaction, transport, time and cost savings (Song, Regan, 2003).

In the collaborative network each participant can be sometimes a contractor and sometimes a subcontractor. The assumption made by (Song, Regan, 2003), is that only one auction may be open at a time. If during this process new loads are available these will wait until current auction will be finished. Contractors have the possibility to re-evaluate the best offer and change the subcontracting decision.

The utility function of a carrier $u(v,c)$ is quasi-linear. V is the payment for the contract and c is the cost of serving the contract. In case carrier wins the contract its utility is the difference between the payment and the cost $u = v - c$, otherwise, its utility will be equal zero. Next variable x is the amount of loads carrier holds for itself and does not initiate an auction

for it. In this model of a collaborative network x will be a binary variable equal one when particular load will be held for the carrier and zero if subcontracted. Considering two participants one contractor (1) and second, the lowest bidder (2), the utility function of each one will look as follows (Song, Regan, 2003):

$$\bar{u}_1 = (v_1 - c_1) * x + (v_1 - v_2) * (1 - x)$$
$$\bar{u}_2 = 0 * x + (v_2 - c_2) * (1 - x)$$

Carriers are rational. The bidder, carrier number 2 will always submit a bid with a price $v_2 \geq c_2$. Carrier who offers this load in an auction will accept the bid only if the price will be less than its cost. Then the total surplus for all carriers can be maximized (Song, Regan, 2003):

$$\max \sum_i u_i = (v_1 - c_1) * x + (v_1 - v_2) * (1 - x) + (v_2 - c_2) * (1 - x)$$

$$= (v_1 - c_1) * x + (v_1 - c_2) * (1 - x)$$

The decision to subcontract will be accepted by both partners when $c_1 > v_2 \geq c_2$. If bidder cost is lower than contractor cost, the surplus of all firms in case of subcontracting will be maximized at $v_1 - c_2$. Described auction format is a Bertrand competition where bidders compete on prices and the one with lowest bidding price wins. Then, the total surplus will be maximized at $v_1 - min\{c_j\}$ (Song, Regan, 2003).

The advantage of presented collaboration network is that all the carriers are better off or their utility does not change. The winning bidder benefits from utility $v_2 - c_2 \geq 0$,so is better off. The others, that do not bid or lose their bid, remain the same utility as without new tool. Further, also the contractor takes advantage from his higher profit. Beginning his profit was: $v_1 - c_1$ and now it is: $v_1 - v_2$. Therefore, the allocation process is a pareto efficient since no one is worse off and some of the carriers may be better off what maximizes the surplus of the network. Lemma resulting from (Song, Regan, 2003) is:

"The post-market negotiation mechanism, carrier collaboration network, is a pareto efficient allocation when each participating trucking firm is rational and has a quasi-linear utility function, hence the sum of all participants' expected utilities is maximized. "

5.2.3 The subcontracting

Information sharing is one of the most important factor influencing efficiency and profit maximization, it is also an advantage resulting from carrier network. On the other hand the system requires also some complex decisions for contractor, as well as for subcontractor to take. For example, the decision for a carrier to subcontract or not is a very hard one and depends on a couple of factors like its capacity, existing demand and risk likeliness. At the beginning carrier needs to calculate its cost with and without this new load. This can be done using policies to solve pick up and delivery vehicle problem. In case of small and medium carriers the problem is not so big and there is a very high chance to solve the problem optimally in a short computation time. Authors (Song, Regan, 2003) define the difference between carriers' optimal costs by adding as a marginal cost a new load. A set of loads is denoted as *L*. Further notations look as follows (Song, Regan, 2003):

R - the revenue a carrier gains from serving new loads, original contract price

C – optimal and total cost when serving each set of loads

LC – direct cost resulting from traveling through lanes with load

EC – cost caused by repositioning or empty movements

MC – marginal cost for a carrier resulting from serving a batch of new loads

MEC – marginal empty cost resulting from serving a batch of new loads

ΔLC – direct cost when serving a package of new loads

Continuing the optimal cost for a carrier before and after serving new loads will be (Song, Regan, 2003):

$$C_1 = LC_1 + EC_1$$
$$C_2 = LC_1 + \Delta LC + EC_2$$

The conditions will be valid only in case of optimal solution. A vehicle can not travel more empty distance than loaded miles:

$$EC_1 \leq LC_1$$

$$EC_2 \leq \Delta LC + LC_1$$

Further assumption is that costs are proportional to traveled miles, it does not matter whether the vehicle is driving with empty or loaded truck (Song, Regan, 2003). Regarding marginal cost, which can never be negative, since adding a new job can't reduce operational costs, following situation can happen:

- *MC = 0*

  In this case carrier should hold the loads for himself because it reduces his empty miles. The new services are complementary with the existing jobs so gain profit and should be performed by the carrier itself. (Song, Regan, 2003).

- *MC > 0*

  This condition can lead to : *MEC = 0, MEC > 0, MEC < 0*. In the first situation, when *MEC = 0* this means that carrier's empty cost stay the same even when a new load is assigned. This is profitable for a carrier, so should be hold to perform it by itself. When *MEC > 0* a new load is not complementary with the existing business and requires either additional capacity or incurs higher costs. This service should be subcontracted, of course as long as the bidding price is lower than carrier's marginal costs. The last situation *MEC < 0* at the first sight looks also profitable and should be hold for carrier itself. However, each additional lane has to be considered in detail and decided whether it is beneficial or causes higher costs (Song, Regan, 2003).

In reality the decision regarding subcontracting depends on optimal marginal costs as well as optimal marginal empty costs. In case there are more new lanes, each one has to be examined in detail. However, in more advanced way carriers may predict what can happen in the future and which lanes may occur later on and leave for itself these ones which have high possibility to be profitable.

Carrier who initiates the auction must remember to award the lowest bidder, but only when the lowest price is less than carrier's reservation price. When adding a new load to the current business, the reservation price will be equal to marginal cost. The lowest bid price is p_B and as long as it is lower than reservation price c, carrier should subcontract. However, it

can happen that during an auction a new load appears, which in combination with the current one can be profitable for the contractor. In such situation it can stop the auction and leave the load for itself (Song, Regan, 2003).

When a carrier bids, it should suggest price higher or equal to its marginal cost. The best is to achieve reasonable profit, what is not always possible. The bidder needs to compete with other participants and depending on auction rules and conditions his possible profit margin can be determined. Considering combinatorial auctions the decision is complex and difficult to calculate but still possible.

Concluding, the new model, namely collaborative carrier network is an efficient tool and improves the operational effectiveness of small and medium sized carriers, by improving and encouraging them to cooperate between each other. The system shows to be pareto efficient one. Each participant may be better off, but never worse off than before (Song, Regan, 2003).

5.3 Delaying and breaking commitments – the shipper strategy

The new policy presented in (Mes, Heijden, Schuur, 2009) has as a first aim revenue maximization for shippers. The model can be used in sequential auctions and focuses on two strategies based on delaying and breaking commitments. Delaying commitment means that shipper will not accept the lowest bid price if it will be higher than a certain reservation price. In this case, a shipper beliefs to make better business in the future. Of course depending on the time left to perform the service a shipper will accept certain bid or not. As the time gets tighter the price he can accept will rise. This mechanism is called dynamic threshold policy. On the other hand breaking commitment is then, when a shipper accepts the situation when a carrier breaks his commitment and pays certain penalty. These penalties are so computed that they cover costs of finding a new carrier to perform the job. It is a decommitment policy.

There are sequential and combinatorial auctions, so situations when carriers bid on more than one job. However, such auction types are difficult. It is hard for the carriers to estimate all possible outcomes from different routes combinations. Also winner determination problem

must be solved. That is why the paper concentrates on sequential auctions, to improve the allocation of services (Mes, Heijden, Schuur, 2009).

In a short summary the model is a maximizing profit strategy for shippers in a spot market. In order to avoid too hard problems, the authors present dynamic threshold policy in which decommitment and delaying are possible. Using probability distribution optimal reservation price paths are determined.

5.3.1 The model description

The market consists of carriers and shippers who offer jobs on auctions and carriers compete by subscribing bids on these jobs. One task consists of full truckload that needs to be transported from one point to another. Following notation will be used (Mes, Heijden, Schuur, 2009): a – announcement time of a job; i - an origin; j – destination; l – will stand for the latest pick up moment , when a carrier will arrive after this time he will need to pay c per each time unit of tardiness. There will be also a soft time window $\sigma = l - a$. The distance between point of origin and point of destination is denoted as d. Shipper wants to pay as low price as possible to the carrier for performing the job. The prices are random variables for the shipper but generated according to probability distribution which is based on historical data. The process starts when there appears a new load to be moved. Shipper identifies this situation and begins an auction by sending messages to all available carriers. They respond with a bid. The shipper would award the one logistics provider which has proposed the lowest price, however in this new method proposed by (Mes, Heijden, Schuur, 2009) dynamic threshold policy is used. So the shipper may decide to award no one, hoping to make better business in the future. It can be possible, because prices fluctuate over time, variable costs change as well as fleet utilization. Then, as long as the lowest bid is above certain threshold price sipper will wait for more attractive price. Shipper may also end the current auction and start a new one some time later. However, when time gets tighter, the deadline of performing the service gets nearer, shipper can increase his threshold price. When considering the decommitment policy, carrier can decommit and pays an agreed penalty. Afterwards shipper starts a new auction.

5.3.2 New dynamic threshold policies

There are two situations in case of delaying commitment. Shipper may wait continuously until he will get a satisfactory bid in the current auction or end current auction and start a new one fixed time later. Now, function developed for the first situation will be presented.

Assumptions (Mes, Heijden, Schuur, 2009) are that at time when new load becomes available shipper starts an auction and all the carriers bid to win this service. However, they may update their bidding price in the future. The lowest bids are independently and identically distributed. The shipper is interested in the lowest bid *b*. Lowest bids can be presented by a continuous distribution function *F(b)*. The time between lower bid's update is exponentially distributed and its rate is denoted as λ. Whenever lowest bid is updated shipper has to make up his mind whether he wants to accept it or wait longer. The time when shipper has to decide if he agrees to assign job to the lowest bidder, ends with the latest pickup time. When the lowest bid will not be accepted and no one gets the job, shipper faces costs $Z(\tau) = \beta + c\tau$, β is a constant and *c* stands for the penalty cost per unit of tardiness τ. The time till latest pickup time is indicated as *t*. Then the value function *V(t)* stands for the minimum price shipper needs to pay. If time-to-go *t* is less than zero, *V(t)* equals *Z(-t)* when beginning of an auction after the latest pickup time. So, the recursive relationship is given by (Mes, Heijden, Schuur, 2009):

$$V(t) = E[\ min\ (\ B,\ V\ (t - Y))]$$

In the formula *B* is a stochastic variable of a lowest bid, whereas *Y* stands for exponentially distributed time till the bid change. In this policy the bid is accepted if it is lower than shipper's minimal expected price at an estimated time of next bid updating. Then, the threshold function looks as follows:

$$\alpha(t) = E\ [\ V\ (\ t\ -\ Y\ )] = E\ [\ min\ (\ B,\ \alpha\ (\ t - Y\ ))]$$

Further, the relative savings *s(t)* when using proposed dynamic threshold policy are given by (Mes, Heijden, Schuur, 2009):

$$s(t) = \left(1 - \frac{4}{\lambda t + 2}\right) * 100\%$$

When we take rate λ equal 1 savings for time t = 2, 8, 18, 38 are 0%, 60%, 80%, 90% respectively. Despite the very good results we can not forget that they hold only when lowest bids are independent and identically distributed. However such assumptions are not very realistic.

In the second situation, so where the shipper ends an auction and starts a new one some time later, the policy takes time dependency and correlation between bids into account so it is more realistic. The time is discretized. In the repeated auction the same job is sold in a series of auctions in different periods. The time between sequential auctions is fixed and indicated as a period R. The timing of an auction will be in this case the number of auction rounds. In each round shipper needs to decide if he accepts the lowest bid in a current auction or not. However, shipper has to calculate the probability of getting lower bid in the future rounds. It can be done using continuous distribution function $F_n(b)$ which may be described in terms of the best bid as a function of the auction round number n. The distribution is possible to estimate from past auction data. The maximal number of auctions equals (Mes, Heijden, Schuur, 2009):

$$N = \left\lceil \frac{(l - a)}{R} \right\rceil + 1$$

Auction rounds are possible only between job announcement a and latest pickup time l. After last possible pickup the costs that arise are expressed as a cost function $Z(\tau)$.

Further (Mes, Heijden, Schuur, 2009) present probability function q^u which estimates the chance of updating the lowest bid between two subsequent auction rounds. In case of Poisson distribution process of updating lowest bids with rate λ the probability can be expressed by:

$$q^u = 1 - e^{-\lambda R}$$

Continuously, the value function $V_n(b_n)$, so the price shipper pays when he decides to accept the lowest bid is given by (Mes, Heijden, Schuur, 2009):

$$V_n(b_n) = \min\{b_n, Z\}$$

$$V_n(b_n) = \min\{b_n, E[V_{n+1}(B_{n+1}|B_n = b_n)]\}$$

During the last auction round shipper has to decide whether to accept current lowest bid or expected price Z, when auction will take place after the latest pickup time.

It can be observed that bids fluctuate over time, this happens because of new job arrivals. The dynamic threshold policy benefits from these fluctuations. The prices depend on the time between rounds and the auction rounds (Mes, Heijden, Schuur, 2009). Now we should take into consideration correlation between lowest bids. The example is that when many carriers are busy the best bid is likely to be high, then in a next round the chance that lowest bid will also be high is quite big. The correlation is studied only between two subsequent auction rounds. The price deviation is examined in terms of sequential lowest bid updates and is then presented by a linear trend with fixed coefficient. A large correlation will have a negative impact on the bid prices.

The second possible policy for the shippers is decommitment strategy. Carrier may resign from their lowest bid commitment however, against some penalties. The penalty amount are determined by the shippers and known for all auction participants from the beginning. In case a carrier breaks his commitment and pays penalties shipper can use the money to cover costs of finding a new carrier. The extra cost arises also because the time until latest pickup is getting tighter (Mes, Heijden, Schuur, 2009). When shipper uses repeated auctions, the extra cost is the difference between threshold prices, so the penalty is given by:

$$D_{s,t} = E[\alpha_t(B_t)] - E[\alpha_s(B_s)]$$

Where $D_{s,t}$ is the decommitment penalty, $t < s$ and finally B_t is the stochastic variable for the best bid.

In the situation when the shipper does not use threshold prices, there is only one auction. In the same round one carrier decommits and shipper searches for other one as a replacement for the other who has broken his commitment. Then, the penalty will be the expected difference in price at commitment start time s and price at current time t (Mes, Heijden, Schuur, 2009):

$$D_{s,t} = E[B_t] - E[B_s]$$

A carrier breaks his commitment when its expected revenue from adding a new job and resigning from the decommitted job will be higher than the current expected profit with the decommitment penalty. In case carrier breaks his commitment for specific job, he will not receive the bid price for this job.

In reality both shippers and carriers do not know exactly all the parameters and functions. They need to estimate it using historical data. The assumptions made by (Mes, Heijden, Schuur, 2009) are: the origin and destination of a service are picked up randomly from Euclidian distance, carrier uses a bid function which is linearly dependent on the increase in penalty costs as well as on the increase in distance to travel. Also the transportation cost variance depends on the distance and time-to-go. Distribution function *Ft(b)* has the mean and standard deviation which look as follows:

$$\mu_{td}^{w} = \alpha_w + \beta_w t + \gamma_w d$$
$$\sigma_{td} = \alpha_\sigma + \beta_\sigma t + \gamma_\sigma d$$

The variables are needed to determine the linear trend.

5.3.3 Experimental settings and simulation

The simulation in (Mes, Heijden, Schuur, 2009) was done for a transportation market where shippers offer new jobs to a group of carriers and choose the best one based on price and delivery time. The area is a square of 100km x 100km. There are 10 trucks driving a speed of 50km/h. When a new load becomes available each carrier or each vehicle calculates insertion cost of the new job into the existing route. The price a carrier will bid is his marginal costs in case of cheapest insertion. If the carrier wins an auction he inserts the new load in a cheapest position. In the decommitment strategy logistics provider also calculates the insertion costs while taking into consideration breaking commitment for other, less efficient job. The carrier tries to remove each job where he is allowed to decommit and inserts a new

one. Then he estimates which situation brings him the highest profit and either decommits from one job and inserts the new one or he does not change the current route. In this situation the bid price must include marginal costs and also possible penalties.

For the simulation purposes authors (Mes, Heijden, Schuur, 2009) took job lengths: 40,60,80,100 and 120 km. The length of particular job will be randomly chosen from this set of values. Additionally to mean and standard deviation described before, also skewness is examined. In the paper it was shown that penalties have positive skew and with decreasing time-to-go also the skewness decreases. Short jobs will have negative skew in terms of transportation costs and long jobs a positive one. Another observation is that short jobs have high probability of being inserted. The long jobs generally are inserted at the end of the route because otherwise it would lead to long empty miles.

Prices increase with increasing distances or when time-to-go decreases. This condition can be observed when performing least squares on the penalty and transportation costs of the best bid. It is logical since when the time to the latest pickup gets tighter there is less flexibility for a shipper to get the best bid he has estimated. Also the standard deviation increases when the time-to-go decreases (Mes, Heijden, Schuur, 2009).

Regarding the efficiency of the described policy savings and competitive advantage were studied. Savings were measured in terms of reduction of total costs in the situation when shipper uses presented policies and when not. In parallel, competitive advantage was estimated comparing the difference in costs per job contrasting the individual shipper with the external market. As costs we take only penalties and empty movements. From the results of the simulation, presented in the table below it can be confirmed that the total costs seems to be each time lower when using one of the policies for the market share of 1%. The competitive advantage for the individual shipper is higher than zero if dynamic threshold policy is used. On the other hand, in case of decommitment strategy, costs per job for individual shipper are higher than for the external market. It can be caused by penalties determined by the shipper. He must estimate his extra cost of finding another carrier but the costs in reality can be higher. For example, when the time to the latest pickup is shorter shipper needs to decide which carrier to choose although the lowest bid is not fully satisfying him (Mes, Heijden, Schuur, 2009). Furthermore, carrier decommits when inserting a new job

is more beneficial than staying with the current one and breaks commitment for it. Then the external market which has offered the new job, benefits from the decommitment.

For the market share of 10% we see that the total costs when using one of the strategies are reduced even more. However, the combination of both policies can lead to costs increase since jobs may be accepted later because of estimation errors. The competitive advantage for one shipper, when using delaying commitment, is slightly lower than in the previous example. The reason is that the discrepancy between expected and market prices increases while the market share increases. Concluding, despite these variations with increasing market share the total costs are reduced (Mes, Heijden, Schuur, 2009).

Network	Indicator	DT	DC	DT and DC
Quiet	Savings	0,2	0,2	0,6
	Advantage	25,5	-21,5	11,6
Normal	Savings	0,4	0,3	0,5
	Advantage	30,6	-24,3	6,5
Busy	Savings	0,6	2,2	0,5
	Advantage	23,1	-78,3	-68,6

Table 2 – The simulation results with a market share of 1% (Mes, Heijden, Schuur, 2009).

Network	Indicator	DT	DC	DT and DC
Quiet	Savings	1,6	1,2	2,5
	Advantage	24,1	-21,7	13,5
Normal	Savings	1,8	1,7	-0,8
	Advantage	24,9	-26,0	-23,1
Busy	Savings	4,3	4,3	-13,4
	Advantage	19,5	-55,7	-69,0

Table 3 – The simulation results with a market share of 10% (Mes, Heijden, Schuur, 2009).

In a summary, presented dynamic threshold strategy allows a shipper to delay commitments when they expect to make better business in the future. Further policy enables carriers to decommit from a job, however requiring to pay an agreed penalty. Both strategies are beneficial, because they reduce the total costs.

5.4 Double auction strategy with elastic demand

The new type of offering and selling transportation jobs, namely online auctions require new tools to perform optimal or best possible bidding strategy and allocation. In the paper (Garrido, 2007), author presents two cases. The first one is a market where multiple carriers operate O-D pair when servicing multiple shippers. The other situation is that multiple O-D pairs are operated by multiple carriers performing jobs for multiple shippers. The shippers' demand is elastic in terms of transportation service price. Shipper chooses one carrier for one particular job based on the lowest bidding price. However, it is likely that a carrier will have empty movements, when, for example going back to the depot. Each carrier will try to sell his service on this particular way even at very low price, in order to decrease the costs he has to carry. For the shippers such offer is very lucrative and they may become auctioneer, they bid on the discounted tours. The double auction model assigns shipments to capacity which is not used when repositioning to the depot. The empty miles in the network are in such way reduced as well as overall transportation costs. The repositioning opens new possibilities to increase the market efficiency.

Empty miles appear almost in all routes. The carrier's objective is to minimize it as much as possible. As (Garrido, 2007) advises, for example in bigger cities the empty movements are up to 30 % of the vehicle's trip. This opens new opportunities for a cost reduction. The advantages of online marketplaces, especially real-time information enables to change empty movements into additional loads bringing revenue. Both partners will be satisfied, carriers because of empty miles reduction and shippers because they will have a service at very low costs. The online platform offers real-time information exchange between shippers and carriers, and because of this possibility it is easier for both of them to assign loads to repositioning tours. It functions as follows: when a carrier knows that he has to reallocate a vehicle from point A to point B he offers his capacity on this route below market price. When

other carriers can offer their service on the same lane, they compete and the one who offers the lowest price wins.

5.4.1 Single origin destination pair

Each time a new load becomes available a carrier has to determine the bidding price. In order to do it he estimates the direct cost of this service and the cost of empty miles caused by this movement. Of course he also has to take into account the probability of winning future load for that movement.

It is assumed (Garrido, 2007) that the probability that the carrier will win the bid is a function of the carrier's characteristics, like risk averseness, market visibility and the frequency of movements open for auction on the particular pair. The higher the frequency, the higher the probability. Furthermore the frequency is a function of the market price for that transportation O-D pair. The rule is that when the transportation price is low this will cause higher frequency of service. The replenishment cycles depend strongly on the transportation costs. So finally, we see that there is a trade-off for the carrier between the transportation price he offers and the probability of winning future services.

Another assumption made by (Garrido, 2007) is that shippers apply EOQ policy. This means that they calculate the frequency of shipments in the way that minimizes their transportation and inventory costs. Of course in this policy we have to assume that the customer's demand is known and lead time is constant, so the frequency of movements will be elastic to transportation prices.

Now, we take into consideration the carrier's perspective. When he has so far assigned all of the capacity to the shipments the optimization task begins, to perform the services at minimum costs. However, it is nearly impossible to have a load on all arcs. For sure the carrier will have some lanes with free vehicle capacity, so without revenue, but those movements must be done anyway. Then, the opportunity appears to offer the capacity on these particular lanes below the market price, for example at marginal costs. In such situation shippers decides when he would like to buy the service, depending on his EOQ policy

(Garrido, 2007). However, the benefits from buying the transportation service at a given time on the particular lane can change the behaviour of a shipper. The reduction in price can exceed the extra inventory costs shipper needs to carry when, for example moving the load earlier than needed. The situation will force shippers to compete on the lane at discounted price.

On the market multiple carriers serve multiple shippers, which have elastic demand. When there is a need to move a load from one point to other, shipper starts an open auction and allocates the service to the carrier who proposed the lowest price. The quality and service level are assumed to be equal for all carriers so the decision depends only on price (Garrido, 2007). Carriers will estimate their bidding price from the marginal costs and repositioning costs associated with this shipment.

At the beginning we will look into the market with single O-D pair and many shippers and carriers. Like so far mentioned, we assume that carrier j performs a shipment at price which is a function of the direct costs and the repositioning costs, (Garrido, 2007). Continuously, the bid realization is a stochastic process which can be mathematically described as follows:

$$b_k = C^k \left(1 + \rho_k \right) + \underline{C}^k * \left(1 - \underline{P}^k \right) + \xi^k \ , k \in K$$

K stands for the set of carriers, b^k is the bid price on the pair of points O-D, C^k means direct costs of serving the lane, ρ^k is the desired profit margin, $\underline{C}^k$ is the cost resulting from repositioning the vehicle, $\underline{P}^k$ stands for the probability of winning and assigning a job to the repositioning tour, and finally ξ^k is the stochastic variable explaining the unexpected changes in the profit margin. The value of desired revenue margin is rather a parameter than a fixed variable and needs to be updated according to current conditions. It is useful for strategy creation. When a carrier has a load to be moved exactly on his repositioning tour, he will accept any price giving him positive revenue (Garrido, 2007).

Another assumption from (Garrido, 2007), is that the probability of winning an auction depends also on the market size and carrier's market position. The probability is not just the number of submitted bids but especially the long term ability to be a winner, so the success of

chosen bid strategies in the past auctions. The mentioned dependency between loaded flow in a lane and the probability to create new demand may be implemented using smooth function, for example logistic operator. Thus, the probability that a carrier will win the auction for a job is given by:

$$P^k = \frac{e^{\alpha_k * f}}{\sum_{\forall j \in K} e^{\alpha_j * f}} = \frac{1}{\sum_{\forall j \in K} e^{(\alpha_j - \alpha_k) * f}} \quad , k \in K$$

f is the frequency of shipments, then α_k is the specific parameter for a carrier, which describes his ability to win in a particular O-D pair. The repetition of shipments is a function of transportation price for servicing this pair. The rule is that when the transportation price is low, the number of shipments will be high (Garrido, 2007). Clearly there will be a trade-off for the participants.

As so far mentioned shippers are assumed to operate in line with the EOQ policy. They want to plan the best schedule of shipments which will minimize their costs, total inventory and transportation costs. When we sum up all the frequencies of the shippers on the market we get a market frequency (Garrido, 2007):

$$f = \sum_{\forall s \in S} f^s = \sum_{\forall s \in S} \sqrt{\frac{h_s * d^s}{2t^*}}$$

Inventory holding costs for a shipper are given by h_s, S is a set of all shippers, d^s is the customers' demand which shippers expect at destination and t^* is the transportation price on the market. Having this new formula we can substitute it into the previous ones and obtain other expression for bidding price for a carrier k (Garrido, 2007):

$$b_k = C^k (1 + \rho_k) + \frac{\underline{C}^k}{\sum_{\forall j \in K} e^{(\alpha_j - \alpha_k) * \sum_{\forall s \in S} \sqrt{\frac{h_s * d^s}{2\underline{t^s}}}}} + \xi^k \quad , k \in K$$

In the formula the sign _ stands for the repositioning tour. Not without a meaning is the fact that the bidding price for O-D pair depends also on the trip, vehicle has to travel to go

back to the depot and also on the bids of other competitors. It is a recursive nature of this model.

5.4.2 Multiple origin destination pairs

In this case we have a network *G(N,A)* where shippers and carriers operate. *N* is a set of points, nodes and a set of directed arcs is denoted as *A*. Because of this chain we have many possibilities of origin destination trips. Demand for each pair of nodes is elastic to the transportation price of serving this particular O-D pair (Garrido, 2007). The origin and destination node is predefined and can not be change, the parameter which only varies in terms of price changes, is the quantity to be moved. Therefore, the higher the quantity of pairs operated by a carrier, the cheaper the costs of repositioning to the depot. In such way the carrier benefits from the ability to offer lower bids in the future, because his reallocation costs are low. Auctions take place one after another. Shippers at one time offer load for particular O-D pair. Continuously, the cost of serving a load splits in two parts. The first are the direct costs of performing the shipment on that specific way and the second the cost of empty movement if no further shipment begins at the destination. Thus, the bidding price for a carrier *k* is given by:

$$b_{ij}^k \ = \ C_{ij}^k \, (\, 1 + \rho_k \,) + C_{j+}^k * \left(1 - P_{j+}^k \right) + \xi_{ij}^k \, , \quad i,j \in N; \; k \in K$$

In the above formula C_{j+}^k denotes the costs of movement without a load from the destination to other, unknown node. This, not sure location may be another shipment to serve. P_{j+}^k is the probability that there will appear a new shipment starting from destination of the previous one (Garrido, 2007). Additionally, when we think that the probability of wining a load for a specific O-D pair is proportional to the market size in that pair, then the chance of wining a shipment starting from a given node is also proportional, but to the total flow of jobs with this node as origin. So, the probability looks as follows:

$$P_{j+}^k \ = \ \frac{1}{\sum_{\forall l \in K} e^{(\alpha_l - \alpha_k)*f_{j+}}}$$

Continuously, the frequency f_{j+} is the sum of flows having the same origin j (Garrido, 2007):

$$f_{j+} = \sum_{\forall u \in N} f_{ju}$$

In case there will be no new shipment available starting from destination of the current one, the vehicle will move empty to other, unknown location (Garrido, 2007). Therefore, the empty costs C_{j+}^k are not sure and can be only estimated:

$$C_{j+}^k = \sum_{u \in N} C_{ju}^k * P_{u+}^k = \sum_{u \in N} \frac{C_{ju}^k}{\sum_{\forall l \in K} e^{(\alpha_l - \alpha_k) * \sum_{\forall \vartheta \in N, s \in S} \sqrt{\frac{h_s * d_{\vartheta u}^S}{2 * t_{u\vartheta}^*}}}} \quad , \quad j \in N \, ; k \in K$$

Substituting all the previous formulas into the bidding price of a carrier k we get:

$$b_{ij}^k = C_{ij}^k (1 + \rho_k) + \sum_u \frac{C_{ju}^k}{\sum_{\forall l} e^{(\alpha_l - \alpha_k) * \sum_s \sqrt{\frac{h_s * d_{ju}^S}{2 * t_{ju}^*}}}} * \left(\frac{\sum_{l \neq k} e^{(\alpha_l - \alpha_k) * \sum_{v,s} \sqrt{\frac{h_s * d_{jv}^S}{2 * t_{jv}^*}}}}{\sum_{\forall l} e^{(\alpha_l - \alpha_k) * \sum_{v,s} \sqrt{\frac{h_s * d_{jv}^S}{2 * t_{jv}^*}}}} \right) + \xi_{ij}^k$$

The described strategies require that all the participants have full information, which is in reality hardly possible.

We now take into consideration a carrier with some jobs won in the previous auction and no other shipments are available on the market so he can not bid for additional loads. The main aim is now to find a way to serve all the shipments at minimum costs. It is almost certain that a carrier will have in his route also arcs to be traveled with no load. The empty movements must be done anyway and no revenue is expected. However, it is possible for a carrier to try to generate a demand for these trips (Garrido, 2007). The benefit for the shippers will be that those particular services will be offered at a very low price, below the market price. An auction to offer and sell such loads may be ascending auction. A significant reduction in transportation price may force shippers to buy the service despite their EOQ policy, especially when the savings exceed additional inventory costs. The special offers are

for a particular time and specific O-D pair, they do not repeat in the future. Shipper will place an order not in line with his EOQ policy if (Garrido, 2007):

$$t_w^* - \tilde{t}_w \geq C\,(\Delta Inv)$$

t_w^* is the price for transportation on the market, $\tilde{t}_w$ is the reduced transportation price and $C\,(\Delta Inv)$ is the extra inventory cost caused by earlier order than planned before. The shipper can decide to apply two possible ways of changing the EOQ policy (Garrido, 2007). The first is to order at a time when the EOQ policy can be shifted and the second to order causing one-time lot size increase. However, both adaptations of the policy lead to inventory that will satisfy the final demand, which is known from the beginning and does not change. After the modifications of EOQ policy shipper will continue to operate as planned in the optimal schedule. The additional inventory costs will be expressed by:

$$C\big(\Delta Inv(t)\big) = d * t * (T - t) * h$$

In the expression (Garrido, 2007), d is the known, final demand and h is the inventory holding cost computed per unit of time. After partial integration and substituting we get the condition when demand should be generated:

$$t_w^* - \tilde{t}_w \geq \frac{d * h * T^2}{6}$$

In the second situation shipper has to decide which lot size to order (Garrido, 2007). In this case, the additional inventory level is denoted as q and the costs of it, as a function of time t:

$$C\big(\Delta Inv(t)\big) = q * (T - t) * h$$

Following the same logic as before we get (Garrido, 2007):

$$C\big(\Delta Inv(t)\big) = \frac{q * h * T}{2} = t_w^* - \tilde{t}_w \rightarrow q = \frac{t_w^* - \tilde{t}_w}{T * h}$$

The important point is that there is no benefit in offering service in sets. Such situation will reduce the efficiency and probability to find a partner, a shipper. Additionally it brings no more benefit than selling the lanes separately.

5.4.3 Numerical example

In order to check the efficiency of the presented strategy, the double auctions, simulation example was designed and tested, (Garrido, 2007). There is a single O-D pair and a couple of shipments to serve. The shipments are auctioned in an open auction. There are three carriers as bidders. Each auction is started sequentially. The vehicles are situated in another depot, not being origin or destination. The stochastic parameter ξ^k varies from 1 to 10. When a carrier has to make an empty movement he offers a reduced price. He offers a discount of 33% of the market price. The transportation costs in both directions, from O to D and from D to O, are equal.

σ	Average transportation price	Average transportation price savings (%)
1.00	124.81 (24.37)	15.17
1.25	120.80 (24.40)	17.80
1.50	118.90 (24.17)	19.00
1.75	118.01 (24.06)	19.50
2.00	116.70 (23.78)	20.30
3.00	114.97 (23.37)	21.10
4.00	113.65 (23.06)	21.53
5.00	112.97 (22.97)	21.63
6.00	111.99 (22.91)	21.70
7.00	111.02 (22.51)	22.07
8.00	109.97 (22.33)	22.27
9.00	109.77 (22.65)	22.00
10.00	108.27 (22.40)	22.60

Table 4 –Average transportation price savings (Garrido, 2007).

The table above shows the average transportation price savings resulting from double auction model. In case the σ is equal 1, so the stochasticity is moderate, the presented strategy leads to price reduction of 15,17%. As the variability increases the savings also increase (Garrido, 2007). This is possible since when the variability grows, the bids may reach lower and lower price levels.

In this section, a policy was described which is suited for selling a transportation services in an electronic marketplace, using real time information. Empty movements that happen due to repositioning, open new opportunities to increase the efficiency of the market, while reducing the total costs. Also the repetition of shipments may be increased. This situation and possibilities to transfer empty miles into loaded ones yields to the fact that both, shippers and carriers are better-off. In this new strategy carriers and also shippers play auctioneer role. The two cases were examined. One, where O-D pair was operated by multiple carriers serving multiple shippers and the second one where multiple O-D pairs were operated by multiple carriers serving multiple shippers. All the time the shippers' demand function to the transportation prices is elastic. Shipper chooses one carrier for one service using open auction. The lowest bidder receives the shipment (Garrido, 2007).

A numerical example showed that the policy is beneficial and efficient. It leads to transportation price reduction. The savings depend on the variability. When the variability increases, also the savings increase. Of course there is still a wide field for further research and we may expect that all the variables may be improved and also the overall efficiency of the system.

6. Conclusions

In this work the new phenomena in global logistics management is described. Outsourcing is a very helpful tool which enables the company to concentrate on its own core competencies and to increase its efficiency and profits. In today's worldwide network each logistics provider needs to be competitive in order to continue operating in the market and to gain larger market share. Outsourcing means subcontracting special logistics services to third parties. Third party logistics providers are experts in some specific logistics activities. The manufacturers choose the best carrier for them and build a close relationship. There are also different contracts that can be used to specify the cooperation rules.

The most popular way to offer a load for a shipment from origin to destination is online auction. At one, virtual marketplace shippers and carriers meet. Shippers propose a service to be performed, afterwards carriers bid to win the shipment. The player who offers the lowest price is the winner, has to serve the shipment and receives instead a payment. Of course there are many ways to win an auction. Both carrier and shipper want to increase their profit so they try to apply the best method to assure the highest possible benefits. In this work there are four different strategies described. The first one is carrier's optimal bid policy in combinatorial auctions. This method simultaneously integrate route generating and route selecting. It is a decision problem which maximizes the utility. Each carrier uses the model to select a package of lanes best suited for him and bid for it in a combinatorial auction. The strategy takes into account not only profit resulting from serving the shipment but also repositioning costs. Continuously, collaborative carrier network is presented. It is dedicated for small and medium carriers in order to help them to be more competitive to larger logistics providers. The aim of this strategy is to build a cooperation network and to exchange information between the players. Each carrier may perform the service by himself or subcontract it to other one. Later on, delaying and breaking commitments , so the method for the shippers is described. The shippers also want to increase their profit. There are two ways to achieve this. First one is to delay commitment, so the shipper will not accept the lowest bid as long as it is above the reservation price. He believes to receive better offer in the future. The other way is to allow breaking commitments. Shipper accepts when a carrier breaks his commitment and pays

instead certain penalty. The high of this penalty must be enough to cover the cost of finding a new carrier. It is shown that both policies are beneficial because they lead to decrease in total costs. Finally, double auction method with elastic demand is shown. There are two cases. First when many carriers operate single origin-destination pair and second when multiple carriers serve multiple origin-destination pairs. The shipper's demand is elastic. As it was also in the previous strategies, carrier tries to minimize the empty movements, because it causes high costs. For those lanes carrier offers discounted price in order not to lose when driving with an empty truck.

Today we know that outsourcing may bring many benefits. It helps all companies to be more attractive and competitive. For sure the process must be lead intelligently and all decisions have to be deeply analyzed. The new possibility to buy or sell transportation services is auction. Auctions have become more and more popular also because of the expansion of the internet. In the literature there exist many strategies and models describing the perfect bidding way. However each of them is created for some special circumstances. There is no one policy which will be the best for all situations. There are methods for carriers and shippers, small and large companies and of course suited for different situations. Concluding, each player has to find its own, individual strategy to gain profits and be competitive.

Bibliography

1. Amaral, M., Saussier, S., Yvrande-Billon, A. (2009), *Auction procedures and competition in public services: The case of urban public transport in France and London*, Utilities Policy 17, 166-175.

2. Andersson, D., Norrman, A. (2002), *Procurement of logistics services – a minute work or a multi-year project?*, European Journal of Purchasing & Supply Chain Management 8, 3-14.

3. Beier, F.J. (1989), *Transportation Contracts and the Experience Effect : A Framework for Future Research*, Journal of Business Logistics, vol.10, No 2.

4. Brewer, A., Button, K. J., Hensher, D. A. (2001), *Handbook of logistics and supply-chain management*, vol.2, Elsevier.

5. Capgemini *Annual Report* 2006.

6. Cheong, M.L.F., *Logistics Outsourcing and 3PL Challenges*, Singapore-MIT Alliance, Nanyang Technological University.

7. Chopra, S., Meindl, P. (2007), *Supply Chain Management*, 3rd edition, Prentice Hall.

8. Deepen, J.N. (2007), *Logistics Outsourcing Relationships*, Physica-Verlag -a Springer Company.

9. Enarsson, L. (2006), *Future Logistics Challenges*, Copenhagen Business School Press.

10. Figliozzi, M.A., Mahmassani, H.S., Jaillet, P. (2003), *A Framework for the study of Carrier Strategies in an Auction Based Transportation Marketplace*, Presented at the 82nd Annual Meeting of the Transportation Research Board.

11. Garrido, R.A. (2007), *Procurement of transportation services in spot markets under a double-auction scheme with elastic demand*, Transportation Research Part B 42, 1067-1078.

12. Goldsby, T.J., Eckert, J.A. (2003), *Electronic transportation marketplaces : a transaction cost perspective*, Industrial Marketing Management 32, 187-198.

13. Gourdin, K.N. (2001), *Global Logistics Management - a Competitive Advantage for the New Millennium*, Blackwell Business.

14. Hensher, D., Gwilliam, K., Burton, M., Smith, N., Velde, D., Fridstrom, L. (2008), *The ideal contract roundtable*, Research in Transportation Economics 22, 188-194.

15. Hertz, S., Alfredsson, M. (2003), *Strategic development of third party logistics providers*, Industrial Marketing Management 32, 139-149.

16. Jharkharia, S., Shankar, R. (2007), *Selection of logistics service provider: An analytic network process (ANP) approach*, Omega 35, 274-289.

17. Johnson, J.C., Schneider, K.C. (1995), *Outsourcing in Distribution: A Growing Importance Transportation Brokers*, Business Horizons.

18. Juscinski, S., Piekarski, W. (2009), *Outsourcing as a logistics function in distribution of spare parts for tractors and farm machines*, Maintenance and Reliability nr 1/2009.

19. Krishna, V. (2002), *Auction Theory*, Elsevier Science, Academic Press.

20. Laarhoven, P., Berglund, M., Peters, M. (2000), *Third-party logistics in Europe – five years late*r, International Journal of Physical Distribution & Logistics Management, vol. 30, No 5, 425-442.

21. Lankford, W.M., Parsa, F. (1999), *Outsourcing: a primer*, Management Decision 37/4, 310-316.

22. Lee, C.G., Kwon, R.H., Ma, Z. (2007), *A carrier's optimal bid generation problem in combinatorial auctions for transportation procurement*, Transportation Research Part E 43, 173-191.

23. Liedtke, G. (2009), *Principles of micro-behavior commodity transport modeling*, Transportation Research Part E 45, 795-809.

24. Logan, M.S. (2000), *Using Agency Theory to Design Successful Outsourcing Relationships*, The International Journal of Logistics Management Vol. 11, No.2.

25. Marasco, A. (2008), *Third-party logistics: A literature review*, International Journal of Production Economics 113, 127-147.

26. Mes, M., Heijden, M., Schuur, P. (2009), *Dynamic threshold policy for delaying and breaking commitments in transportation auctions*, Transportation Research Part C 17, 2008-223.

27. Rabinovich, E., Windle, R., Dresner, M., Corsi, T. (1999), *Outsourcing of integrated logistics functions – An examination of industry practices*, International Journal of Physical Distribution & Logistics Management Vol.29, No.6, 353-373.

28. Sadler, I. (2007), *Logistics and Supply Chain Integration*, SAGE Publications.

29. Sangam, V.K. (2009), *Global Logistics outsourcing trends: Challenges in managing 3PL relationship*, Massey University.

30. Silver, E., Pyke, Peterson, (1998), *Invetory Management and Production Planning and Scheduling*, Chapter 12 and 13, 3rd edition, JohnWiley & Sons.

31. Simchi-Levi, E., Kaminsky, P. (2008), *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*, 3rd edition, McGraw-Hill.

32. Song, J., Regan, A.C. (2003), *An Auction Based Collaborative Carrier Network*, Submitted for consideration for publication in Transportation Research, Part E: Logistics and Transportation Review.

33. Stock, J.R., Lambert, D.M. (2001), *Strategic Logistics Management*, 4th edition, McGraw Hill.

34. Tyan, J.C., Wang, F.K., Du, T.C. (2003), *An evaluation of freight consolidation policies in global third party logistics*, Omega 31, 55-62.

35. Van Mieghem, J.A. (2008), *Operations Strategy*, Dynamic Ideas.

36. Walters, J., Jansson, J.O. (2008), *Risk and reward in public transportation contracting*, Research in Transportation Economics 22, 26-30.

Abstract

This thesis concentrates on the new trend in logistics, namely outsourcing. Outsourcing may be prescribed as subcontracting special logistics companies to perform services in which they are experts. It can be seen as a growing alternative for traditional manufacturers which carry out all services in-house. The main aspects, advantages, profits and risks of outsourcing are presented. Continuously characteristics of logistics service providers and outsourcing contracts are described. As a main point online transportation auctions are introduced. The importance of it is rapidly expanding, because the biggest advantage of the online auction is real time information and possibility to connect different actors from distinct locations at one place. In case of transportation auctions, at the marketplace meet manufacturer as an auctioneer and carrier as a bidder. Manufacturer offers load to be shipped and carriers bid, submitting their cost of service. Carriers compete based on price and the one who will offer the lowest price will be chosen to perform the shipment. There are also different auction types which are explained.

Another aspects presented in the thesis are different bid strategies. The model of an optimal bid policy for the carrier is described as well as collaborative carrier network, designed specially for small and medium carriers in order to increase their efficiency and profit by a common cooperation. Optimal bid strategy concentrates on route generation and selection with an aim to reduce the empty movements and increasing the profit. Furthermore, also method for shipper is explained, namely delaying and breaking commitments. Shipper is able to postpone the choice of a carrier as long as his expected price will not be reached, and on the other hand he allows the carrier to break his commitment, paying instead some penalties. Finally strategy for a double auction is introduced, which consists of two situation single origin destination pair served by the carriers and multiple origin destination pairs. However, there is no general best way to bid in the auction process. It all depends from a specific situation, rules and resources.

Zusammenfassung

Dieser Arbeit konzentriert sich auf das Outsourcing als den neuen Trend in der Logistik. Outsourcing kann in diesem Fall als Auslagerung von Dienstleistungen an Logistikunternehmen beschrieben werden. Diese Logistikunternehmen sind Experten auf ihrem Gebiet. Outsourcing stellt zunehmend eine wachsende Alternative für traditionelle Hersteller dar, sämtliche Dienstleistungen außer Haus durchführen zu lassen. Die wichtigsten Aspekte, Vorteile, Gewinne und Risiken des Outsourcings werden vorgestellt und kontinuierlich charakteristische Merkmale der Logistik-Dienstleister und Outsourcing-Verträge werden beschrieben. Als Hauptpunkt werden online Transportauktionen eingeführt. Unter Berücksichtigung der Vorteile von Echtzeitinformationen und der Möglichkeit, verschiedene Akteure aus unterschiedlichen Standorten an einem Ort zu verbinden, wächst die Bedeutung der online Auktionen schnell. Im Falle der Transportauktionen, treffen Hersteller als Auktionator und Spediteur als Bieter auf dem Marktplatz zusammen. Der Hersteller gibt an welche Ladung geliefert werden muss und der Spediteur bietet anhand der Kosten, die berechnet, falls er gewinnt und die Ladung transportiert. Die Frachtführer konkurrieren und derjenige, der den niedrigsten Preis anbietet, bekommt den Zuspruch und muss die Ladung liefern. Es gibt verschiedene Auktionstypen die ebenfalls erläutert werden.

Anschließend, werden unterschiedliche Angebotstrategien in der Arbeit präsentiert. Das Modell eines optimalen Angebots-Politik für den Spediteur wird beschrieben sowie kollaborative Lieferanten-Netzwerke, die speziell für kleine und mittelständische Unternehmen entworfen wurden, um Effizienz und Profit durch eine gemeinsame Zusammenarbeit zu erhöhen. Optimale Angebots-Strategien konzentrieren sich auf die Wege Generierung und Selektion, mit dem Ziel, die leeren Bewegungen zu reduzieren und den Gewinn zu erhöhen. Darüber hinaus werden auch die Strategien von Hersteller und Zulieferer erklärt, die vor allem auf der Verzögern von Zusagen und dem Nichtnachkommen von Verpflichtungen beruhen. Der Hersteller kann die Wahl eines Spediteurs solange herauszögern bis sein erwarteter Preis nicht mehr erreicht wird. Auf der anderen Seite wird dem Lieferanten ermöglicht seine Zusage zu brechen, und stattdessen eine Strafe zu zahlen. Schließlich wird die Strategie einer Doppel-Auktion erläutert. Die Methode konzentriert sich auf zwei Situationen. Erstens, wenn ein einziges Ursprung Destination Paar in dem Netzwerk

existiert und zweitens, wenn mehrere Paare enthalten sind. Es besteht jedoch keine generelle beste Strategie. Es hängt alles von der besonderen Situation, den Regeln und den Ressourcen ab.

Curriculum Vitae

Personal data

- Name: Katarzyna Prokopowicz
- Date of birth :   23.10 1986 Oswiecim
- Citizenship :   Poland

Education

Since 10.2005	University of Vienna International Business Administration
	KFK : Transportation Logistics and Supply Chain Management
	Thesis : "Outsourcing in Transportation"
2002-2005	1st Grammar School in Oswiecim

Foregin Languages

- English – fluent
- German - fluent
- Spanish – basic

Professional Experience

Since 10.2009	Sales Administration Specialist
	Logistics Department Valeo Electric and Electronic Systems Sp. z o.o
01.03.2009-31.06.2009	Student Assistant
	Chair of Production and Operations Management University of Vienna
01.07.2008-31.08.2008	Supply Chain Trainee
	Logistics Department Valeo Electric and Electronic Systems Sp. z o.o.