Review of Full Truck Load (TL) Transportation Service Procurement

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Abstract

The aim of this work is to review the literature on full truck load transportation service procurement and identify the gaps from the points of view of researchers and practitioners. Full truck load procurement is particularly considered for review since it is encountered more in freight movement than others forms and also it has many challenges. A framework is developed to have a systematic review of literature and the findings are discussed in detail. Some key findings include the simplistic assumption of demand pattern, less focus on non-price variables, a limited number of case studies, a lesser consideration of sustainability aspects and the lack of detailed studies on emerging economies.

Keywords— Transportation service; full truck load; procurement; review

1. Introduction

Outsourcing logistical activities have become common in various industries. Mostly companies (shippers) try to establish long term service agreements with the logistics service providers (carriers) in the form of two or three year contracts, known as contract logistics. Growth of contract logistics is tremendous across the world, according to the report of Transportation Intelligence (2012). The region wise global logistics market is estimated at 42.6% in Asia Pacific, 18% in Western Europe, 17.7% in USA and 21.8% in rest of the world. The global logistic market worth 1216 Billion USD and the contract logistics market accounts to 15.7% (TI Global Contract Logistics 2012). Country wise contract logistic market is detailed in the table 1.

Insert Table 1 about here

The growth of contract logistics is promising and, at the same time, presents several challenges. According to the survey conducted by the American Transportation Research Institute (2011), several issues identified as critical are ranked in Table 2.

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Four out of five top critical issues (economy, hours of service, drivers shortage and fuel price) are related to operational efficiency. The others are related to safety, congestion, finance, infrastructure and technology. According to Rajagopal (2009) the operational inefficiency is the universal concern and it has to be improved. On the operational efficiency front, the contract logistics purely depends on the economic situation of the country and that has a huge impact upon the customer demand as well as the freight demand. The hours of service refer to the drivers working hours that have to be regulated in order to minimize the driver's fatigue. The pragmatic issue for the logistics service provider is the availability of qualified drivers. This will become one of the important problems in the trucking industry in the next decade (American Transportation Research Institute 2011). Accordingly, there is an urgent need to develop methods for improving the quality of life of the drivers so that they will remain in this industry. Studies relevant to environmental sustainability measures like clean truck program and its associated health benefits (Lee et al. 2012; Sathaye et al. 2010 ; Konur 2014) are found in the literature, but it is limited.

Other than the operational efficiency front issues, the study by Huang and Lin (2010) points out few more external issues that would force the carriers to increase their efficiency, such as the rising cost of energy, the infrastructural bottlenecks, the restrictive legal regulations and the tough competition within the transportation sector. Apart from the above, it has been proved that the political environment (Zvirblis and Zinkeviciute 2008) and compatible operating systems have a huge impact on the performance of the transportation service provider (Punakivi and Hinkka 2006).

Besides the overall macro level challenges in contract logistics industry, it is also interesting to notice micro level challenges within trucking industry from the shipper and carrier perspectives (Inbound Logistics 2011; Zhang and Figliozzi 2010). These micro level

challenges based on the empirical survey conducted by Reilly (2011) among motor freight carriers and shippers and the details are shown in Table 3.

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Usually, Shipper level expectation is to obtain high quality service with low cost, whereas carriers' challenges are oriented towards operating at low cost abiding by various regulations. There is a compulsion for carriers to improve the operational efficiency. Also, it is to be noted that the degree of impact of the above mentioned challenges will vary with regional context. This paper aims to review the literature in transportation service procurement for a decade, i.e. from 2000 until 2013 to depict how far researchers have considered the various factors mentioned in the framework and to understand the current status of research with respect to each criteria. Most of contract logistics will ship the consignment as FTL. Hence, the paper only focuses on the full truckload (FTL) procurement process in contract logistics because its presence is more than any other transportation modes (Langenfeld et al. 2007). It is evident from table 4 that the volume of full truckload transport percentage is substantially higher than other modes of transport in various countries. The transportation service procurement process includes both bundled and unbundled purchases. Bundled procurement refers to purchase of service that includes total shipment comprising of freight transport, warehousing, customs clearance etc. Whereas unbundled purchases refers to pure freight transport. This paper considers unbundled freight transport service procurement because it is very hard to distinguish from the previous studies whether the procurement is bundled or unbundled. From the practitioner point of view, truck load transportation service procurement is an important activity because it has tremendous impact on the overall cost of business. In addition to the above recent study by Doll et al (2014) endorses the importance of transport service procurement and stated that the procurement contract decision has to be based on shorter product cycle time. Moreover turbulent factors such as oil prices, economic crises and environmental regulations imposed in various regions compels shippers and carriers to workout a suitable transportation service procurement contract to tackle the uncertainty. Considering the volume of FTL, FTL's impact on businesses, decision on FTL's contract length based on product cycle time and influence of turbulent factors on FTL agreement between shippers and carriers motivates us to relook the previous studies to

understand the FTL service procurement evolution over time and to identify potential research gaps.

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This work develops a framework to critically understand the inclusion of various challenges in the procurement process by researchers through various scholarly databases (Business source premier, ProQuest, MetaPress, Scopus, Emerald, Springer, Taylor & Francis, Informs, Ingenta, and Indersceince). As a matter of context in the field of study, Bontekoning et al. (2004) publish a review article discussing the inter-modal rail-truck transportation literature published between 1977 and 2001. They propose an inter-modal research agenda and derive insights to improve efficiency, profitability and level of competitiveness of intermodal transportation. With regards to the challenges reported in Table 3, the focus has shifted during the last decade. The need to address research works that have helped to solve the critical problems identified becomes then clear.

The major contributions of the paper are as follows. This review paper is the first one addressing the area of full truck load transportation service procurement. It reveals the research gaps in transportation service procurement with respect to criteria presented in the proposed framework. Moreover, this systematic review also emphasise the need to address sustainability aspects and economic regulations in the process of full truck load transportation service procurement.

The remaining part of the paper is structured as follows. The transportation service procurement issue is discussed in section 2. The framework for review is provided in section 3. The literature as per the framework is reviewed and discussed in section 4. Section 5 summarizes the key research finding and gaps. Finally, the paper concludes with future scope of research in transportation service procurement in section 6.

2. Procurement of transportation service

Truck load procurement process starts with call for quotation, which is initiated by the shipper, followed by bidding (bid generation) by various carriers who are interested in the offer. Carriers may then either bid for each lane individually or as a package bid called

combinatorial bids. After receiving bids from various carriers, the shipper's job is to evaluate the submitted bids and find out the winning bids (carrier assignment). Major research work is carried out with respect to both the bid generation and carrier assignment aspects. Various types of procedures adopted for transportation service procurement auction are given in detail in appendix.

3. Framework for review

This paper classifies the literature in full truckload transportation procurement published from 2000 up to 2013 based on the framework shown in figure 5. Two common methods used for conceptual classification are taxonomies and topologies (Autry et al. 2008). This framework is based on the taxonomy proposed by Carter and Jennings (2002) in logistics social responsibility (LSR). In general, transportation service can be either procured on spot market (one-time procurement) or on the contract market if there is a long-term agreement to move the loads. Contract market includes FTL and less than truckload (LTL). Also, a recent study discusses the shipment size and selection of corresponding truck size in each lane (Abate et al. 2014).

Insert Figure 1 about here

In FTL transportation, the truck moves directly from the origin to the destination without visiting any intermediate locations, whereas the LTL carriers require the use of terminals and scheduled routes to collect smaller shipments and consolidate them into larger loads. Out of the two, FTL's contribution to the contract market is higher than LTL (Tsai et al. 2009). It is important to note that the freight rates of LTL are generally higher than that of FTL. But, FTL freight transportation market of US is 524 Billion USD which accounts for 75.4% of the total freight transportation market. On the other hand, LTL contributes to only 40 Billion USD with the market share of 5.8%. (American Trucking Associations, 2010) Similarly, in European Union, FTL is 72 Billion USD market where as LTL volumes 32 Billion USD (The Statistics Portal). FTL procurement process has two major modelling issues such as bid generation problem (BGP) and carrier assignment problem (CAP). BGP is to be solved by the carrier (bidder) with the general objective of maximizing the profit. In this stage, the carriers

have to decide on the lanes they have to bid for and on their rate. This leads to the complex combinatorial optimisation problem.

The problem of Carrier Assignment consists of finding the optimal allocation of lanes to the bidders that minimizes cost. It is a NP-hard problem (Rothkopf et al. 1998) in which the magnitude of difficulty increases according to the number of lanes to be assigned. Both shippers and carriers in trucking industry wish to operate efficiently (Ergun et al. 2007). This can be achieved either by collaboration between shippers or among carriers. In shipper collaboration setting, shippers can identify collaborative routes with reduced empty-haul movements. Similarly, carriers collaborate with each other depending upon their regional network so that empty haul movement can be reduced.

The demand of loads to be moved in each lane by the carrier is normally assumed as constant in most of the literature. In practice, seasonal and stochastic demand is frequently encountered. The objective of the problem (for both BGP and CAP) is generally cost oriented although there are some other non-financial objectives that are mentioned by Sheffi (2004), such as on-time performance (both transportation time and response time), familiarity with the shipper's operations, availability of the right equipment, carriers' non-transportation activities (such as collecting payments and delivery beyond the receiving dock), and pick-up performance.

4. Review of the literature

The literature in FTL transportation service procurement is reviewed based on the framework shown in the figure 5. The criteria considered by researchers as per the framework are shown in Table 5.

4.1. Type of the problem

As far as literature on Truckload procurement is concerned, the focus is mainly on either BGP or CAP. Some of the authors discussed the collaboration, either at the shipper level or among carriers.

4.1.1 Bid Generation Problem (BGP)

BGP is a problem handled by the bidder, namely the carrier. In the case of individual lane bidding, setting the bid price for a particular lane is simple since it depends upon the existing lane coverage in the region. If there is an economy of scope, then bid price is competitive. In recent times, the use of combinatorial bidding is very popular because it can overcome the exposure problem. In combinatorial auction, shipper request carriers to bid in the form of lane packages. The carriers form their packages based on their own economics, their existing client base, their driver's domiciles, and their underlying maintenance networks (Sheffi 2004). In this setting, the carrier's major goal is to identify and take advantage of interdependencies in their transportation operations, and to determine the optimal utility maximizing the packages to bid for. As it is a non-linear integer programming and NP-hard problem (Lee et al. 2007), the problem has had reasonable attention among researchers and the contribution other researchers in this area is discussed in detail.

Lee et al. (2007) develop a model that integrates route (package) generation and selection simultaneously and present a column generation approach to solve the underlying non-linear quadratic integer programming problem. The model represents a utility maximizing decision problem that carriers can use to determine the best packages for bidding in a combinatorial auction. The model trades off revenue from servicing a set of lanes and repositioning cost. The algorithms for the carrier model can handle scenarios involving hundreds of lanes. Song and Regan (2005) examine computationally tractable approximation methods for estimating bid values and constructing bids. The benefit of the approximation method is that it provides a way for carriers to identify their real costs and construct optimal or near optimal bids by solving a single NP-hard problem. This represents a significant improvement in the computational efficiency. The method is evaluated both analytically and using simulation.

The bidder's optimality criterion of a combinatorial bid is addressed by Wang and Xia (2005) who use the bundling method to solve the problem. This heuristic is comparable with a simple nearest insertion method. Simulation results show that the former outperforms the latter in most cases. Chang (2009) aims to develop a bidding advisor to help truckload (TL) carriers to overcome such challenging problems in one-shot combinatorial auctions. Their proposed advisor integrates the load information in e-marketplaces with carriers' current fleet management plans, and then chooses the desirable load bundles. They formulate it as a synergetic minimum cost flow problem by estimating the average synergy values between loads and attempt to solve it through approximation method.

4.1.2 Carrier Assignment Problem (CAP)

This problem encounters the bid analysis stage of transportation procurement process, which is NP-complete problem (Sandholm 2002). A Carrier Assignment Problem (CAP) aims to minimize the shipper's total costs, while ensuring that each lane is served and its required capacity is satisfied. In (Guo et al. 2006), the objective is to solve the winner determination auctions for transportation procurement to include shipper non-financial objectives and carrier transit point costs. The model includes penalty and transit point costs. The optimisation process uses Branch and Bound (B&B), Genetic Algorithm (GA), Tabu Search (TS) and combination of Genetic Algorithm and Tabu Search (GA+TS) for the new model. Computational experimentation shows that Meta-heuristics perform well for small size problems but do not guarantee good performance for large size problems. As far as computational time is concerned, branch and bound requires considerably more time than Meta-heuristics. Among Meta-heuristics, performance and computational time is better for TS and GA + TS than GA.

Yadati et al. (2007) consider the case in which the suppliers provide a quantity-discount function of prices, instead of a single bid. The winner determination problem in this case is NP-hard since this is a generalization of the normal bidding process. They develop mathematical programming formulations for winner determination that are applicable to hybrid procurement mechanisms. They present a heuristic solution scheme, where solutions are constructed in a greedy manner.

Ma et al. (2010) propose a two-stage stochastic integer programming model for the CAP in combinatorial auctions to hedge the shipper's risk under shipment uncertainty. In addition, many other important comprehensive business side constraints are included in the model. Computational results indicate that moderately sized realistic instances can be solved by branch and bound method using commercial solvers in reasonable time. Tian et al. (2011) propose mixed integer programming and heuristic methods to solve CAP in combinatorial auction setting. In the winner determination problem, Rekik et al. (2012) propose to consider the reputation of carriers. Allocation of lanes is based on both bidding price and reputation of the carrier.

4.1.3 Collaboration

Carriers constantly seek ways to reduce operating costs as substantial fraction of a truckload carrier's operating costs comes from the repositioning movements of its trucks (no revenue is generated as the truck moves empty, but costs are incurred). Consequently, minimizing repositioning movements of trucks is one of the primary objectives of dispatching truckload carriers (Kuyzu 2007). By collaboration, empty movement of trucks can be minimized by forming cycles, thus carriers costs are reduced. A portion of the carrier's cost saving is shared with the shipper in the form of lower price for freight movement (Verdonck et al 2013). Ergun et al. (2007) discuss the optimization- based techniques used in the identification of repeatable, dedicated truckload continuous move tours with little truck repositioning. Ozener and Ergun (2008) develop cost-allocation mechanisms using cooperative game theory. They define a set of new properties, such as a guaranteed discount from the standalone cost for each shipper, and propose several cost-allocation schemes that could lead to implementable solutions. A computational study on randomly generated and real-life data is performed to derive insights on the performance of the allocation schemes developed. Berger and Bierwirth (2010) consider a network of collaborating freight carrier companies that provide an equivalent transport service in their regional areas. They propose a framework for post market based optimization to improve the network profit. A Lane exchange mechanism is proposed by Ozener et al. (2011) for truckload carrier collaboration, which differs from others in terms of information sharing requirements. Gujo and Schwind (2008) and Schwind et al. (2009) propose a Combinatorial Exchange (comEx) mechanism for collaboration. Schwind et al. (2009) present ComEx system for auction based exchange of delivery routes among profit centres. Gujo and Schwind (2008) propose ComEx for exchanging the delivery contracts. They adopted this study in medium sized food delivering industries organized in profit centre structures.

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4.2. Problem Objectives

4.2.1 Cost objective

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In BGP, the objective is to maximize the profit (Berger and Bierwirth 2010; Chang 2009; Lee et al. 2007; Song and Regan 2005; Song and Regan 2003; Wang and Xia 2005). In the case of CAP, the objective is minimizing the transportation cost (Caplice and Sheffi 2003; Caplice 2007; Cohn et al. 2008; Lim et al. 2008; Ma et al. 2010; Srivastava et al. 2008; Yadati et al. 2007).

The general formulation of the optimisation problem for BGP is as follows.

$$\text{Maximize } R = \sum_j a_j z_j$$

Where,

R - Revenue generated by serving the lanes

a_j – Asked price for serving lane 'j'

z_j – Decision variable.

Berger and Bierwirth (2010) aim to maximize the total profit of Collaborative Carrier Network (CCN). The objective of minimizing the net total cost is considered in Chang (2009). Lee et al. (2007) solve the BGP with the objective of maximizing the profit. They make use of decomposition strategy to reduce the complexity of the problem. A bid construction problem with the objective of minimizing the empty movement cost is dealt by Song and Regan (2005). Wang and Xia (2005) formulate the BGP with the objective of minimizing the distance covered to reduce the transportation cost.

Similarly, the objective of CAP takes the form

$$\text{Minimize } C = \sum_i \sum_j b_{ij} x_{ij}$$

Where,

C - Total transportation cost spend by the shipper

b_{ij} - Bid value of the carrier 'i' for serving the lane 'j'

x_{ij} – Decision variable expressing whether the carrier i is assigned to the lane j.

Ma et al. (2010) develop a stochastic winner determination model with the objective of minimizing the total expected purchasing cost. Minimizing the total cost involved in transportation is the objective considered by few researchers (Caplice and Sheffi 2003; Caplice 2007; Cohn et al. 2008; Srivastava et al. 2008; Yadati, Oliveira and Pardalos 2007), whereas maximizing the total saving is the objective considered by Lim et al. (2008).

4.2.2 Non Price objective

Beyond the cost objective, there are many other objective types, which are very important from the operations perspective. This includes on-time performance of the carrier, familiarity with shipper's operation, availability of right equipment, pick up performance, and billing accuracy. Guo et al. (2006) and Sheffi (2004) discuss the non financial objective. Guo et al. (2006) aim at minimizing total transportation cost considering the non financial objectives. The benefits of using combinatorial auction and the importance of considering non financial objectives are studied in detail by Sheffi (2004). Coulter (1989) categorizes the customers of transportation service into six groups and analyses the influence of the factors such as reliability of performance, insurance of service provision, quality of service, personalizing factor and handling services for each group. They offer strategies for each segment of customers based on these five factors. Rekik et al. (2012) include service attributes in terms of hidden cost and this cost depends upon the reputation of the carrier. Reputation is evaluated through different service attributes and corresponding weights assigned for each carrier based on previous performance.

4.3. Market considered for analysis

4.3.1 Contract Market

In contract market, shippers allocate lanes to the carriers such that the particular carrier would haul the agreed amount of loads in long term basis. This market is given more attention in the literature (Caplice and Sheffi 2003; Caplice 2007; Chang 2009; Ergun et al. 2007; Figliozzi et al. 2006; Guo et al. 2006; Lee et al. 2007; Lim et al. 2008; Ma et al. 2010; Sheffi 2004; Song and Regan 2005; Song and Regan 2003; Wang and Xia 2005; Yadati et al. 2007; Rekik et al. 2012; Zhang et al. 2014). Ergun et al. (2007) discuss the cycle generation in collaborative market place. Andersson and Norrman (2002) compare the purchase of basic and advanced logistics services. They emphasize the need for reducing the time spent in establishing contracts between shippers and carriers. In general, the negotiation process takes one or two years because of uncertainty and other complexity involved.

4.3.2 Spot Market

Spot market is also addressed by the various researchers (Agrali et al. 2008; Berger and Bierwirth 2010; Figliozzi 2004; Figliozzi et al. 2003; Garrido 2007; Mes et al. 2009; Robu and Poutre 2009; Xu et al. 2013). In the spot market, the purchase of logistics services is one

time and the volume of load moved is relatively small. Usually in the market, both local and in-transit carriers would be competing for winning lanes/loads. Analytical models are available to analyse the effect of various system parameters such as order, carrier arrival and abandonment rate on the system performance. Berger and Bierwirth (2010) develop a framework for collaboration among carriers in a competitive market setting. Figliozzi (2004) discusses the truckload procurement in spot markets using a sequential auction format. Figliozzi et al. (2003) analyse online transportation market place using an agent based system. Garrido (2007) studies the procurement of transportation services based on the fact that empty movements may be used with real time information about shipper's needs to exploit spot market opportunities. Mes et al. (2009) develop profit maximization strategies for shippers in the spot market. A partial truckload transportation auction model in spot market is considered by Robu and Potre (2009). Xu et al. (2013) proposed solution methodology to address transportation service procurement with asymmetric demand and supply pattern in spot market.

4.4. Nature of demand

4.4.1. Constant demand

In most of the studies, demand for load to be moved in each lane is generally assumed to be constant in order to reduce the complexity of the problem (Sheffi 2004; Wang and Xia 2005). In some cases, unit demand is considered for simplification (Ergun et al. 2007; Guo et al. 2006; Lee et al. 2007; Mes et al. 2009; Song and Regan 2005; Song and Regan 2003). Moreover, some authors formulate the models based on the known demand, which is an estimate of previous data (Caplice and Sheffi 2003; Caplice 2007; Chang 2009; Garrido and Mahmassani 2000; Yadati et al. 2007; Rekik et al. 2012). An estimate of loads per week or month is accounted in the mathematical model developed by Caplice (2007). Chang (2009) assumes that the total quantity of load to be moved consists of auctioned load, booked load and forecasted load. To estimate the freight demand, Garrido and Mahmassani (2000) propose a Multinomial Probit (MNP) model and apply it to an actual data set in order to evaluate its performance. Yadati et al. (2007) allow the carriers to submit a bid price for each lane along with the range of volume of loads to be moved. Figliozzi et al. (2004) study various technologies available in the dynamic vehicle routing problem to compare the performances of different technologies.

4.4.2 Variable Demand

The condition of variable demand nature of loads to be moved in each lane is also discussed in a few works (Agrali et al. 2008; Garrido 2007). Moreover, a seasonality factor is considered by Lim et al. (2008). Agrali et al. (2008) propose an analytical model to analyse the performance of the logistics spot market in Turkey. One of the important features of the model is that it can also be applied to other procurement auctions where the number of participants varies randomly over time. Spot market case is studied by Garrido (2007) using double auction system to match demand and supply.

4.4.3. Stochastic demand

Very limited works address the stochastic nature of demand. Ma et al. (2010), developed a two stage stochastic model for the carrier assignment problem taking into account shipment volume uncertainty. Zhang et al. (2014) is also attempted to solve two stage stochastic WDP by using Monte Carlo Approximation method.

4.5. Lane bid type

4.5.1. Single bid

In this type, carriers bid for individual lanes. Agrali et al. (2008) adopt a reverse auction in logistics spot market, where a shipper initiates the auction process by releasing transportation order. The carriers who are interested will bid on line. Based on the received bids, the carrier with the lowest bid price will be awarded the particular order. Their logistic market setting has three parties: shippers, local carriers and in-transit carriers. Figliozzi et al. (2006) study a logistics market operating in real time and in which the auction is performed one at a time as the shipment reaches the auction market. Mes et al. (2009) discuss the automated transportation market where bids are initiated for a single lane and use a threshold price for continuous auction. Figliozzi et al. (2005) compare the performance of different sequential auction settings used in truckload transportation service procurement. Computational experiments shows that auction setting and information disclosure affect the performance of truckload procurement market.

4.5.2 Combinatorial bids

Auctions where bidders are allowed to submit bids on combinations of items are usually called combinatorial auctions, a topic which receives much attention among researchers

(Vries and Vohra 2003). Combinatorial bid is more attractive because of the potential advantage over individual bids (Berger and Bierwirth 2010; Caplice and Sheffi 2003; Caplice 2007; Chang 2009; Cohn et al. 2008; Guo et al. 2006; Lee et al. 2007; Lim et al. 2008; Ma et al. 2010; Sheffi 2004; Song and Regan 2005; Song and Regan 2003; Srivastava et al. 2008; Wang and Xia 2005; Yadati et al. 2007; Tian et al. 2011; Rekik et al. 2012; Zhang et al. 2014). Berger and Bierwirth (2010) develop a combinatorial auction for the reassignment problem in collaborative carrier networks.

Chang (2009) develops a bidding advisor to create combinatorial bids in the one shot combinatorial auction in spot market. Cohn et al. (2008) develop an implicit bidding mechanism for solving fully enumerated combinatorial auction in a single round. Guo et al. (2006) attempt to solve a CAP with combinatorial bids using optimization models including shipper's non-price business objectives. Lee et al. (2007) propose an integrated model for simultaneous route generation and selection for carrier's bid generation problem under combinatorial settings. Ma et al. (2010) develop a two stage stochastic model for CAP in combinatorial auction. Sheffi (2004) emphasizes the need to use combinatorial auctions in order to exploit the economies of scope in transportation service procurement. Moreover, the use of optimization techniques in CAP has the added advantage of dealing with non-price attribute and system constraints. Song and Regan (2005) propose an optimization based bid construction strategy for BGP to investigate the benefits of using combinatorial auction from the shipper and the carrier perspectives.

Song and Regan (2003) analyse shipper and carrier problems related to transportation service procurement process based on combinatorial auction. Benefits of combinatorial auctions are compared with traditional call for quote and negotiation procurement. Srivastava et al. (2008) propose combinatorial auction based methods for global logistics procurement. Wang and Xia (2005) discuss the formation of combinatorial bids in Bid Generation Problem. Yadati et al. (2007) consider hybrid combinatorial auctions in CAP for transportation service procurement. A hybrid auction is where a carrier not only gives the price for each lane but also the relationships between the different prices and different quantities of items moved in a particular lane.

4.6. Nature of work done

4.6.1 Conceptual developments

There are several theoretical studies that report issues and challenges in transport service procurement without any mathematical or simulation models (Caplice and Sheffi 2003; Garrido 2007; Sheffi 2004; Srivastava et al. 2008; Rekik et al. 2012). Caplice and Sheffi (2003) discuss the transportation service procurement as a whole in which uncertainty in bidding, carrier assignment model, business considerations and other lessons based on practice are expressed in detail. Sheffi (2004) studies the benefits of having combinatorial bidding in transportation service procurement and also the importance of considering non price attribute in carrier assignment problem. The scope, challenges and design issues in modelling global logistics procurement are discussed by Srivastava et al. (2008). Rekik et al. (2012) introduce the concept of reputation-based allocation of lanes to carriers in truckload transportation procurement auction for long term contract.

4.6.2 Mathematical Modelling Approaches

Most of the studies attempt to develop mathematical models and propose appropriate solutions. Berger and Bierwirth (2010) consider collaborative carrier networks where carriers exchange lanes in order to maximize the total profit without decreasing the individual profit of the carriers. Chang (2009) develops a bidding advisor for solving BGP as minimum cost flow network model. His approach is to formulate the problem as a collaborative carrier routing problem and try to solve it using a heuristic procedure. Ergun et al. (2007) develop a model for cycle covering problem involved in shipper collaboration and solve it using a heuristic procedure.

Guo et al. (2006) formulate a mathematical model for CAP including cost involved at transit points in order to make more realistic models. A combination of Branch and bound technique and a heuristic is used to find a solution to the problem. Lee et al. (2007) develop a nonlinear integer programming model for bid generation problem with the objective of maximizing the profit and solve it by using Branch and Bound method. Lim et al. (2008) formulate an integer programming model for carrier assignment problem considering the aspect of minimum volume guarantee to the carriers which smoothen the irregularities in demand of freight movement on each lane. Ma et al. (2010) formulate a two stage integer programming model for CAP, considering stochastic nature of demand of loads to be hauled in each lane. Mito and Fujita (2004) consider the general winner determination problem and proposed a heuristic to solve it. They prove the effectiveness of the proposed heuristic over conventional

solution methodologies. Özener and Ergun (2008) consider the cost allocation problem in the shipper collaborative environment and derived an effective mechanism for cost allocation among shippers in order to maintain the collaborative structure. Yadati et al. (2007) formulate an integer programming model for a hybrid carrier assignment problem with a heuristic algorithm to solve the same. A mixed integer programming model is proposed by Tian et al. (2011) and the CPLEX solver is used to solve the developed model.

4.6.3 Simulation techniques

Simulation based studies are widely used in transportation service procurement. Agrali et al. (2008) use a simulation study to identify the effect of various factors such as order time, carrier arrival time and abandonment rate on the performance of the spot market where both local and in-transit carriers compete for transportation orders. Chan and Kroese (2008) use two randomized algorithms namely Cross-entropy based algorithm and simulation based on Markov chain Monte Carlo techniques to solve the WDP. Monte Carlo Approximation method is used by Zhang et al. (2014) for solving two stage stochastic WDP under volume uncertainty. Figliozzi et al. (2003) develop a simulation based framework using agents for market place, shippers, and carriers to analyse the complexity of the engineering and economic processes involved in transportation market place.

Figliozzi et al. (2006) derive an expression for opportunity cost in sequential auction for transportation service procurement and use a simulation framework to evaluate different strategies adopted. Mes et al. (2009) conduct a simulation study to analyse the performance of the dynamic threshold policy adopted by the shipper in spot market environment. Song and Regan (2005) conduct a simulation based experiment to examine the performance of proposed bid construction method involved in BGP. Their study reveals that the performance of the proposed methodology in terms of number of new lanes is high and that the empty movements are comparable to the results of the traditional techniques. A framework for modelling a full truckload transportation network is developed by Rossetti and Nangia (2007) who prove its helpfulness in simulating real networks.

Multi-agent technology can be used as an important tool in transportation service procurement process. Lavendelis and Grundspenkis (2006) discuss the use of agent technology in multi criteria decision making involved in transportation service procurement.

Robu et al. (2011) provide insight into the effectiveness of application of agent based system in day-to-day transportation outsourcing activities. An agent based framework for freight transportation system is modelled by Roorda et al. (2010) and used in business decision making, including logistic service contract, and provides sensitivity analysis with respect to technological trends, business trends and policy scenario.

4.6.4 Case Study

Case studies in full truck load transportation service procurement are carried out by very few researchers (Agrali et al. 2008; Ergun et al. 2007). Agrali et al. (2008) consider the logistic spot market in Turkey, namely the ESO Logistics Centre. Ergun et al. (2007) use data obtained from Strategic sourcing consortium for $14 billion sized US industry to test the effectiveness of the algorithm developed for lane cycle generation. Tian et al. (2011) consider the transportation service procurement process of Royal Philips Company for the analysis and solve by using a heuristic method and Integer programming model.

5. Key findings and research gap

50 peer reviewed journal articles from 2000 to 2014 are selected (searched via Emerald, Ingenta, Inderscience, Business Source Premier, Springer, Taylor & Francis, Informs, MetaPress, ProQuest, and ScienceDirect), reviewed and analysed based on our framework. Figure 2 depicts the number of papers published per year. The first observation is that there is an increase in the number of publications during 2008 and 2009. One of the reasons is to address the cost minimization challenges in the trucking industry during the period of recession.

Table 6 shows the distribution of the literature according to classification criteria considered in the framework. It is clear from the table 6 that CAP is more addressed by the researchers than BGP. Furthermore, any non-price objectives are given a low importance.

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Insert Figure 2 about here

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5.1 Problem type

The truckload service procurement process is carried out using an auction mechanism. In this procedure, two phases are important, namely bidding by the carriers and determining winners of various lane bids by shipper. The former problem is known as Bid Generation Problem (BGP) and the latter is the Carrier Assignment Problem (CAP). As far as the problem considered by the researchers is concerned, the number of works addressing CAP is higher than BGP. The reason behind the difference is that the complexity involved in solving CAP is comparatively higher than that of BGP. In today's online truckload allocation market situation, it is difficult to generate bids. BGP is developed as a bidding advisor to the carriers in spot market as well as in contract market. With the evolution of combinatorial bidding, solving BGP is more critical. On the same note, solving CAP becomes a more tedious task.

Insert Table 6 about here

5.2 Objectives

The objective of the problem discussed in the literature, whether it is a Bid Generation Problem or Carrier Assignment Problem, is mostly cost oriented. Various non financial objectives such as service level, percentage of acceptance of new loads, response time, billing accuracy, etc. are given less attention. In addition, the literature addressing collaboration issues needs more focus to unearth new ways and means of reaching effective lane cycle formation and cost allocation mechanism among the partners, in order to maintain the collaboration.

5.3 Bid type

From the survey, it is clear that the use of combinatorial bidding is promising for full truckload transportation service procurement. Benefits of using combinatorial auction are clearly explained especially in (Ledyard et al. 2002). In a combinatorial auction, a carrier could submit single bids for several distinct lanes. If a particular bid is successful, then the

carrier would obtain the right to serve all lanes within the set (package) submitted. Otherwise there would be no obligation to ship any incomplete set. This would minimize the risks for carriers in obtaining only a subset of lanes that are not worth much, or that would incur a loss in servicing the incomplete set of won lanes due to different repositioning costs.

5.4 Type of Market

Contract market is widely considered by researchers because of the amount of load to be hauled by the carrier on the one side, and the period of agreement between the two parties (shipper and carrier) on the other side, which is considerably higher compared to spot market. The contract is always associated with terms and conditions upon which both parties agree. Works do not only focus on establishing contract but also on sustaining it. For the one time procurement of transportation service, spot or online market is best suited. In this aspect, there is quite a considerable number of works considering procurement scenario in spot market. Moreover, few authors consider the use of agent technology in full truckload procurement. Further research can be carried out using intelligent agent system with more realistic input to agents. Similarly, works may be done to include a number of carrier performance measures during the period of contract for the next allocation period.

5.5 Collaboration

Both shipper collaboration and carrier collaboration are addressed in the literature. The objective is mainly to minimize the empty movement of trucks in the case of carrier collaboration, so that their profit is maximised. In addition, there are works emphasising the strategies to be adopted for maintaining the collaboration. However, the survey shows that only a limited number of works are carried out with a collaboration perspective. Some real life information and data regarding shipper or carrier collaboration can also be used to unearth more findings.

5.6 Demand consideration

In most of the papers, it is assumed that there is a unit demand in all the lanes for simplification of the problem (i.e. the number of loads in each lane is equal to one). In some other papers, the demand is determined by forecasting techniques and used in the assignment of lanes to carriers. But in practice, there is always an uncertainty over the amount of loads to be moved in each lane. In truckload procurement auction, most of the lanes are specified with the volume to be moved as an estimated quantity. Lanes are awarded before the actual

volume requirements are known. Thus, assignments of lanes to carriers may not be optimal after the volume uncertainty is resolved. For example, a carrier that wins a set of lanes may be asked to ship less volume than actually awarded and thereby portion of revenue may be lost. Sometimes, the volume may be greater than the expected amount such that an assigned carrier may not have sufficient truckload capacity. In this case, the shipper may need to procure additional third-party services at extra cost to meet the actual volume demand. In either case, uncertainty can have a detrimental effect and the Carrier assignment Problem (CAP) should properly account for this possibility. This demand uncertainty factor is only addressed by Ma et al. (2010). There is then more scope for work addressing stochastic demand pattern involved in lane estimation for truckload procurement.

5.7 Nature of Work done

One of the most important findings is the limited number of real-world cases; very few authors have conducted case studies. Procurement of transportation service with respect to emerging economies has not been studied so far. Some of the reasons are the low penetration rate of modern logistic concepts and freight transport and the lack of good infrastructure. As far as problem modelling is concerned, most of the literature has a focus on mathematical and simulation models, but few authors use meta-heuristics to solve the problem.

5.8 Work done in Regional context

The survey reveals that most of the research articles published in this topic are based on US logistic market. Almost 90 percentage of the literature deal with various issues in transportation service procurement which are based on US market. Most of the terminologies are also evolved from this region only. Few studies are also addresses the other markets such as China, India, Canada, Turkey etc., It is also observed from the survey that there is a wide gap between the developing and emerging markets in terms of infrastructure, technology, environmental regulation and so on. As an important observation of this study, it is identified that there is a huge opportunity for the researchers to carry out the case studies based on emerging logistic markets.

6. Conclusion

FTL transportation service procurement is an important logistical activity, as it will highly impact logistics cost and customer service. In this paper, Full truck load procurement is

considered for review. The review is based on a framework with several criteria such as problem type considered, objective, type of market, nature of demand, type of collaboration and the methodology used.

In terms of problem formulation, the inclusion of non financial objectives along with the cost related objective will yield outstanding results in truckload procurement auctions. Cycle generation methods are used by researchers to reduce empty movement of trucks. In this way, both shipper and carrier can benefit.

On the methodological side, future research directions should consider stochastic models for the truckload requirement in each lane, so that it will mimic reality. From the modelling point of view, both BGP and CAP are formulated as single objective problems. However, as the problem becomes complex, there is a need to consider multi-objective frameworks to cope with its real complexity.

The review work is completely based on the articles available in full truckload procurement and it outlines the current status and trend of research in this topic with the available articles. The paper simply elaborates the outcome of systematic literature review based on the framework considered without proposing solutions for specific cases of full truckload procurement.

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Table 1: Country wise contract logistic market

S.No	Country	Contract logistic Market in Million USD
1	USA	60739
2	Canada	5786
3	UK	22332
4	Germany	19629
5	France	10241
6	China	33690
7	Japan	21163
8	India	8049

Table 2: Issues in logistics and their Ranks

Rank	Issues	Rank	Issues
1	Economy	6	Congestion
2	Hours of service	7	Transportation funding
3	Driver shortage	8	Tort Reform
4	Implementation of safety rules	9	Onboard truck technology
5	Fuel price	10	Truck size and weight

Table 3: Typical challenges

Shippers Challenges	Carriers Challenges
1. Reducing transport cost	1. Driver related cost
2. Price pressure from customers/competitors	2. Fuel cost
3. Customer service	3. Equipment cost
4. Finding capacity	4. Safety regulations
5. Matching supply to demand	5. Insurance cost and liabilities

Table 4: Countrywise Truckload Market

S.No	Country	Billions of Tonne Kms	Percentage share by Transportation mode
1	US	1898.7	29.52
2	China	6740.4	35.56
3	EU	1740.3	44.76
4	Japan	379.3	62.54
5	India	9975.6	59.62

Table 5: Literature review summary based on the framework

S. No.	Author	Problem Type		Objective		Market considered		Collaboration Among		Demand		Lane Bid type		Nature of work			
		BGP	CAP	Cost	Non price	Truck Contract	Spot/For-hire	Shipper	Carrier	Known/Constant/unit	Stochastic/Seasonal	Single	Combinatorial	Conceptual	Mathematical	Simulation	Case Study
1.	Agrali et al. (2008)			X			X				X	X				X	X
2.	Berger and Bierwirth (2010)	X		X			X		X				X		X		
3.	Caplice (2007)		X	X		X				X			X		X		
4.	Caplice and Sheffi (2003)		X	X		X				X			X	X			
5.	Chang (2009)	X		X		X				X			X		X		
6.	Cohn et al.(2008)		X										X		X		
7.	Ergun et al. (2007)		X	X		X		X							X		X
8.	Ergun et al. (2007)			X				X		X					X		
9.	Figliozzi et al. (2003)					X	X									X	
10.	Figliozzi et al. (2006)			X		X					X	X				X	
11.	Garrido (2007)						X				X			X			
12.	Guo et al. (2006)		X	X	X	X				X			X		X		
13.	Lee et al. (2007)	X		X		X				X			X		X		
14.	Lim et al. (2008)		X	X		X					X		X		X		
15.	Ma et al. (2010)		X	X		X					X		X		X		

#															
16.	Mes (2008)			X			X			X		X				X
17.	Özener and Ergun (2008)			X				X							X	
18.	Rekik et al. (2012)		X		X	X				X			X	X		
19.	Sheffi (2004)		X	X	X	X				X			X	X		
20.	Song and Regan (2005)	X		X		X				X			X			X
21.	Song and Regan (2003)	X		X		X				X			X			X
22.	Srivastava et al. (2008)		X	X									X	X		
23.	Tian et al. (2011)		X	X		X				X			X		X	
24.	Wang and Xia (2005)	X		X		X				X			X			X
25.	Xu et al. (2013)		X	X			X			X		X			X	
26.	Yadati et al.(2007)		X	X		X				X			X		X	
27.	Zhang et al. (2014)		X	X		X					X		X			X

Table 6: Distribution of literature as per the criteria in framework

S.No.	Classifying Criterion	Type considered	No. of Papers published
1.	Problem Type	BGP	6
		CAP	11
2.	Problem Objective	Cost	21
		Non-Price	2
3.	Market considered	Contract	15
		Spot	5
4.	Collaboration	Shipper	3
		Carrier	2
5.	Demand of loads	Known/constant/ unit	12
		Seasonal/ Stochastic	6
6.	Lane Bid Type	Single	3
		Combinatorial	16
7.	Nature of Work	Conceptual	4
		Mathematical	12
		Simulation	8
		Case study	2
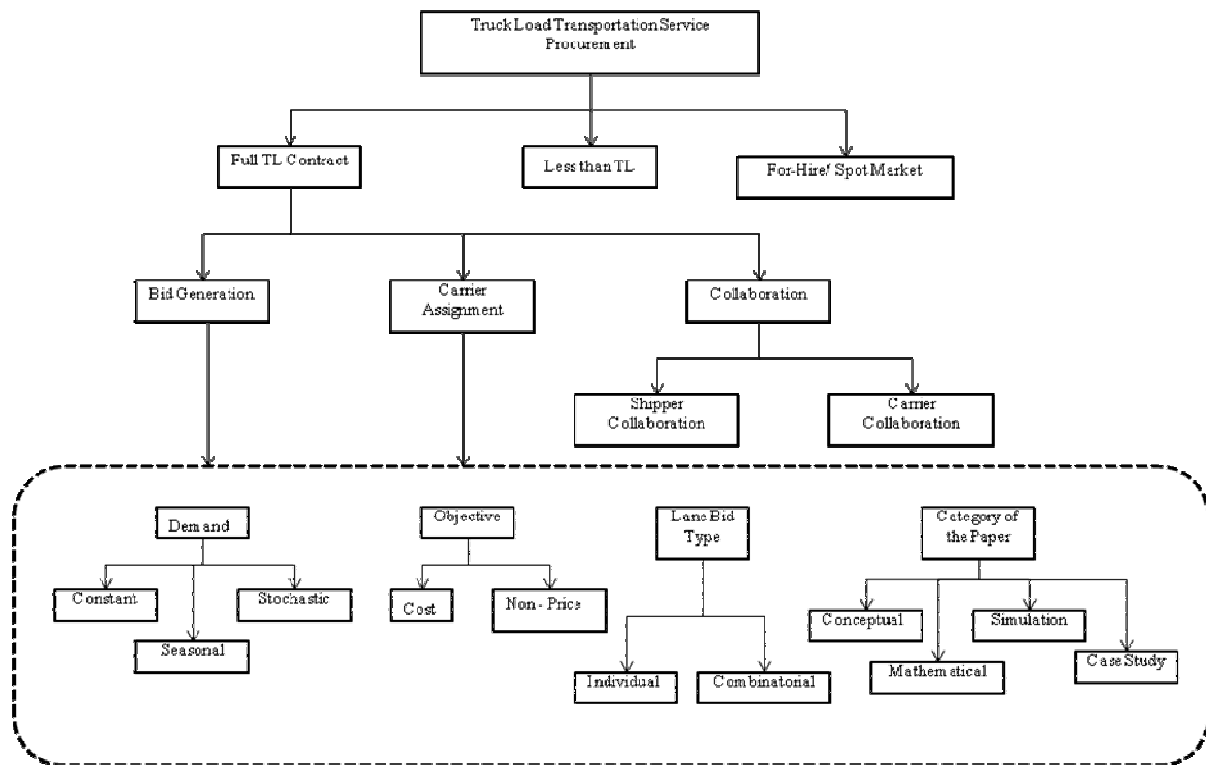
Figure 1: Framework for review of truckload transportation procurement
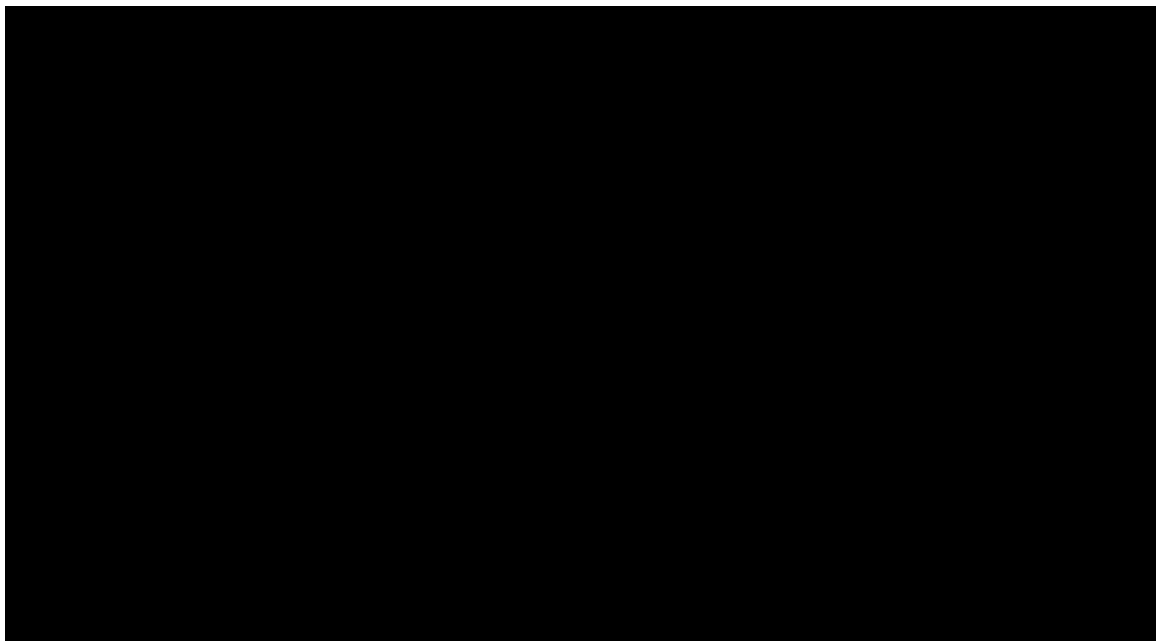
Figure 2: Literature published in transportation service procurement

Appendix: Terminology and process involved in transportation service procurement

A1. Terminology

As the area of FTL technically involves many concepts, which are of a high importance in the domain, the following terminology is adopted for this paper.

Shipper: Shippers may be manufacturers, distributors, retailers, and other organizations that need to move freight.

Carriers: Carriers are trucking companies that have trucks and other transportation facilities.

Lane: It is the basic unit of interest and is defined as a unidirectional movement from an origin to a destination for a certain time period.

Cycle: A cycle is a set of lanes originating and terminating at the same physical location. In general, cycle generation is achieved by shipper or carrier collaboration.

Individual Bids: Carriers submit bid for each lane separately, and the shipper will designate the winner based on the bid price for the particular lane submitted by carriers.

Combinatorial Bids: In combinatorial bidding, carriers bid for set of lanes and each carrier can submit any number of sets. If a carrier wins a particular set, then he has to haul all the lanes in the set.

Economy of Scope: The cost of serving a lane not only depends upon the amount of loads to be moved on that lane but also on the number of loads carried on other related lanes. Suppose a carrier is moving 10 loads from city A to city B and return to the city A without load (empty haul) for further loading. In this scenario, load from city B to city A will reduce the repositioning cost of the carrier, and it is referred as an economy of scope.

Empty haul: It is the empty movement of the vehicle from the delivery point to the home. This may be because of repositioning of the truck for further freight loading or change of driver or for servicing the vehicle, etc.,

A2. Process involved in Transportation Procurement

Shippers procure transportation services in order to move their loads, which are based on their freight forecast and planned freight cost. According to Caplice (1996), the procurement process consists of five steps: carrier screening, information exchange, carrier assignment, load tendering and performance review. The first three steps constitute the planning phase, and the last two steps are components of the execution phase as shown in figure A1.

Planning Phase

The first step in the planning phase is carrier screening. In this stage, the shipper filters the number of potential carriers to decrease complexity, reduce cost and increase service level. The second step is the iterative process of information exchange in which shippers and carriers exchange information about lanes, volume details and prices.

Insert Figure A1 about here

The shipper then assigns the carriers to its network and assembles the routing guide. The routing guide ranks which carrier is assigned to a specific load, based on the lane and capacity of the carrier during the execution phase. Routing guides can vary in complexity and range from a paper-based system to a central electronic database that uses sophisticated software to integrate the shipper to the carrier Enterprise Resource Planning (ERP) system. These systems are known as Transportation Management Systems (TMS) and have many capabilities to handle transportation planning and execution.

Execution Phase

The execution phase has two steps: load tendering and performance review. The Load tendering step selects the carrier for each load as it becomes ready to ship. Organizations must make real time choices picking alternative carriers to mitigate changes between planning and execution. These changes include adding, moving, adjusting and deleting freight volume as a result of anticipated activities such as closing of facilities, acquiring new suppliers or mergers with other companies. The final step is the performance review of the carrier. The performance review includes some measures such as the carrier refusal rate and

the on-time rate. Generally, long term contracts are established by the manufacturing industries with carriers by following the above set of procedure and in logistic terms it is a part of contract logistics. The volume of the market can be understood from the figure A2, which shows the revenue of the world top 5 contract logistic companies in the year 2013.

Insert Figure A2 about here

Ma (2008) uses a similar procedure to explain the overall procurement process for transportation services. In addition to the activities in the comprehensive procurement process, multi round auctions for transportation procurement have few more activities as shown in figure A3. Multi round auction has the advantage of adjusting different strategies by the bidders based on the price change. In this type of auction, the winner of the first round is determined, and then bidders are called for second round. The package submitted by the carriers for the second round may be different from the previous one. This procedure is repeated until stopping criteria are achieved.

Insert Figure A3 about here

According to Chen (2010), in a basic truckload procurement auction, the auctioneer specifies a set of bid lanes, each defined by an origin, a destination and expected number of loads. Given a bundle of bid lanes, carriers determine the least-cost set of tours to serve these bid lanes, then use this cost to calculate their bid price for this particular bundle. Finally, the auctioneer solves the winner determination problem (WDP) to select bundles and allocate the corresponding lanes to the winning carriers. Demand driven online market situation is explained by Mes (2008) and shown in figure A4.

Insert Figure A4 about here

Shippers post their required number of full truckloads online and the carriers bid for it based on their on-hand open capacity. If the requirement and the available capacity match, an agreement is then reached. As a next step, vehicle scheduling consists of allocating each load to a vehicle and a driver. Carriers may be able to find out the remaining available capacity after including the loads in their schedule. The carrier searches for online jobs to match the ready for use capacity in an iterative manner. This type of procedure is followed in for-hire truckload industry, an important logistic sector in developed market like US. In US, it accounts to 300 Billion USD (Schulz. 2014).
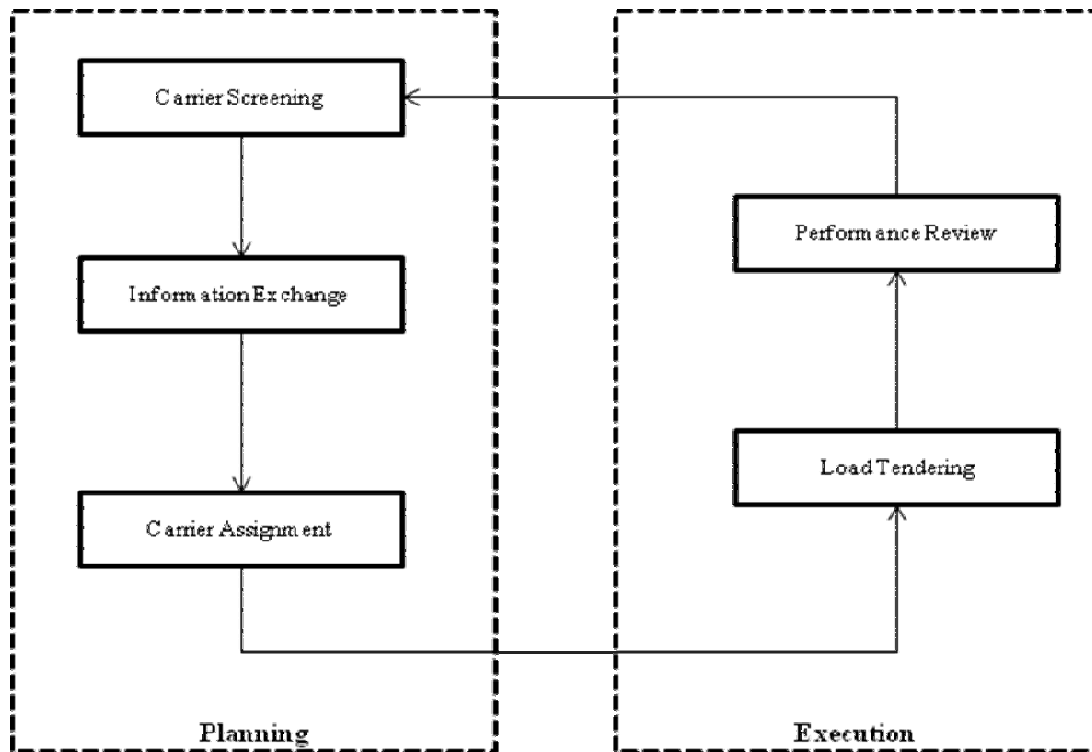
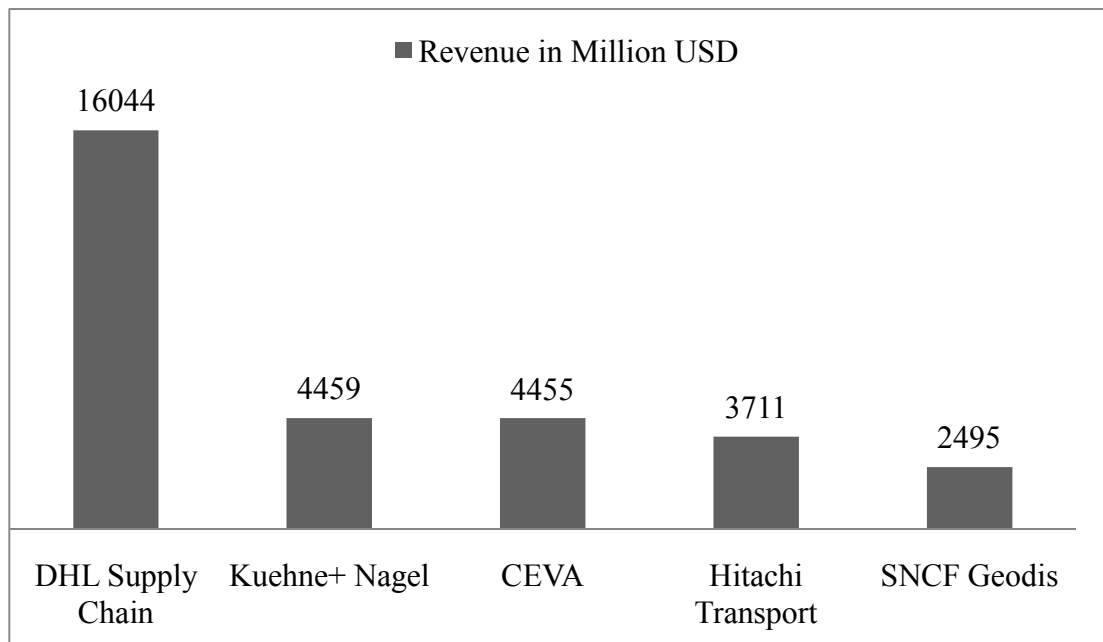**Figure A1:** Transportation service procurement process

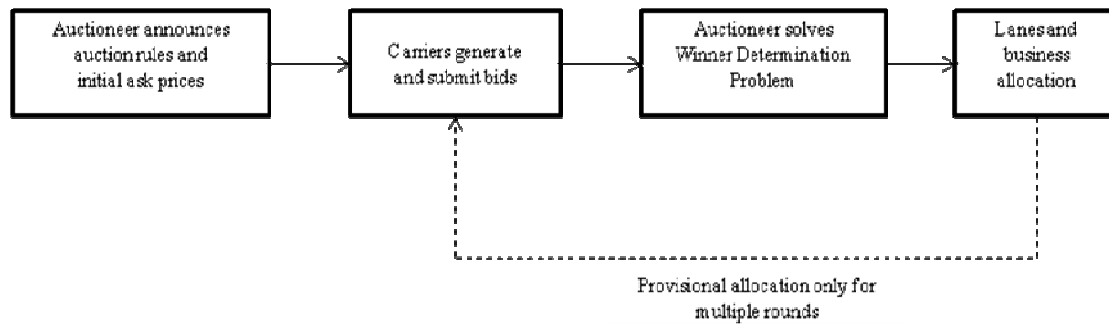**Figure A2:** Revenue of Top 5 Contract logistic companies of the world
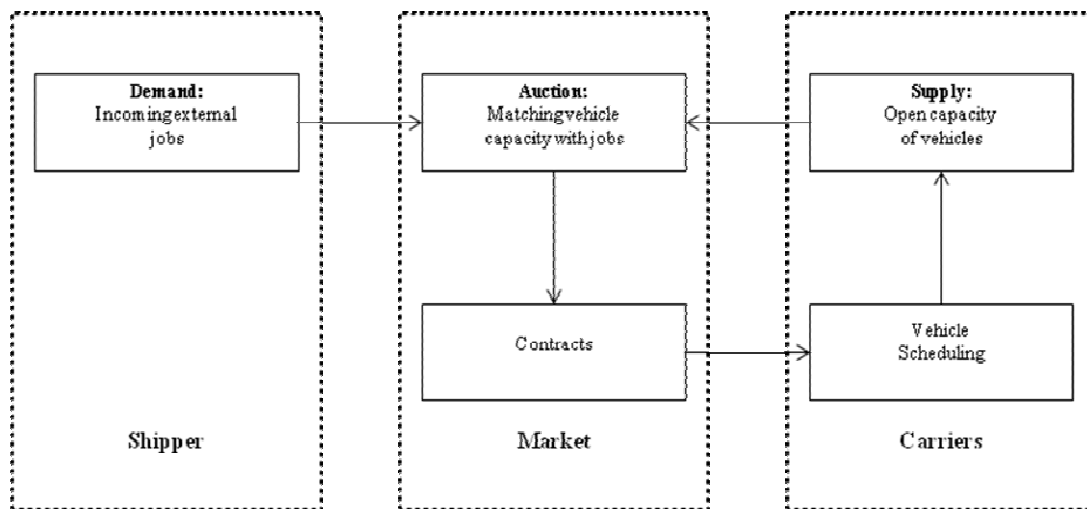
Figure A3: Basic structure of multi round auction

Figure A4: Online transportation service market