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Combinatorial Auctions in the Procurement of Transportation Services

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Most shippers use annual auctions to procure transportation services, leading to annual contracts. By using combinatorial auctions they can reduce their operating costs while protecting carriers from winning lanes that do not fit their networks, thereby improving carriers' operations as well. Combinatorial auctions account for carriers' economies of scope, which many consider more important than economies of scale in transportation operations. Any transportation procurement procedure, however, must account for level of service and other nonprice variables, which are as important as price in determining which carrier should serve what lane. These considerations can be incorporated into the combinatorial auction framework easily and holistically. After several years of using this approach, leading shippers have adopted it, and several software providers offer the requisite software.

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Freight transportation carriers provide the physical connection between shippers and their customers. Shippers are the beneficial owners of freight, for example, manufacturers, distributors, and retailers. Carriers are transportation companies, such as trucklines, railroads, airlines, and ocean transport providers. Standard and Poor (2001) estimated freight transportation expenditures in 2001 in the US at $713 billion, or about eight percent of the US gross domestic product.

Most of the commercial work in combinatorial auctions has been focused on trucking, which represents over 83 percent of the freight transportation expenditure in the US (Wilson 2002), and in particular on the truckload (TL) segment of this industry, which accounts for over half of it. In TL operations, the truck is generally dedicated to a single shipment moving between an origin and a destination, in contrast with less-than-truckload (LTL) and parcel carriers, which consolidate many smaller shipments on a single truck.

Thus, a reduction in TL costs can have a large impact on total cost and therefore the profitability of shippers' operations.

To realize the potential profits locked in transportation, managers must understand how to buy transportation services. A growing number of leading shippers have taken advantage of combinatorial auctions to save three to 15 percent of transportation costs while maintaining or increasing their service levels. (Usually service level is measured in such terms as on-time performance, equipment availability, and extent of damage to the goods hauled.) Just as important, the optimization framework inherent in determining the winners in these combinatorial auctions helped shippers achieve many corporate goals beyond minimizing transportation costs.

Buying Transportation Services

Large shippers buy transportation services using requests for proposals (RFPs), leading to contract prices that are typically in effect for one to two years.

While the RFP process for transportation is similar to that of general goods and services, it differs in some important aspects. The most important of these is that transportation costs are influenced to a greater extent by economies of scope than by economies of scale. In addition, transportation services include many attributes besides price, and they usually involve a large number of items and bidders.

TL motor carrier operations exhibit strong economies of scope, and therefore shippers applied most transportation combinatorial auctions to the procurement of TL services. Many shippers, however, used the same principles to procure other transportation services, such as LTL trucking, ocean, rail, and air.

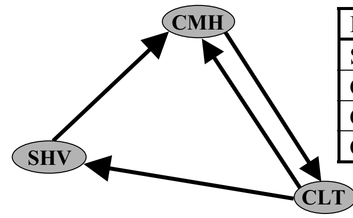
Foster and Strasser (1991) describe the traditional RFP process that most large shippers used until the late 1990s and many still use today. They typically begin by estimating the freight they will need to ship in the coming year, usually by compiling the prior year's movements. They transmit information to the carriers as a list of lanes on which they expect the carriers to bid. As defined by Jara Diaz (1988) and others, a lane is a one-way movement from an origin to a destination with the associated set of shipments for the period covered by the RFP. Carriers then quote the prices at which they are willing to haul the loads. The shipper evaluates the bids lane by lane, using a single criterion, usually price, to select the winner. Thus, while this process is a simultaneous multiple-unit auction (Krishna 2002), most shippers look at it as a set of individual auctions, one for each lane, ignoring lane interdependencies.

Economies of Scope

Shippers move freight between given origins and given destinations, and thus evaluating each lane independently makes sense for them. Carriers' economics, however, are not based on one-way movements; they must maximize the utilization of their equipment and balance their needs for equipment and drivers. Thus, a carrier's cost to serve a single lane is not independent of the other traffic moving throughout its network.

To understand this point, assume that a carrier is transporting 10 loads per week from Atlanta to St. Louis for a given shipper. Suppose the shipper asks the carrier to haul an additional 10 loads from Atlanta to St. Louis. Because it is doubling the carrier's volume, the shipper expects a price concession. To the shipper's surprise, the carrier may refuse to reduce its rate and may even set a higher price for the additional loads. It does so because additional business from Atlanta to St. Louis may only exacerbate its existing problem of balancing equipment and drivers. For example, the carrier may end up with too many trucks and drivers in St. Louis, forcing it to send empty trucks to other locations where they can pick up the next load, rather than move from St. Louis with a load. If, on the other hand, the shipper were to offer 10 additional loads going in the opposite direction, from St. Louis to Atlanta, the new business might help the carrier to balance its equipment and drivers, permitting it to reduce its rate.

In this example, the cost of operations on one lane depends not only on the number of loads the carrier hauls on that lane (giving it economies of scale), but also on the number of loads it carries on other, related lanes (giving it economies of scope). A back-and-forth movement is a simple example of the effect of economies of scope. Complicated multilane movements can also help carriers to balance their networks. If the shipper in this example were to offer, say, 10 loads from St. Louis to Dallas and 10 loads from Dallas to Atlanta, the carrier could use the resulting closed loop to increase its equipment utilization and improve its efficiency.



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

Figure 1: The network shown in this figure includes shipments between Columbus, Ohio (CMH), Charlotte, North Carolina (CLT), and Nashville, Tennessee (SHV). Each lane represents the same number of loads per week. The table depicts the bids (per load) by two carriers, QUIK and FAST, for the four lanes in the network. Given these quotes, QUIK will win lanes SHV → CMH, CLT → SHV, and CLT → CMH, while FAST will win the lane CMH → CLT. Nothing in a lane-by-lane bid-evaluation process avoids this result in which neither carrier wins a balanced set of lanes. Neither carrier wins the three-lane loop: SHV → CMH → CLT → SHV, nor the two-lane loop: CMH → CLT → CMH.

Carriers need balanced networks for two reasons: (1) follow-on loads allow for better utilization of their equipment, and (2) balanced networks allow carriers to maintain their equipment regularly at fixed locations and to get their drivers home frequently and predictably. Getting home is crucial to driver satisfaction in the TL industry, in which many US companies report a driver turnover rate of over 100 percent per year. Costello (2003), reporting this turnover rate by trucking company type, also mentions that TL carriers spend $9,000 on average to find and replace a driver.

Because shippers evaluate lanes independently (comparing all competing bids for each lane and choosing a winning carrier for that lane), carriers cannot ensure that they win a set of balanced lanes (Figure 1).

Combinatorial Auctions

Several large shippers and third-party-logistics (3PL) providers have turned to combinatorial auction mechanisms to reduce their transportation costs during procurement. They seek to entice carriers to bid more aggressively by ensuring that they can bid in a way that reduces their own costs, that is by offering service on lanes that will balance their networks. The practice is also called combinatorial bidding, combinatorial procurement, and conditional bidding.

In a combinatorial auction, the shipper asks the bidding carriers to quote prices on groups or packages of lanes, in addition to individual lanes. The carriers can form their own packages based on their own economics, their existing client base, their drivers' domiciles, and their underlying maintenance networks. The idea is to help carriers form packages that, if granted, will allow them to cut their costs for operating the lanes included in the packages and pass part of the lower costs on to the shipper in the

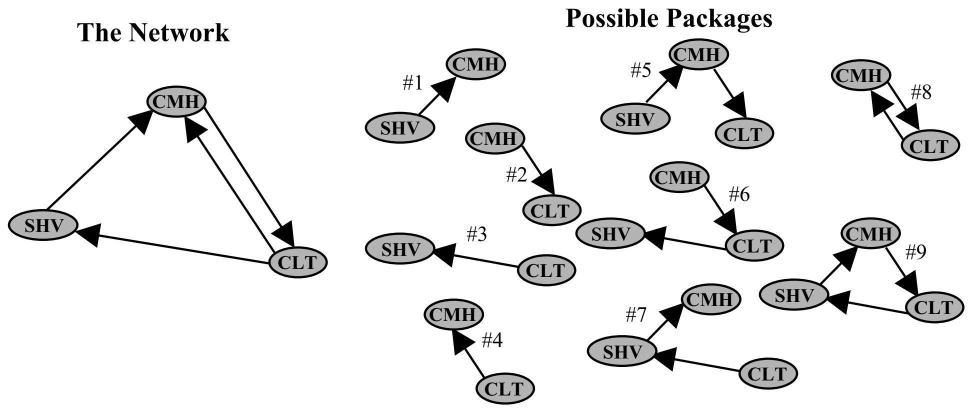


Figure 2: The right side depicts nine packages a carrier could use to bid on the network shown on the left side. The nine packages include four single-lane and five multiple-lane packages reflecting the carriers' economics.

form of lower bids. Carriers can also submit bids for individual lanes and partial packages to protect themselves against shippers' insisting on a low package price while awarding only a single lane or a part of a package.

In a standard auction, a carrier responding to an RFP for the lanes in the network in Figure 1 would submit at most four bids, one for each lane. In a combinatorial bid, a carrier might submit many more packages. For the network in Figure 1, a carrier might submit nine bid packages: four individual lane bids (packages 1, 2, 3, and 4), three continuous-move packages including two lanes each (5, 6, and 7), and two closed-loop tours, one including two lanes (8) and the other three lanes (9) (Figure 2).

Other combinations of lanes are also possible. Carriers can form many more packages by also specifying the volume desired on each lane. In practice, a carrier might specify one package bid with 100 percent of the lane volumes and another package bid at 50 percent of the lane volume. Different packages can also be associated with different levels of service commitments. For simplicity, the focus here is only on the use of lane combinations.

When bidding on packages, each carrier may submit multiple quotes for a single lane, because each lane can be a part of many packages. The shipper may therefore receive many more bids than the number of lanes, with overlapping lane quotes, making evaluating these quotes much more difficult than evaluating individual lane quotes.

De Vries and Vohra (2003) review applications of combinatorial auctions in several fields and focus on mathematical-programming formulations to solve the auctioneer's problem of determining the winning bidders. In the context of transportation procurement, this is the shipper's problem once the bids are in: it must determine which carrier will haul the freight on each lane.

Caplice and Sheffi (2003) discuss several publications on combinatorial auctions for freight transportation. Elmaghraby and Keskinocak (2002) describe the use of combinatorial auctions for transportation services by The Home Depot Inc. (using software from i2 Inc.) and by Wal-Mart Stores Inc., Compaq Computer Corporation, Staples Inc., The Limited, and several other companies (using software from Logistics.com Inc.). De Vries and Vohra (2003) mention Logistics.com Inc.'s use of combinatorial auctions to procure transportation services for K-Mart Corporation and Ford Motor Company. They also mention Saitech Inc. as a company with capabilities in this area. In addition, Manugistics Inc. offers combinatorial-auction software for the procurement of transportation services, and Schneider Logistics offers combinatorial procurement as part of its services. Moore et al. (1991) describe an early application (during the early 1980s) of combinatorial auctions at Reynolds Metal Company, and Porter et al. (2002) describe a 1992 application of combinatorial auctions (which they refer to as a combined value auction) by Sears Logistics Services. They report savings of six to 20 percent.

Allocating Lanes Through Formal Optimization

To determine the winning bid for each lane, the shipper has to solve an optimization problem. The objective is to minimize the total expenditure on transportation, subject to the constraint that each lane be served by one carrier. This standard operations research problem is known as the set-covering problem. De Vries and Vohra (2003) suggest several mathematical-programming formulations and solution procedures. Caplice (1996) and Caplice and Sheffi (2003) discuss formulations and solution methods in the transportation context.

	Carrier QUIK									Carrier FAST								
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#1	#2	#3	#4	#5	#6	#7	#8	#9
SHV → CMH	1				1		1		1	1				1		1		1
CMH → CLT		1			1	1		1	1		1			1	1		1	1
CLT → SHV			1			1	1		1			1			1	1		1
CLT → CMH				1				1					1				1	
Bid ($)	500	525	500	475	975	950	975	900	1,325	525	500	525	500	1,000	925	925	900	1,375

Table 1: In this matrix, each row represents a lane (identified in the first column on the left) and each column represents a bid package from a given carrier (identified in the top two rows). A "1" in a column indicates that the corresponding lane is part of the package represented by that column. The bottom cell in each column is the price that the corresponding carrier bids on that package of lanes. With this formulation, the optimization problem reduces to choosing a combination of packages such that the sum of the bid prices chosen is a minimum. This minimization is subject to the constraint that each lane is served by one carrier. (Naturally, the problem can also easily be formulated with "at least" one carrier serving each lane.) In this particular example, the optimal solution is to use Carrier QUIK exclusively, combining its bid package #9 (SHV → CMH → CLT → SHV) with its package #4, which is a simple bid on lane CLT → CMH, for a total of $1,325 + $475 = $1,800.

To get a general notion of how to tackle this optimization problem, assume that each of the two carriers in the example submits a bid that includes the nine packages shown in Figure 2 (Table 1).

A small problem like that shown in Table 1 can be solved using a spreadsheet. Real problems, which may include thousands of lanes, dozens or hundreds of carriers, and millions of combination bids, are more challenging and require special code. While the theory is not new, the solution algorithms involve decomposition and require iterative procedures. In fact, solving arbitrary cases of such problems is not trivial. The four largest auction software and services providers in the marketplace—i2 Inc., Manugistics Inc., Manhattan Associates Inc., and Schneider National Inc.—seem to be using very similar decomposition methods. They typically imbed domain knowledge in the problem formulation and in the rules designed to price out various solutions so they can solve the problem of determining the winners in practice efficiently.

Accounting for Level of Service

In practice, shippers do not determine the winning carrier for each lane solely on the basis of the transportation price. Shippers take into account both lane service attributes and system constraints.

Lane attributes include characteristics of the transportation service beyond price that may be particular to individual lanes. The following lane attributes are typically important to shippers:

—On-time performance (both transportation time and response time),

—Familiarity with the shipper's operations,

—Availability of the right equipment,

—Accessorial services (carriers' nontransportation activities, such as collecting payments, delivery beyond the receiving dock, and midroute stop-offs),

—Pick-up performance (mainly the percentage of loads a carrier accepts), and

—Ease of doing business (including such factors as billing accuracy, electronic data interchange (EDI) capability, and the availability of shipment-tracking systems).

Many of these attributes are carrier specific and can be accounted for on every bid that carrier makes. More commonly, however, these attributes vary among the lanes each carrier serves because of regional differences in the carrier's network.

To account for lane attributes and particularly for level of service, shippers traditionally decided a priori how many carriers to allow to participate in the auction, creating a core carrier group (Gibson et al. 1995). The criteria for becoming a core carrier are based on meeting some threshold of lane attributes.

For example, in 1994 MicroAge Computer Centers Inc. invited 300 carriers to bid on its business and asked them to consider 18 key attributes. MicroAge then focused on 47 respondents, normalizing their responses by assigning each attribute in the carriers' responses a score of 1 to 10 (for example, it used 10 for on-time performance above 97 percent and zero for performance below 89 percent). It also gave each service attribute a relative weight (Table 2). It then normalized these weights and assigned each carrier a score based on the normalized, weighted sum of the attributes. It then considered the top eight carriers as core and invited them to participate in the actual bidding process, with the winner determined by price.

Many shippers use similar processes (Bradley 1998). The drawback is that such processes do not allow for continuous trade-offs between price and level of service. Carriers whose service is above some cutoff level become core carriers while others do not. For example, a shipper may not invite a carrier to bid because its billing process is inaccurate, increasing

Attribute	W	Attribute	W
On-time percentage	8	Cut-off times	5
Equipment availability	8	Break bulk usage	5
Direct service points	8	Hub locations	5
Full state coverage	8	EDI capability	5
Discount percentage	8	Bar code tracing	4
FAK class rate	8	Quality/safety program	3
Claims ratio	8	Operating ratio	3
Claims payment	6	Safety ratings	2
Cargo insurance	6	Two-day service	2

Table 2: These are examples of attributes and weights shippers use to rank carriers and choose a core group before initiating the auction.

the shipper's costs for auditing and processing freight bills. The carrier's transportation rates may be low enough to compensate for those costs. If, however, the shipper does not invite the carrier to bid, it will not be able to make this trade-off.

Shippers can use the optimization framework while accounting for nonprice considerations by letting all carriers bid on their business. To manage the large amount of resulting data consistently, shippers can use level of service and other lane attributes to modify the bids of the carrier and then solve the optimization problem using the modified prices. In practice, shippers use this process in conjunction with combinatorial auctions.

To see how this works, assume the shipper has bids from two carriers on a given lane: $500 from carrier A, and $475 from carrier B. Furthermore, the only relevant nonprice attribute is on-time performance and carrier A is 98 percent on time while carrier B is only 95 percent on time.

Prior to the auction, the shipper goes through a formal process (typically facilitated by the software provider) to determine how much each percent of on-time performance on each lane is worth. Assume, for example, that it determined that each one percent of on-time performance on the lane under consideration is worth $10. Using a single level of service as a benchmark, the shipper modifies the bid prices. If the benchmark service level is 95 percent the shipper would not modify carrier B's bid. It would modify carrier A's bid to be $\$500 - \$30 = \$470$. The winner-determination optimization algorithm will then compare the modified price of $470 to the $475 submitted by carrier B, and it will choose carrier A (Table 3). The shipper will still pay carrier A $500 to carry loads on that lane; it will not choose the carrier with the lowest actual rate in this example because of service considerations.

The challenge in such situations is to specify the monetary value of service attributes. Shippers conduct this process prior to running auctions using standard utility-theory tools, but it is not a trivial process.

Carrier	Raw Bid	Service	Service Modification	Modified Bid
A	$500	98%	−$30	$470
B	$475	95%	0	$475

Table 3: This table demonstrates the price/service trade-off using a level of service of 95 percent as a benchmark. When the level-of-service adjusting mechanisms are linear, as they are in practice, it does not matter which level of service is used as a benchmark.

People in the organization must agree on a value system, and their view may be neither uniform nor static. In many cases, shippers comment that the greatest value they derive from the auction process is the formal determination of the price/service trade-off, which forces group consensus on the value of nonprice attributes.

Naturally, a shipper could use such a one-step process whether or not it ran a combinatorial auction. A combinatorial auction with a formal optimization to determine winners, however, integrates this approach naturally. Typically a third party (a software provider or an auction manager) runs the sometimes contentious intracompany process.

System Constraints

In addition to lane attributes, many RFP processes incorporate constraints representing business rules placed on a group of lanes. These constraints may include requirements on all lanes in and out of a facility or a region (for example, serving a particular plant with at least three carriers and at most five); giving certain carriers a minimum or maximum volume of business (for example, to ensure that a local carrier wins at least a given amount of business); carrier-initiated constraints (for example, a small carrier bidding on a large volume of business may indicate that it cannot carry more than a given number of loads per week); or systemwide constraints (for example, ensuring that a certain percentage of the expenditure goes to minority-owned carriers). To determine the winners consistently under such constraints, shippers can use a combinatorial formulation whether or not they use packages in the bidding process. When using a mathematical program for determining the winners when the carriers submit package bids, shippers can add any required system constraints to that formulation.

To see the effect of a system constraint, assume a shipper specifies that at least two carriers should serve its network (Table 1). For reasons of risk mitigation, flexibility, future capacity needs, or whatever, the shipper wants to avoid dependence on a single carrier. It can include a constraint in the optimization program to insure that it chooses at least one lane

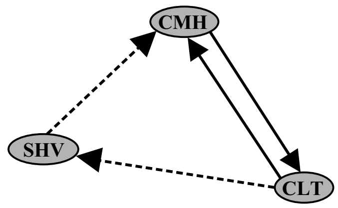


Figure 3: In these results of a constrained assignment in which at least two carriers must serve the network, the solid lines represent Carrier QUIK and the dashed lines represent Carrier FAST. To get to this solution, the shipper must choose package #8 (lanes CMH → CLT and CLT → CMH) from QUIK and package #7 (lanes SHV → CMH and CLT → SHV) from FAST for a total of $900 + $925 = $1,825.

package from carrier A and at least one from carrier B (Figure 3).

The difference between the solution value without the constraints ($1,800) and the solution value with the constraints ($1,825) is the price that the shipper will pay for requiring that no one carrier serve the entire network. This provides a threshold value the shipper must cross to justify imposing the business rule that the constraints represent.

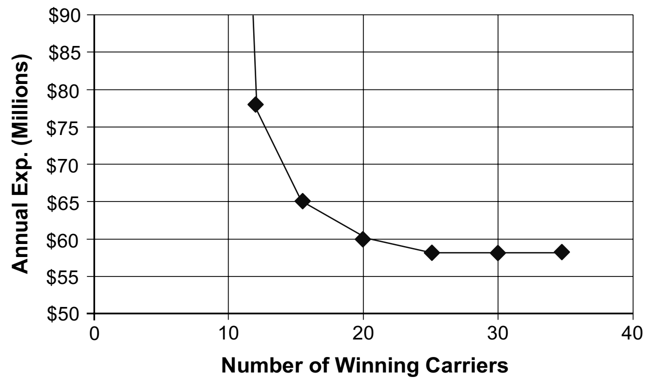


Figure 4: The data on annual transportation expenditure as a function of the number of carriers the shipper considers comes from a large (Tier 1) automotive supplier that ran a transportation-services auction in 1998. The expenditure includes all payments to carriers for hauling freight during one year. Each point represents one run of the winner-determination problem. The horizontal axis represents the constraints on the maximum number of carriers in various computer runs, and the vertical axis represents the resulting annual expenditure. For example, if the cost of dealing with an additional carrier is in the range of $1 million per year, the shipper should use 15 to 20 carriers. If the cost is higher, it should use a smaller number of carriers and vice versa. Interestingly, most shippers claim that the costs of using an additional carrier are much smaller.

Example—Core Carrier Program

To understand the advantages of optimization-based bidding in a specific context, consider the traditional practice of establishing a core carrier group a priori. Most shippers decide how many carriers to include arbitrarily. To see how shippers can determine this number with optimization-based bidding, assume that a shipper has orchestrated an RFP process with many carriers. Instead of running the winner-determination optimization only once to allocate the lane awards, the shipper can run it many times, each time with a constraint controlling the overall number of winners (Figure 4).

As expected, the shipper needs some minimum number of carriers to haul its freight, the annual transportation expenditure falls as the number of carriers participating increases, and beyond a certain number of winning carriers (25 in this example), increasing the number of carriers does not decrease the annual expenditure any further.

The results are typical of any constrained optimization problem: when the constraints are too strict, there is no feasible solution; as constraints are relaxed, the solution improves; and after enough constraints have been relaxed, further relaxations have no effect.

Naturally, the shipper has relevant costs beyond the transportation expenditure. Its cost for dealing with each incremental carrier include setting up communications links between its systems and the carrier's, familiarizing the carrier's drivers with its business and facilities, and charting the carrier's performance and conducting quarterly performance reviews. Thus, shippers should not conclude from this analysis that they should always use a large number of carriers. Instead, they should use the analysis to determine the financial consequences of restricting the number of carriers. If they know the annual administrative costs of dealing with an incremental carrier, they can determine the optimal number of carriers in the core group, which is the point at which this administrative cost equals the reduction in the annual freight bill from using one more carrier (Figure 4).

Process Administration

Procuring transportation services is a complex process partly because of its scale: shippers offer all lanes for bid simultaneously. The reasons are that doing so helps them to concentrate their buying power, they can take better advantage of economies of scope, and they can impose system constraints on their entire network. Even medium-size bids must take into account thousands of different, interdependent items.

Furthermore, to take advantage of economies of scope, shippers may aggregate their transportation needs across all their business units, divisions, and plants, and even across enterprises. Some shippers invite noncompeting enterprises to participate in joint RFP processes. In many cases, it makes sense for suppliers and customers to work together because their freight lanes are likely to be complementary, creating greater economies of scope than each of them could realize alone. Carriers often encourage shippers to bid together so that they can consider a large volume of freight simultaneously and take advantage of opportunities to form packages and to match their current network. By considering many freight lanes at once, carriers can avoid making commitments to shippers that do not give them ideal opportunities for network building.

In addition to the large number of freight lanes, transportation procurement may involve hundreds of vendors whose characteristics, service levels, equipment availability, and communications capabilities differ.

Because of this administrative complexity and the inclusion of system constraints in the winner determination, shippers are not inclined to conduct multiple-round bidding processes. Most shippers use single-round, sealed-bid auction processes. Consequently, combinatorial bidding is important for carriers in environments in which they cannot build their networks through successive bidding rounds. (Bidders can use multiple rounds to signal to each other which lanes they want, thus converging on their desired networks. Flagrant use of such an approach has been observed in several spectrum auctions, as documented by Klemperer 2002).

Bottom-Line Results

Most large shippers now use combinatorial auctions to procure transportation services. Software for conducting such auctions is available from several providers. The savings from such auctions vary widely because some shippers focus on cost savings while others focus on nonmonetary objectives.

Nevertheless, the final savings in such auctions typically range between three and 15 percent. It is difficult to ascertain what fraction of the savings shippers would have achieved with any auction mechanism and how much can be attributed to the use of combinatorial auctions. Clearly shippers can achieve some savings by using any auction mechanism. Combinatorial auctions, by comparison, are typically conducted by large, sophisticated shippers that are likely to have low transportation rates even before the auction. Such shippers were likely to gain additional savings by using combinatorial auctions.

In practice, most shippers do not use the straightforward cost-minimizing solution. Instead, they test and implement many system constraints, ending up with carrier assignments that cost more than the cost-minimizing solution. In practice, carriers usually give up about half the potential savings to comply with the systems constraints.

The number of lanes carriers put together in lane packages is not very large. Fewer than 10 percent of the total lanes in typical combinatorial auctions are part of packages (with wide variation, however). The reason may be that many carrier networks do not present any bundling opportunities or that carriers have limited trust in shippers to follow through during operations and therefore do not bother to form packages. Anecdotal evidence suggests that lack of carrier sophistication is not a hurdle; leading carriers understand and embrace the process. They can put together packages based on a specific shipper's offerings and can combine newly offered business with their existing business to create favorable network-wide traffic patterns.

As important as the savings are, many shippers have been using combinatorial bids to select carriers who promise and have a track record of providing good service in addition to meeting the corporate goals imbedded in the system constraints.

Conclusions

Recognizing that transportation procurement is different from general procurement, most companies empower their transportation professionals, rather than their procurement professionals, to conduct specialized RFP and negotiation processes. Combinatorial bidding allows both shippers and carriers to exploit the economies of scope inherent in TL operations. The use of optimization in the winner determination process has an added benefit of dealing effectively with nonprice attributes and system constraints.

Dozens of leading companies, such as Colgate-Palmolive Company, Compaq Computers Inc., Ford Motor Company, The Home Depot Inc., International Paper Company, Lucent Technologies Inc., Nestle S. A., The Procter and Gamble Company, Quaker Oats (a unit of Pepsico Beverages and Foods Inc.), Sears Roebuck and Co., and Wal-Mart Stores Inc., have used combinatorial auctions to obtain low transportation rates and high levels of service. Some shippers have collaborated with others in combined RFP processes to increase the benefits of combinatorial procurement.

A Note and Acknowledgments

I have participated in and had unrestricted access to over 100 transportation auctions from 1988 to 2002 as the principal in a third-party-logistics provider, LogiCorp (between 1988 and 1997) and in software and procurement services providers, PTCG Inc. (in 1996) and Logistics.com Inc. (between 2000 and 2002). Almost half of these were combinatorial auctions. Many of the observations in this paper are based on my experience. I have neither financial nor any other commercial interest in any of the companies mentioned in this paper.

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