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Insinking: A methodology to exploit synergy in transportation

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Abstract

Over the last decades, companies' average profit margins have been decreasing and as a result efficiency of transportation processes has become critical. To cut down transportation costs, shippers often outsource their transportation activities to a Logistics Service Provider of their choice. This paper proposes a procedure that puts the initiative with the service provider instead. This procedure is based on both operations research and game theoretical insights. To stress the contrast between the traditional *push* approach of outsourcing, and the here proposed *pull* approach where the service provider is the initiator of the shift of logistics activities from the shipper to the Logistics Service Provider, we will refer to this phenomenon as *insinking*, the antonym of outsourcing. Insinking has the advantage that the logistics service provider can proactively select a group of shippers with a strong synergy potential. Moreover, these synergies can be allocated to the participating shippers in a fair and sustainable way by means of customized tariffs. Insinking is illustrated by means of a case study in the Dutch grocery transportation sector.

Keywords: Insinking, Cooperative Game Theory, Shapley Monotonic Path, Retail, Vehicle Routing, Logistics Service Providers

JEL-codes: C61, C71

1 Introduction

A Logistics Service Provider (LSP) is defined as a provider of logistics services that performs logistics functions on behalf of his customers (cf. Coyle et al. (1996)). In recent years, LSPs have had to cope with stricter requirements of shippers in terms of speed, flexibility and price. In addition, because of broader product assortments and shorter life cycles, streams through the LSPs' networks became highly fragmented. This causes load factors and, by consequence, profit margins to drop. To cope with these

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heavy market conditions, LSPs are on a continuous search for opportunities to increase their efficiency and discern themselves from competitors (cf. Langley et al. (2005)).

1.1 Insinking versus Outsourcing

Razzaque and Sheng (1998) define logistics outsourcing or *third party logistics* as the provision of a single or multiple logistics services by a vendor on a contractual basis. It has been estimated that about 40% of global logistics is outsourced, and increasing numbers of shippers consider it an attractive alternative to the traditional logistics service mode (cf. Wong et al. (2000); Hong et al. (2004)).

For their turnover, LSPs heavily depend on the extent to which industrial shippers outsource their logistics activities. Wilding and Juriado (2004) provide a literature review of empirical papers on outsourcing, investigating which activities are typically outsourced and what are the most important reasons for doing so. Table 1 shows the top-5 reasons for outsourcing.

Rank	Reason
1	Cost or revenue related
2	Service related
3	Operational flexibility related
4	Business focus related
5	Asset utilization or efficiency related

Table 1: Reasons for outsourcing logistics activities

The outsourced activities can be related to Transportation and Shipment, Warehousing and Inventory, Information Systems and Value Added Services. It turns out that the most basic logistics functions of transportation, warehousing and inventory are outsourced most frequently.

The general idea behind outsourcing is a focus of companies on their core businesses. For example, customers of an LSP benefit from the LSP's larger economies of scale that enable him to perform transportation and warehousing more efficiently than his customers. Traditionally, the initiative for outsourcing lies with the shippers: once it is reckoned by management that logistics activities can better be performed by a third party, an invitation to submit a tender is sent out to a number of pre-selected LSPs. Based on this invitation, the LSPs then propose a price for their services.

The subject of this paper is the reverse mode of operation, where the initiative for the contract lies with the LSP. To stress the contrast between the traditional *push* approach of outsourcing, and the here proposed *pull* approach where the service provider is the initiator of the shift of logistics activities from the shipper to the LSP, we will refer to this phenomenon as *insinking*, the antonym of outsourcing.

The advantage of insinking over outsourcing is that it enables LSPs to gain maximum synergetic effects by tendering for multiple shippers whose distribution networks can be merged very efficiently. We observe that there exist promising business opportunities for insinking in practice. One example is the introduction of the so-called transport-arrangements in the Dutch Randstad metropolis. In this project, a Dutch LSP offers prominent shippers in the fashion sector to perform the distribution to their shops in the city centers against very sharp tariffs. These tariffs are low because of the strong synergies the LSP can benefit from in case he replenishes multiple fashion outlets in the same city center. The Dutch branch organization for fashion companies, actively participates in this project by stimulating their members to accept the offer. Engaging in the transport-arrangements project is beneficial for the individual producers because transportation costs are reduced and customer satisfaction is likely to increase since the number of visits per shop decreases when multiple shippers make use of the transport-arrangements. As a result, trucks interrupt store personnel less frequently. Moreover, congestion in the city center will decrease as a result of the smaller number of vehicle movements. Apart from the time investments that all partners in this project are making, the financial risk rests solely with the LSP. After all, the tariff offers are based on the *expectation* that a certain minimum number of shippers will participate. So when only 1 or 2 shippers accept the offer, the required synergies to break even may not be attained. When the behavior of potential customers is highly unpredictable, this risk might be prohibitive for the LSP. To resolve this issue, this paper offers a methodology for LSPs to apply insinking while eliminating this financial risk.

1.2 Co-opetition

Shippers who are active in the same sector, such as the fashion producers in the transport-arrangements example, will sell products with roughly the same characteristics and ordering dynamics (time windows, order sizes, conditioning, etc). This creates strong synergy potential for an LSP, because he can operate the same truck types and sometimes even the same routes to service multiple shippers. When shippers are served on the same route, insinking creates a situation of so-called 'co-opetition' (cf. Brandenburger and Nalebuff (1996) and Zineldin (2004)). Although the shippers are competitors on their core businesses, they tacitly cooperate with each other on the non-core domain of transportation since they agree that their products are distributed in a single shipment with their competitors' products. Transportation, the area where the cooperation takes place, is not visible to customers. Bengtsson and Kock (2000) consider visibility for the customer as the most important characteristic for determining whether competition or cooperation should take place on a certain activity. For example, if there is cooperation on transportation activities, competition and differentiation can remain unchanged on other domains such as product prices and product assortments. Bengtsson and Kock (1999) state that co-opetition must not be seen as dangerous. Instead, top management should understand and communicate to organizational members that cooperation and competition can be applied simultaneously, and both can contribute to achieving organizational goals. Particularly in transportation and logistics, where there are almost no unique technologies, companies must often rely on applying innovative concepts such as co-opetition to achieve growth. In practice, co-opetition is quickly gaining momentum in the grocery industry. In this sector profit margins are thin and demand variation is strong. Examples of co-opetition in the consumer goods industry can be found in Bahrami (2003), and LeBlanc et al. (2005).

Since cooperation takes place among (potential) competitors, by the definition of Piercy and Cravens (1994), insinking is an example of *horizontal* cooperation. Unfortunately, no formal large-scale research has been done on the views of shippers about horizontal cooperation with regard to their logistics activities. However, the views of LSPs are better identified and can provide useful insights into the industry opinion on this subject. Carbone and Stone (2005) state that horizontal cooperation between LSPs is mainly aimed at one of three objectives:

(i) Strengthening the present geographical network,
(ii) Developing new competencies, and
(iii) Penetrating new geographical markets.

They also give four practical examples of horizontal cooperation between major European LSPs. There are however important barriers that can prevent initiatives from prospering. In Cruijssen et al. (2005) nine potential impediments for horizontal cooperation are presented to Flemish LSPs. Table 2 presents the evaluations of these impediments (5-point Likert scale).

	Impediment	**Avg**	**Std dev**
1	A fair allocation of the benefits is essential for a successful cooperation.	4.11	0.84
2	It is hard to find a reliable party that can coordinate the cooperation in such a way that all participants are satisfied.	4.00	0.87
3	Smaller companies in the partnership may lose customers or get pushed out of the market completely.	3.95	1.01
4	It is hard to find commensurable LSPs with whom it is possible to cooperate for (non-) core activities.	3.84	0.96
5	It is hard to ensure a fair allocation of the shared workload in advance.	3.73	0.89
6	Benefits cannot be shared in a fair way; the larger players will always benefit most.	3.60	1.19
7	It is hard to determine the benefits or operational savings due to horizontal cooperation beforehand.	3.54	0.89
8	When an LSP cooperates with commensurable companies, it becomes harder to distinguish itself.	3.52	0.90
9	Cooperation is greatly hampered by the required indispensable ICT-investments.	3.43	0.97

Table 2: Impediments for horizontal cooperation (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree)

1.3 Gain Sharing

Because impediments for LSPs will supposedly also hold for horizontal cooperation among shippers, we assume that the evaluations by the LSPs provide an indication for the attitude of shippers. Table 2 shows that the impediments about the fairness and stability of cooperation (impediments 1, 3, 5, and 6) rank high. In particular, guaranteeing a fair allocation of the achieved benefits is the most important impediment for horizontal cooperation. 80% of the respondents (strongly) agreed with this proposition, 16% was neutral, and as little as 4% (strongly) disagreed. Mistrust about the fairness of the applied allocation rule for the savings has caused many horizontal logistics cooperation initiatives among shippers, and/or LSPs to marginalize or disintegrate.

In practice, a plethora of allocation rules for horizontal cooperation among shippers can be observed. Most often these are simple rules of thumb that distribute savings proportionally to a single indicator of either size or contribution to the synergy. Some examples are:

- Proportional to the total load shipped
- Proportional to the number of customers served
- Proportional to the transportation costs before the cooperation
- Proportional to distance traveled for each shipper's orders
    - based on inter-drop distances of constructed joint routes
    - based on direct distances from depot to outlet
- Proportional to the number of orders

Because these rules are easy and transparent and since each embodies a construct that arguably represents the importance of an individual shipper to the group, they are likely to appeal to practitioners initially. However, when using a single construct, the others are obviously disregarded. In the long run, some participants will inevitably get frustrated since their true share in the group's success is undervalued. For example, if gain sharing takes place according to the number of drop points of each participant, a certain shipper who delivers a large number of drop points in a small geographical region will get a large share of the benefits, while his de facto contribution to the attained synergy is negligible when the other participants serve only few drop points in this area.

To ensure a fair gain sharing mechanism, the marginal contributions of each shipper to the total gain have to be accurately quantified. The insinking approach uses the true contributions to the group's synergy to calculate customized prices that fairly distribute the monetary savings that are attained by consolidating flows of multiple shippers. In our approach, the applied methodology is explained to the shippers and the LSP's cost structure is deliberately made transparent.

It is illustrated above that practical rules of thumb might not always be the best choice for fair gain sharing. Our proposal is to employ solution procedures from cooperative game theory instead. Cooperative game theory models the negotiation process within a group of cooperating agents (in this case shippers) and allocates the generated savings. This field has proved capable of solving fairness issues in many fields. Some logistics related examples are: (Vertical) Supply Chain Coordination (cf. Cachon and Lariviere (2005)), Hub-and-Spoke network formation (cf. Matsubayashi et al. (2005)), and Outsourcing (cf. Elitzur and Wensley (1997)). Other sectors where game theoretical methods have been successfully applied in practice include among others: Automotive (cf. Cachon and Lariviere (1999)), Retail (cf. Sayman et al. (2002)), Telecommunication (cf. van den Nouweland et al. (1996)), Aviation (cf. Adler (2001)), and Health Care (cf. Ford et al. (2004)). Cooperating companies in these sectors benefit from game theoretical methods that objectively take into account each player's impact within the group as a whole and produce compromise allocations that distribute the benefits of cooperation based on clear cut fairness properties. Different fairness properties are represented by well-known allocation rules such as the Shapley value (Shapley (1953)), the nucleolus (Schmeidler (1969)) and the tau-value (Tijs (1981)). As will become clear in the remainder of this paper, cooperative game theory offers a solution to the four gain sharing related impediments for horizontal logistics cooperation in Table 2.

1.4 Price Setting

With the insinking procedure, the LSP establishes fair gain sharing by means of customized pricing. This enables the LSP to explicitly incorporate participants' marginal contributions to the group's synergy potential. The business opportunities offered by intelligent pricing strategies are being increasingly recognized in Marketing (cf. Desiraju and Shugan (1999)) and Psychology (cf. Hermann et al. (2004)). The advent of Information and Communication Technology (ICT) in the last decade has opened up a vast array of new pricing possibilities (cf. Dixit et al. (2005)). The most important challenge of such information enhanced pricing strategies is to be perceived by customers as fair. Perceived fairness depends on comparisons to past prices, competitor prices, and perceived cost of the product or service (cf. Bolton et al. (2003)). Although these factors come from a Business-to-Consumer setting, we hypothesize that the same constructs are relevant for the Business-to-Business situation that we consider in this paper.

An important aspect of fair pricing is the principle of dual entitlement (cf. Kahnemann et al. (1986)). This means that a profit increase by the selling firm (the LSP) is only accepted when it does not harm the customer's interest. This egalitarian principle sometimes conflicts with the utilitarian principle of cost-based pricing. Under cost-based pricing, an LSP will charge the total costs plus a 'reasonable' percentage. Dixit et al. (2005) argue that dissatisfaction about fairness of prices could be avoided by proper implementation and communication of price composition. Therefore, openness of information is an important aspect of insinking and, as will become clear in the next section, both the egalitarian and utilitarian principles mentioned above are satisfied.

Despite its obvious business opportunities, only few firms take full advantage of intelligent pricing. The vast majority still uses pricing strategies based on historical cost benchmarks, whereas more forward-looking and clientele-oriented pricing is likely to be more promising (cf. Noble and Gruca (1999)). Especially in the very competitive and low-margin transportation sector, smart pricing offers LSPs an excellent opportunity to gain a competitive edge.

The remainder of this paper is organized as follows. In the next section the insinking procedure for exploiting synergy in transportation will be explained and illustrated by means of a small hypothetical example. In section 3, the applicability of the procedure is established by a real life case study in the Dutch grocery transportation sector. Finally section 4 concludes.

2 The Insinking Procedure

The insinking procedure builds on customized pricing by an LSP. These prices (or: *tariffs*) are induced by the varying claims of shippers' order sets on the LSP's resources. Among other properties, order sets may differ in the number of orders, the geographical spread of the drop points, the location of the shipper's warehouse(s), the tightness of time windows, and the average and standard deviation of the order sizes. In Cruijssen and Salomon (2004) it is shown that each of these aspects has a clear influence on the synergy potential when the order sets are combined. In this section we introduce the insinking procedure by describing its three steps:

(i) Target group selection,

(ii) Cost reductions, and

(iii) Negotiation and structure of sequential offers.

2.1 Target group selection

As a first step, the LSP has to select the group of shippers he wishes to serve. It was argued above that opting for a group of shippers from the same industry comes at the advantage of having similar product characteristics and ordering dynamics. It also fits in the current trend of (sectoral) specialization in the logistics sector: having multiple customers in e.g. the chemical, consumer electronics, paper or textile sector strengthens the market position of an LSP and offers a safeguard for future survival.

Three necessary ingredients of successful market targeting are: information, the LSP's capabilities and synergy. The first two provide the prerequisites. First, the LSP must have enough market information to assess its chances to obtain the required amount of contracts. In some cases this information is publicly available, such as in the grocery case discussed in section 3, but for other markets obtaining this information will require a more thorough market analysis. The second condition is the good match between the market and the LSP's capabilities. For example, if an LSP's past experience involves predominantly unconditioned palletized transportation, it might not be advisable to target the specialized petrochemical industry. When market info is available and the LSP has the capabilities to serve the market, the attractiveness of a target group depends on the synergy potential that exists between them. Gupta and Gerchak (2002) have studied operational synergies for mergers and acquisitions, which can be seen as an upper bound for the synergy under horizontal cooperation. In this paper we assume that the LSP is able to make a reliable estimate of the monetary synergy potential, which we define as the sum of the costs that individual shippers make in the present situation minus the costs when the whole set of shippers would be serviced collectively by the LSP. Besides these operational considerations however, often also relational issues play an important role. For example, it may be the case that an LSP already has (informal) contacts with a coherent group of shippers of whom he knows they are interested in the service. Although this group may not be optimal from a synergy perspective, this may be outweighed by the group's cohesion and their established contacts with the LSP. In fact, applying an innovative concept such as insinking requires a considerable amount of trust between the LSP and the shippers, which will benefit from positive past business experiences.

2.2 Cost reductions

When the LSP has identified the group of shippers targeted, he is ready to calculate the cost reductions for each of the shippers involved. Since we use cooperative game theory in this step, we first recall some basic notions from game theory. Myerson (1991) defined game theory as "the study of mathematical models of conflict and cooperation between intelligent and rational decision-makers. Game theory provides general mathematical techniques for analyzing situations in which two or more individuals make decisions that will influence one another's welfare". Cooperative game theory focuses on cooperative behavior by analyzing the negotiation process within a group of players in establishing a contract or joint plan of activities, including an allocation of collaboratively generated revenues. In particular, the possible levels of cooperation and the revenues of each possible coalition (a subgroup of the cooperating players) are taken into account so as to allow for a better comparison of each player's role and impact within the group as a whole. In this way, players in a coalition can settle on a compromise allocation in an objectively justifiable way. Having this in mind, the game underlying the insinking methodology is evidently a cooperative game. The problem of allocating the jointly generated synergy savings is critical to any logistics cooperation (cf. Table 2; Thun (2003)).

Let *N* be a finite set of players and denote by 2^N the collection of all subsets of *N*. Elements of 2^N are called *coalitions, N* is the *grand coalition*. The cost savings that a coalition S can jointly generate without the players in $N \setminus S$ is called the *value* of coalition S. The values of all coalitions S are captured in the so-called characteristic function $v: 2^N \to \mathbb{R}$. The Shapley value (Shapley (1953)) is a well-known solution concept that constructs an allocation vector $\Phi(N,v) \in \mathbb{R}^N$ that allocates the value $v(N)$ of the grand coalition based on the values $v(S)$ of all coalitions S. The idea behind the Shapley value is that, when the grand coalition *N* is formed one by one, each player i upon entering an (intermediate) coalition S will demand $v(S \cup \{i\}) - v(S)$ as a fair compensation. These so-called *marginal contributions* are then averaged over all permutations of *N*, representing all orderings in which the grand coalition *N* can be formed. This idea boils down to the following formula:

$$\Phi_i(N,v) = \sum_{S \subset N: i \notin S} \frac{|S|!(|N|-1-|S|)!}{|N|!}\left[v(S \cup \{i\}) - v(S)\right], \text{ for all } i \in N. \quad (1)$$

For a coalition S the subgame $(S, v|_S)$ is given by the restriction of *v* to 2^S, with for all $T \subset S$ $v|_S(T) = v(T)$. In particular, for the Shapley value $\Phi(S,v) := \Phi(S, v|_S) \in \mathbb{R}^S$ we find:

$$\Phi_i(S,v) = \sum_{T \subset S: i \notin T} \frac{|T|!(|S|-1-|T|)!}{|S|!}\left[v(T \cup \{i\}) - v(T)\right], \text{ for all } i \in S. \quad (2)$$

The Shapley value can also be motivated by a number of fairness properties. Below we will briefly discuss four of these properties that are useful in our context. First, the *efficiency* property of the Shapley value ensures that the total value of the grand coalition is distributed among the players, i.e., no value is lost.

The Shapley is also *symmetric*, meaning that two players that create the same additional value to any coalition receive the same share of the total value. The *dummy* property states that players that do not contribute anything to any coalition except their individual value indeed receive exactly their individual value as a final share of the total value. Finally, we mention the Shapley value's property of *strong monotonicity.* This guarantees that the payoff of a player can only increase if none of the player's marginal contributions decreases. Since these four properties make perfect sense from a practical perspective, we make use of the Shapley value in this paper.

We are now ready to formulate the cooperative game, which forms the basis of the insinking procedure: the *insinking game*. In the current step, the LSP knows his target group of shippers (from now on called the *players*) and faces the problem of distributing the group's synergy potential, i.e., the value $v(N)$ of the grand coalition.

In order to cover the extra overhead costs needed to service the players and to gain profit, the LSP claims a pre-determined percentage. This percent claim is called the *synergy claim* and is denoted by $p \in [0,1]$. In choosing the value of the synergy claim the LSP faces a trade-off between a higher prospected profit by setting *p* high, and a larger probability that the players will indeed cooperate by choosing a smaller value. The LSP can make this decision based on a qualitative assessment of his bargaining power in the market.

The value $v(S)$ of a coalition S in the insinking game is determined as follows:

$$v(S) = (1-p)\max\left\{\sum_{i \in S} C_0(i) - C(S), 0\right\}. \qquad (3)$$

Here, $C_0(i)$ are the costs of player i in the status quo situation, i.e., when player i privately performs the distribution of his own goods, while $C(S)$ represents the costs of the LSP to serve all players in S collectively. Obviously, a coalition S can only be established when the LSP can serve the players in S at a lower cost than the sum of the costs that the players in S incur when they perform their own orders individually. Whenever this it not the case, the value of the coalition under consideration is 0. This explains the use of the maximum with 0 in (3).

We will illustrate the procedure by means of a hypothetical 3-player example, for which the relevant information is summarized in Table 3. For convenience of calculations, we assume that p=0.

S	$\sum_{i \in S} C_0(i)$	$C(S)$	$v(S)$	$\Phi(S,v)$
{1}	350	300	50	(50; . ; .)
{2}	300	260	40	(. ;40; .)
{3}	100	120	0	(. ; . ;0)
{1,2}	650	500	150	(80;70; .)
{1,3}	450	390	60	(55; . ;5)
{2,3}	400	370	30	(. ;35;-5)
{1,2,3}	750	570	180	(95;75;10)

Table 3: A hypothetical 3-player example

The last column of Table 3 shows that cooperation between players 2 and 3 only will not occur since in this case both players receive a value that is lower than the value they would be able to get individually.

2.3 Negotiation and structure of sequential offers

Despite the fact that in our example all possible coalitions have a positive value, the LSP still has to select an effective way to establish the grand coalition. He does so by choosing the most suitable sequence in which he proposes offers to players. Every time a player from the selected target group is approached with such an offer, the method that the LSP will consistently use is clearly explained to this player. By communicating openly, the player's involvement in the project increases and the LSP has better possibilities to crosscheck the assumptions and data he used to calculate the proposals. Sequentially, a player i receives an opening offer based on $\Phi_i(S \cup \{i\}, v)$, if S is the coalition of players that have already committed before. Moreover, it is explained to player i that his offer may further improve when more players consign to the LSP's service. These reductions are also announced to the player, together with the accompanying scenarios for commitment of the players that are not yet contacted. Figure 1 graphically shows the offered percentage cost reductions with respect to the costs of in-house execution by the players. We use the percentage reduction of the current costs of the players rather than the absolute reduction, because the players may considerably differ in size.

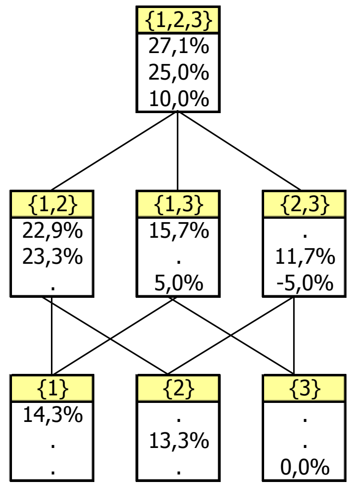

Figure 1: Percentage cost reductions in the 3-player example

In the example above, when players are contacted in the sequence 123, during the negotiations player 1 knows that he is sure to save 50 (14.3%), and that his cost reduction will increase to 80 (22.9%) if later on player 2 consigns, and even to 95 (27.1%) if besides player 2 also player 3 commits. Together, the opening offer and the prospected future cost reductions should persuade the player to accept the offer.

Based on Figure 1, the LSP has to decide the actual sequence in which he contacts the players (i.e., the *path* through Figure 1). Compared to a simultaneous approach, the one-by-one modus operandi offers the benefit that the obtained commitment of one or more players leverages the value proposition that can be made to the remaining players, since a certain level of scale and synergy is already attained.

The usage of a fixed synergy claim p makes that the LSP's profit is maximized when the grand coalition is attained. Therefore, the LSP is interested in finding the path through Figure 1 that gives the highest "probability" that all players will accept his insinking offer. To this end, we introduce the notion of a *Shapley Monotonic Path* (SMP). Along such a path all committed players will be better off when the coalition grows through the decision of the next player to accept the insinking offer. In the example above, 123, 132, 213 and 312 are SMPs. The others are not because one player's offer worsens during at least one of the steps. When the target group is carefully selected based on a strong synergy potential among the players, there will indeed exist SMPs. Note that the value of p does not affect the Shapley Monotonicity of paths.

If there are more SMPs, the next question becomes how to choose between them. For the hypothetical 3-player example, the four SMPs together with the offered percentage cost reductions with respect to the present (in-house) cost are displayed in Figure 2.

path 123

player	1	2	3
own costs	350	300	100
first	14,3%	.	.
second	22,9%	23,3%	.
third	27,1%	25,0%	10,0%

path 132

player	1	3	2
own costs	350	100	300
first	14,3%	.	.
second	15,7%	5,0%	.
third	27,1%	10,0%	25,0%

path 213

player	2	1	3
own costs	300	350	100
first	13,3%	.	.
second	23,3%	22,9%	.
third	25,0%	27,1%	10,0%

path 312

player	3	1	2
own costs	100	350	300
first	0,0%	.	.
second	5,0%	15,7%	.
third	10,0%	27,1%	25,0%

Figure 2: Example of possible sequential offers according to SMPs

Although all four paths described in Figure 2 are SMPs, path 312 does not seem to be a reasonable choice for the LSP. This is because in the first step, player 3 is not offered a cost reduction because he can perform his own orders more efficiently individually than the LSP can. This is captured in the concept of *first offer rationality*: the first offer of the LSP to an entering player indeed represents a cost reduction compared to player's status quo situation of performing the orders individually. SMPs that satisfy this criterion are referred to as *Rational Shapley Monotonic Paths* (*RSMPs)*. In the remainder, we will restrict attention to RSMPs.

There might be various ways to judge which RSMP is best from the LSP's perspective of achieving the grand coalition. It seems reasonable however that the reductions on the diagonal and bottom row in Figure 2 are the most relevant considerations for players. The first correspond to the cost reductions that the players are guaranteed to achieve when accepting the offer (*certain gain*), and the second are the maximum possible cost reductions that are attained when the grand coalition is indeed achieved (*top gain*).

One can argue that the relative importance of the certain gain and top gain depends on a player's risk aversion. When risk aversion is very high the certain gains are most important, since the players will be sure of this reduction irrespective of the future decisions of other players further up the path. On the other hand, when risk aversion is low, the top gain is also an important concern for a player. Here we assume that risk aversion is high and we select an RSMP on the basis of the certain gains. Table 4 shows the certain gains for the three RSMPs. Consequently, we propose to select the "best" RSMP in the following way: first select those RSMPs that have the maximal lowest cost reduction. In our example, these are 123 and 213 with a lowest certain gain of 10%. Then, from those RSMPs, select the one that has the maximal second-lowest certain gain, etc. In our hypothetical example, 123 will be selected with a second-lowest certain gain of 14.3%.

	Certain gain			*Sorted certain gain*		
Path	**Player 1**	**Player 2**	**Player 3**	***Lowest***	***2nd lowest***	***3rd lowest***
123	14,3%	23,3%	10,0%	*10,0%*	*14,3%*	*23,3%*
213	22,9%	13,3%	10,0%	*10,0%*	*13,3%*	*22,9%*
132	14,3%	25,0%	5,0%	*5,0%*	*14,3%*	*25,0%*

Table 4: RSMP selection based on certain gains

This finishes our discussion of the insinking procedure. In the next section we illustrate the insinking procedure by means of a real world case study from the Dutch grocery transportation sector.

3 Case study

Many grocery retailers are not performing well and have been facing a loss of profitability in recent years. Together with the complexity and dynamism inherent to the grocery industry, this has made it difficult for retailers to survive in isolation of their competitors (cf. Ballou et al. (2000)). There is growing empirical evidence that retailers as a result turn to co-opetive behavior to construct win-win situations together with their competitors. For example, Kotzab and Teller (2003), present a case study in which the largest Austrian retailers cooperate in their logistics processes by introducing uniform load units and performing joint replenishment. This cooperation runs parallel to fierce price competition and heavy promotional spending. In this section we present a co-opetive insinking case study that results in considerable efficiency gains for retailers in the Dutch grocery transportation sector. For reasons of confidentiality, the company names in this case study are not disclosed.

3.1 Background

The case focuses around an LSP that has a large temperature controlled distribution center for frozen goods (FDC) in the geographical center of the Netherlands. Taking advantage of its established position in ambient food retail, the LSP's goal is to fill this FDC with the frozen food products of grocery retailers, and perform the transportation from the FDC to their stores. Among other things, this means that in the new situation suppliers of frozen products must only visit the central FDC instead of the multiple FDCs of individual retailers, thereby reducing the number of drops that suppliers make on their delivery routes. As a side effect to the synergy attained in the retailers' distribution process, this will increase the efficiency of the suppliers' transportation process.

The LSP applies the insinking procedure outlined in section 2 to attract a number of large and medium sized grocery retailers as his customers. Below we discuss how the three steps of the procedure can be applied here.

3.2 Target group selection

Table 5 shows some characteristics of four grocery retailers A,B,C, and D with whom the LSP maintains close contacts.

Retailer	# Outlets	Weekly demand (roll pallets)	Yearly turnover (mln EURO)	Symbol in Figure 3
A	37	17,366	367	● (red)
B	61	25,369	616	■ (green)
C	63	18,634	373	▲ (blue)
D	195	62,857	1,187	● (black)

Table 5: Characteristics of targeted retailers (2003)

These retailers have the same (or at least a comparable) customer base and Figure 3 shows that their distribution networks have considerable geographical overlap. Furthermore, they have not yet outsourced their transportation activities to an LSP. All four retailers use a standardized roll pallet for shop deliveries, which makes it easy to consolidate loads of different retailers in one truck. The encouraging synergy potential, the existing contacts and the fact that the capacity of the FDC is sufficient to fulfill their orders, make that these four retailers form the LSP's target group.

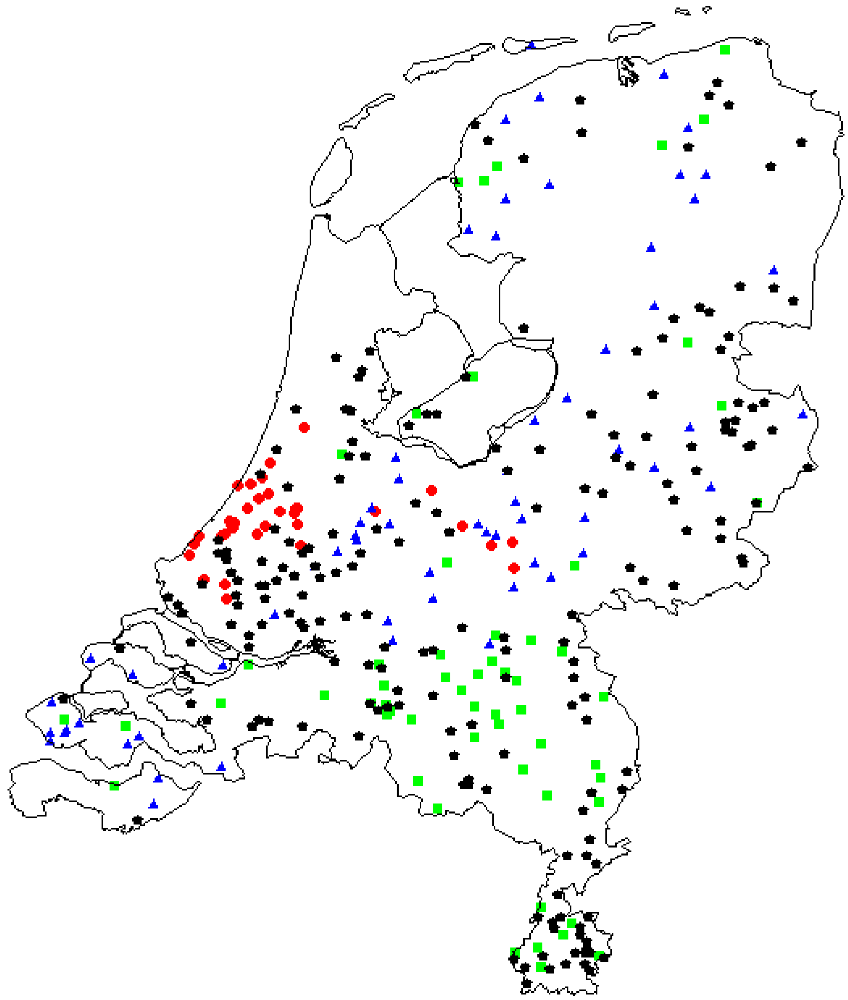

Figure 3: Geographical overlap of stores of retailers

3.3 Cost reductions

In step 2 of the insinking procedure we calculate the value of all subcoalitions of {A,B,C,D}. The cost reduction that the LSP will be able to offer then depends on the synergy among the order sets of the retailers. Additionally, the offers are influenced by the LSP's synergy claim. This claim must cover the extra administrative (back office) costs, the costs of storage at the central FDC, and profit. In this case study, the synergy claim is set to 0.2.

Below we comment on the data and the routing problems that form the basis of the calculation of the cost reduction proposals.

Data

Order data of the four retailers are estimated on the basis of the commercial surface of their stores and the average turnover of frozen products per square meter of commercial surface. The daily frequency of delivery per retailer is based on de Koster and Neuteboom (2001) and information from other industry experts. Based on these data five daily order sets are constructed, representing the working days in a typical week.

By assumption, the trucks operated by the retailers and by the LSP all have a capacity of 57 roll pallets and a uniform cost structure. This cost structure is based on the published market averages for the Netherlands and consists of a fixed cost per truck per day of EURO 120 and a cost of EURO 0.33 per minute that a truck is driving or unloading at the store. The fixed costs are incorporated in the cost structure, because the retailers can dispose of the specialized temperature controlled trucks when the transportation of the frozen products is taken over by the LSP.

Besides transportation costs, also the costs of operating an FDC are incorporated. In the Netherlands, storage of one roll pallet of frozen goods costs on average EURO 2.79 per week. These costs include handling, depreciation and cooling. Whereas they are fixed for the LSP, the retailers can eliminate these costs by accepting the LSP's insinking offer. We assume that the FDCs of each retailer have a capacity equal to a week's throughput of pallets.

Routing problems

To calculate the costs for all coalitions we have to solve 95 vehicle routing problems with time windows. This is because for each of the five working days in the planning period, there are 2^4-1 routing problems representing the non-empty coalitions that can be served by the LSP and four extra routing problems because for the 1-player coalitions also the scenario exists that the player rejects the insinking offer and performs the transportation himself.

Orders are to be delivered to the stores between 8 am and 6 pm. The dataset shows that the number of deliveries per store per day is either 1 or 2. When stores are delivered twice a day, there is a morning delivery between 8 am and 1 pm and an afternoon delivery between 1 pm and 6 pm. To solve the 95 vehicle routing problems with time windows (VRPTW) we use the heuristic of Bräysy et al. (2004). Details of the solutions to the routing problems can be found in Table 6.

S	# Roll pallets	# Orders	Location costs	# Trucks	Total time	Transportation costs
{A}-self	580	370	509	20	5,251	4,133
{B}-self	716	244	743	28	11,161	7,043
{C}-self	513	189	546	23	8,852	5,681
{D}-self	1,758	585	1,841	45	16,345	10,794
{A}	580	370	.	20	5,254	5,558
{B}	716	244	.	28	11,519	7,161
{C}	513	189	.	20	8,954	5,354
{D}	1,758	585	.	44	16,114	10,597
{A,B}	1,296	614	.	48	17,997	11,699
{A,C}	1,093	559	.	45	16,314	10,783
{A,D}	2,338	955	.	62	23,025	15,038
{B,C}	1,229	433	.	44	17,630	11,097
{B,D}	2,474	829	.	63	23,686	15,376
{C,D}	2,271	774	.	51	20,590	12,914
{A,B,C}	1,809	803	.	60	23,801	15,054
{A,B,D}	3,054	1,199	.	78	29,383	19,056
{A,C,D}	2,851	1,144	.	72	26,826	17,492
{B,C,D}	2,987	1,018	.	74	28,566	18,306
{A,B,C,D}	3,567	1,388	.	89	34,390	22,028

Table 6: Routing results aggregated over five working days

The first four rows of Table 6 represent the cases where the retailers perform the transportation individually from their private FDCs, while for the other rows the service of the LSP is used. The location costs and the transportation costs form the necessary input to calculate the coalitional values from equation (3). Table 7 displays the structure of all coalitional values and the allocation over the retailers according to the Shapley value. Figure 4 depicts all paths from the 1-retailer coalitions to the grand coalition. Note that the percentage cost reductions in this figure are the quotient of the allocations given in Table 7 and the individual location and transportation costs of the retailers provided in the first four rows of Table 6. As mentioned earlier, a synergy claim of 0.2 is incorporated in the coalitional values.

S	$\sum_{i \in S} C_0(i)$	$C(S)$	$v(S)$	$\Phi(S,v)$
{A}	4,642	5,558	0.0	(0.0; . ; . ; .)
{B}	7,786	7,161	500.0	(. ;500.0; . ; .)
{C}	6,227	5,354	698.4	(. ; . ;698.4; .)
{D}	12,635	10,597	1,630.4	(. ; . ; . ;1,630.4)
{A,B}	12,428	11,699	583.2	(41.6; 541.6; . ; .)
{A,C}	10,869	10,783	68.8	(-314.8; . ; 383.6; .)
{A,D}	17,277	15,038	1,791.2	(80.4; . ; . ; 1,710.8)
{B,C}	14,013	11,097	2,332.8	(. ; 1,067.2; 1,265.6; .)
{B,D}	20,421	15,376	4,036.0	(. ; 1,452.8; . ; 2,583.2)
{C,D}	18,862	12,914	4,758.4	(. ; . ; 1,913.2; 2,845.2)
{A,B,C}	18,655	15,054	2,880.8	(91.6; 1,473.6; 1,315.6; ,)
{A,B,D}	25,063	19,056	4,805.6	(297.2; 1,669.6; . ; 2,838.8)
{A,C,D}	23,504	17,492	4,809.6	(-61.1; . ; 1,771.7; 3,098.9)
{B,C,D}	26,648	18,306	6,673.6	(. ; 1,478.4; 1,938.8; 3,256.4)
{A,B,C,D}	31,290	22,028	7,409.6	(265.9; 1,805.4; 1,907.5; 3,430.7)

Table 7: Cost reduction offers

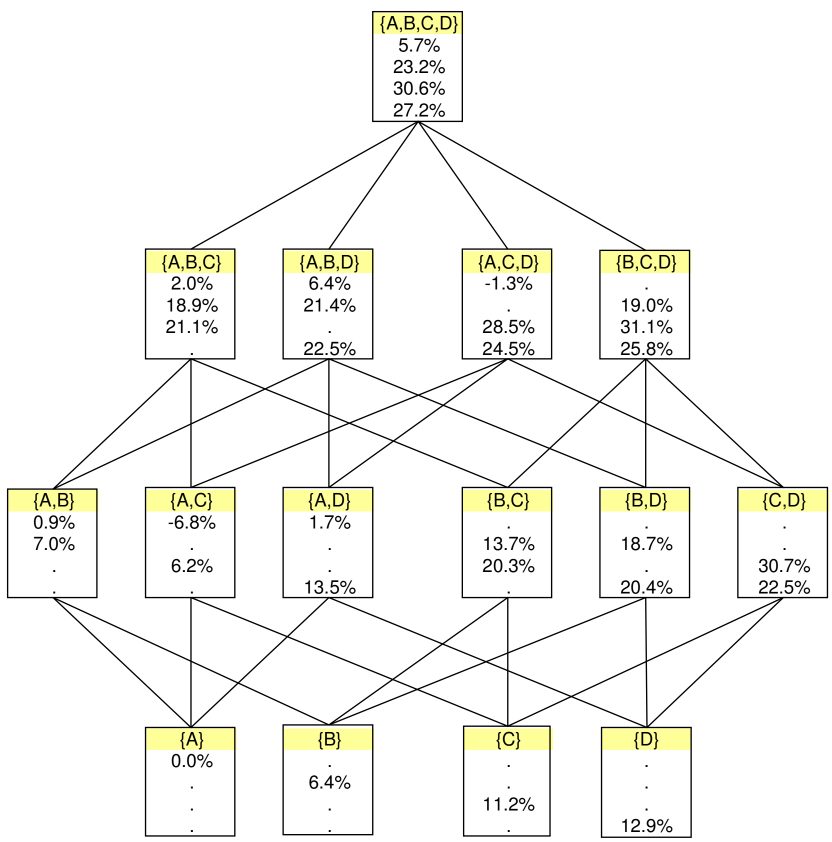

Figure 4: Percentage cost reduction paths

In practice the LSP will transfer the cost reductions to player i by means of a lower tariff t_i^S per roll pallet, depending on the coalition S that he serves. This tariff can easily be calculated from the cost reductions attributed to player $i \in S$ and his demand $D(i)$ in roll pallets:

$$t_i^S = \frac{C_0(i) - \Phi_i(S,v)}{D(i)} \tag{4}$$

The development of these tariffs along the paths is shown in Figure 5. This shows that player D has by far the lowest tariff, representing the cost effectiveness of operating his dense nation-wide network of stores.

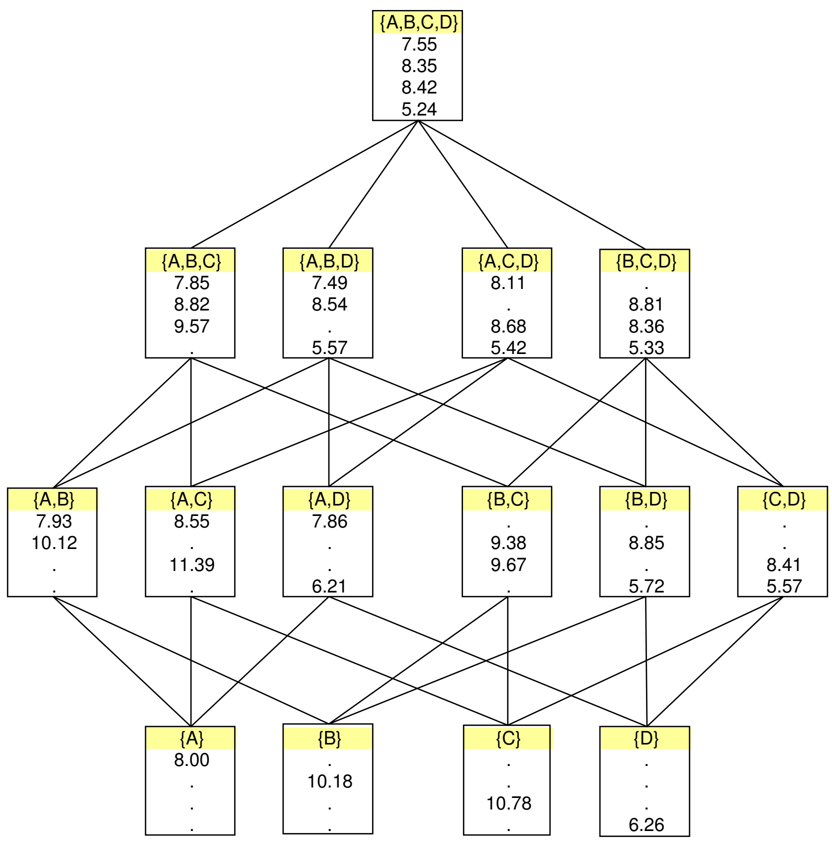

Figure 5: Tariff paths

3.4 Negotiation and structure of sequential offers

Negotiation takes place on a bilateral basis between the LSP and the individual retailers. Only the LSP has perfect information because he has calculated all coalitional values and knows the tariffs he is going to offer to each individual retailer. The retailers on the other side only know their own current and future tariff offers and have to make their accept/reject decision based on these private data.

Figure 4 clearly shows that there are many paths along which retailers get a positive cost reduction at every step. It is however readily verified that the only three RSMPs are CBAD, BCAD, and BACD. Table 8 shows that, according to the criterion proposed in section 2.3, CBAD is the best RSMP.

	Certain gain				***Sorted certain gain***			
Path	**A**	**B**	**C**	**D**	***Lowest***	***2nd***	***3rd***	***4th***
CBAD	2	13.7	11.2	27.2	*2*	*11.2*	*13.7*	*27.2*
BCAD	2	6.4	20.3	27.2	*2*	*6.4*	*20.3*	*27.2*
BACD	0.9	6.4	21.1	27.2	*0.9*	*6.4*	*21.1*	*27.2*

Table 8: RSMPs sorted lexicographically according to the certain gains

3.5 Discussion

Table 7 shows that all coalitions, except {A}, have a positive value. This means that for almost every coalition the LSP can perform the orders more efficiently than the corresponding players can if they reject the offer and perform the orders individually. In particular, all retailers benefit when the grand coalition is reached, i.e., if all retailers accept the LSP's insinking offer. In that case, the monetary savings attained from the synergy between the four retailers, are distributed as presented in Table 9.

Retailer	**Monetary gain**	**Percentage gain**
A	265.9	5.7 %
B	1,805.4	23.2 %
C	1,907.5	30.6 %
D	3,430.7	27.2 %
LSP	1,852.4	.

Table 9: Distribution of monetary savings

The LSP reserves 20% of the total savings, which provides him with a gain of 1852 EURO per week. This gain is used to cover the extra administrative (back office) costs and the costs of storage at the central FDC. The remainder is profit. Retailer D brings in the most orders and is rewarded for this by getting the largest part of the savings from cooperation in absolute terms. Retailer C however gets the largest percentage cost reduction because his orders relatively exhibit most synergy with the other retailers. Figure 3 indeed shows that the stores of retailer C in a way glue together the geographical locations of the stores of the other retailers.

An important decision is to choose in which of the 24 possible sequences the LSP approaches the retailers. It turns out that in the case at hand there are only three RSMPs, implying that Shapley monotonicity is a quite discriminatory property for a path. Of the three RSMPs available, path CBAD performs best in this respect. This means that the LSP can best contact C first, then B, then A, and finally D. The virtue of an RSMP is that in every step along the path all committed players benefit when another player accepts the offer. This type of monotonicity makes that no committed player is harmed by the event that one of his competitors joins the cooperation. This is a very important condition for companies entering a co-operative relation.

The small number of RSMPs encourages the insinking LSP to perform extra effort in the target group selection. When the possibility exists to pick shippers from a larger set than the LSP can effectively handle, he can proactively perform step 2 of the procedure on test groups of shippers and evaluate the number and quality of the RSMPs present. By doing so the LSP avoids targeting a group of shippers that may have great synergy potential, but no attractive RSMP to reach the grand coalition. As argued in section 2.3, the attractiveness of an RSMP depends on the minimum over all certain percentage cost reductions that are experienced by the players along the RSMP.

By applying insinking, the LSP offers shippers the opportunity to considerably cut down transportation and location costs. In order to reap the maximum benefits, all involved parties depend on each other, which creates a beneficial lock-in that contributes to the probability of lasting success of the project. However, it should be noted that the numbers in Figure 4 represent the 'ideal' situation in which every player accepts the LSP's offer. Although the clear initiative of the LSP makes his competitors less visible to the shippers, and insinking brings the retailers considerable cost reductions, still the retailers might have the strongest negotiation power. As a result, there is the chance that a retailer will (initially) reject the offer. In this case, the LSP still has some room for bargaining by decreasing his synergy claim for this specific retailer. When the LSP cannot persuade the retailer to accept the offer by lowering his synergy claim, the rejection is definitive. This retailer then has to be removed from the grand coalition. If for example on the best RSMP CBAD retailer C would reject the offer, the new grand coalition N' becomes {A,B,D} and the insinking game is restricted to the subgame $\left(N', v|_{N'}\right)$. An identical analysis reveals that the best RSMP in this case would in fact be DBA, instead of the sequence BAD proposed by the original

RSMP. If players further up the path reject the offer, no new negotiations with the already committed players will take place, although the negotiation plan with future players will have to be reconsidered.

4 Conclusions

In this paper we have introduced the so-called insinking procedure that LSPs can use to attract new customers and improve their market power. The given format for approaching the potential customers ensures that the LSP does not run financial risks and that his business proposals to all shippers are as good as possible. Customized prices based on each shipper's actual contribution to the total synergy accomplish a fair allocation of the monetary savings from the cooperation. The procedure uses an operations research algorithm to calculate the value of every possible coalition of shippers, and a game theoretical solution concept to construct the customized tariffs.

Insinking seems to be a viable alternative for the traditional outsourcing paradigm. With outsourcing the initiative for transferring the execution of transportation activities to an LSP lies with the shipper, and the occurrence of strong synergies with other shippers served by the LSP is more or less a matter of chance. With insinking however, the initiative lies with the LSP. He can use his market knowledge and experience, enriched by operations research techniques, to target exactly those shippers that exhibit strong synergies. Therefore, having the LSP in the driving seat seems natural because the LSP is the actor in the supply chain with the best competencies to exploit synergies in transportation systems. Moreover, the LSP has a clear economic incentive to attract as many shippers as possible since this increases his turnover and profit. Due to the property of Shapley Monotonicity, all parties involved benefit when the LSP attracts additional customers.

From an organizational perspective insinking also has advantages compared to outsourcing, because it facilitates horizontal cooperation without the difficulties arising from the sharing of sensitive information between the cooperating companies. Open communication about the methodology and the consistent usage of an objective and fair game theoretical solution concept to allocate savings to shippers, make the LSP a trustworthy partner. In general, transportation is a hands-on and low-tech sector and practical cases have shown that practitioners often regard the problem of constructing a fair gain sharing mechanism as too difficult or academic. The insinking procedure has the advantage that this complex task now lies with only one actor who performs all necessary calculations and communication to the shippers. This avoids long and difficult rounds of discussion among the cooperating companies.

Although the calculation of customized tariffs for new customers based on their actual synergy with existing customers of an LSP seems quite logical from an economical point of view, tariff proposals by LSPs are often based on static rules of thumb, past prices and (conjectured) competitor prices. Modeling the problem as a cooperative game makes LSPs more aware of the actual value that a new customer creates for his business. The advantageous customer – service provider combinations that will result from applying a more sensible tariff quotation methodology will benefit both individual companies and society as a whole.

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