DEPARTMENT OF ENGINEERING MANAGEMENT

Gain sharing in horizontal logistic collaboration
A case study in the fresh fruit and vegetables sector

Christof Defryn, Christine Vanovermeire, Kenneth Sörensen
Alex Van Breedam, Bart Vannieuwenhuyse & Sven Verstrepen

UNIVERSITY OF ANTWERP
Faculty of Applied Economics
City Campus
Prinsstraat 13, B.226
B-2000 Antwerp
Tel. +32 (0)3 265 40 32
Fax +32 (0)3 265 47 99
www.uantwerpen.be

FACULTY OF APPLIED ECONOMICS

DEPARTMENT OF ENGINEERING MANAGEMENT

Gain sharing in horizontal logistic collaboration
A case study in the fresh fruit and vegetables sector

Christof Defryn, Christine Vanovermeire, Kenneth Sörensen,
Alex Van Breedam, Bart Vannieuwenhuyse & Sven Verstrepen

RESEARCH PAPER 2014-004
FEBRUARY 2014

University of Antwerp, City Campus, Prinsstraat 13, B-2000 Antwerp, Belgium
Research Administration – room B.226
phone: (32) 3 265 40 32
fax: (32) 3 265 47 99
e-mail: joeri.nys@uantwerpen.be

The research papers from the Faculty of Applied Economics
are also available at www.repec.org
(Research Papers in Economics - RePEc)

D/2014/1169/004

Gain sharing in horizontal logistic collaboration

A case study in the fresh fruit and vegetables sector

Christof Defryn[1], Christine Vanovermeire[1], Kenneth Sörensen[1], Alex Van Breedam[2], Bart Vannieuwenhuyse[3] and Sven Verstrepen

[1]University of Antwerp Operations Research Group ANT/OR
[2]Antwerp Management School
[3]Groep T

April 2013

Abstract

This paper applies several cost allocation methods to a real life case study of fresh produce traders, jointly organising their transportation from the auction to a joint transport platform. The allocation may differ depending on whether the costs are divided on a daily basis or aggregated over a longer period. Moreover, the choice of allocation method determines the specific incentive — to grow, to be flexible towards delivery terms — that is given towards the collaborating parties. In conclusion, although the literature on game theory offers some support, the coalition has to determine what it perceives as a 'fair' cost allocation.

1 Introduction and Literature review

1.1 Gain sharing in horizontal logistics collaborations

In order to improve the efficiency of transportation networks and in light of the growing debate on sustainability many initiatives have been taken, including the idea of horizontal cooperation, where companies at the same level of the supply chain join forces (European Commission, 2011). The positive effect of such collaborations has been shown by means of simulation (Hageback and Segerstedt, 2004; Cruijssen and Salomon, 2004; Palander and Väätäinen, 2005; Le Blanc et al., 2006; Ergun et al., 2007) and by reporting on actual cases (Bahrami, 2002; Wiegmans, 2005; Cruijssen et al., 2007; Frisk et al., 2010).

Horizontal collaboration in logistics is gaining traction as a viable way to reduce transportation costs and increase efficiency and sustainability. By combining the shipments of several companies, the number of trucks on the road can be reduced and their fill rate can be increased (European Commission, 2011; Initiative and Capgemini, 2008). The main motivation for companies to collaborate is the fact that the total transportation cost of the coalition is lower than the sum of the stand-alone costs. The difference between these costs is called the *coalition gain*, and needs to be divided among the different partners.

When gains are generated as a result of collaboration between different partners, it is not trivial to determine which partner has a right to which fraction of these gains. The way in which this should be done depends on the attributes of each of the partners' collaboration strategy that the coalition deems important. Some coalitions will wish to encourage the partners to take a flexible stance with respect to their delivery terms (e.g. wide time windows, orders that can be delivered on different days), whereas others will prefer partners to ship as much as possible. A wide range of so-called *gain sharing methods*, also called *profit allocation methods*, exist, ranging from straightforward rules of thumb to more complicated concepts described in the game theory literature. Rather than dividing the coalition gain between the partners, the coalition can also agree to share the total cost. In this case, a *cost allocation method* is used. Although all cost allocation methods can also be used to allocate the profit, the result for each partner is generally not the same, and the decision to allocate the coalition gain or the coalition cost should be taken with caution.

In practice, simple proportional allocation methods are used most often. Most likely, this is due to the fact that most game-theoretical allocation methods can be difficult to understand, require more complicated calculations, and need more information to calculate (Leng and Parlar, 2005). For a review of gain sharing methods, we refer to Vanovermeire et al. (2013).

In this paper, several cost allocation methods are compared on the data provided by the coalition of produce traders (see section 2). The selected methods are the *Shapley value*, the *Nucleolus*, the *Equal Profit Method (EPM)* and the *Alternative Cost Avoided Method* (ACAM). The cost allocations generated by each of these methods are compared to each other, and to the currently used *Volume method*.

1.2 Properties of gain sharing

In the field of game theory a number of properties have been formulated that are considered important when evaluating a profit (or cost) allocation (Tijs and Driessen, 1986). We summarise the most important ones. First of all, the allocation needs to be *Pareto-efficient*, which means that the entire profit (or cost) needs to be divided among the partners.

The property of *individual rationality* ensures that the situation of a partner does not worsen by joining the coalition. In other words, when using a profit allocation method, each partner should be assigned a positive profit. If this property is not realized the global coalition will tend to break up, as the affected partner will have an incentive to leave. If the allocation method ensures individual rationality for every sub-coalition, it is called *stable*. In other words, when using a stable allocation method none of the parties can improve their situation by forming a sub-coalition. The set of all possible stable cost or profit allocations is called the *core*.

The *additivity* property ensures that the allocation cannot be influenced by making larger coalitions in advance. The profits, allocated to company i and j, are therefore equal to the profit a company would receive that represents $i+j$.

Finally, the *dummy player property* states that a partner that neither helps nor harms any coalition is allocated a zero-profit or a cost equal to its stand-alone cost.

Multiple allocation methods have been developed that each possess a subset of the desirable properties. A single method that has all properties does not exist.

Table 1 shows the properties of each of the cost allocation methods described in this section. In the remainder of this section, each cost allocation method is briefly introduced. Table 2 contains the symbols used in this paper.

Table 1: Properties of the different allocation mechanisms

	Shapley	Nucleolus	ACAM	EPM	Volume
Pareto-efficiency	X	X	X	X	X
Individual rationality	X	X	X	-	-
Stability	-	X	-	-	-
Additivity	X	-	-	-	-
Dummy player property	X	X	-	-	-

Table 2: Symbols

N	=	the complete coalition with all partners	m_i	=	the marginal contribution of partner i
S	=	a sub-coalition ($S \subseteq N$)	w_i	=	the weight indicating the proportion of the gain partner i receives
$\|S\|$	=	the number of partners in the coalition			
i, j	=	indices of different partners in a coalition	x	=	vector of allocated gains
$c(.)$	=	the cost of a (sub)–coalition	x_i	=	the allocated gain for partner i
$e(.)$	=	the excess of an allocation	V_i	=	the volume of partner i
$s(i)$	=	the stand-alone cost of partner i			

1.3 Methods for gain sharing

1.3.1 The Shapley value

The formation of the grand coalition can be seen as a sequential process, where the partners enter one by one (Tijs and Driessen, 1986). Each time, a partner pays the additional costs that arise by joining its predecessors. If this is repeated for any possible permutation of the order of entering, and the obtained costs are averaged in a uniform manner, the *Shapley cost allocation method* is obtained. This method is based on the *Shapley value*, introduced by Shapley (1953).

Because the Shapley value takes into account the marginal effect of a partner on *all (sub)coalitions* it is said to be based entirely on a partner's *co-operative productivity*. The portion of the cost assigned to partner i is given by the following formula:

$$x_i = \sum_{S \subseteq N \setminus i} \frac{|S|!(|N| - |S| - 1)!}{|N|!} (c(S \cup i) - c(S)) \tag{1}$$

Using the Shapley value as an allocation method is increasingly popular, in part because it has been put forward by the European CO^3-project (`www.co3-project.eu`), a peer group of more than fifty important industrial companies. This project, co-financed by the Directorate-General for Research and Innovation of the European Commission, strives to encourage a structural breakthrough in the competitiveness and sustainability of European logistics by stimulating horizontal collaboration between European shippers. Nevertheless, the CO^3-consortium also acknowledges the need to select a gain or cost allocation mechanism on a case-by-case basis (Biermasz, 2012).

1.3.2 The Nucleolus

The Nucleolus, defined by Schmeidler (1969), is a cost allocation mechanism based on the idea of *minimizing maximum 'unhappiness'* of the partners. Unhappiness is measured by the *excess* of the proposed allocation, defined as:

$$e(x, S) = c(S) - \sum_{i \in S} x_i \tag{2}$$

The excess can be interpreted as the gain that the companies in sub-coalition S obtain if they withdraw from the grand coalition N. To evaluate different allocations based on the excess, a number of linear programs (LPs) need to be solved. For increasing coalition sizes, these LPs increase in complexity and computation time. Nevertheless, a unique and stable solution is guaranteed in the centre of the core.

1.3.3 The equal profit method (EPM)

A more intuitive way of dividing the coalition gain is based on the idea of *equal profit*. Frisk et al. (2010) proposed this method in order to obtain relative savings as equal as possible for the different partners. The calculations can be done by solving a straightforward linear program that minimises the largest relative savings difference between any pair of partners. The EPM can only be calculated if the core is non-empty. In this case a stable solution is guaranteed.

It can be argued that it might seem 'fair' to offer the same relative savings to every partner in the coalition. However, the equal profit method uses the stand-alone cost to define the relative importance of each partner. As a result, companies with higher stand-alone costs receive a bigger absolute part of the coalition gain when the method is used for gain sharing.

1.3.4 The alternative cost avoided method (ACAM)

As discussed by Tijs and Driessen (1986), a sub-group of allocation methods is based on the principle of first dividing the total coalition gain in a *separable* (m_i) and a *non-separable part* ($c(N) - \sum_j m_j$). The first part, linked to one specific partner, is defined as the *marginal cost when that partner enters the coalition consisting of all other partners* (Vanovermeire et al., 2013). The remaining, non-separable, part can then be divided in various ways. Based on the individual contributions of each partner, the *alternative cost avoided method* (ACAM) defines a set of weights that can be used to divide of the non-separable costs. These weights are based on the differences between the stand-alone cost and the marginal cost of a partner. The part of the total coalition cost allocated to partner *i*, is thus:

$$x_i = m_i + (c(N) - \sum_j m_j) \frac{s(i) - m_i}{\sum_j (s(j) - m_j)} \quad (3)$$

1.3.5 Volume-based allocation

In practice, companies mostly stick to the more straightforward allocation methods that can be easily interpreted and offer a certain transparency (Frisk et al., 2010). For these *proportional allocation methods* the coalition gains are divided by calculating a weight for each partner. When a volume-based allocation is used these weights are based on the volume, e.g. the number of pallets, the total weight, ..., shipped by that partner with respect to the total coalition volume. This method is currently used by the fresh produce shuttle service.

$$w_i = \frac{V_i}{\sum_i V_i} \quad (4)$$

2 Collaboration among fresh produce traders

Fresh fruit and vegetables are typically traded at an auction from which they are transported to the customers in temperature controlled trucks. Fresh produce is highly perishable and an efficient supply chain is of crucial importance to maintain customer service levels.

In 2012, three traders at a Belgian fruit and vegetables auction launched, under the supervision of a neutral third party, a joint shuttle service between the auction and the traders common transport platform, about 250 km to the east. This shuttle service was outsourced to a specialized logistics service provider (LSP).

A twofold, positive effect could be observed. First, the shuttle service guaranteed the traders that their goods, even the ones bought last-minute, can be transported in an appropriate way. A reliable truck, departing no later than 11.00am from the quay at the auction, provided the necessary temperature controlled (8°C) transportation. Furthermore, by combining the orders of the three traders and thereby increasing the transported volume, better prices could be negotiated from the LSP.

A yielding pace list was negotiated that determined the transportation price as a function of the total shipped order size (i.e., the number of pallets). The regressive character of this instrument was meant to stimulate the traders to increase their order quantities. Since the total cost of the shuttle truck is calculated based on the consolidated volume, the traders are pushed to avoid small shipments by buying extra products at the auction or by moving their delivery to the next day, if feasible.

From their side, the auction authorities encourage this horizontal collaboration project in two ways. First, priority is given to the shuttle service by assigning a specific quay to it. Secondly, the auction also acts as a neutral party by keeping track of the consolidation gains (i.e., the profit obtained by switching from individual transport to the shuttle service). Periodically, these gains are divided among the traders, using the Volume method, i.e., proportional to the number of traded pallets.

In this paper, we scrutinize the way in which the consolidation gains are divided by the agreement between the traders. Next to the current way of working, we examine the properties and results of the gain sharing methods discussed in Section 1.3. We find that different gain sharing mechanisms give largely different results, and also result in different incentives for the partners in the coalition. For these reasons, we conclude that it is important to select an adequate gain sharing mechanism.

3 Simulation results

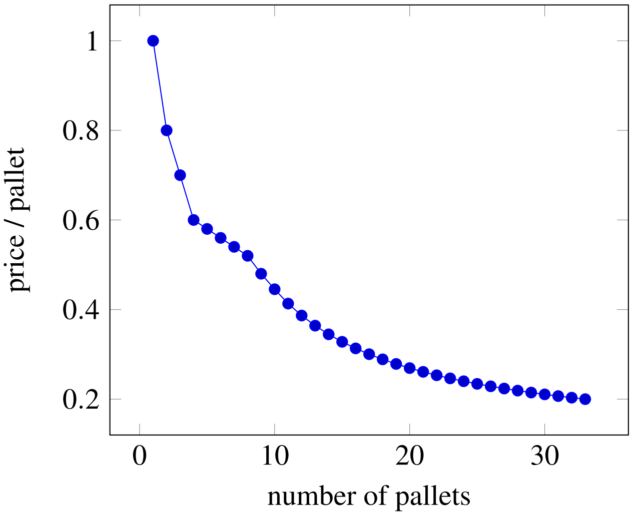
The shipped volumes of the coalition were observed during a period of eight weeks. The cost of every (sub)-coalition is calculated based on a pace list (Figure 1), negotiated with the logistics service provider[1]. In case of multiple trucks on one day an optimal load distribution (minimal costs) is assumed. During the considered period the total coalition gain reached more than €2000, which corresponds to a cost reduction of 16%. A full truck load consists of 33 pallets.

The parties involved agreed on a volume based gain sharing method, because of simplicity and transparency reasons. The traders receive a part of the coalition gain according to their individual volumes, calculated by the number of pallets, which gives them the incentive to place larger orders. The profits, held by the auction authorities as a neutral party, are periodically divided among the traders. The logistics service provider is paid according to the consolidated volumes.

We will examine the characteristics of the partners (Section 3.1) and discuss the need for a gain sharing method that produces a stable allocation (Section 3.2). Gain sharing can be done on a day-to-day basis or on an aggregated (e.g. weekly) basis (Section 3.3). Section 3.4 handles the difference between the rigid and the flexible scenario.

[1]The pace list is anonymised by normalising it between 0 and 1

Figure 1: The relative pace list for the traders' shuttle truck



3.1 Characteristics of the partners

The first partner (A) transports high volumes (61% of the total volume of the coalition) but, therefore, requires full truckloads (FTL) on a regular basis. As no bundling is possible with these shipments, FTLs are not beneficial to the total coalition.

Partner B on the other hand also makes use of the shuttle truck on a very regular basis, but with lower average order sizes. In this way, the collaborative effect with this partner will be the highest, because orders can be combined into one truck.

Lastly, the third partner (C) also places small orders, but in total his degree of participation is rather low (only 9% of the total volume), reducing again his impact on the grand coalition.

3.2 Stability

When setting up a new coalition, the potential partners need to take into account the stability of the grand coalition. If a sub-coalition exists that is in any way more beneficial for one collaborating partner, than the long–term stability of the grand coalition can no longer be guaranteed. Stability is ensured in two ways.

Firstly, the gain of a sub-coalition may never exceed the total coalition gain. If this is the case, a better performing sub-coalition could be formed by leaving out some partners. This is known as the problem of *strong sub-coalitions* (Vanovermeire et al., 2013).

For the shuttle truck case study it can be seen in Table 3 that the total cost of a (sub)-coalition is always smaller than the summed stand-alone costs of the partners involved. Additionally it is clear that by forming the grand coalition the highest gains are obtained. Although the stability of the aggregate data, it remains possible that on a daily basis non-stable collaborations existed. During one day, a strong sub-coalition was found for this case study, where a collaboration of only two partners would generate a higher profit compared to the grand coalition. This possible short-term instability does not necessary endanger the long-term stability of the total coalition and is rather rare and temporary. However, it causes an infeasible solution for the equal profit allocation method.

Table 3: Aggregated total cost of the (sub)-coalitions for the shuttle truck case study

Sub-coalitions		**A**	**B**	**C**	**A–B**	**B–C**	**A–C**	**A–B–C**
Original	cost	€6142	€4844	€1646	€9847	€5733	€7441	€10564
	profit				€1138	€757	€347	€2068
Flexible	cost	€6096	€4680	€1475	€9548	€5400	€7038	€10110
	profit				€1229	€756	€534	€2142

Secondly, the allocation mechanisms need to ensure that the costs paid by the different partners in the grand coalition are always lower than the corresponding stand-alone costs. If this property is not fulfilled, a partner may not want to collaborate and the grand coalition may split up.

3.3 Aggregation of profit allocation

Depending on the allocation method, a different division of the profits is realized when the allocating on a daily basis or on aggregate level (e.g. weekly or monthly). These differences between the allocation methods are demonstrated in Table 4(a).

For the Shapley value, the Nucleolus and ACAM, similar results are reported in the rigid planning method on a daily basis. This is due to the fact that most of the time only two partners make use of the shuttle truck on the same day. In a coalition with only two partners, these three allocation methods split the profit in two equal parts. The volume based allocation and the equal profit method however differ, allocating less to the smaller partners, B and C, in favour of partner A.

Significant differences are found comparing daily allocation with respect to aggregated allocation. On aggregate level the gains are divided among the three partners based on their total contribution during the period. Due to the aggregation, the multiple two–party collaborations that are observed will be summed and the Shapley Value, Nucleolus and ACAM no longer divide the gains equally among the partners. Here, the Nucleolus tends to allocate more to partner A, due to his higher stand-alone cost and the property of finding a solution in the centre of the core.

It can be argued that a daily allocation gives a better approximation of the real costs and profits per partner. Aggregating costs flattens the real costs of single transports, which is thus taken less into account when calculating the profit allocation. The differences between daily and aggregated allocation can be up to 46%.

Table 4: Allocation of coalition gain by the different methods. For the aggregated allocation we assume that the cost allocation was only done at the end of the eight-week sample.

(a) rigid planning *(total profit = €2068)*

	Daily allocation			Aggregated allocation		
	A	B	C	A	B	C
Volume	€1034	€673	€361	€1264	€611	€193
Shapley	€684	€891	€494	€684	€890	€494
Nucleolus	€684	€976	€409	€846	€757	€464
ACAM	€685	€893	€495	€684	€898	€485
EPM	€866	€792	€411	€1005	€793	€269

(b) flexible planning *(total profit = €2142)*

	Daily allocation			Aggregated allocation		
	A	B	C	A	B	C
Volume	€1097	€692	€353	€1309	€632	€200
Shapley	€756	€868	€520	€756	€867	€519
Nucleolus	€731	€953	€459	€930	€756	€457
ACAM	€734	€851	€559	€741	€876	€498
EPM	€909	€746	€387	€1050	€810	€255

Exceptionally, the Shapley value, because of the property of additivity that this method possesses and the fact that it is fully based on efficiency of the transportation, is insensitive to the level of aggregation.

3.4 Flexibility to support the coalition

In our simulations, two alternative scenarios are considered. In the *rigid* scenario (Table 5(a)) all orders are shipped on the day they are placed (which is the current situation). The *flexible* scenario (Table 5(b)) assumes that small order sizes (less than 10 pallets) can be stored at the auction for one day and combined in the next day truck if this yields a smaller total cost.

The price that has to be paid by the traders for the transport depends on the shipped volume according to a negotiated pace list, which makes smaller shipments rather costly. In order to avoid this undesirable situation the coalition has agreed to strive towards shipments of at least ten pallets. If this threshold is not reached the traders are motivated to buy extra products or to delay the delivery by one day if possible.

In reality, during the eight weeks of observation, postponement of the transport occurred only once. Therefore, it is simulated that orders of less than ten pallets are automatically moved to the next day,increasing the possibilities of combining orders. As an example, Table 5(b) contains an application of this flexibility to the data sample. Although the total cost of the coalition is lower when flexibility is enforced, the coalition gain is smaller. The reason is that the stand-alone cost

Table 5: One-week sample of shipped volumes per partner and for the grand coalition

(a) Rigid planning

	A	**B**	**C**	**Grand coalition (A+B+C)**	
	volume	volume	volume	volume	coalition cost
day 1	3×33	10		$3 \times 33 + 10$	€1212.7
day 2		5	4	9	€219
day 3	13	22		33 + 2	€410
day 4					
day 5	11	10	10	31	€320.54
aggregated	**123**	**47**	**14**	**184**	**€2159.24**

(b) Flexible planning

	A	**B**	**C**	**Grand coalition (A+B+C)**	
	volume	volume	volume	volume	coalition cost
day 1	3×33	10		$3 \times 33 + 10$	€1212.7
day 2					
day 3	13	22 + 5	4	33 + 11	€557.37
day 4					
day 5	11	10	10	31	€320.54
aggregated	**123**	**47**	**14**	**184**	**€2090.61**

of the partners also decreases when flexibility is enforced. Nevertheless, because of the lower coalition cost, the flexible approach will still be beneficial for the coalition.

According to Table 3, a flexible approach to the entire eight-week data set, increases the coalition gain to €74 (3.6%). On 12.5% of the reported days, the orders of that day would remain at the auction. An average profit of around €15 is made for every postponement.

The allocated profits are shown in Table 4(b). Depending on the chosen allocation mechanism, this flexible strategy is not profitable for every partner in the shuttle truck case study. Most of the time, the flexible strategy is less beneficial for partner B. As the order sizes of B are rather small, a flexible behaviour of B will results in an improved stand-alone position with a rather small effect on the grand coalition. For partner A on the other hand, orders will only be postponed if the order size is small, which occurs only a few times. As it is difficult for partner A to combine this small order with the FTLs that he normally delivers, all synergies occur by interacting with the other partners in the coalition making this flexibility beneficial for everyone.

4 A different allocation method, a different incentive

The incentive given by each method is slightly different. As a coalition, it is necessary to agree on the *preferred incentive*. If the *volume based allocation* is chosen, the partners shipping the highest volumes are favoured although these transportations may not be that efficient for the coalition. This method therefore gives an incentive to grow. The *ACAM* produces similar results compared to the *Shapley value*. This last one puts a lot of stress on efficiency by taking into account the marginal cost of the different partners in *every* (sub)–coalition. Here, the efficiency of a single partner (e.g. the partner is participating a lot and the order sizes leave enough room for combining with others) is rewarded. The *Nucleolus* refers to long term stability because a solution in the centre of the core is guaranteed. Therefore, no partner feels the incentive to abandon the grand coalition. In contrast to the Shapley Value and the ACAM, the Nucleolus is less steadfast when gains are divided periodically. In both the rigid and the flexible scenario, we observe a significant divergence on the aggregate level where the method is less sensitive for day to day efficiency of the transport. Lastly, the *Equal Profit Method* can only be calculated if the coalition is stable. Although we find that for this case study the coalition remains stable in the long run, the stability can not be guaranteed every single day. It can also be seen that, because of the fact the EPM uses relative savings, partners with a high total stand-alone cost are favoured at the expense of the efficient ones. It can be argued that this may result in an unfair allocation if the partners differ significantly.

5 Concluding remarks

In this paper a real life horizontal collaboration was confronted with the most important allocation methods. By joining forces, the partners were able to reduce the total transportation cost by 16%. Nevertheless, significant differences were observed between the approaches. The parties involved therefore need to define which incentive they believe to be the most important one.

It can be seen that a Volume-based allocation therefore favours the growth of the partners. The Shapley value and ACAM on the other hand strive toward efficiency by means of marginal costs. In order to achieve stability, the parties can choose for the Nucleolus as it assures a solution in the centre of the core. The fairness of the EPM can be questioned in heterogeneous collaborations.

We also confirm that a more flexible attitude of the collaborating parties results in higher possible profits for the entire group. Still, it remains important to weigh the extra profits against the engagement of being flexible.

References

K. Bahrami. Improving supply chain productivity through horizontal cooperation: The case of consumer good manufacturers. In S. Seuring and M. Goldbach, editors, *Cost management in supply chains*, pages 213–232, Heidelberg, 2002. Physica-Verlag.

Jikke Biermasz. Report on the legal framework for horizontal collaboration in the supply chain. Technical report, august 2012.

F. Cruijssen and M. Salomon. Empirical study: Order sharing between transportation companies may result in cost reductions between 5 to 15 percent. Discussion Paper 80, Tilburg University, 2004.

F. Cruijssen, M. Cools, and W. Dullaert. Horizontal cooperation in logistics: Opportunities and impediments. *Transportation Research Part E: Logistics and Transportation Review*, 46(3): 22–39, 2007.

O. Ergun, G. Kuyzu, and M. Savelsbergh. Reducing truckload transportation costs through collaboration. *Transportation Science*, 41(2):206–221, 2007.

European Commission. Guidelines on the applicability of article 101 of the treaty on the functioning of the european union to horizontal co-operation agreements. *Official Journal of the European Communities*, 2011.

M. Frisk, M. Göthe-Lundgren, K. Jörnsten, and M. Rönnqvist. Cost allocation in collaborative forest transportation. *European Journal of Operational Research*, 205(2):448–458, 2010.

C. Hageback and A. Segerstedt. The need for co-distribution in rural areas - a study of pajala in sweden. *International Journal of Production Economics*, 89(2):153–163, 2004.

Initiative and Capgemini. Future supply chain 2016. Technical report, Global Commerce Initiative and Capgemini, 2008.

H.M. Le Blanc, F. Cruijssen, H.A. Fleuren, and M.B.M. De Koster. Factory gate pricing: An analysis of the dutch retail distribution. *European Journal of Operational Research*, 174(3): 1950–1967, 2006.

M. Leng and M. Parlar. Game theoretic applications in supply chain management: a review. *Information Systems and Operational Research*, 43(3):187–220, august 2005.

T. Palander and J. Väätäinen. Impacts of interenterprise collaboration and backhauling on wood procurement in finland. *Scandinavian Journal of Forest Research*, 20(2):177–183, 2005.

D. Schmeidler. The nucleolus of a characteristic function game. *SIAM Journal on Applied Mathematics*, 17(6):1163–1170, 1969.

L.S. Shapley. A value for n-person games. *Annals of Mathematics Studies*, 28:307–317, 1953.

S.H. Tijs and T.S.H. Driessen. Game theory and cost allocation problems. *Management Science*, 32:1015–1028, 1986.

C. Vanovermeire, D. Vercruysse, and K. Sörensen. Analysis of different cost allocation methods in collaborative transport setting. *International Journal of Engineering management and Economics*, 2013.

B. Wiegmans. Evaluation of potentially succesful barge innovations. *Transport Reviews*, 25(5): 573–589, September 2005.