Gain sharing in horizontal logistic co-operation
A case study in the fresh fruit and vegetables sector

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Abstract More and more companies start to notice the potential of setting up a logistic co-operation. They realize however that this idea is also a source of new challenges and impediments. We will focus on the challenge of dividing the total coalition gain among all partners. In this chapter, we show that significant differences exist between allocation methods and we examine the impact of defining gain sharing on a short term (daily) or a long term (monthly) basis. Too often, the selection of an appropriate allocation mechanism is considered as an independent decision with *fairness* as the single criterion. The companies involved, however, should realize what the impact of a certain allocation method might be, when applied in the broader context of horizontal co-operation. A selection of well known allocation methods and concepts is introduced and applied to a real life case study of fresh produce traders, jointly organising their transportation from the auction to a joint transport platform.

1 Introduction and Literature review

1.1 Gain sharing in horizontal logistics co-operations

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 co-operation*, where companies at the same level of the supply chain join forces (European Commission, 2011). The positive effect of such co-operations 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

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et al., 2007) and by reporting on actual cases (Bahrami, 2002; Wiegmans, 2005; Cruijssen et al., 2007; Frisk et al., 2010).

Horizontal co-operation 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.

However, before a successful co-operation can be established, the partners involved have to overcome certain barriers (Cruijssen et al., 2007). Multiple initiatives arise (e.g. CO^3-project, LOG2020,...), bringing together the peer groups from the industry and catalysing the debate on related topics (Cruijssen et al., 2014; Lu and Liesa, 2013). We can conclude that one of main challenges is to ensure a fair allocation of the benefits to all partners, next to finding the right partner(s) and a reliable third party that can coordinate the co-operation in such a way that all participants are satisfied (often referred to as the *neutral trustee*). In this chapter, we will focus on the question of gain sharing.

When gains are generated as a result of co-operation between different partners, it is not trivial to determine which partner has a right to which fraction of these gains. In the current literature, the focus lies on the formulation of the concept of *fairness* by questioning which allocation is *fair* for every partner in the coalition. Different definitions of the fairness criteria have resulted in a large set of *gain sharing methods* — also called *profit allocation methods* — going 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 this chapter, a new approach is introduced that can help a coalition in choosing the appropriate allocation mechanism. In stead of focusing on fairness, which remains rather subjective, we argue that gain sharing should be evaluated within the broader idea of horizontal co-operation. As for every gain sharing method certain partner characteristics are favoured, the coalition as a whole implicitly imposes the incentive to the partners to score well on these characteristics. 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.

This approach is studied on real life data, provided by a coalition of produce traders (see section 2). The selected gain sharing methods are the *Shapley value*, the *Nucleolus*, the *Equal Profit Method (EPM)* and the *Alternative Cost Avoided Method* (ACAM). The results of these allocation methods are compared to each other, and to the *Volume-based method*, that is currently used in this particular horizontal co-operation.

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). The most important ones are described in Table 1. Furthermore, we indicated which allocation method, discussed in this chapter, possesses the described property.

In the remainder of this section, each cost allocation method is briefly introduced. Table 2 contains the symbols used in this chapter.

Table 1 Properties of the different allocation mechanisms

Property	Definition	Shapley	Nucleolus	ACAM	EPM	Volume
Pareto-efficiency	*The exact total cost (or profit) should be allocated among the partners.*	✓	✓	✓	✓	✓
Individual rationality	*A player should not be allocated a cost that is higher than its stand-alone cost.*	✓	✓	✓	-	-
Stability	*Individual rationality is ensured for every sub-coalition.*	-	✓	-	-	-
Additivity	*The allocation can not 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 $i+j$.*	✓	-	-	-	-
Dummy player property	*A partner that neither helps nor harms any coalition is allocated a zero-profit or a cost equal to its stand-alone cost.*	✓	✓	-	-	-

Table 2 List of 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 coalition S		
i, j	= indices of different partners in a coalition	x	= vector of allocated gains
$s(i)$	= the stand-alone cost of partner i	x_i	= the allocated gain for partner i
$e(.)$	= the excess of an allocation	V_i	= the volume of partner i
$c(.)$	= the cost of a coalition		

1.3 Methods for gain sharing

In this Section, the selected allocation methods are introduced briefly. For a more elaborate review on gain sharing methods, we refer to Vanovermeire et al. (2013).

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:

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

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[1], 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 co-operation 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 approach (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:

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

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] `www.co3-project.eu`

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 $s(i)$ and the marginal cost m_i of a partner. The part of the total coalition cost allocated to partner i, is thus:

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

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 (see Equation (4)). This method is currently used by the fresh produce shuttle service.

$$w_i = \frac{V_i}{\sum_i V_i} \tag{4}$$

2 Co-operation 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 co-operation 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 chapter, 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.

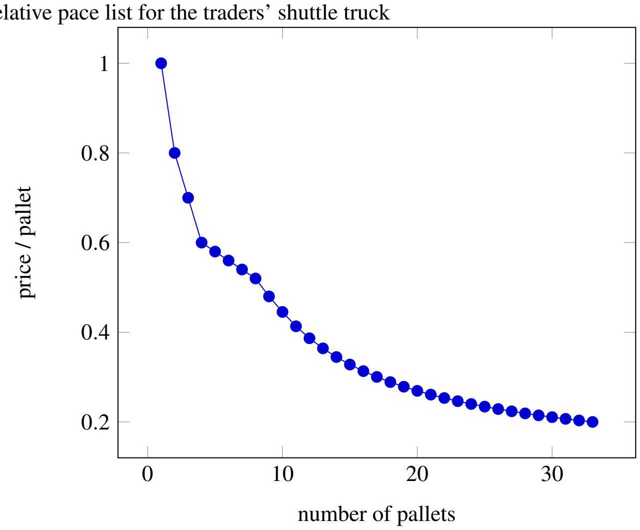
3 Simulation results

The shipped volumes of the coalition were observed during a period of eight weeks. The cost of every (sub)-coalition is calculated based on the pace list (Figure 1), negotiated with the logistics service provider[2]. In case of multiple trucks on one day

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

an optimal load distribution with minimal total costs is assumed. A full truck load consists of 33 pallets.

Fig. 1 The relative pace list for the traders' shuttle truck



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. During the considered period of eight weeks, the total coalition gain reached more than €2000, which corresponds to a global cost reduction of 16%.

In this section, the characteristics of the different partners are introduced (Section 3.1) and the need for a gain sharing method that produces a stable allocation is discussed (Section 3.2). The difference between gain sharing on a day-to-day basis or on an aggregated (e.g. weekly) basis is shown in Section 3.3. Finally, Section 3.4 handles the difference between the original rigid scenario and a flexible scenario where partners accept that small orders are stored at the auction and delivered the next morning in order to avoid the higher price per pallet for small order sizes.

3.1 Characteristics of the partners

The shuttle truck service is shared by three partners (A, B and C). The first partner (A) transports high volumes (61% of the total volume of the coalition) and nearly every day. Therefore, this partners requires a full truckloads (FTL) on a regular basis. As no bundling is possible with these shipments, FTLs are not beneficial for the total coalition.

Partner B also makes use of the shuttle truck on a very regular basis, but with lower average order sizes. In the stand-alone scenario this will result in a higher cost per pallet. By combining the orders with other partners, significant synergies can be expected. Because orders of partner B are less-than-truckload, they can be combined more easily with other less-than-truckload orders.

Lastly, the third partner (C) also places small orders that can be combined easily with other partners. However, the degree of participation is rather low for this partner (only 9% of the total volume, and 30% of the transports) reducing again his impact on the synergy of the total 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, studied in this chapter, 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 (A-B-C) the highest gains are obtained. Although the stability of the aggregate data, it remains possible that on a daily basis non-stable co-operations existed. In the sample studied in this chapter, one observation involved a strong sub-coalition. On this day, a co-operation of only two partners would generate a higher profit, compared to the current situation that includes all three partners. 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 for this one day.

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. In Section 1.2 this idea was introduced as the property of individual rationality. If this property is not fulfilled, a partner may not want to collaborate and the grand coalition may split up.

In Table 1 in Section 1.2 it can be seen that only one of the five allocation methods proposed in this chapter, the Nucleolus, guarantees a stable solution. Even the less restrictive property of individual rationality is not guaranteed in some of the methods. However, it might be useful to remark that, although it is not guaranteed mathematically, all results obtained for this case study are individual rational — no partner is allocated a negative profit — and stable — except for one day, as described above.

3.3 Aggregation of profit allocation

Depending on the allocation method, a different division of the profits is realized when the allocation takes place 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 co-operations 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%.

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.

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

3.4 Flexibility to support the coalition

The price that is 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 high transportation costs 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 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.

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		$3\times33+10$	€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		$3\times33+10$	€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**

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. Table 5(b) contains an example of this practice. As the small volume that is to be shipped on day 2 is relatively expensive, the flexible scenario imposes that these pallets stay at the auction for one more day and are shipped the next morning. Although the total cost of the coalition is lower when flexibility is enforced, the coalition gain might decrease. This is due the fact that the stand-alone cost of the partners also decreases when flexibility is enforced. Nevertheless, because of the lower total 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 with €74 (€2142 - €2068). An additional decrease in total coalition cost of around 4.3% can be witnessed by imposing the flexible strategy in stead of the original scenario. This implies that on 12.5% of the reported days, the orders of that day remain at the auction.

The allocated profits for the flexible scenario are shown in Table 4(b). Depending on the chosen allocation mechanism, this flexible strategy turns out to be not that 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 in the place result in an improved stand-alone position. For partners A and C, this flexibility will affect their stand-alone position less. For partner A, this is due to the fact that its volumes are already large most of the times, so they are shipped anyway. Partner C is not shipping regularly, so leaving its orders at the auction will not lead to any improvement as the probability that this partner will ship again the next day is low. We can therefore state that for partners A and C only benefits are created when the co-operation is set up. This positive effect on the coalition is captured by the Shapley Value, Nucleolus and ACAM. For the Volume and the Equal profit method, the shipping day is not important and the gains are allocated pro rata. The drop in allocated gain for partner C for the EPM in the different scenario is only due to the on day of strong sub–coalitions, for which no EPM can be calculated, as explained in Section 3.2.

4 A different allocation method, a different incentive

Every gain sharing method takes as an input a limited number of parameters and partner characteristics to obtain the final profit that is allocated to every partner. In Section 1.3 it could be seen that the Shapley value method is based only on costs, where the volume-based method does only take the shipped volume into account. Similar to the Shapley value, the ACAM is also based on costs but it does not include all possible sub-coalitions. This can also be said for the Nucleolus, but from a completely different perspective. The EPM is not based on absolute costs or profits, but divides the gains based on their relative differences. We can therefore state that by choosing a gain sharing method, a certain incentive is given to the partners in the coalition. Because if they are able to improve on the characteristics that are taken into account by the allocation method, a higher gain can be allocated to this partner. This idea is summarised in Table 6.

Table 6 The incentives of different gain sharing methods

Allocation Method	**Partner characteristics**	**Incentive**
Shapley value	stand-alone cost cost of all sub-coalitions	efficiency
Nucleolus	stand-alone cost cost of sub-coalitions with $\|N\|-1$ partners	stability
Equal profit method	stand-alone cost	stand-alone inefficiency
Alternative cost avoided method	stand-alone cost cost of sub-coalitions with $\|N\|-1$ partners	efficiency
volume-based allocation	volume	ship large volumes

If the *volume-based allocation* is chosen, the partners shipping the highest volumes are favoured although their shipments might 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. By stabilizing as much as possible the situation as it is, it will give no incentive to the partners to adapt their behaviour. We therefore state that the Nucleolus gives an incentive of stability to the partners. 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, that are therefore inefficient, are favoured at the expense of the efficient ones. It can be argued that this might result in an unfair allocation if the partners differ significantly.

5 Concluding remarks and further research

In this chapter, the effect of the selected gain sharing method in a horizontal co-operation is examined by using an empirical approach. For the simulation, we selected five well known allocation methods and applied them on real life data, obtained from a coalition of fresh produce traders. By joining forces, the partners were able to reduce the total transportation cost by 16%.

Firstly, we can conclude that significant differences might exist if the gain sharing is done on a short or a long term basis. This is due to the fact that in the long term the efficiency of individual transportations average out and the results are based on the average performance of the coalition. We recommend an allocation of the gains on the short term, as here the efficiency of the individual transportations is used, resulting in a more adequate approximation of the real costs. One exception here is the Shapley Value, that is not influenced by the problem of aggregation.

In stead of focussing on the concept of fairness, the coalition should be aware of the impact of an allocation method on the more global idea of horizontal co-operation. As every allocation method is based on certain partner and coalition characteristics, incentives are given when selecting a certain mechanism. It can be seen that a Volume-based allocation favours the growth of the partners, without questioning flexibility of the partners or efficiency of the transport. 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. However, no direct link to operational parameters or partner characteristics can be found. Therefore, the results might be hard to interpret. Finally, the fairness of the EPM can be questioned in heterogeneous co-operations.

This study also confirms 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.

This specific co-operation between fresh produce traders is perceived as a success story for both the traders and the logistic service provider (LSP). Due to bundling the traders were able to reduce transportation costs significantly. The LSP on the other hand can use his vehicle capacity more efficiently.

The current literature on horizontal co-operation is rather scarce and remains on the surface. For further research we believe that it might be useful to study in more detail the interactive relationship between the partners behaviour, the operational solution at the level of the coalition and the gain sharing (or cost allocation) mechanism. The Venlo traders case study shows clearly that a flexible behaviour of the partners — allow a shift of one day in the transportation date — can result in a positive cost effect for the coalition. This flexible behaviour should therefore be encouraged by giving the right specific incentives by means of a well-chosen gain sharing or cost allocation mechanism.

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