LOGISTICS COLLABORATION CONCEPTS FOR SUSTAINABILITY IMPROVEMENT IN THE DUTCH FOOD RETAIL SECTOR

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Abstract

Purpose: Following recent developments, supply chain actors are rethinking their logistics structures and management practices to arrive at sustainable concepts able to deliver perishable food products to retail outlets responsive, at lower cost, with less food waste and with less environmental impact. Literature has already shown opportunities of horizontal and vertical collaboration to increase logistics performance. However, one of the key gaps in literature is which particular logistics collaboration concept (LCC) is best used in particular case settings when all mentioned performance aspects are included in the integral decision making process in conditioned chains. Most research on collaboration concepts has concentrated on standard Key Performance Indicators (KPIs) such as profit margin and costs. For the food retail sector however, domain specific KPIs such as freshness and food waste should also be taken into account. Therefore, this paper aims (1) to present different LCCs together with their advantages and disadvantages for different stakeholders in the food retail sector and (2) to illustrate possible collaboration advantages using a case study in the context of perishable products.

Research approach: First, literature analysis is used to provide an overview of LCCs together with their advantages and disadvantages. Next, a case study is executed at a Dutch retail consortium (comprising 13 food retailers) to determine collaboration scenarios based on the LCCs found. Then, the impact of these LCC based scenarios is assessed using an explorative scenario study. This research results in an application oriented assessment of different LCCs. The findings of this paper are summarized in a conceptual model that links collaboration concepts to sustainability performance.

Findings and Originality: This paper provides an overview of relevant LCCs with their advantages and disadvantages. Furthermore, it provides insight into promising logistics collaboration scenarios for sustainability performance improvements. This is done by the execution of a case study in the Dutch fresh food retail sector.

Research impact and practical impact: This research broadens knowledge on LCCs applied to the food retail sector with emphasis on sustainability improvement. Moreover, it provides insights into the practical relevance of different LCCs. A conceptual model links collaboration to sustainability performance, thus providing practical ideas on how sustainability performance can be improved via collaboration.

Keywords: *Food supply chains, logistics, sustainability performance, collaboration.*
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Introduction

Global changes related to population growth, resource scarcity, global warming, and environmental deterioration confront modern food industry with additional challenges. For example, the current financial crisis has stimulated food retailers to provide the lowest product prices, hence requiring efficient supply chains. Traffic jams and more strict requirements on city logistics have increased travel time uncertainty, which can result in a lower responsiveness to retail outlets, which might result in stock outs. Critical consumers and product recalls have stimulated retailers to place even more emphasis on food quality attributes as taste, looks and shelf life (Van der Vorst, 2014).

These developments pushed the whole society towards an emphasis on sustainable practices, and therefore the agri-food industry also has to incorporate sustainability into its thinking (Van der Vorst, 2014). Especially companies in conditioned food chains try to improve their performance related to people, planet and profit: the three sustainability pillars. This results in a trade-off between multiple performance indicators, such as efficiency, responsiveness, food quality, and greenhouse gas emissions (c.f. Large et al., 2013; Soysal et al., 2013; Van der Vorst et al., 2009).

Sustainable Food Logistics Management

Food logistics have an extra challenge compared to other sectors: products need to comply to quality standards, and need to be sold well before the 'best before date' (Lipinski et al., 2013). FSCs have to deal with special product characteristics such as perishability, which lead to the development of Food Logistics Management (FLM) (Soysal, 2015)). Next to food specific concerns, global developments lead to the consideration of environmental and social aspects next to the economic aspects of operations in Supply Chain Management (Soysal, 2015) (Brandenburg et al., 2014). This leads to the developments of a fast growing concept called Sustainable Food Logistics Management (SFLM) (Soysal, 2015).

Supply Chain metrics

Traditionally, logistics performance is mainly measured by an economic Key Performance Indicator (KPI): cost. However, the development of SFLM has caused a need for taking additional KPIs into account such as responsiveness, food quality, environmental sustainability and food waste. Literature however indicates a lack of industry-specific research on sustainable supply chain management and performance measurement systems (Hassini et al., 2012).

KPIs can be used to measure if targets have been realized in practice. Traditional supply chain metrics are, for example, facility utilization, inventory fill rate and transportation cost (Chopra and Meindl, 2007). These metrics are relevant for each supply chain, but the aforementioned specific aspects of sustainable food production call for specific metrics. Traditional indicators are insufficient for finding the best supply chain configuration and multiple KPIs should be managed simultaneously (Bloemhof et al., 2015). Baldwin (2011) suggested food production metrics related to the three pillars of sustainability: social, environmental and economic (Table 1). Another issue is that performance measurement has been extensively studied in single firms (Rafele & Cagliano, 2006), but they have not yet been studied in a (perishable) network structure (Van der Vorst, 2014).

Table 1. People, planet, profit- related metrics for food production (Baldwin, 2011)

Social	Environment	Economic
Employment	Food Miles	Material use
Quality of life	Water use	Percentage of food lost
Food Safety	Carbon intensity of energy	Transport efficiency
Nutritional value of food	Land usage	Output growth
Fair trade	Use of fertilisers	Added value
Share of food in consumption	Generated waste	Waste recycling/reuse

Logistics Collaboration

Research shows in the period of 2001-2010 around 20% of freight kilometres driven in the EU are conducted by empty vehicles. Moreover, the trucks that are loaded, used only 56% of their weight capacity. The annual costs of this inefficiency in 2010 were €160 billion (Cruijssen and ArgusI). Next to an economic burden, this inefficiency has an environmental cost, as a high amount of greenhouse gases are unnecessarily exhausted into the atmosphere.

The perishability of fresh foods causes an extra challenge for a firm that wants to efficiently use the truck capacity available. This type of food needs to be transported fast (e.g. sometimes before the truck is completely full) in order to prevent spoilage. Logistics collaboration could enable different firms to combine truck loads such that trucks are used more efficiently and the delivery of the products is still fast enough. The decrease of truck use also results in a decrease in costs.

Supply chain collaboration is defined as two or more autonomous firms working jointly to plan and execute supply chain operations (Simatupang and Sridharan, 2002). Horizontal collaboration is a specific type of collaboration: it happens between firms that operate at the same level of the supply chain (Cruijssen, 2006). Research has shown that collaboration can yield various types of benefits: reduction of transaction costs, stronger competitive positions, shared risks, access to complementary resources, enhanced productivity, and enhanced competitive advantage (Cao and Zhang, 2011). Collaboration can enlarge the size of joint benefits and give each member a share of greater gain that could not be generated by each member on its own (Jap, 1999).

Cruijssen (2006) however mentions impediments to horizontal collaboration, of which the following three relate to the division of sharing the gains from collaboration:
1. It is hard for the partners to determine the benefits or operational savings of horizontal cooperation beforehand;
2. Partners find it hard to ensure a fair allocation of the shared workload in advance;
3. A fair allocation of benefits to all the partners is essential for a successful cooperation.

To ensure a successful collaboration, it is thus important that the partners perceive the gain allocation as fair. This paper will use the Shapley value {Shapley, 1953 #59} as a method for calculation of allocation of the gains because this method has shown to be generally perceived as fair. And often, this allocation ensures that no firm that joins the collaboration is better off on its own.

Research question

How can logistics collaboration be used to improve (sustainability) performance of supply chains?

<u>Methodology</u>

First, different LCCs are analysed in more depth in the Literature Review. Then, the case study addresses the issue of sharing costs when different members of the consortium decide to collaborate and make use of the same LSP. This can be seen as a first step towards horizontal collaboration as it does not imply physical changes for the members.

Framework introduction

According to Van der Vorst (2000) a Supply Chain (SC) can be seen as a large system comprising several subsystems (organizations) together with the relationships between them. Each subsystem, and therefore the system, can be described by the four elements of the 'logistical SC concept': managed system, managing system, information system and organization structure (Table 2). These elements are also part of the SC scenario: an internally consistent view of a possible instance of the logistical SC concept (Vorst, 2000). The main focus of the case study described in this paper is the Organisation structure.

Table 2. Explanation of the different elements of the supply chain scenario (Vorst and Beulens, 2002)

Supply Chain Scenario Element	Explanation
Configuration	network structure, facilities and means; the parties involved and the roles to be performed in the supply chain.
Control structure	the set of decision functions that govern the execution of operational activities aimed at realising logistical objectives within the constraints set by the chain configuration and strategic objectives (e.g. delivery frequency, order acceptance policy and production planning structure).
Information system	the systems (with their characteristics) that support decision making (enable information exchange and make data available) are required to perform operations (e.g. transport management systems and electronic data interchange).
Organization (and governance) structures	assign tasks (along with corresponding responsibilities and authorities) to organisations and persons in the supply chain. Depending on the sustainability strategy chosen, specific sustainable transportation means or warehouses will be (or will not be) selected, planning systems will include sustainable criteria, information systems will gather and exchange sustainability data and dedicated sustainability departments will be established. The choice for a certain strategy will also influence the assessment of the sustainability performance, that is, the choice of performance indicators.

The design of the SC scenario results in a certain performance, which can be measured by KPIs. In Figure 1, these KPIs are linked to the three pillars of sustainability: people (social), planet (environmental) and profit (economic). This paper aims to start a research on possibilities to accomplish a more sustainable SC, and thus to improve KPIs from all three sustainability pillars. Logistics Collaboration is chosen as a method because research suggests that it has the potential to improve multiple indicators simultaneously. The assumed mechanisms is as follows: logistical collaboration will lead to a more efficient truck use, which leads to a lower amount of trucks needed (environmental and economic improvement). Also, it is expected that collaboration leads to a faster fill rate of trucks, which will give firms the possibility to order smaller batches with a high frequency instead of large batches with a low frequency. As a result, the food quality will increase (social improvement) and food waste will decrease (environmental and economic improvement).

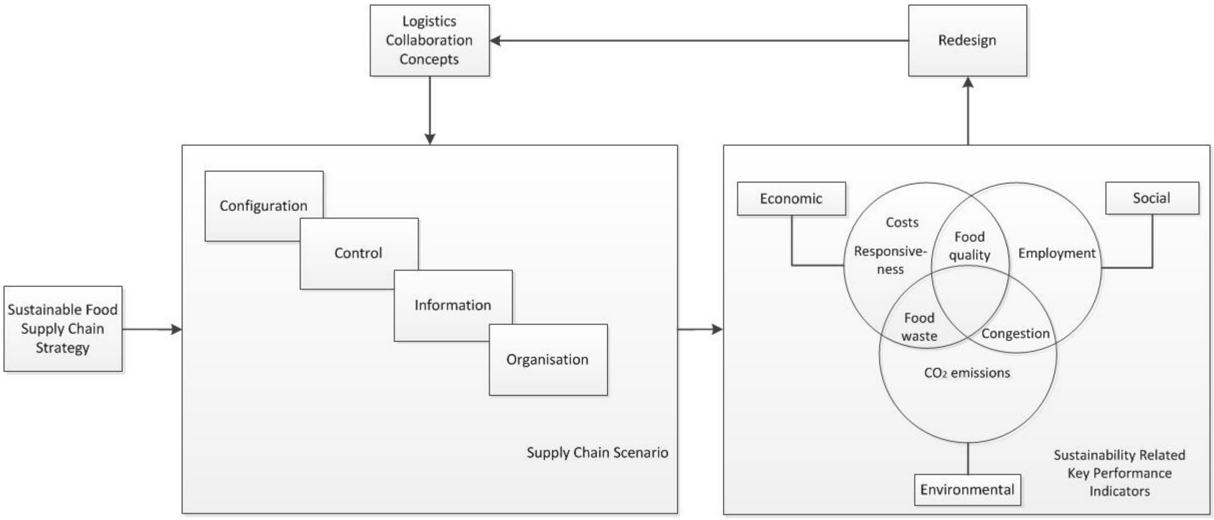

Figure 1. Sustainability framework for food chain logistics

However, firms can and should not be forced to collaborate. It should be clear for every firm that there is an advantage in joining the collaboration. An important prerequisite to reach this is that there should be a financial advantage in joining the collaboration and that the financial advantages of the collaboration are divided in a way that is perceived as fair by all firms that possibly join the collaboration. The Shapley value is used to calculate the allocation of benefits because previous research has shown that that allocations calculated using this value are often perceived as fair by all participants.

The *Shapley value* (Shapley, 1953a, b) is an allocation rule that satisfies the following axioms:

1. *Symmetry*: for all permutations π of N, $\varphi_{\pi i}(\pi v) = \varphi_i(v)$, where $\pi v(S) = v(\pi S)$ for all S;
2. *Dummy player*: if i is a null player, i.e. $v(S \cap \{i\}) = v(S)$ for all $S \subset N$, then $\varphi_i(v) = 0$.
3. *Efficiency*:$\sum N\varphi_i(v) = v(N)$.
4. *Additivity*: $\varphi_i(v + w) = \varphi_i(v) + \varphi_i(w)$ for any pair of cooperative games (N,v) and (N,w).

- There are pairs *(N,v)* where *N* is a set of *N* = {1,2,...n} firms and v: $2^N \rightarrow \mathbb{R}$ is the characteristic function.
- N is the grand coalition and the subset $S \subseteq N$ is a coalition.
- *v(S)* is the value that the members of coalition *S* can generate on their own.
- Definition of the other symbols:

  φ allocation (the Shapley value is an allocation that satisfies specific axioms)
  π permutation
  O_i is the set of products to transport by firms *i*
  $C_O(i)$ costs of transporting products O_i by firm *i* in the status quo situation
  g(i) cost savings (%) for player (firm) *i* if all players cooperate

To calculate the Shapley value, all possible orderings of players should be considered to define the marginal contribution of firm *i* with respect to a given ordering. This marginal worth is formed by the firms before him in the order *v({1, 2, . . . , i - 1, i}) - v({1, 2, . . . , i - 1})*, where *1, 2, . . . , i - 1* are the players preceding *i* in the given ordering. The Shapley value gives the expected payoff for firm *i* by averaging the marginal contributions for all possible orderings (Nagarajan and Sošić, 2008). This average is given by

$$\varphi_i(N,v) = \sum_{\{S:i\in S\}} \frac{(|S|-1)!\,(n-|S|)!}{n!}\big(v(S) - v(S\backslash\{i\})\big)\ \forall i\ \in N \qquad (-) \qquad (6)$$

and it was shown by Shapley that (6) is the unique allocation rule which satisfies the four abovementioned axioms.
The cost savings for each firm are given by

$$g(i) = \frac{C_O(i) - \varphi(i)}{C_O(i)} * 100 \quad if\ S = N \qquad (\%) \qquad (7)$$

Literature review

Logistics Collaboration Concepts (LCCs)

Logistics Collaboration Concepts intend to improve the efficiency and effectiveness of logistic processes. Some examples are shared vendor managed inventory (VMI), joint warehousing and joint route planning (c.f. Cruijssen, 2012; Ramanathan and and Gunasekaran, 2014; Lyu et al., 2010; Van der Vorst and Beulens, 2002).

A business survey study shows that collaboration between supply chains and its facilities is considered most as future options to further improve sustainability. Also this research points out that the influence of collaboration on sustainability involvement in the food sector is a topic for further research (Bloemhof et al., 2015).

Table 3 summarises various LCCs that can be found in literature, together with an explanation on how they work (collaboration mechanism), advantages, disadvantages and references.

Table 3. Logistics collaboration concepts

LCC	Collaboration mechanism	Advantages	Disadvantages	References
joint ware-housing	Opening DC at more appropriate location or expanding the most useful ones and closing the unnecessary ones	reduction of inventory reduction number of pick-ups reduction number of trucks increased drop size	Investment new planning higher response time	Aydin and Porteus, 2005 Chopra and Meindl, 2013 Cruijssen, 2007
VMI	Vendor is responsible for getting the products to the buyer. Buyer provides vendor with information on its inventory and minimum and maximum inventory levels	more efficient resource utilization improved inventory management increased service levels reduced LTL reduced bullwhip effect	Requires advanced IT facilities	Disney and Towill, 2003 Walter et al., 1999
cross docking	a cross dock can be seen as a DC without inventory: products go directly from receiving to shipping dock	requires IT control requires integration of logistics networks	Requires investment	Apte and Viswanathan, 2000 Lee et al., 2006 Yu and Egbelu, 2008
transport bundling	exchange nodes enable combination of truck loads	increased vehicle loading increased delivery frequency increased service levels	increased operational time increased handling costs	Kreutzberger, 2010
joint route planning	pooling vehicles to enable multiple routes to be served by multiple trucks	increased reliability reduction of slack time reduction number of vehicles increased load factor	increased scheduling complexity necessity of stand-by vehicles	Cruijssen, 2007 Furth and Nash 1985 Gonzalez, 2010

Case study

Collaboration between Dutch fresh food retailers

In a Dutch food retail consortium, several members (Supermarket chains) act as a buying organisation. When the orders arrive at the DC, they separately take care of the logistics, which most do by hiring a Logistic Service Provider (LSP). The members differ in size (36 to 260 stores each) and in location: some have stores in all of the Netherlands, and some are more focused in a certain area or province. Five of these members (anonymised to a, b, c, d and e) have a contract with the same LSP. They face several issues:

- the minimum order quantity is at least one pallet, e.g. it is uneconomical to order less than one pallet. This can cause a high inventory at the supermarket, extra food waste in case of perishable products and a lower freshness;
- the more pallets ordered at once, the lower the price per pallet (Figure 2). This stimulates supermarkets to order more than necessary, which can again cause high inventory, extra food waste, and lower freshness;
- the LSP has a pricing strategy in which stores further away from most of the member's stores are charged a higher price per pallet.

These issues especially influence smaller and more scattered supermarket chains. As the consortium wants to improve the logistic efficiency, responsiveness, environmental sustainability, and food quality at its members, it suggested that the members collaborate using the aforementioned LSP could be treated as one entity. The LSP is responsible for pooling the orders such that logistics will be more efficient, and is asked to give a fixed box price, instead of the pricing policy described before. It is assumed that the LSP has the in-house knowledge to use LCCs to improve their logistics after the members decide to order together.

Figure 3 compares the prices all the members (a, b, c, d, e) had to pay before collaborating ('original costs') with the price of the per-box pricing policy suggested by the LSP ('LSP costs') and the price that each member would have to pay according to the Shapley value ('Shapley costs'). This Figure shows that the per-box pricing policy of the LSP ('LSP costs') results in a lower cost for all members. However, the relative advantage that each member has, differs a lot. The bar 'Shapley costs' shows that all members have a comparable relative advantage (lowest: 41,7% for d, highest: 43,2% for b). The income lost by the LSP is the same as in the per-box pricing strategy: 43%.

Another issue in the cost structure of the old price seems to be the closeness of the stores of the member to each other. For example, when a member has most stores in the province of Friesland and also a few in Zuid-Holland, it is more expensive to transport to Zuid-Holland. This problem however will probably not play a role anymore when all parties collaborate.

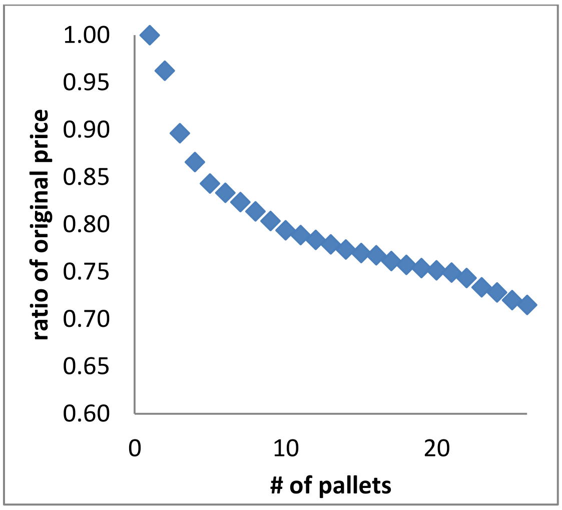

Figure 2. Price per pallet (ratio of original pallet price)

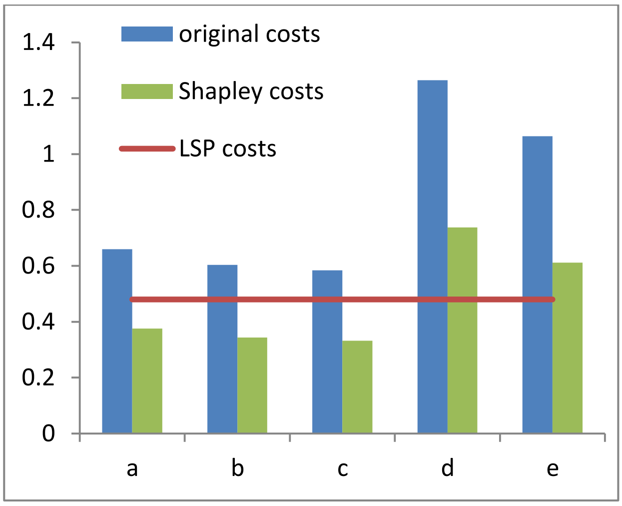

Figure 3. Logistics costs comparison: original costs, new costs suggested by LSP, and Shapley costs

Conclusions and future research

Conclusions

- The lack of literature and the limited scope of this research suggest that more research is needed on how LCCs can improve sustainability performance in industry specific settings.
- Costs and fairness are important aspects in creating willingness to collaborate, thus these should be the aspects to take into account when establishing a collaboration. The Shapley value is a useful tool to calculate gain allocations.
- Collaboration has the potential to improve economic, environmental and social performance simultaneously.

Future research

Case study

The first case study is mainly focused on cost. Collaboration lowers the total cost of logistics, and the implicit assumption made was that this is caused by the LSP's expertise to make the logistics more efficient when the members order together. This could cause a lower amount of trucks needed, which leads to a decrease in GHG emissions. Also, it is assumed that ordering together will result smaller order sizes and more frequent deliveries, which positively influence food quality and freshness, and reduction of food waste. The only data used however, are related to logistics costs, and the other KPIs need more research to show the actual effect that collaboration can cause. The advantage of collaboration on all KPIs could be analysed using optimization and simulation modelling. Data of the current situation regarding truck use, food quality, freshness and food waste are needed. Moreover, cost data considering a longer period of time could make the results more reliable. Also, if the consortium members are willing to implement the suggested changes, measurements should be executed again to analyse their impact.

Another aspect that should be analysed is if the Shapley gain allocation is in the core (e.g. is there no other coalition under which part of the grand coalition is better off?)

Abbreviations

FLM	Food Logistics Management
FSC	Food Supply Chain
GHG	Greenhouse Gas
KPI	Key Performance Indicator
LCC	Logistics Collaboration Concept
SC	Supply Chain
SFLM	Sustainable Food Logistics Management
VMI	Vendor Managed Inventory

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