Innovative Approaches to Improve Sustainability of Physical Distribution in Dutch Agrifood Supply Chains

Reinder Pieters, Paul van Beek, Hans-Heinrich Glöckner, Onno Omta and Stef Weijers

Abstract Sustainability has become an important issue in all aspects of corporate policy. This also applies to organizations operating in agrifood supply chains. Most literature on sustainability in the agrifood industry focuses on food security or prevention of food losses. However, little attention has been paid to how organizations working in agrifood supply chains use new approaches and innovations for making physical distribution more sustainable. Therefore we set up a study on how companies in the agrifood supply chains use innovations to improve the sustainability of the physical distribution. For this purpose, we have interviewed key managers of 14 Dutch companies—6 logistics service providers, 3 wholesalers and 5 food processors—all involved in agrifood value chains on how they approach, and innovatively improve, sustainability within physical distribution. We found that all the groups of companies have sustainability in their mission and use various innovations for improving the sustainability of their physical distribution. We also found that various links in the chain preferred different types of innovations e.g. food processors preferred innovations linked to reduction strategy and wholesalers focused on innovations related to efficiency strategy. The applied innovations were not linked to the supply chain as a whole, but concentrated on a specific aspect of the supply chain and were often initiated by a partner from outside the agrifood supply chain.

Keywords Sustainable physical distribution · Agrifood supply chains · Innovations

R. Pieters (✉) · H.-H. Glöckner · S. Weijers
HAN University of Applied Sciences, Ruitenberglaan 31,
6826 CC Arnhem, The Netherlands
e-mail: reinder.pieters@han.nl

P. van Beek · O. Omta
WUR Wageningen University, Hollandseweg 1,
6706 KN Wageningen, The Netherlands

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1 Introduction

Since the publication of the Brundlandt report (1987), companies have put sustainability at the top of their agendas (Szekely and Knirsch 2005) and incorporated sustainability into their strategy (McDonough and Braungart 2002; Porter and Kramer 2004). Organizations in the agrifood sector have also incorporated sustainability into their strategy (Van der Vorst et al. 2013). This aspect is not a recent issue, as the agrifood sector has a long history of sustainable awareness on the use of land, water, pesticides, fertilizers and energy (Maloni and Brown 2006; Smith 2008; Leaver 2011; Leach et al. 2012). In 2008, the Dutch agrifood sector generated 50.5 billion Euros added value, which was 9.6 % of the total added value of the Dutch economy, employing approximately 685,000 people. Distribution of agrifood products in the Netherlands accounted for 12 billion Euros and 178,000 jobs (Van der Vorst 2011). The logistics sector is also important to the Dutch economy, contributing € 40 billion (8.5 %) to the Dutch GDP and an estimated 750,000 jobs (10 %) in 2010. In 2008, freight transportation was responsible for 6 % of all CO_2 production within the Netherlands (Van der Meulen and Kindt 2010; Pieters et al. 2012). Agrifood transport makes up 28 % of all physical transport (RLI 2013b), generating 1.7 % of all CO_2 production within the Netherlands.

Most literature on transportation of agro-business products concentrates on food security (Henson and Caswell 1999; Maloni and Brown 2006; Godfray et al. 2010). An amount of studies has addressed the role of sustainability when transporting agrifood products (Wognum et al. 2011; Van der Vorst et al. 2013; Schott and Andersson 2015; Papargyropoulou et al. 2014). But it remains unclear how the main players in the agrifood supply chain (logistics service providers, food processors and wholesalers) translate strategic policies into tangible innovations to make physical distribution within the agrifood sector more sustainable. With 1.7 % of all CO_2 production, Dutch logistic service providers and shippers of agrifood products should consider their responsibility to control, or even better, lower the amounts of CO_2 produced.

This research focuses on sustainability in the physical distribution of agrifood products and the role the various partners in the supply chain—logistics service providers, shippers and private carriers—play in this process. Do they approach sustainability as an integrated and repeatable phenomenon or is it seen as a singular action concerning individual situations or do these actions require cooperation within or outside the supply chain? And what are the new, innovative ideas concerning making physical distribution more sustainable? The purpose of this study is to help increase our understanding on how the relationship between shipper, private carrier and logistics service provider in the agrifood industry relates to improving sustainability. If properly understood, it will help us in making physical distribution in the agrifood industry more sustainable.

Environmental issues enjoy wide attention, governments, companies and institutions have incorporated sustainability in their business strategies (McDonough and Braungart 2002). The EU wants freight transport to be cleaner (European

Commission 2004, 2011). It is expected that sustainability will become one of the prime drivers within the supply chain (Rao and Holt 2005; Carter and Rogers 2008; Ploos van Amstel 2008; Van den Broek 2010). In 2008, transportation was responsible for 21 % of all CO_2 production within the Netherlands. The main part (79 %) of this figure was taken up by road transport (private and freight). The remainder was divided into inland shipping (5 %), air transportation (2 %) and sea transport (14 %). Within road transport, freight transport had a share of 36 % (Van der Meulen and Kindt 2010). These figures show that the Dutch freight transport sector did produce a considerable amount (6 %) of CO_2 in 2008.

This increased environmental awareness for making physical distribution more sustainable will require a change in management policy as well as new technological innovation (Colicchia et al. 2013). Can lessons be learned from experiences with innovations in making physical distribution in the Dutch agrifood supply chains more sustainable? And what is the role played by co-operation on a horizontal or vertical level within these supply chains?

First we will introduce a concept for innovation in physical distribution and secondly we will setup a framework to determine the sustainability of physical distribution of agrifood products. Thirdly we will discuss the various strategies which can be employed to make physical distribution of agrifood products more sustainable. After these theoretical discussions we explain and defend our chosen methodology and show the results of our research.

2 Innovation and Physical Distribution

Innovation involves the creation and marketing of new ideas (Kline and Rosenberg 1986; Van de Ven 1986; Baregheh et al. 2009). Organizations introduce new ideas in order to achieve a cost advantage, a quality improvement, a competitive differentiation, or a combination of these results. These innovations should achieve a competitive advantage over other players in the market. Most definitions of innovation fall back on Schumpeter's idea that innovation is either: a new product or service, new method of production, new way to organize business or opening up new markets—purchasing markets as well as sales markets (Hospers 2005, p. 23). Innovations do not have to be 100 % new. They can be a combination of old ideas, or a copy, or an imitation of existing ideas. An idea is called an innovation as long as the people who are involved perceive this idea as new (Van de Ven 1986, pp. 591–592). For our research we consider anything to be an innovation, provided the interviewee mentioned this as being new to either his organization or his supply chain.

Jacobs (2009) discerns innovations in being (a) technical—based on new technology—or (b) non-technical—requiring human skills or intervention. New technology often requires help from partners—often suppliers—who have access to this technology. For non-technical innovations, a change is required when implementing these new ideas or new approaches in either their own organization, in the

supply chain or between different supply chains. We will follow this division and for our research concentrate on innovations, which have an impact on the CO_2 emissions during physical distribution, increase food quality, improve food security or result in reduction in losses of agrifood products during the whole distribution process.

3 Sustainability and the Physical Distribution of Agrifood Products

What makes freight transportation services sustainable is not altogether clear (Rittel and Webber 1973; Levin et al. 2012). This could partly be due to a lack of a generally accepted definition of sustainable transportation (Pezzey 1997). As for the concept of sustainability, the definition of sustainable development provided by the Brundtland Commission (World Commission on Environment and Development 1987) is often used (Mihyeon Jeon and Amekudzi 2005):

> Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987).

As, for instance, most trucks still employ a combustion engine, it can be stated that every liter of gasoline used for transportation today will not be available for future generations. The Brundtland-based definitions therefore fail to be realistic and usable for our research. A definition of Environmentally Sustainable Transportation (EST) as developed by the Organization for Economic Co-operation and Development (OECD) is more precise and will therefore serve as the basis for our research:

> Transportation that does not endanger public health or ecosystems and meets the needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes (OECD 1999).

This definition takes three aspects of EST into account: public health, ecosystems and natural resources.

When discussing sustainable transportation, the attention focuses on reducing exhaust gases. For the Netherlands, the main exhaust gases are carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (PM) (Francke et al. 2009). There are more polluting exhaust gases concerning transportation like carbon monoxide (CO) and hydrocarbons (HC) (Van der Meulen and Kindt 2010). The available literature on sustainable freight concentrates on CO_2 reduction. The other gases are hardly mentioned. Our research follows this lead and also concentrates on innovations, which result in a reduction of CO_2.

Holden and Gilpin (2013) discern three main sustainable transport strategies in literature: efficiency, alteration and reduction. The efficiency strategy concentrates

on developing more efficient transport logistics, which could result in improved load factor and better utilization of available transport equipment. Alteration strategy recognizes the need to change present transport patterns and behavior fundamentally. The reduction strategy concentrates on avoiding unnecessary—not value-added—transport. These strategies may correlate with each other. An alteration in transport mode could also result in a more efficient use of transport space or in a decrease in transport movements.

The shipper as a customer of the logistics service provider plays an important role when we want to discuss innovations to obtain an improved sustainability in physical distribution. The transport market is best described as being dominated by heavy competition and low profit margins, so the customer is certainly "King" (Christopher 2005). But how important are sustainability and innovations for shippers when selecting a logistics service provider? A survey among shippers conducted by Van der Meulen and Kindt (2010) found that Dutch shippers used certain criteria when selecting a logistics service provider. The criteria included: reliability, price, service, sustainability and innovation. When asked to rank these criteria, price and reliability are placed at the top, with sustainability near the bottom, in fourth place and innovation in last position. These findings are further supported by literature concerning logistical considerations; choices made in regard to transportation, are usually determined by two things (Christopher 2005; Visser 2010):

1. effectiveness i.e. speed and reliability
2. efficiency (low cost).

But it also shows that both sustainability and innovation do not seem to play an important part in the choice of a shipper for a logistics service provider. The combination of innovation and sustainability is not researched, but based on the ranking in the survey of Van der Meulen and Kindt (2010); it will certainly not be a decisive factor in the selection procedure of a shipper for logistic services (Pieters et al. 2012).

4 Strategies in Making Physical Distribution More Sustainable

As mentioned before, three strategies can help to make physical distribution more sustainable: (1) efficiency strategy; (2) alteration strategy and (3) reduction strategy (Holden and Gilpin 2013). We first need to discuss innovations linked to each of these strategies.

(1) Efficiency strategy
The efficiency strategy aims at making better use of the available modes of transportation. This can be accomplished by (a) improving the amount

transported in one ride—load factor—or (b) reducing the amount of fuel needed to make a specific ride. Both approaches will be discussed below.

(a) Improving the load factor.
In this way, more goods are transported in one haul. This can be achieved by combining rides—or freight bundling—which demand less than full truckload capacity. Not all combinations are possible. Products like bananas could affect the quality of other fresh food products and should, preferably, not be shipped in one transport unit. Frozen agrifood products do not mix very well with fresh agrifood products, which will freeze and deteriorate. But also, combining agrifood products with non-agrifood products could cause problems. Some agrifood products do transmit an odor, which might cling onto non-agrifood products and make these products unsalable. These problems can be solved by splitting a truck into various compartments, each with its own storage regime. Freight bundling is a typical way for all logistics service providers to lower cost on the actual transport itself. If shippers or receivers are in close proximity, bundling freight could be interesting. But this is not always possible, as shippers, as well as receivers, sometimes demand specific pickup or delivery times, making freight bundling impossible. The answer here lies in convincing the parties concerned to amend their requested pickup or delivery times to co-ordinate with each other. Another obstacle for freight bundling is that some shippers demand that their products are to be shipped without any product from other shippers. For transporting unprocessed agrifood products, this could be a valid reason. For processed agrifood products, the fear of—mutual—contamination could be less and therefore freight bundling might be a possible option for processed agrifood products. Another obstacle might be that some trucks carry the logo of the shipper and are considered an extension of branding the shipper's name. They even might insist that the logistics service provider first checks with them to ensure that the image of their own brand name is not harmed in any way. Sharing cargo space with competitors might also generate negative emotions, preventing freight bundling of these shipments.

(b) Reducing fuel consumption for a given distance.
As CO_2 production is directly linked to the amount of fuel used for the transportation, the less fuel used, the lower the amount of CO_2 produced during a transport. This can be achieved by ensuring that drivers are taught to be more energy conscientious and drive accordingly: the new driving style or ecodriving (Stillwater and Kurani 2013; Thijssen et al. 2014). Besides a reduced fuel consumption, the logistics service provider will also achieve savings on brakes and tires which do not need to be replaced as often as with a less careful driving style. Ecodriving can be monitored by placing a device in the truck, which stores all actions of the driver. The gathered information per truck and per driver can be analyzed to search for

improvements. Some systems transmit this information directly in real time, using a wireless network. In this way, the logistic service provider—and sometimes also the shipper—can see online the exact location of the truck and react directly to any change monitoring the actual delivery or pickup. A second way to improve the mileage is to replace the existing fleet with trucks of better mileage. The average Dutch truck will have an economic lifespan between four and seven years. So, after this period, the whole fleet will have been replaced with newer, cleaner models. By adding fuel saving techniques and by ensuring a proper maintenance of the existing fleet, mileage can be improved by the logistics service provider.

(2) Alteration strategy

With the alteration strategy, the company aims at changing the way in which operations always were done. For transport, this means that the traditional mode used for transportation could be replaced by other modes, which produce less CO_2. For instance, compared with truck transportation, air transportation will be approximately 900 times more polluting. Most agrifood transportation within mainland Europe will be done by truck, rail or inland shipping. For these modes, the CO_2 per ton/km ranges between 85 and 122 for trucks up to 20 tons loading capacity (1 TEU) to 21–42 for inland shipping with barges with a loading capacity of 5500 tons (a container ship with 200 TEU). Rail and inland shipping generate less CO_2 per ton shipped over one kilometer as compared with shipment by truck (Den Boer et al. 2008). From this point of view, every environmentally-conscious shipper or logistic service provider should opt for—partly—rail or boat transportation and not for trucks alone—intermodal transportation. Every shipment starts at the sending party and ends with the receiving party as its destination. Most of these sending and receiving parties are not directly located near a loading platform for rail transportation or near an inland harbor. This means that trucks will be used to transport to and from the freight station and harbor. Every change of mode will take time, result in additional costs and increase risks for the cargo. All three aspects may entice the organization to continue using the familiar pattern of transportation instead of opening up new distribution channels. In contrast to all these concerns with intermodal transportation, trucks have the advantages of being flexible and able to reach almost all destinations. For this reason, most agrifood products are shipped by truck and this will not change in the near future. But for very long hauls—500 km or more—this could be a possible, interesting alternative for road transportation.

Another form of alteration strategy often employed for achieving a more sustainable physical distribution is the use of alternative fuels. These fuels could be either (a) cleaner—producing less CO_2—or (b) renewable energy sources. Both will be explained below:

(a) Using cleaner fuels.
An easy way to change to fuel that is less polluting is to use mineral oils, which will generate less CO_2, or change to alternative fuels like electricity or fuel made from agrifood products: biofuel (Holden and Gilpin 2013). Biofuel will be discussed in the next point under renewable fuels. Less polluting fuels are e.g. liquid gas, natural gas or cleaner gasoline. Another alternative for mineral fuels is electricity. Engines which run on electricity emit no CO_2 during transportation, but they have a limited range of 70 km. This means that long hauls by electric trucks cannot yet be considered as a reasonable option for gasoline-fuelled trucks. Producing electricity is another issue, as electricity often is generated by power plants running on mineral fuels, still resulting in CO_2 production. Electricity generated by nuclear power plants hardly produces CO_2 (Fthenakis and Kim 2007) but results in radioactive waste, which needs to be stored for several thousand years (Pickard 2010), burdening future generations. During the last sixty years, atomic energy has been generated and twice—1986 Chernobyl and 2011 Fukushima—we have seen problems with nuclear plants. Much is expected from the development of fuel-cell technology by which electricity is directly generated by a battery using chemical processes. Unlike combustion engines, no heat loss occurs during the conversion process (Capros et al. 2014).

(b) Using renewable fuels.
Mineral fuels like gasoline and petrol are by definition not sustainable, as they are non-renewable (OECD 1999) and deprive future generations the use of these energy sources (World Commission on Environment and Development 1987; Holden and Gilpin 2013). Renewable energy will solve these problems. For physical distribution, this implies at this moment the use of electricity or biofuels. Electricity generated by solar power, wind power or water power is more in line with the general concept of sustainability and generates far less CO_2 as compared with fossil fuels (Raadal et al. 2011). The Dutch government wants to raise the amount of renewable energy from 4 % in 2013 to 16 % in 2026 (SER 2013), so non-renewable fuels will still be responsible for the remaining 84 % of Dutch energy consumption. Another alternative fuel source for mineral fuels is biofuels. But in a world (figures 2011–13) with an estimated 842 million people suffering from hunger (FAO 2013), growing food for fuel and not for human or animal consumption poses ethical questions and could lead to more pressure and competition for good quality agricultural land (Godfray et al. 2010).

(3) Reduction strategy
The reduction strategy aims at reducing the use of material and equipment. This may be the result from actions taken using the efficiency strategy as explained before. Improving the load factor will also decrease the need for rides to be done by using better planning systems and freight bundling

procedures. Agrifood industries could also reduce the kilometers between them and their farmers. A nice example of how this can be achieved is given by FP4 (Framework Programme 4). They used to have farmers all over the Netherlands but during the last 15 years they enticed local farmers near the factory to produce for them, resulting in fewer kilometers driven to transport food to the production unit from the fields.

Reducing the distance between farmer and food processing factory also has a positive impact on quality and reduces food losses during transportation or storage. Innovations that do reduce food losses will also result in CO_2 reduction; not only in less CO_2 during cultivation or production, but also due to less transport movements for shipping products to and from the production plant, which eventually will not lead to agrifood products suited for consumption. Quality reduction of agrifood products during physical distribution can be prevented in two ways: (1) proper conditioning of the agrifood product during transportation and storage, and (2) speeding up the good flow in the supply chain by opting for smaller production and transportation lots (Van Beek 2010). For instance, while harvesting an agrifood product, waiting for a full truckload can take so long that the quality of the food product could deteriorate. So trucks used to ship harvested, fresh food products will often transport less than a full truckload. Other agrifood products require conditioned transport, as they need to be kept cool or frozen. Keeping these products in a frozen or cool state means that cooling systems will have to be employed. These cooling systems require energy, which means the transport will use up more fuel. Mileage will improve if new cooling systems are developed, which use less energy. A very simple solution to keep food products fresh is to consume only food that is produced nearby. This would reduce the food miles needed to transport the food to its destination (Scheer et al. 2011).

5 Methodology

For the current research we will proceed as follows. First, we review the forces for change literature on innovations. We then present our view on the concept for "sustainable" physical distribution, laying out the various aspects for the Dutch agrifood sector. Next we introduce structures for sustainable physical distribution, which are being utilized by logistics service providers, private carriers and shippers in the Dutch agrifood sector. This section is based on interviews we held in the period December 2013 till June 2014 at 14 companies: six logistics service providers (LSP), three retail organizations or wholesalers (WS), and five food processors (FP) of agrifood products. We used a convenience sample, selecting companies, which actively supported sustainability and we ensured that various aspects (size, ownership, place in the value chain) were represented in our sample as is shown in Table 1. All interviewed companies are connected to the University of Applied Sciences of Arnhem and Nijmegen through work-placement schemes, etc.

Table 1 Characteristics of the interviewed companies

Aspect		Company													
		Wholesalers			Logistics service providers						Food processors				
		WS1	WS2	WS3	LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	FP1	FP2	FP3	FP4	FP5
Member lean and green		×			×	×	×	×	×	×			×	×	
Own trucks		×		×	×		×	×	×	×					
Food transported as	Can/Glass	×	×	×	×	×	×	×	×		×	×	×		
	Fresh	×	×	×							×				×
	Frozen	×	×	×						×				×	
Size in FTE	<201								×			×			
	201 < 501														×
	501 < 1001			×	×	×				×					
	>1001	×	×				×	×			×		×	×	
Ownership	PLC	×					×	×		×		×			×
	Family owned		×	×	×	×			×		×		×		
	Cooperative													×	
	Dutch	×	×	×	×	×			×	×	×	×	×		×
	Rest EU							×							
	USA						×							×	

All logistics service providers, two food processors (FP3 and FP4) and one wholesaler (WS1) are members of Lean and Green, an award scheme for companies, who want to improve sustainability of their physical distribution. This scheme has been set up by the Dutch government to speed up the process and to structure discussions (Pieters et al. 2012). One logistics service provider (LSP6) also buys fruit and processes pulp, which is then frozen and sold to other food processors. In principle, LSP6 could also have been seen as an agrifood processor, but it sees physical distribution as its main activity. Therefore, it has been placed under logistics service providers. LSP2 is an expediter and has no trucks of its own. It organizes the whole transport for customers and rents anything it might need from other logistics service providers. Except LSP6, that only transports agrifood products, all other logistics service providers interviewed transport non-agrifood products as well. One (FP5) also trades in fresh flowers for the consumer market. WS3 operates a chain of biological food corners within supermarkets. It only delivers agrifood products; fresh and processed. WS1 and WS2 sell also non-agrifood products. WS1 mainly sells to large institutional customers like hospitals and canteens. WS2 is a regional chain of supermarkets. LSP6 buys fruit from a wholesaler, processes it into fruit pulp and sells the frozen fruit pulp to another food-processing industry for further processing.

The interviews were held at the company's location and the interviewee was always (co-) responsible for developing the company's strategy on sustainable physical distribution. Every interview was recorded, transcribed and send to the interviewee for correction and omissions. In the interview, we asked how the company approaches and improves sustainability from its own point of view within physical distribution of agrifood products. Which strategies it has developed for sustainability. What kind of actions did it undertake in the field of sustainability and, what kind of innovative ways it has introduced to make physical distribution of agrifood products more sustainable.

To limit our scope, the current research will concentrate on the sustainability aspects of the actual transport itself. In order to concentrate on the actual physical distribution itself, innovations undertaken to improve sustainability, but not related to the actual transport—such as more environmentally friendly ways of cleaning cars etc.—are additionally not included in our research.

6 Results

For our conceptual framework, we assume that every logistics service provider, private carrier or shipper operates within its own specific environment (finance, market, customers and location) and has its own special mix of forces for change (drivers, enablers and barriers). Combining these elements, the logistics service provider, private carrier or shipper could each on its own develop a plan for achieving a higher level of sustainability. This strategy can be written down explicitly, or implicitly embedded into the company's mission. Based on this

strategy, the logistics service provider, private carrier or shipper implements the plan or maintains the status quo. Using this conceptual framework, we want to understand if innovations have been developed due to a change in the company's strategy for sustainability. These innovations could be either organizational, like new types of physical distribution networks, or technical, like new software or fuels, or a combination of both. This change in strategy may (or may not) be influenced by the forces for change as explained above. We expect these innovations will result in new demands on physical distribution systems and, even further, that they will drive innovations in sustainable physical distribution.

Based on this conceptual framework, for our research we asked our interviewees:

1. How they approach strategically sustainability within physical distribution of agrifood products?
2. What were the drivers, enablers and barriers for the sustainability innovations?
3. What kind of actions do they undertake on the field of sustainability and if so, what kind of innovative ways they have introduced to make physical distribution of agrifood products more sustainable?
4. Who initiated these innovations?

Ad (1) All interviewees mentioned sustainability as part of the mission of the company. Only one (FP5) took a higher level and also mentioned corporate social responsibility (Maloni and Brown 2006) as the focus of its mission. It placed sustainability in this framework, but was more concerned with employees' health programs, local schools and local food programs. The main driver for being sustainable is cost reduction. All mention that they perceive sustainability in physical distribution, with a higher rate of efficiency and therefore reduced costs. One (FP3) states that new innovations may be taken on, providing costs are equal to the former situation. This concept that sustainability should be linked to lower costs is also found in the Lean and Green award scheme. Members of this Dutch scheme set themselves the goal of reducing in five years' time CO_2 by at least 20 % and to lower the cost for physical distribution (Pieters et al. 2012). All logistics service providers mention that a higher price for sustainable physical distribution will not be acceptable for the customer. Two food processors and one wholesaler (FP3, FP4 and WS1) agree with this view. The remaining five interviewees (WS2, WS3, FP1, FP2 and FP5) mention that they find either a combination of higher price with improved quality, trust or reliability more important. For FP5 there is no alternative but to use air cargo to ship the products from East Africa to Europe. Shipping by boat would deteriorate the product before it reaches destination. It has one competitor that produces the same product in South America, and fails to deliver a standard quantity/quality ratio. But if it were possible, FP5 would use a container barge for the East Africa-Europe route. All other interviewees place the cost for physical distribution at between 3 and 8 % of total cost, but FP5 has calculated a staggering 34 %. Another driver was personal commitment from the owners of the company (LSP1 and FP3).

Ad (2) The enablers for making physical distribution more sustainable have for all companies a technological (Jacobs 2009) approach, e.g. new vehicles or IT

solutions. Two companies choose an organizational approach by setting up an innovation think tank (LSP1) or appointing a sustainability manager for the whole supply chain (FP3). Other enabler that was mentioned is the availability of infrastructure like rail (LSP1, LSP2 and LSP4) or water (LSP1, LSP2, LSP3, LSP4, LSP6 and FP3). All members of the Lean and Green award scheme (all LSPs, WS1, FP3 and FP4) consider the program to be an inspiration and a help with achieving sustainability within their physical distribution. This is confirmed by FP1, whose logistics service provider is a member of Lean and Green. FP4 and LSP3 joined in 2013 Green Freight Europe (GFE), founded in 2012 to unite shippers and carriers in order to promote sustainable logistics. GFE has the ambition to establish credible performance criteria and review test data to ensure that such practices, vehicles, equipment and technologies will help fleets improve their efficiency and reduce emissions. Their aim is to create a pan-European standard similar to the program of SmartWay Partnership in the USA.

As for barriers to making physical distribution more sustainable, all logistics service providers pointed to shippers' emphasis on cost issues and lack of co-operation to find new innovative ways to enhance sustainability. One food processor (FP1), voiced his concern that the division between partners of the benefits and costs of the innovation would not be fairly done. Three food processors (FP1, FP2 and FP5) and one wholesaler (WS2) mentioned restrictions set by nature on ripeness of the agrifood products. One wholesaler (WS3), two logistics service providers (LSP1 and LSP3) and one food processor (FP5) considered governmental —local, national and European—regulations or the lack of support a major obstacle for introducing innovations. The wholesaler pointed to the time frames set by local governments for allowing deliveries within specifically designated areas—often city centers. This problem is also mentioned by WS1 but his problem is caused by the unwillingness of some customers to align their delivery schedules with neighboring customers. In this way WS1 has to go first to Amsterdam, then to Alkmaar, back to Amsterdam to finish north of Amsterdam again. In total, this one haul could have a potential saving of 12 % in kilometers if customers could be persuaded to adjust delivery times to fellow customers. LSP1 wanted to create a new harbor near its main location but the local government waited over 15 years before it gave permission for the project. LSP3 wanted to use Longer Heavier Vehicles (LHV), also called super lorries, for rides through Germany. The LSV is allowed on Dutch roads, but not in Germany. So every time it wanted to use a LHV for a short cut through Germany to reach a Dutch destination, it had to apply for special dispensation from the German authorities. FP5 sees the rules for not being able to employ certain pesticides against fungi as a barrier for getting products into Europe in a slow way instead of using air cargo. One logistics service provider (LSP2) saw the focus of the planner on directly serving the wish from a customer as a barrier. The planner should look for alternatives, which might be more sustainable but still interesting for the shipper.

Ad (3) We asked the interviewees to describe the recent new actions they had undertaken or would soon undertake for making physical distribution more sustainable. It was up to the interviewee to decide what these innovations were in

accordance with Van de Ven (1986). We labeled the given answers and split them into two categories (1) the basic form of an action being either: (a) non-technical—requiring human skills or intervention—or (b) technical—based on new technology (Jacobs 2009) and (2) the intended strategy of the innovation—(a) efficiency strategy; (b) alteration strategy and (c) reduction strategy (Holden and Gilpin 2013). Combining these two categories, we obtained an overview of the innovations our survey group use or will be using to make physical distribution more sustainable, as is shown in the Tables 2 and 3 below:

For the non-technical innovations, no reduction strategy actions were undertaken by the respondents. This does not mean that no reduction of CO_2 was generated by these innovations, but that reduction strategy was not the prime one for non-technical innovations, as mentioned by the interviewee. We were surprised to see that only three interviewees mentioned the new driving style, which features as a much-used action by members of Lean and Green for achieving sustainability (Pieters et al. 2012). Another surprise was that not all respondents mentioned planning as something they intend to alter. We had expected that this aspect, in combination with co-operation, would be a straightforward choice. Co-operation, vertical and horizontal, is very popular. WS2 and LSP5 want to work together with competitors. The logistics service providers LSP1, LSP2 and LSP3, as well as the food processors FP1 and, FP2, see more integration with another link in the supply chain. FP3 wants to tackle both forms of co-operation. FP3 has shared for some months river boat capacity with other shippers of food products, even if they are all competitors for the same agrifood market. Without sharing capacity, this mode of transportation would have been out of reach for FP3 and its competitors alike. Now they all have lower CO_2 emissions and have drastically reduced their transportation costs. This project was co-initiated by FP3.

If we look at new product and market, we have found two interesting examples. LSP2 is an expeditor and arranges transport and other logistic services for customers. The company does not have a fleet of transport equipment itself, but when needed rents transport capacity from other logistics service providers. In order to help customers to decide, LSP2 developed a software tool to calculate the prices, times and CO_2 production of various alternative routes between the starting position and the desired finish. For this calculation, the software program uses information on the customer's attitude towards price, time and sustainability. This software program calculates various alternative routes and the planner preselects the five best routes for the customer to choose from. As alternative options are given for one route, this system has been called synchromodal transportation. LSP1 introduced a new service by which the customer paid for CO_2 neutralization. With this money, trees were planted to compensate for the CO_2 emissions during transportation. The extra costs amounted to 5 %, but only 1 % of all trade was handled under this scheme.

Some technical actions that we were expecting—like fleet maintenance or electrical vehicles—were not mentioned at all. Splitting trucks was done by all wholesalers. In the case of WS2 by its logistics service provider on request of WS2. This seems logical, as the wholesalers have to ship a wide variety of products from their central warehouses to the shops or institutional customers. Of the three

Table 2 Non-technical innovations for making physical distribution more sustainable

Strategy	Action	Company												
		Wholesalers			Logistics service providers						Food processors			
		WS1	WS2	WS3	LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	FP1	FP2	FP3	FP4	FP5
Efficiency strategy	Planning	×	×					×	×	×	×				
	New driving style	×			×		×								
Alteration strategy	Modal transport				×	×		×		×			×		
	Horizontal co-operation		×						×				×	×	
	Vertical co-operation				×	×	×				×	×		×	
	New markets				×	×									×
	New products or services		×			×	×								×
	New methods				×		×	×							

Table 3 Technical innovations for making physical distribution more sustainable

Strategy	Action	Company													
		Wholesalers			Logistics service providers						Food processors				
		WS1	WS2	WS3	LSP1	LSP2	LSP3	LSP4	LSP5	LSP6	FP1	FP2	FP3	FP4	FP5
Efficiency strategy	Planning software	×							×	×					
	Fuel efficient trucks							×	×						
	Split trucks into multiple compartments	×	×	×											
Alteration strategy	Larger heavier vehicles (LHV)	×	×				×				×				
	Alternative fuels						×		×						
	Bio fuels								×						
	Monitoring the truck data	×													
Reduction strategy	New packaging and wrapping material as used in transportation										×	×		×	×
	Conditioning		×							×				×	

interviewees who were using the new driving style, only one mentioned that it will monitor the information gathered with this new driving style. FP5 mentioned that its supplier suggested a change of wrapping material. Due to this new material, the processed and packed vegetables did not turn black at the cutting edge. Bent vegetables, which previously had to be rejected, can now be chopped, packed and sold as prime products for the European market. The wrapping material also helps to extend the shelf life of the other uncut vegetables, which gives the company an extra advantage on the market. Packaging seems to be a food processor aspect. FP4 started a new way of packing, which resulted in less air being packed with the products. This meant that (a) more products could be stored and shipped and (b) less energy was needed to cool the products. FP1 used a new material for canning, which needed less energy to manufacture and which was easier to recycle.

In total, 58 innovations were mentioned. The majority (30 = 52 %) of these innovations were mentioned by the logistics service providers; the wholesalers mentioned 13 (22 %) and the food processors mentioned 15 (26 %). Of the innovations, 17 (29 %) were intended to improve efficiency, 34 (59 %) are aiming at changing the existing patterns and 7 (12 %) were connected to reduction. Most (35–60 %) innovations were of a non-technical nature, with the remainder (23–40 %) focusing on technical solutions. For the 23 technical solutions, the division in the three strategies is almost even. Efficiency and Alteration strategy having eight innovations and reduction strategy scoring 7. But the food processors seem to concentrate on innovations connected with reduction strategies and have not mentioned any innovation aimed at efficiency. A change in packaging and wrapping up products for distribution was particularly mentioned by food producers. The wholesalers and logistics service providers concentrate on innovations connected with efficiency and changing existing patterns as can be seen in Fig. 1.

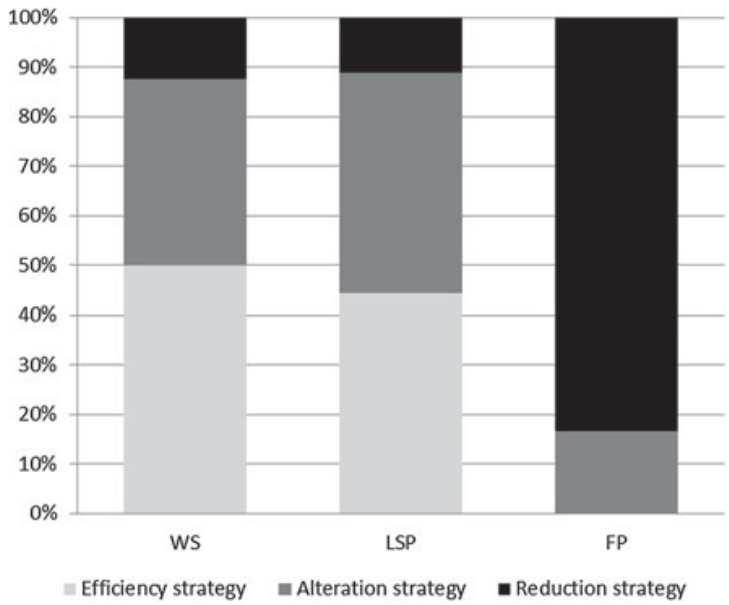

Fig. 1 Innovations and strategies for technical solutions

WS - Wholesaler
LSP - Logistics Service Provider
FP - Food processing company

Looking at the non-technical solutions, we see a very different picture: 9 (26 %) innovations can be placed under efficiency strategy and 26 (74 %) innovations fall under alternation strategy; and not one for reduction. In short, changing existing patterns seems to be the important objective of innovations in our target group. Especially, the logistics service providers and the food processors focus on alteration strategies. As for the wholesalers, the bulk of innovations is on efficiency improvement (60 %), but 40 % on alteration is impressive as can be seen in Fig. 2.

Ad (4) Finally we were interested in how an innovation entered the company. We found that with technical innovations, the supplier played an important role. He is the one who generates interest in the company for this innovation. LSP1 has developed a special relationship with a major truck manufacturer, which uses LSP1 for testing new products. In return, LSP1 knows these new developments in advance of other competitors. For the non-technical innovations, a more internal approach is taken. For instance, LSP1 has created a special team of experienced people and FP3 has nominated a manager for sustainable physical distribution. Both companies have concentrated on non-technical innovations and actively stimulate innovations, especially with third parties in the supply chain. None of the interviewees mentioned a government as an initiator for innovations. This is strange, as governments have set up charges related to the amount of pollution generated by a truck. For instance, the more a truck pollutes, the higher the toll for trucks driving on the German motorways will be, e.g. € 0.155 per kilometer for a Euro 6 norm truck of four axles or more, whilst a similar Euro 3 norm truck will have to pay € 0.204 per kilometer. This is still better compared with the lowest class of trucks paying € 0.288 per kilometer (figures Toll-Collect 2014). The price difference could be an incentive to replace the existing fleet with cleaner trucks.

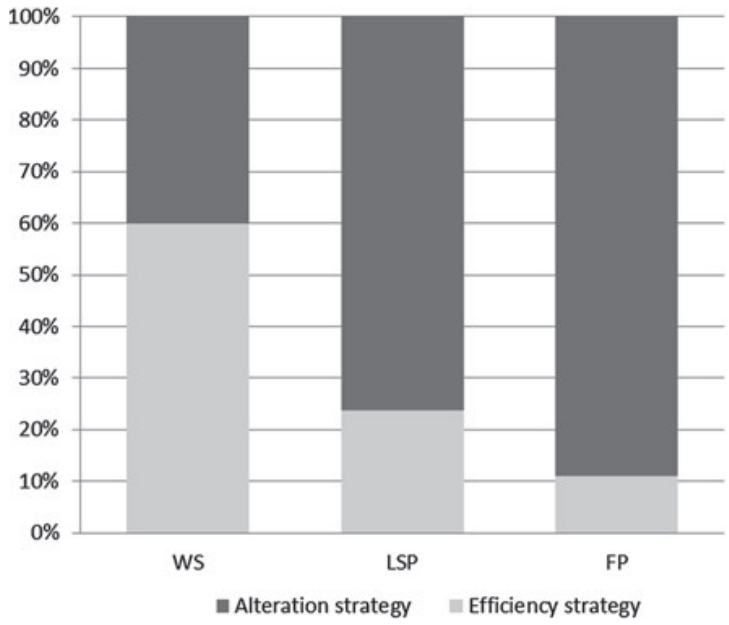

Fig. 2 Innovations and strategies for non-technical solutions

WS - Wholesaler
LSP - Logistics Service Provider
FP - Food processing company

7 Conclusions

Prior work has shown that for making physical distribution more sustainable, various strategies can be distinguished (e.g. Holden and Gilpin 2013). Research of agrifood products (Henson and Caswell 1999; Maloni and Brown 2006; Godfray et al. 2010; Van Beek 2010; Wognum et al. 2011; Van der Vorst 2011; Van der Vorst et al. 2013; Schott and Andersson 2015; Papargyropoulou et al. 2014) has focused primarily on aspects like cost reduction, food safety and prevention of food losses as much as on being green in distribution. However, these studies did not focus on the role of innovations for making physical distribution more sustainable and the position in the supply chain from where an innovation originates.

In this study, we researched how 14 organizations—logistics service providers, food processor and wholesalers—translate strategic policies into tangible innovations to make physical distribution within the agrifood sector more sustainable. During the—open and unstructured—interviews, we asked the interviewee how her/his company approached sustainability in physical distribution and what she/he considered to be new.

From our question—what innovative actions have Dutch logistics service providers, shippers and private carriers in the agrifood industry undertaken to make physical distribution more sustainable?—we found that the researched companies used technical innovations as well as non-technical innovations for improving the sustainability of their physical distribution. Certain types of innovations were common amongst a specific group, like innovative packaging among food processor and trucks with multiple compartments for wholesalers.

As for the initiator of these innovative actions, we found that applied technical innovations were mainly put forward by someone from outside the company, especially suppliers of transport material, packaging material, cooling equipment and software programs, e.g. for planning, truck monitoring and temperature regulation. These technical innovations require a thorough insight in the functioning of the new product or service and how this innovation can be adapted, used or applied for usage in the company. Non-technical innovations often involve co-operation with other links in the supply chain or in parallel supply chains. Here the initiator could come from inside its own company.

From the experience of innovations in making physical distribution in the Dutch agrifood industry more sustainable, we learned that the strategy for achieving sustainability as employed by the organization seems to be vital. Innovations at food processors relied more on reduction strategy and wholesalers were more focused on innovations related to efficiency strategy. Logistics service providers relied more on changing the traditional patterns. Our results indicate that our interviewees had a focus on a specific aspect—a transport or a product—involving their own organization and, perhaps, the previous or next link in the value chain, or identical organizations in different value chains. This could be called a “bottom up” approach. Surprisingly, not one of the interviewees mentioned an innovation intended for the supply chain as a whole. By looking at the supply chain from a

holistic approach—or "top down"—sub-optimization could be avoided. By approaching sustainability "bottom up", an improvement in one link in the value chain might result in a deterioration somewhere else. For instance, applying Life Cycle Assessment (Guinée et al. 2002; Finnveden et al. 2009). Dagran (2011) has shown that a different way of packaging concentrated fruit juices will not only result in a reduction in transported containers or in energy spend on cooling, but also in less energy used on making and recycling the actual package itself.

We found the initiator of innovations to be either coming from inside its own company or coming from a link closely connected to the organization. However, some limitations are worth nothing, as we used a convenience sample for establishing our target group and we only investigated a small number of companies we can draw no general valid conclusions. Understanding the role of the supply chain as a whole whilst initiating innovations in sustainability in physical distribution will require further investigation.

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