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Synchromodal transport for the horticulture industry

Requirements for implementation
in the Westland-Oostland greenport

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Abstract

The purpose of the thesis is to determine to which extent shippers in the Westland-Oostland greenport meet the requirements for synchromodal transport. Synchromodality is a new logistic concept which aims to increase the efficiency of transport and achieve lower transport costs. The main characteristics of synchromodal transport are the parallel availability of at least two modalities; the no longer pre-determined modal choice; the adaption of all infrastructure, services and stakeholders to one another; and bundling of product flows. Requirements with regards to the connectivity and organization of transport have to be fulfilled to implement synchromodal transport successfully. Based on these requirements, four potential flows of horticultural products are selected and six key characteristics for the organization of synchromodal transport are presented. The product flows and characteristics of organization are applied to four potential synchromodal corridors. There are also requirements which shippers have to fulfill in order to make the implementation of synchromodal transport possible. The degree to which shippers currently meet the requirements are determined, based on interviews with shippers in the greenport. The conclusion of the thesis is that the extent to which the shippers in the Westland-Oostland greenport meet the requirements for synchromodal transport depends on the type of horticultural products which the shippers handle. Shippers of flowers meet most of the requirements for synchromodal transport; shippers of vegetables meet some of the requirements; shippers of plants meet all requirements and shippers of fruit fulfill few requirements of synchromodal transport.

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1. Introduction

The first chapter provides background information on the Dutch logistics industry, the development of synchromodality and the horticulture industry of the Westland-Oostland greenport. The goal of this thesis and the research questions are introduced next. The methodology and structure of the thesis are described afterwards.

1.1 Background

The Dutch logistics industry is prominent on a global scale and is essential for the economy of the Netherlands. It adds forty billion euros to the gross domestic product (which equals 8.5 percent of total Dutch GDP) and offers 750,000 direct jobs (Topteam Logistiek, 2011). But this leading position can't be taken for granted. The performance of the Dutch logistics sector is gradually declining (World Bank, 2007, 2010, 2012), among others because of longer delivery time, lower flexibility and decreased reliability (Lodewijks et al., 2005). The costs which are currently occurred because of this are estimated to be 2.7 to 3.6 billion euros for logistic companies on the Dutch highways alone (Platform Agrologistiek, 2009). Moreover, the full capacity of vehicles isn't used, there is a high number of small flows and there isn't sufficient exchange of information between the various stakeholders (Topteam Logistiek, 2012). In addition to this, transport causes negative externalities such as the emission of greenhouse gases (Borger & Mayeres, 2004). The negative externalities of road transport are considerably higher than of transport by waterway or rail, whereas the amount of tonne-kilometers of road transport is the highest (EC, 2012; OECD, 2002). Limiting the emission of greenhouse gases is of increasing importance to both governments and companies themselves. Logistic companies have to take a growing amount of related regulations into account (Dekker et al., 2012). Along with this demand for a more efficient and sustainable and efficient logistic system, the need for freight transport is expected to increase strongly. The global transport of goods is estimated to increase fourfold in comparison to the current levels before 2050 (OECD, 2012), with the amount of tons transported to and from the Rotterdam and Amsterdam mainports increasing with fifty percent between 2007 and 2020 (TNO, 2010).

Measures need to be taken to ensure the continued efficiency and attractiveness of the Dutch logistics industry. The implementation of synchromodal transport can contribute to sustainable, competitively priced, reliable, quick and timely transport of goods (Topteam Logistiek, 2011). There is no definitive definition of synchromodality yet, but the core of this logistic concept is the flexible assignation of loads to the available modalities. Instead of pre-assigning loads to a certain modality by default, the requirements of the load and the availability of capacity of infrastructure and services are taken into account to select one or more modalities which are most suitable given the characteristics of each individual load. This allows for a more flexible and efficient utilization of vehicle and infrastructure capacity. Both monetary and environmental costs of transport are expected to be impacted accordingly (SPL, 2010). Taking these core characteristics into consideration, synchromodality can be defined at this point as "the continual synchronization of chains of goods, chains of transport and infrastructure in such a way that the best modal choice can be made at any moment for the aggregated demand for transport" (TNO, 2011b, p. 6).

Logistics isn't an end in itself, but enables and supports the processes of other industries. As such, the demand for transport is derived from the demand for the products of other industries (Blauwens et al., 2008). The horticulture industry is an important example of this. Accounting for forty percent of the Dutch agricultural industry as a whole, the horticultural industry of the Netherlands yearly adds nine billion euros to the gross domestic product. By achieving an export value of 17 billion euros, it is responsible for no less than 24 percent of the trade surplus of the Netherlands (CBS, 2011; Greenport Nederland, 2010; Nijkamp, 2010). The horticultural industry provides more than 120,000 direct jobs and 450,000 indirect ones, of which many relate to distribution and other transport activities (Topteam Tuinbouw en Uitgangsmaterialen, 2011). The five main clusters of horticultural activities in the Netherlands are labeled as greenports and account for roughly two-third of all value added in the horticultural industry. Westland-Oostland is the most prominent of the five greenports in terms of total production (Nijkamp, 2010; Provincie Zuid-Holland, 2011). Figure 1 shows the various greenports and their proximity to the mainports and transport corridors.

The horticulture industry requires logistic companies to transport products between the various stakeholders within the horticulture supply chain. This enables the logistics industry to create 0.3 to 1 billion euros of additional value to horticultural products. The demand of transport which is generated by the horticulture industry is considerable (Topteam Tuinbouw en Uitgangsmaterialen, 2011).

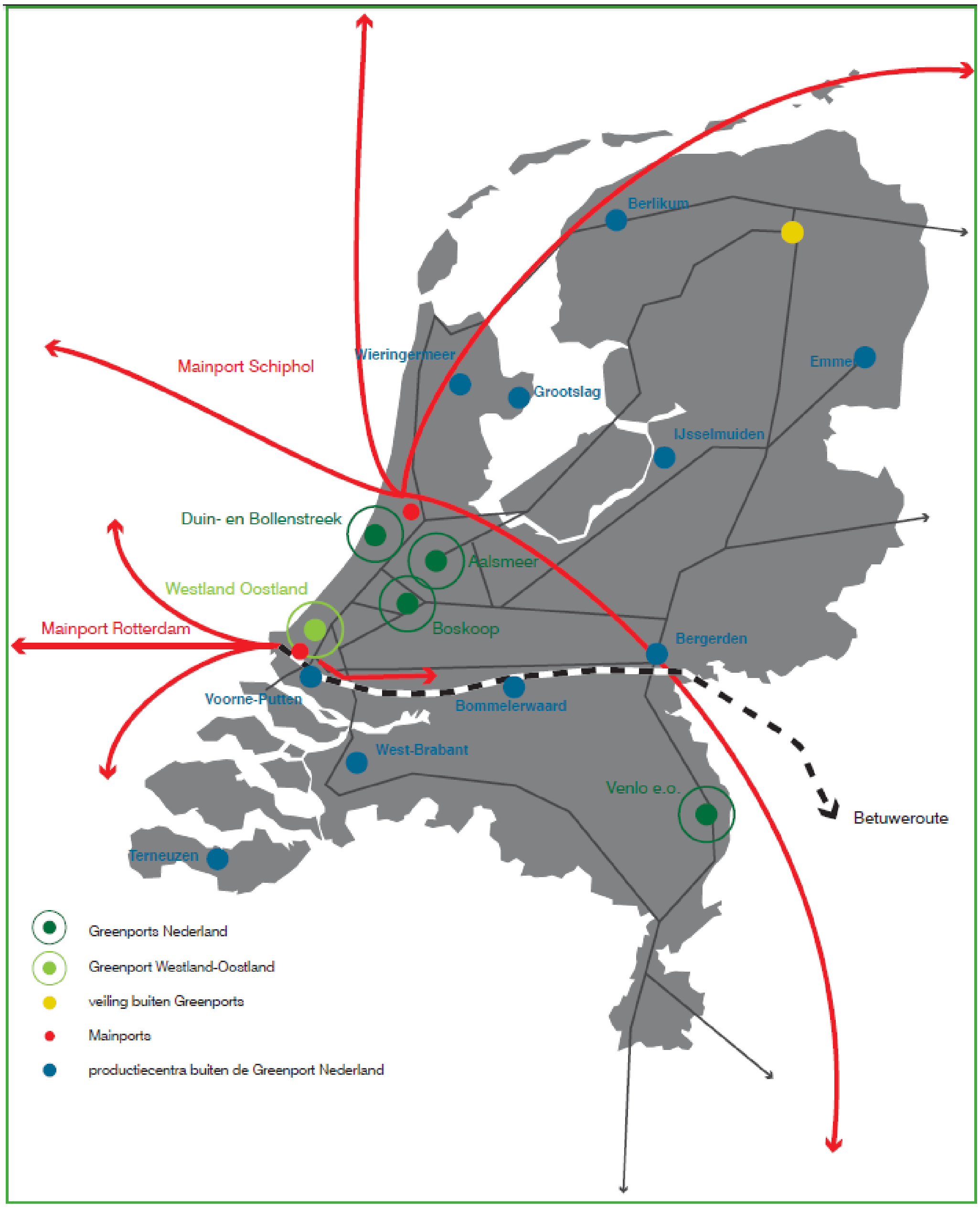


Figure 1: The location of the five Dutch greenports in relation to the mainports and various transport corridors (Greenport Westland-Oostland, 2008).

It is estimated that one of every ten trucks in the Netherlands transports horticultural products and that one of every six cargo airplanes calling at Schiphol airport carries horticultural products aboard (Hubways, 2010; Topteam Tuinbouw en Uitgangsmaterialen, 2011). This means that transport generated by the horticulture industry adds to the negative externalities caused by logistic activities. At the same time, the horticulture industry is confronted with the consequences of those negative externalities. Agro-logistic companies for example occur 300 million euros of costs each year due to congestion on the Dutch highways (Platform Agrologistiek, 2009). The implementation of synchromodal transport could thus not only have a potential positive impact on the performance of the logistics industry, but also on companies in the horticulture industry.

1.2 Research questions

With the quality of supply under pressure and the demand for transport increasing, the leading position of the Dutch logistics industry is under pressure. This is troublesome both for logistic companies themselves and for the industries that they provide services for. Synchromodality is a concept which can potentially diminish the problems which logistic companies face and create more value for other industries, such as the horticulture industry.

The concept of synchromodality is recently developed and much talked about, but isn't fully implemented in practice yet. As a result, the availability of literature on both a national and international level is limited. The goal of this thesis is on one hand to contribute to the theoretical analysis of the newly introduced concept of synchromodality. On the other hand, the thesis aims on a more practical level to determine to what extent the requirements of synchromodal transport are currently met by shippers in the horticulture industry. The research is focused on the Westland-Oostland greenport due to its economic importance and proximity to the port of Rotterdam.

The main research question is formulated as follows: *To what extent do shippers in the Westland-Oostland greenport currently fulfill the requirements for synchromodal transport?*

Three research questions are used to answer the main research question. These three questions are divided into nine supporting questions:

What is synchromodality?

1. What are the definitions and characteristics of synchromodal transport?
2. What are the objectives of synchromodal transport?
3. What are the requirements of synchromodal transport and what can stakeholders do to fulfill them?

What are the main flows of horticultural products to and from the Westland-Oostland greenport?

4. Which types and quantities of horticultural products are grown and traded in the greenport?
5. What are the roles and characteristics of the stakeholders in the greenport?
6. Which flows of horticultural products from and to the Westland-Oostland greenport can be identified?

What are the characteristics of potential synchromodal transport for the Westland-Oostland greenport?

7. What are potential corridors for the implementation of synchromodal transport in the greenport?
8. What are the characteristics of potential organization of transport within the synchromodal corridors?
9. To what extent do shippers meet the requirements for synchromodal transport?

1.3 Methodology

Several methods are used to find answers to the research questions. Desk research is performed to answer the first two research questions. The required information about synchromodality is based on publications on synchromodal transport and literature on multimodality. The information about the horticulture industry is mostly based on reports from consultancy institutions. A quantitative comparison of the product flows to and from the Westland-Oostland greenport is performed to determine which flows include the most volume. The second main method are the interviews which are conducted. Two types of stakeholders are selected for the interviews. Firstly, experts on synchromodal transport are interviewed to provide additional information about synchromodal transport. Secondly, shippers of horticultural products in the Westland-Oostland greenport are interviewed to determine which requirements synchromodal transport has to fulfill in order to be attractive to the shippers.

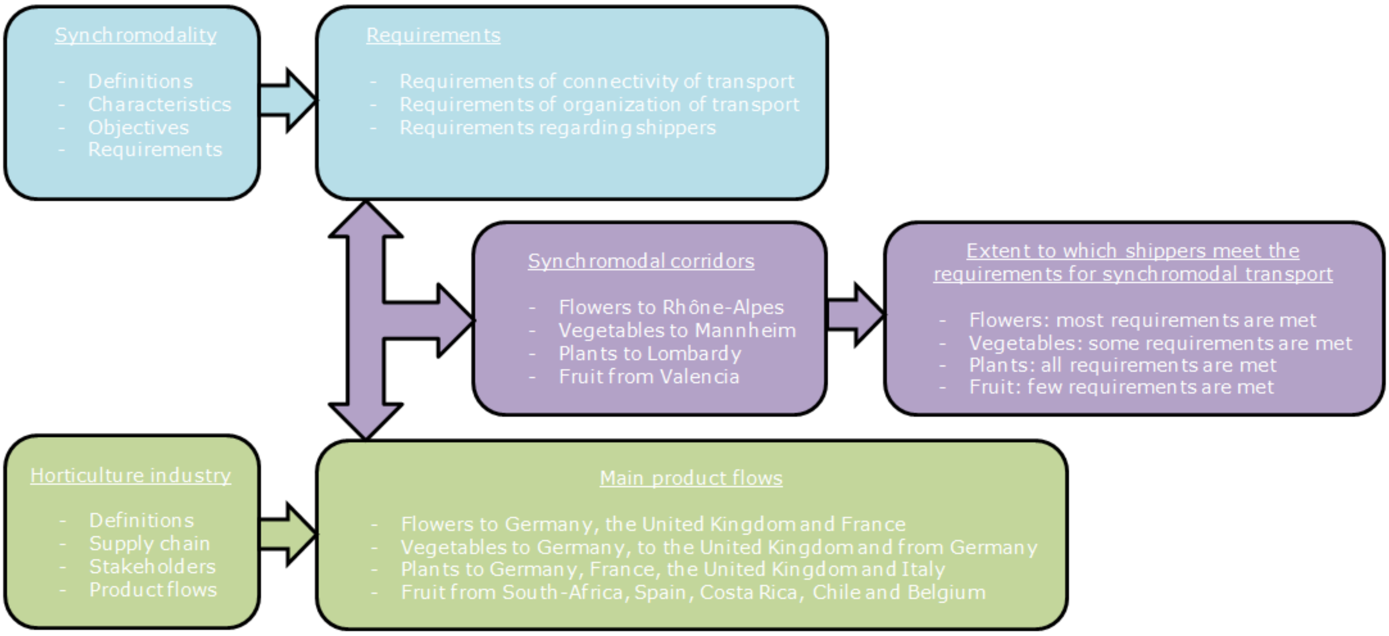


Figure 2: Schematic overview of the topics and structure of the thesis.

1.4 Structure

After the introductory chapter, the thesis includes three main chapters, a conclusion, a reference list and an appendix:

- Chapter 2 discusses the concept of synchromodality to answer the first research question. The chapter starts with an overview of the definitions and main characteristics of synchromodality. The objectives and requirements of synchromodal transport are described as well.
- Chapter 3 identifies the main flows of horticultural products of the Westland-Oostland greenport to provide an answer to the second research question. The chapter includes a description of the goods which are produced and traded in the greenport, an overview of the stakeholders and an analysis of the product flows to and from the greenport.
- Chapter 4 explores the potential for the implementation of synchromodal transport in the greenport to answer the third research question. The chapter includes the selection of four synchromodal corridors, discusses the key characteristics of the organization of transport in the synchromodal corridors and determines to which extent shippers currently meet the requirements for synchromodal transport.
- Chapter 5 is the conclusion of this thesis. The content of the previous chapters is briefly summarized and the main research question is answered. The limitations of the research are discussed and some recommendations are given as well.
- Chapter 6 is a reference list which contains all literature, publications and interviews which are used.
- The appendix contains additional data on the horticultural product flows from the Westland-Oostland greenport.

Figure 2 shows the various topics discussed in the thesis.

2. Synchromodality

The second chapter is focused on the first research question: *What is synchromodality?* The definitions, objectives and requirements of synchromodality are described to illustrate the potential advantages which synchromodal transport could achieve.

2.1 Definitions and characteristics of synchromodal transport

Chapter 2.1 is dedicated to the first supporting research question: *What are the definitions and characteristics of synchromodal transport?* The origin, development, descriptions and characteristics of synchromodality are discussed to establish the definition which is used in the remainder of the thesis.

2.1.1 Origin and development of synchromodal transport

Synchromodality was introduced in 2010 by the Strategisch Platform Logistiek, an organization which represents the Dutch logistics sector. The concept is an important part of the advice that this organization offered the government of the Netherlands at that time regarding the development of the Dutch logistics industry. According to the advice, synchromodal transport can achieve considerable logistic improvements by no longer assigning loads to the same modalities by default (SPL, 2010). Due to its emphasis on the combined utilization of modalities, synchromodality can be considered as "an innovative form of co-modal transport" (BCI, 2011, p. 4).

In practice, synchromodal transport is implemented by companies such as ECT, the main container terminal operator in the port of Rotterdam. Figure 3 shows ECT's European Gateway Services, which flexibly connects the deep sea terminals in Rotterdam with the various locations in the port's hinterland by barge, train and truck (ECT, 2011). Additionally, several synchromodal pilots are carried out to develop the various innovative aspects of synchromodal transport in practice (Veenstra, 2012).

Figure 3: The European Gateway Services network (ECT, 2012).

2.1.2 Definitions of synchromodal transport

The concept of synchromodality was introduced only two years ago, but various definitions of the concept are already used. The definitions are analyzed here to identify the core characteristics of synchromodal transport and to establish the definition which is used in the remainder of the thesis.

In chapter 1.1 synchromodality is defined as *"The continual synchronization of chains of goods, chains of transport and infrastructure in such a way that the best modal choice can be made at any moment for the aggregated demand for transport."* This definition is based on a TNO report (2011b) and is referred to as "the core of the concept" (p. 6) of synchromodality. This definition focuses on synchronization of goods, transport and infrastructure, and the aim to make the most suitable modal choice.

Later on in the same report, a more extensive definition of synchromodality is given (TNO, 2011b, p. 8): *"The supply of services of the various modalities is synchronized to a cohesive transport product, which meets at any moment the transport demand of shippers in terms of price, punctuality, reliability and/or sustainability. This synchronization includes both the planning of services, the performance of services and the information about services."* This definition includes the synchronization of the modalities as well and puts emphasis on both the various demands of shippers and the offered service. The definition also explicitly refers to the planning, performing and informing of transport.

In an earlier report, also by TNO (2010, p. 16), another definition is used: "*Between and within the three layers that collectively are the transport system (shippers, carriers/terminals and the infrastructure managers), the aggregated demand for transport is synchronized to the extent that the right modality always can be selected, in such a way that:*

- *the carrier is offered the transport that suits his competitive strategy;*
- *a profitable utilization is possible for the shipper (or terminal);*
- *the infrastructure and available space is optimally used;*
- *the chain performance in terms of sustainability is optimized."*

This description takes the synchronization between the three layers of the transport system and the right modal choice into account as well. It also includes four additional conditions regarding the profitability for the involved parties and the optimization of the transport processes.

Topteam Logistiek (2011, p. 14) stresses the importance of synchromodality to ensure the continued success of the Dutch logistics industry: *"The flexible utilization of all transport modalities based on cooperation between modalities (instead of competition between modalities). Depending on the wishes of the shipper and the currently available capacity of modalities and infrastructure, water (barge or short sea), rail, air and/or road can be used."* This description focuses on the flexible use and parallel availabilities of the modalities. It also mentions the cooperation between the modalities of transport and the demands of customers are emphasized as well.

Container terminal operator ECT uses the following description of synchromodality (2011, p. 9): *"(Synchromodality) offers companies the ability to time and select the most appropriate mode of transport for that particular moment and circumstances with the customer's wishes as a starting point. This requires a choice from various modalities of transport in A, but if possible also in B. Thus, an optimally flexible and sustainable transport system is created in which companies are always assured of optimum transport combinations depending on the circumstances - product, required speed, physical conditions etc. - and can easily switch between modalities of transport if necessary."* This more practical description focuses on the transport needs of the demand side. It puts much emphasis on the various available modalities and the possibility to switch between modalities during transport.

BCI (2011, p. 3) describes synchromodality as follows: *"The orchestrated use of synchronized transport modalities, such that the user can always be offered various transport services, depending on his wishes regarding speed, reliability, run time, quality, sustainability and costs."* This definition expresses the flexible utilization of modalities and it explicitly states the orchestration aspect of the concept.

Stuurgroep synchromodaliteit (2012, p. 5) offers this definition: *"The optimally flexible and sustainable use of various kinds of modalities in a network orchestrated by a logistic service provider, in such a way that the customer (shipper or shipping agent) is offered an integrated solution for his hinterland transport."* The description focuses on the flexible and parallel availability of modalities and also points out the benefits for the customer.

The various descriptions offer a variety of characteristics of synchromodal transport. Based on the analysis of the definitions, four characteristics can be identified which are the core of synchromodal transport: a-modal booking of transport, synchronization between the suppliers and users of transport, parallel availability of modalities and bundling of product flows.

2.1.3 Characteristics of synchromodal transport

Section 2.1.2 identities four main characteristics of synchromodal transport. The characteristics are elaborated below to increase the understanding of the key aspects of synchromodal transport.

A-modal booking

A-modal booking is the practice of placing a transport order in which the shipper only specifies the location and time of delivery, not the modality by which the transport is carried out (Stuurgroep synchromodaliteit, 2012). In this case, a third party selects one or more modalities based on the lead time of the order and the available capacity. Because not all road transport actually requires the speed which trucks provide, modalities such as trains and barges can be utilized instead. The available infrastructure and capacity of the transport supply as a whole can thus be more efficiently used (BCI, 2011).

Synchronization

Synchronization is the adjustment of production, warehousing and transport to one another to limit waiting time. Synchromodal transport includes synchronization between the infrastructure and transport services on one hand and the transport demands of carriers and shippers on the other. Transport units are compatible and the time tables of the various transport services suit the transport demands of the shippers (BCI, AFI, TNO, 2003; Rodrigue, 1999). The synchronization of the various modalities and services includes the information which is related to the product flows as well (TNO, 2010).

Parallel availability of modalities

At least two different modalities are simultaneously available in synchromodal corridors. This allows for the flexible utilization of the various modalities and capacity, also - if necessary – when transport is already underway. Specifically, synchromodal transport aims to make better use of the available capacity of trains and barges, without excluding the possibility for road transport if the load requires this (Topteam Logistiek, 2011). Figure 4 is a visual example of the parallel availability of modalities within a synchromodal corridor in the hinterland of the port of Rotterdam.

Bundling

Synchromodal transport takes the aggregated transport demand into account. By combining the products of different origins during transport, better use can be made of the available vehicle capacity. The products can be separated into "quick" and "slow" flows as well, depending on the lead time of the order. Because "slow" flows tend to be designated to modalities which have more capacity, such as trains and barges, more product volume is needed to fully use the capacity of those modalities. Bundling also results in this case in optimized utilization of the modalities (TNO, 2010).

Figure 4: Overview of the synchromodal Rotterdam-Moerdijk-Tilburg corridor which shows the various available modalities and the hubs where loads can be bundled and switched (TNO, 2012b).

2.2 Objectives of synchromodal transport

Chapter 2.2 is dedicated to the second supporting research question: *What are the objectives of synchromodal transport?* The objectives are the advantages which can be achieved by synchromodal transport and thus illustrate the benefits which synchromodal transport can accomplish. The objectives discussed below are selected from the relevant available publications and reports on synchromodality and multimodality which were read as part of the desk research. The relevant references are listed in the text.

2.2.1 Reduced environmental costs

Synchromodal transport aims to utilize modalities which are most suitable given the requirements of individual loads. It also makes the utilization of modalities such as trains and barges more convenient (Veenstra, 2012). This could lead to a larger product volume being transported by modalities other than trucks. Modalities such as trains and barges cause less environmental damage than road transport, both in terms of external costs and absolute emissions per tonne-kilometer (TNO, 2011b). External costs are costs which are not included in the price that a user pays for a service, thus leading to a consumption of such a good that is higher than is optimal from a societal point of view (Maddison, 1996). External costs of freight transport are not incurred by the carrier or the shipper, but by society as a whole. These costs are related to damage the natural environment, for example by air pollution, the emissions of greenhouse gases and noise (Forkenbrock, 1999; Maddison, 1996). Table 1 shows a summarized analysis of various researches on the external transport cost per modality. The external costs of air pollution and climate change of barges and trains per tonne-mile are considerably lower than of road transport (De Palma, 2011).

Table 1: External costs of various modalities per tonne-mile in 2006 dollar cents (adapted from De Palma et al., 2011).

External transport costs per mode			
	Road	*Rail*	*Water*
Air pollution	0.10 – 18.7	0.01 – 0.35	0.08 – 1.7
Climate change	0.02 – 5.9	0.01 – 0.047	0.00 – 0.23
Noise	0.0 – 5.3	0.05	n.a.
Congestion	0.54	0.03	n.a.

Table 2 focuses on the absolute emissions of greenhouse gases of the three modalities and shows that trains and barges are less damaging to the natural environment than trucks in this regard as well (TTI, 2012).

Table 2: Emissions of various modalities (adapted from TTI, 2012).

Emissions per mode (per grams/tonne-mile)										
	HC/VOC		*CO*		*NO_x*		*PM*		*CO_2*	
	Hydrocarbons / Volatile organic compounts		*Carbon monoxide*		*Nitrogen oxides*		*Particulate matter*		*Carbon dioxide*	
	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009
Barge	0.0174	0.0168	0.046	0.0447	0.469	0.454	0.0116	0.011	17.48	16.92
Rail	0.0242	0.0219	0.064	0.058	0.654	0.592	0.0162	0.015	24.39	22.08
Truck	0.12	0.10	0.46	0.37	1.90	1.45	0.08	0.06	171.87	171.83

Similar results are also found in practice. A modal shift from uni-modal truck transport to intermodal road-rail transport on nineteen European corridors achieved a decrease in CO_2 emissions from 20 to 50 percent (IFEU & SGKV, 2009). Barges and trains are only less damaging to the environment per tonne-kilometer when their capacity is adequately utilized. Since achieving enough volume by means of bundling is an important aspect of synchromodal transport, sufficient volumes could be potentially ensured this way (TNO, 2010). Synchromodal transport has already proven to be capable of leading to reduced environmental costs. In the synchromodal pilot of the Rotterdam-Moerdijk-Tilburg corridor, three shippers achieved a level of CO_2 emissions which was 22 percent lower than the emissions of regular freight transport in that corridor (Stuurgroep synchromodaliteit, 2012).

2.2.2 Increased efficiency

The implementation of synchromodal transport could lead to increased transport efficiency in three different ways: by the better utilization of available vehicle capacity, a reduction of road congestion and an increase in transport reliability (TNO, 2011b). The three targets are elaborated below.

Improved utilization of capacity

A considerable part of the available capacity of all modalities isn't utilized (Topteam Logistiek, 2011). The implementation of synchromodal transport could improve the rate of utilization of vehicles in two different ways.

Firstly, loads which would otherwise partially fill two trucks can be bundled. Although no modal shift takes place, the combination of the loads could make one of the trucks redundant while making better use of the capacity of the remaining truck. Secondly, traditional truck loads could be transported by other modalities instead if the requirements of the load allow for this. As a result of this modal shift, the capacity of modalities such as trains or barges is better utilized while some transport by trucks is no longer required (TNO, 2010).

Reduced road congestion

Congestion of roads is a considerable bottleneck of transport by truck, since it causes the travel speed to be reduced. It's caused by a lack of transport capacity or by blocked traffic corridors (Beamon, 1999). The amount of time lost due to congestion on the Dutch roads is increasing, particularly in and around Amsterdam and Rotterdam, where both Dutch mainports are located. Table 1 shows that the external costs of delays due to congestion are considerable. This is a threat to the performance of the Dutch logistics industry (Ministerie I&M, 2012b). Transport by train and especially by barge avoids this problem. The capacity of the necessary infrastructure and services of both railways and inland waterways is expected to be able to accommodate the increase of volume which a partial modal change would cause (Ecorys, 2010; TNO, 2012a). Additionally, the objective of synchromodal transport to improve the utilization of capacity leads to a reduction of congestion due to the decrease of the number of vehicles required.

Increased transport reliability

Transport reliability is about providing the expected level of transport quality and is an essential part of logistics (OECD, 2010). It indicates whether the transport can reach its destination and whether it does so in time (Sánchez-Silva et al., 2005). The importance of the reliability of transport is increasing because supply chains are becoming more inter-related and complex. Consequently, a disruption at one point of the supply chain can negatively affect other activities in the rest of the chain (OECD, 2010). The implementation of synchromodal transport could contribute to avoiding this in several ways. Firstly, synchromodal transport offers within a corridor at least two modalities which are simultaneously available. In case one modality is unavailable, another one can be selected. Secondly, a synchromodal corridor includes transport hubs where loads can switch modalities. If a later part of a route becomes inaccessible due to unforeseen circumstances while transport has already commenced, another modality can be selected along the route to deliver the load after all (TNO, 2010). Finally, a reduction of road congestion allows the vehicles which remain on the road to move with less delays and thus with more reliability.

2.2.3 Reduced monetary costs

The costs of transport could be reduced if synchromodal transport is implemented. This is due to the price of the various modalities, the optimized utilization of vehicles and reduced waiting time.

Modal price

Synchromodal transport provides the opportunity to utilize at least one of several modalities. Given the requirements of the load, the least expensive combination of modalities can be effectively and flexibly selected. Trucks are cheapest on short distances, but the total costs per container become lower after approximately 150 kilometers if trains are utilized. The cost of barges becomes yet lower if the distance increases to approximately 350 kilometers (NEA, 2006).

Optimized utilization of capacity

Synchromodal transport could improve the utilization of vehicle capacity. Bundling loads in such a way that less vehicles are required doesn't only increase efficiency, but also omits the costs which this additional vehicle otherwise would have caused (TNO, 2010). Better utilization of vehicle capacity could also lead to lower costs due to economies of scale (Cruijssen et al., 2007).

Reduced waiting time

The implementation of synchromodal transport could lead to an increase in transport efficiency. This in turn reduces the waiting time within a supply chain and lowers the number of irregularities, which can leads to considerable cost savings (OECD, 2010). An increase of synchronization between the various infrastructure layers is an objective of synchromodal transport as well. This reduces waiting time in terminals and warehouses, which in turn can also lower transport costs (Rodrigue, 1999).

2.3 Requirements of synchromodal transport

Chapter 2.3 is dedicated to the third supporting research question: *What are the requirements of synchromodal transport and what can stakeholders do to fulfill them?* The requirements and the measures to meet them are established in order to select potential synchromodal corridors, characteristics of synchromodal transport organization and the requirements which shippers have to meet in chapter 4. The requirements which are discussed below are based on publications on synchromodality. They are about the connectivity and organization of synchromodal transport and relate to shippers as well. The relevant references are listed in the text.

2.3.1 Requirements of connectivity

The requirements related to the connectivity which synchromodal transport provides are discussed below. They include product volume, availability of at least two modalities and transport responsiveness.

Availability of infrastructure and services

Synchromodal transport offers per definition the possibility to utilize at least two different modalities which are simultaneously available. Any synchromodal route thus includes a corridor where more than one modality is operated. Within this corridor, the various modalities have to offer services of a sufficient frequency and quality in order to provide regular and reliable transport. Specifically, the infrastructure and services have to be able to provide transport which are satisfactory given the lead times which shippers face. Since the availability of infrastructure and services can't be directly influenced, especially not on the short term, synchromodal transport can only be implemented in corridors where the requited infrastructure and services already exists.

Volume of product flows

Infrastructure and services are only available when enough volume is already available to make the supply of the modalities profitable. A sufficient percentage of this product quantity has to be assigned to modalities other than trucks in order to make the parallel availability of modalities feasible and optimize the utilization of vehicle capacity. This can most easily be accomplished by implementing synchromodal transport in corridors where a considerable product volume already exists. Bundling of products can ensure a larger flows as well (TNO, 2011a). Bundling is the consolidation of product flows between transport hubs. Although bundling can lead to additional handling time and longer transport distances, it can result not only in the better utilization of vehicle capacity, but also in economies of scale, an increase in destinations that the vehicle calls at and higher transport frequencies (BCI, A&F, TNO, 2003; Notteboom, 2008). These are attractive additional benefits for synchromodal transport.

Responsiveness of transport

Synchromodal transport aims to offer flexibility and reliability not only by assigning loads to the most suitable modalities before transport commences, but also by providing effective solutions if unforeseen circumstances occur during transport. If an incident leaves one part of infrastructure inaccessible, synchromodal transport provides the possibility to shift the load between modalities and thus avoid the infrastructure which is no longer available. A change between modalities can also be required when the urgency of a shipper's order changes unexpectedly while transport is already underway. If this occurs, a load should be able to be moved to the modality which is most suitable given the changed conditions. This change between modalities is referred to as switching, which means "having the opportunity to change to the best transport modality at any time to optimize network utilization and fulfill transport demand" (TNO, 2012b, p. 63). Because of this, synchromodal corridors ought to include hubs where loads can be efficiently switched between modalities. Figure 4 shows examples of such hubs. Switching between modalities doesn't only require physical infrastructure, but the related services have to suffice as well. The paperwork related to switches between modalities are also of importance. They are described in section 2.3.2. There are currently no formal processes for the switching of loads between modalities. The organization of the various modalities is separated, which further complicates switching. The impact of this might be limited in practice, because the number of containers which could benefit from switching is expected to be small. The synchromodal pilot in the Rotterdam – Moerdijk – Tilburg corridor concludes that the possibility to switch modes is only attractive for approximately five percent of all containers considered int hat study (TNO, 2012b).

2.3.2 Requirements of organization

The requirements related to the organization of synchromodal transport are described below. They are the management and the scope of the synchromodal project, real time planning of transport, cooperation between stakeholders and paperwork procedures.

Management of synchromodal transport

Synchromodal transport includes the involvement of various carriers, shippers and infrastructure managers. Orchestration is required to select the most suitable modalities for each load and coordinate transport on the shipper's behalf. Orchestration ensures that the carriers which perform transport tasks are contracted and it also manages transport in unforeseen circumstances (TNO, 2010). Return transport can also be arranged this way (Lamers, 2012). Because the party which carries out the orchestration task has an overview of the various stakeholders, it can go beyond the sub-optimization of transport which occurs when individual parties only take their own opportunities into account (TNO, 2012b). Orchestration can include various additional tasks (Hinterhuber, 2002):

- Defining the goal, mission and objectives of the network;
- Defining and enforcing performance standards for each party in the network;
- Maintaining and developing the physical and intellectual assets of the network;
- Securing the voluntarily participation of all network partners, rewarding performances and clarifying the roles of each partner.

There are various ways to arrange orchestration (Lamers, 2012; TNO, 2012b):

- A joint venture of various involved market parties;
- A third party such as a logistic service provider can be contracted to orchestrate;
- A shipper or carrier which is part of the network can perform the orchestration task.

Scope of synchromodal transport

Before implementing synchromodal transport, the scope of the project has to be carefully determined and agreed upon by the involved stakeholders. Innovative projects such as synchromodal transport have a higher chance of being successful when infrastructure and services which are already operational are utilized. The goals of the implementation should be clear in advance as well. Suitable and committed stakeholders have to be selected as well before synchromodal transport is implemented (Lamers, 2012; Wenink, 2012).

Pricing of synchromodal transport

Because the utilized modalities and the related services are no longer predetermined, synchromodal transport lacks a direct link between the price that shippers pay and the transport which is actually sold. The price of synchromodal transport reflects a mix of possible transport solutions instead of the costs of a specific modality and route. This price should be equal for all solutions in order to prevent shippers from preferring to use only the cheapest options. Shippers require knowledge of the costs of the transport solutions which are available to them in advance. Suppliers of synchromodal transport thus have to provide price information despite not knowing in advance which services are actually going to be used. Consequently, the demanded prices may either too high to be attractive for shippers or too low to be profitable to carriers. To prevent this, a price can be determined which is based on the (estimated) modal split and the costs for each modality (TNO, 2012b). Alternatively, a pricing mechanism can be used in which a basic price is charged from which any cost savings caused by synchromodal solutions are deducted (Lamers, 2012).

Real time planning of transport

Synchromodal transport aims to make optimal use of all available vehicle capacity, infrastructure and services. Reliable and up to date information regarding the demand and supply of transport is needed in order to assign loads to the most suitable modality. Such information allows for an effective match between the available transport capacity and the products which have to be transported (BCI, 2011). To ensure efficiency, all stakeholders have to plan and act based on the same (perceived) circumstances, which means that the stakeholders need to have access to the same information. Such shared situational awareness can be created by a virtual dashboard which visualizes all necessary information (TNO, 2012b). The information is based on milestones in the transport processes and are measured by key performance indicators, such as the time it takes for a vehicle to move between terminals (Woxenius, 2012). Key performance indicators can be measured with tools such as GPS, which gives insight into for example the speed, current location and expected arrival time of a vehicle. Software is required to gather and process the data which the dashboard depends on. Such software is already utilized to some extent, but isn't available yet on the scale of an entire transport network. The software which is needed to create a dashboard on the level of a synchromodal network is currently in development (TNO, 2011; TNO, 2012b). Additionally, synchromodal transport aims to provide efficient solutions when unforeseen circumstances hinder the progress of transport. In order to arrange alternative solutions on short notice whenever incidents occur, a comprehensive list of possible scenarios and required reactions should be available in advance (Wenink, 2012).

Cooperation between stakeholders

In case of synchromodal transport, there is no direct link between the costs and revenues of transport services, which makes pricing complex. In addition to this, transport can be provided by more than one carrier and the use of assets can be shared among various stakeholders. As a result, the profits of individual companies are depending on the performance of the network of stakeholders (TNO, 2012b). A cost and gain sharing model has to be developed to determine which share of the costs and revenues each stakeholder occurs and receives (Eng-Larsson & Kohn, 2012). Mathematical modeling within cooperative game theory can be used to determine the allocation of costs and profits among the various stakeholders (Bell, 1999; Slikken, 2010). The joint control over the assets of individual companies can be difficult to achieve, especially when stakeholders are traditionally competitors (Wenink, 2012). Transaction costs can arise as well, as a result of the contractual specifications which need to be made to avoid opportunistic behavior (Allen, 1999). The formalization of the roles and responsibilities of each stakeholder on one hand and commitment and trust on the other hand can in turn result in successful cooperation between the various stakeholders (Lamers, 2012; TNO, 2012b).

Paperwork procedures

Synchromodal transport strives to carry out any aspects of transport as efficiently as possible. Modalities can't be flexibly utilized if paperwork procedures take too long to complete, which undermines the potential advantages which synchromodal transport has to offer. Customs procedures and documentation are no exception to this. Currently it's an administrative hassle to change modalities once the transit declaration has been submitted, whereas synchromodal transport requires such procedures to be much more convenience due to its heavy reliance on the flexible allocation of loads to modalities. Similarly, insurance prices and types depend on the utilized modality. A change of modality therefore requires a change of insurance as well, but this is difficult to achieve, especially on short notice. The administrative burden can be lowered by creating formal procedures which allow for changes between modalities and include them in a "single window": a preferably fully digitalized facility where all necessary paperwork procedures can be carried out efficiently. The "single window" concept is already in use and could be extended to include synchromodal transport (TNO, 2010; TNO, 2012b).

2.3.3 Requirements regarding shippers

There are two types of requirements regarding shippers:

- Requirements for shippers. These are requirements which shippers have to meet in order to be suitable for synchromodal transport, namely the lead time of orders, the perception of synchromodal transport and an urgency to innovate transport.
- Requirements by shippers. These are requirements which synchromodal transport has to meet in order to be attractive to shippers, namely the price of synchromodal transport and insight into transport progress.

The five requirements regarding shippers are described below.

Lead time of orders

Although trucks are both the fastest and most utilized modality, synchromodal transport aims to make efficient use of all modalities available. In order to use modalities other than trucks, the infrastructure and services of other modalities have to suffice. Section 2.3.1 discusses this. Additionally, the utilization of other modalities requires sufficient lead time. If the time between the moment that an order is placed and that a customer wants to receive the ordered products is by default too short to utilize any modality other than road transport, there is no option to make more efficient use of the various available modalities. To prevent this, at least a part of the orders has to be placed at such a moment that there is enough time to utilize modalities such as rail transport. In relation to this, the products with sufficient lead times ought to be able to physically endure longer transit time. All relevant characteristics of products with regards to lead time should be considered to determine suitability for transport with the various modalities. Consequently, aspects such as the perishability of products have to be taken into account as well (Lamers, 2012; Wenink, 2012)

Perception of synchromodal transport

Shippers tend to presume that innovative transport solutions such as multi-modal transport – and thus synchromodality by extension – are accompanied by longer transit times, reduced reliability and lowered flexibility. Their negative perception of the performance of modalities other than trucks makes shippers reluctant to implement logistic solutions such as synchromodal transport. Yet, shippers who only utilize trucks perceive the performance of other modalities lower than they actually are (Eng-Larsson & Kohn, 2012). Increased awareness of the true performance of various modalities, especially when utilized the way synchromodal transport aims to, can lead to a "mental shift" in which the potential of innovative transport solutions is accepted (Stuurgroep synchromodaliteit, 2012; Wenink, 2012).

Urgency of innovation

Shippers are much more likely to implement innovations such as synchromodal transport when they are faced with issues regarding their current transport, for example with regards to costs, sustainability or information. Similarly, shippers who are content with their existing logistic arrangements are inclined to leave transport the way it is and reject any changes (Eng-Larsson & Kohn, 2012). In this sense, shippers who are aiming to innovate are more likely to adopt synchromodal transport.

Price of synchromodal transport

Although the price for synchromodal transport is in the first place an organizational issue, it also directly affects shippers. The price of synchromodal transport is one of the main requirements of synchromodal transport from the shippers' perspective. In general, the prices of synchromodal transport shouldn't be higher than what shippers currently pay for transport. Additionally, the financial benefits which synchromodal transport could achieve have to be distributed in such a way that shippers profit from them.

Insight into transport progress

Since most shippers prefer to have real time insight into transport progress, they should have sufficient access to the virtual dashboard described in section 2.3.2 to monitor the status of their loads (BCI, 2012).

2.4 Conclusion

Chapter 2 has provided the answer to the first research question: *What is synchromodality?* The definition, characteristics, objectives and requirements of synchromodal transport are analyzed to answer the question.

Chapter 2.1 has provided an answer to the first supporting research question: *What are the definitions and characteristics of synchromodal transport?* Synchromodality is a new logistic concept which aims to improve the efficiency of transport by optimizing the utilization of infrastructure and vehicle capacity. This can be accomplished by taking the requirements of each individual load into account and assigning it accordingly to the most suitable modality. Synchromodal transport has four key characteristics: there are at least two modalities available, the modal choice is no longer pre-determined, all infrastructure, services and stakeholders are adapted to one another and product flows are bundled.

Chapter 2.2 has led to an answer to the second supporting research question: *What are the objectives of synchromodal transport?* The implementation of synchromodal transport has three aims:

- Reduced environmental costs by means of increased use of less environmentally damaging modalities.
- Increased transport efficiency through improved utilization of vehicle capacity, reduced road congestion and increased transport reliability.
- Reduced monetary costs due to an increase of the utilization of less expensive modalities, improved utilization of vehicle capacity and reduced waiting time.

In general, synchromodal transport intends to increase flexibility both on the supply and the demand side of transport. Combined with the more conscious selection of modalities, synchromodal transport could lead to an improved performance of transport.

Chapter 2.3 has provided an answer to the third supporting research question: *What are the requirements of synchromodal transport and what can stakeholders do to fulfill them?* The discussed requirements relate to connectivity, organization and shippers. Table 3 summarizes all requirements and the measures which can be taken to meet them.

Table 3: Overview of the requirements for synchromodal transport and the measures which can be taken to fulfill them.

	Requirement	**Measure(s) to fulfill requirement**
Connectivity	Availability	Selection of multimodal corridors
	Volume	Inclusion of existing flows and bundling of flows
	Responsiveness	Inclusion of hubs for modal shifts
Organization	Management	Orchestration
	Scope	Formulation of goals and selection of stakeholders
	Pricing	Pre-determined or based on cost savings
	Planning	Creation of dashboard with real time information
	Cooperation	Cost and gain sharing model and commitment
	Paperwork	Expansion of a "single window"
Shippers	Lead time	Suitability of order and product characteristics
	Perception	Accomplishment of a "mental shift"
	Urgency	Confrontation with (unresolved) logistic issues
	Price	Not more expensive than current transport
	Insight	Shippers have access to virtual dashboard

At this point, the first research question can be answered. Synchromodal transport is defined as follows: "*Flexible and reliable transport for which at least two modalities are simultaneously available; the modal choice is no longer pre-determined; all infrastructure, services and stakeholders are adapted to one another; and product flows are bundled, in such a way that the most suitable modality can be chosen given both the requirements of each individual order and the aggregated demand for transport.*"

3. Horticulture industry

The third chapter is dedicated to the second research question: *What are the main flows of horticultural products to and from the Westland-Oostland greenport?* Because synchromodal transport requires sufficient volume of product flows, this chapter selects the largest flows of horticultural products. The selected flows are the basis for the analysis of the potential implementation of synchromodal transport for the greenport in chapter 4. First, the horticultural production and trade of the greenport is determined. Next, the stakeholders and their roles within the greenport are described. Finally, the product flows to and from the greenport are analyzed.

3.1 Products of the horticulture industry

Chapter 3.1 is dedicated to the fourth supporting research question: *Which types and quantities of horticultural products are grown and traded in the greenport?* These products are the basis of product flows which are analyzed in chapter 3.3. Here, the definition and characteristics of the horticulture industry in general are described, just like both the horticultural products which origin in the greenport and the ones which are traded there.

<u>3.1.1 Definition of the horticulture industry</u>

The horticulture industry is a diversified sub-sector of the agriculture industry. Horticulture can be defined as "the science and art of growing fruits, vegetables, flowers and ornamentals" (World Bank, 2005, p. 3). Horticultural products have five main characteristics, which also separates them from agricultural products:

- produced for fresh consumption;
- high perishability rate;
- high (added) value per unit;
- produced with intense use of land, labor and knowledge;
- produced for selected export markets.

Horticultural products can be divided into two categories, namely fruits and vegetables on one hand and ornamentals such as cut flowers, plants and bulbs on the other (World Bank, 2005).

The primary horticulture industry includes the activities which are carried out by the growers to create the horticultural products. These activities are the core of the horticulture industry and fit the definition of the horticulture industry in the narrow sense of the word. The broad definition also includes the sub-sectors which are related to the core activities. The sub-sectors include the supply of inputs for the primary horticultural activities, the trade and sales of horticultural products and inputs, the processing of horticultural products and the provision of services related to horticultural activities, such as transport and distribution (Nijkamp et al., 2010; SEOR, 2007).

3.1.2 Horticulture production in the Westland-Oostland greenport

The Westland-Oostland greenport is the main contributor to the production of the Dutch horticulture industry. The greenport is located in the west of the Netherlands and includes various municipalities. Figure 5 visualizes this.

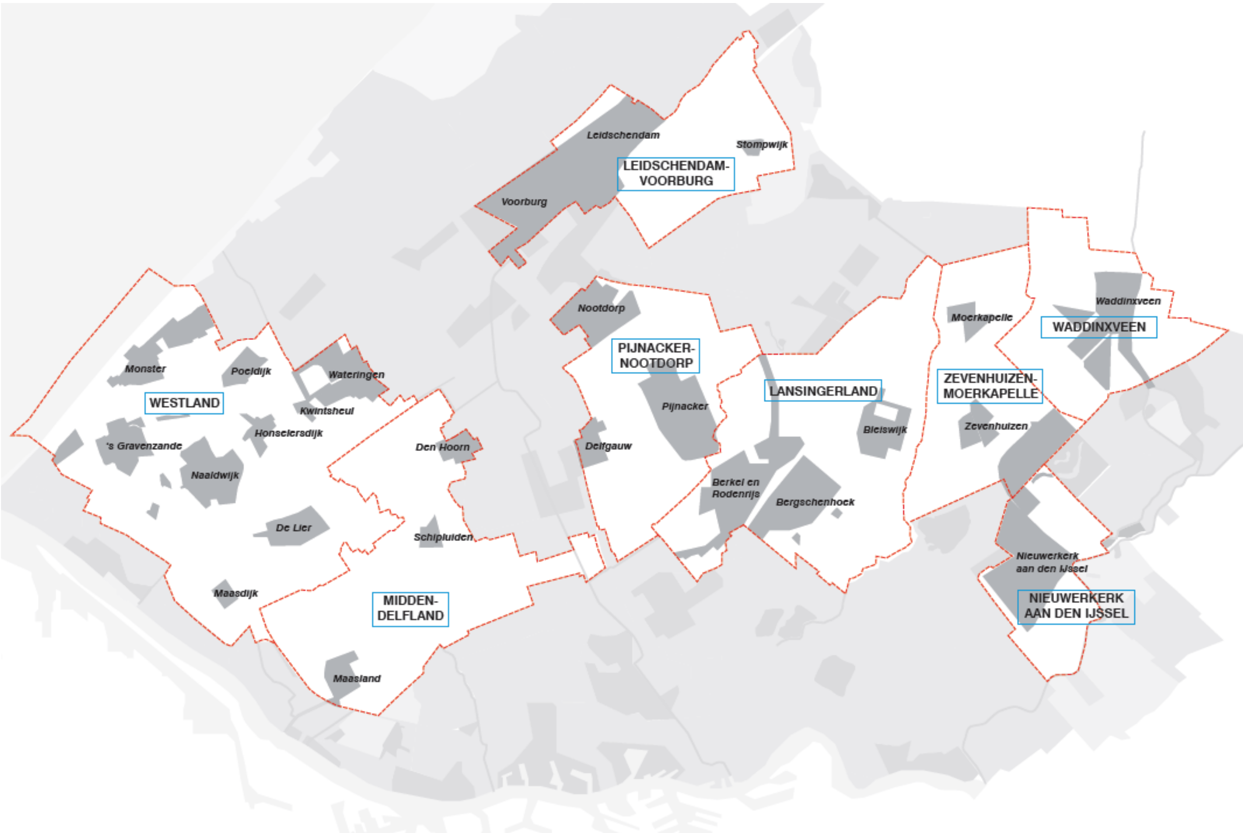


Figure 5: Overview of the location and municipalities of the Westland-Oostland greenport (Greenport Westland-Oostland, 2008).

Six million tonnes of goods are produced in the greenport each year. Cut flowers, plants and vegetables, the great majority of them grown in greenhouses, are the main types of products grown in the greenport. The production value of all horticultural products from the greenport equals 2.3 billion euros, which is 44 percent of the total Dutch horticultural production value (Greenport Westland-Oostland, 2008).

The production value of flowers and plants accounts for more than three quarters of the total production value which is achieved in the greenport. Roses, chrysanthemums and lilies are examples of cut flowers which are produced in large quantities in the greenport. Orchids, ficuses and cyclamen are examples of popular plants. In terms of export value, these plants and flowers from the Westland-Oostland greenport account for no less than 48 percent of the total Dutch export value of floricultural products (Provincie Zuid-Holland, 2007).

The production value of vegetables accounts for less than a quarter of the total production value of the greenport. Almost 800 million kilogram of vegetables are grown in greenhouses in the greenport each year, which accounts for 44 percent of the vegetable greenhouse productions of the Netherlands as a whole. Tomatoes, cucumbers and paprikas are the types of vegetables which are grown in the greenport in by far the largest quantities (CBS, 2012; Greenport Westland-Oostland, 2008; PT, 2011).

Because the products which are traded in the greenport aren't necessarily also grown there, the total volume traded exceeds the total horticultural production of the greenport itself. This is particularly the case for fruit. The fruit production of the greenport is very limited, but a considerable flow of both fruit and vegetables is transported through the greenport. This is due to the close proximity of the port of Rotterdam, which is the main port for the import of vegetables and fruit in Europe. The total volume of vegetables and fruit which is handled by various companies in the Westland-Oostland greenport annually exceeds nine million tons, which is considerably more than the six million tons worth of horticultural goods which are produced in the greenport itself.

Figure 6 visualizes the origin of the total quantity of products traded in the Westland-Oostland greenport (Greenport Westland-Oostland, 2008; Ministerie van I&M, 2012a).

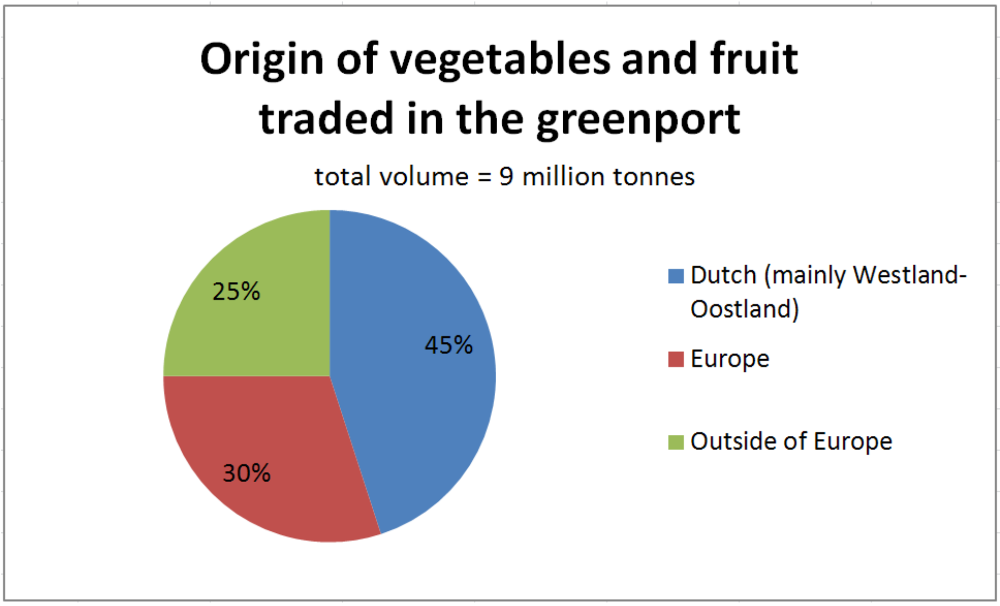


Figure 6: Origin of vegetables and fruit traded in the Westland-Oostland greenport (adapted from Ministerie van I&M, 2012a)

3.2 Supply chain of the horticulture industry

Chapter 3.2 is focused on the fifth supporting research question: *What are the roles and characteristics of the stakeholders in the greenport?* This information is required to determine which stakeholders handle the various flows of horticultural products. First, an overview is given of the supply chain of the horticulture industry in order to identify the involved stakeholders. The stakeholders are described in more detail next. Lastly, the trends and issues related to logistics in the horticulture industry are discussed.

3.2.1 Overview of the horticultural supply chain

Figure 7 shows the supply chain of the horticulture industry. It describes both the horticultural supply chain of the Westland-Oostland greenport and of the horticulture industry of the Netherlands in general. The various stakeholders are visualized by the rectangular shapes and the arrows display the way the stakeholders are related.

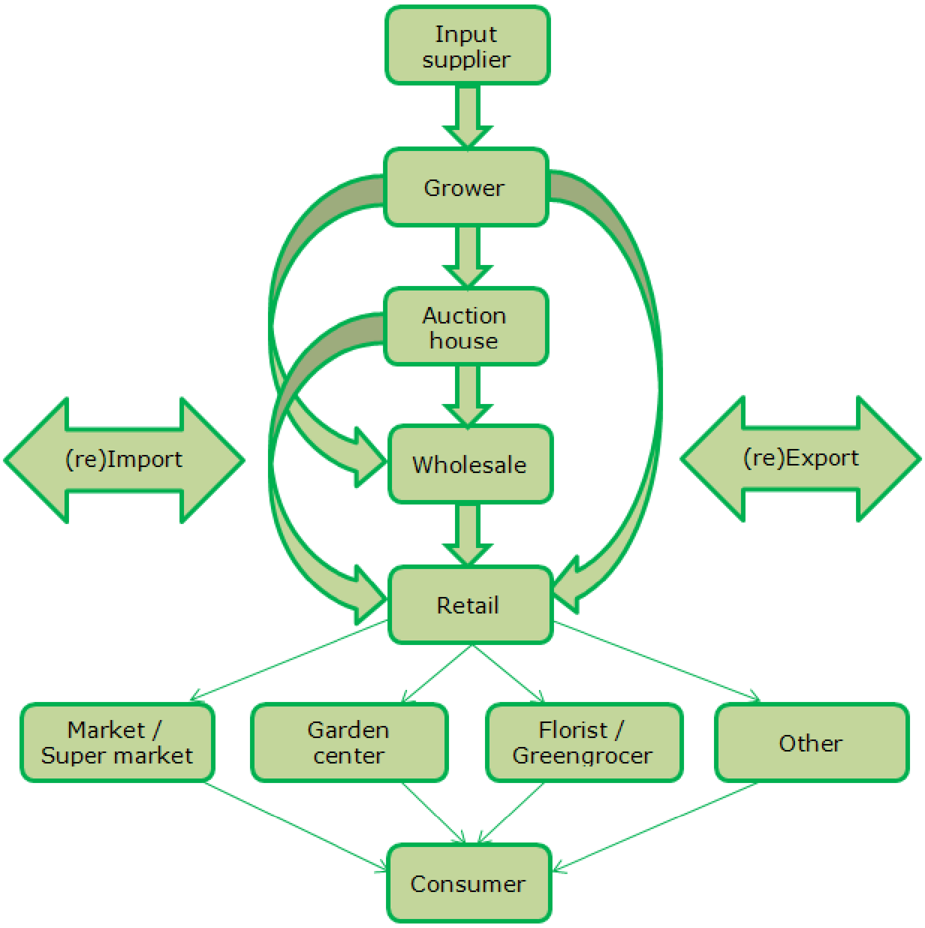


Figure 7: Supply chain of the horticulture industry (adapted from CBS, 2008 & VGB, 2010).

The companies which supply all necessary input to the growers of the horticultural products are at the beginning of the supply chain. The growers utilize the supply of input materials and sell the resulting products. The auction house can serve as an intermediary between the growers and the buyers (either wholesalers or retailers), but growers can also sell their products directly to wholesale or retail companies. If wholesalers are involved, they sell the products to retailers. Consumers eventually buy the horticultural products at a variety of retail companies.

The supply chain doesn't only exist on a domestic level; there are many interactions with stakeholders in other countries. Most importantly, a large number of horticultural products are imported or exported by wholesaling companies. Products which are imported aren't necessarily for domestic consumption. They can also be exported, and vice versa. Figure 7 visualizes this by the broad arrows marked as '(re)Import' and '(re)Export'.

Transport is required to move the horticultural products between the locations of the stakeholders. Figure 7 displays this by means of narrow arrows. The stakeholders can carry out the transport themselves or contract a carrier to do so (CBS, 2008; VGB, 2010).

3.2.2 Stakeholders in the horticultural supply chain

The stakeholders which were identified in section 3.2.1 are described in more detail. The purpose is to establish the main characteristics and functions of suppliers, growers, auction houses, wholesalers, retailers and consumers in the horticulture industry of the Westland-Oostland greenport.

Suppliers

Suppliers provide the growers with all input which is required to grow horticultural products. The main inputs are electricity, water, CO_2, fertilizer, equipment and fossil fuel (Provincie Zuid-Holland, 2011). A grower may acquire the seeds, bulbs and cuttings which are required to grow the products within the company itself, but they can also be bought from suppliers of both domestic and foreign origin (Kenlog, 2009).

Growers

The great majority of production in the greenport is carried out in greenhouses. Growers employ the required input to optimize the environment for the development of the products. Both sunlight and light of artificial sources is used to enable the process of photosynthesis, which leads to the growth of the products until they are harvested and sold (Provincie Zuid-Holland, 2011). In 2007, there were 1860 growers of horticultural products in the greenport, which is more than one third of the total number in the Netherlands (Greenport Westland-Oostland, 2008).

Auction houses

Auction houses for horticultural products are traditionally grower-owned, cooperative entities, created to ensure higher prices for the products of their members. By providing a market place for both the supply side (the growers) and the demand side (wholesalers and retailers), both the price and quantity of the horticultural products is determined each day. The power of buyers is limited due to the large, aggregated supply and the sales by means of Dutch auction (Kenlog, 2009). There are three auction houses remaining in the Westland-Oostland greenport: two for flowers and plants (in Honselersdijk and Bleiswijk, both owned by FloraHolland) and one for fruit and vegetables (also in Bleiswijk, owned by The Greenery) (VGB, 2010; The Greenery, 2012).

Due to increased cooperation between growers on one hand and retailers and wholesalers on the other, the importance of auction houses and their intermediary function have been decreasing throughout the years. The majority of plants and flowers is nowadays still sold at auction houses, but auction houses are no longer of any considerable importance for the sales of fruit and vegetables (Provincie Zuid-Holland, 2007; WUR, 2009).

Wholesale

Wholesalers buy large quantities of horticultural products and sell them either to retail companies, both within and outside the country of origin, or to other wholesalers. Wholesalers carry out the great majority of all import and export of horticultural products in the greenport, but wholesalers which import usually don't export, and vice versa. Exporting or importing wholesalers often focus on specific regions and types of horticultural products. Most wholesalers also engage in the distribution and marketing of horticulture products. Especially due to the increased collaboration and direct trade between growers and retailers, services such as personalized logistic services and promotional activities are of growing importance to wholesale in order to ensure revenues (Kenlog, 2009; NEA, 2010; SEOR, 2007; VGB, 2010). There are several hundreds of wholesalers of horticultural products in the Netherlands as a whole. About 40 percent of them is located in and around the Westland-Oostland greenport (HBAG Bloemen en planten, 2012; HBAG Groenten en Fruit, 2012).

Retail

Retailers sell the horticultural products to the consumers. The retail companies can be dedicated to horticultural products, such as florists and green groceries, or horticultural products can be only a part of the total assortment, such as (super)markets and garden centers. The retail companies can be either independent or part of a franchise (CBS, 2008; VGB, 2010).

Carriers

The transport which is required to move the horticultural products between the different stakeholders can be carried out by the stakeholders themselves, but they can also contract carriers to do so. Carriers are specialized in transport and the services related to it. Within the horticulture industry, many of them are solely focused on the transport of horticultural products. Traditionally, transport from the growers to the auction houses is mostly done by the growers themselves, thus limiting the role of carriers. In recent years, it's much more common for growers to outsource the transport tasks to carriers, mostly due to the cost savings which can be achieved this way. Unlike growers, most wholesalers and retailers have traditionally outsourced transports to carriers (EVO, 2009; NEA, 2010).

Consumers

Consumers ultimately buy and consume horticultural products on a daily basis. They are at the end of the supply chain of the horticulture industry and they can be located both inside and outside of the country where the products originate from. Consumers demand year round supply of a large variety of horticulture products, while also requiring an increasingly high level of quality and convenience of use of these products. Yet, most consumers are willing to spend only as little money as possible on the products (NEA, 2010).

3.2.3 Trends in the horticultural supply chain

The supply chain of the horticulture industry is traditionally push-based, but it is becoming more and more pull-based. In the past, growers did not have insight into the demands of consumers and consumers had no influence on the products which were offered to them by retailers. Although consumers nowadays still have no direct impact on the products which growers provide, retailers are actively researching the demands of consumers and base their orders and assortment on this information. Retailers and wholesalers are also increasingly approaching growers to directly buy their products instead of doing so at auction houses. Both the use of long-term contracts and orders which are placed on very short notice is becoming more common. When the demand for horticultural products such as flowers spikes before festive days, the entire supply chain is involved to accommodate this demand. In the fruit and vegetable industry develops an increased collaboration between growers and wholesalers to ensure a continuous supply and more market power opposite retailers (EVO, 2009; Slim fruit, 2004; VGB, 2010).

The horticultural industry is also characterized by increased efforts to avoid the spoiling of products during transport and storage. The quantity of vegetables and fruits which becomes unsuitable for sale due perishability is considerable. Throughout the supply chain, no less than thirty percent of products becomes unsuitable for sale (WUR, 2011). Ensuring the right conditions during transport and storage prevents this, mostly by regulating humidity and cooling the unit in which the products are kept. The conditions which are most suitable for each particular type of product are actively researched and improved (EVO, 2009).

3.3 Product flows in the horticulture supply chain

Chapter 3.3 is dedicated to the sixth supporting research question: *Which flows of horticultural products from and to the greenport can be identified?* The product flows which are handled by auction houses, wholesalers and retailers are analyzed in order to determine the quantities of transported products and the characteristics of the related transport. The analysis is based on the product flows from and to the Netherlands as a whole. This is because the majority of the Dutch trade of horticultural products is carried out in the Westland-Oostland greenport, whereas most of the transported products don't originate there.

3.3.1 Auction houses

The product flows and logistic processes which are related to auction houses are discussed below. Because auction houses have lost their importance for the trade of vegetables and fruit (WUR, 2009), the focus is on flowers and plants.

Product flows of auction houses

Although the market share of auction houses for the sales of flowers and plants has decreased throughout the last decades, the great majority of all flowers and plants is currently still physically sold at auction houses. In recent years, this number includes between 11.2 to 11.8 billion cut flowers and 1.2 to 1.4 billion plants (Kenlog, 2009; VGB, 2010). Seventy percent of these numbers, particularly plants, are of Dutch origin (Wenink, 2012). Auction houses facilitate two types of sales (EVO, 2009):

- Dutch auction: products are sold to the highest bidder. The sold products are physically distributed via the auction houses.
- Intermediated sales: buyers and sellers are directly linked without carrying out the traditional bidding process. The sold products aren't necessarily physically distributed via the auction houses.

Figure 8 shows the frequency with which the various types of sales occur.

Logistics of auction houses

Growers are free to decide at which auction house(s) they sell their products, based on where they expect to receive the best price in the bidding process (Wenink, 2012). 92 percent of all flowers and plants is directly brought to the auction houses by truck. The remaining 8 percent, which is an equivalent of 500 full freigt aircrafts, is imported from abroad by plane. These products are transported from the airport to the auction houses by truck as well (FloraHolland, 2012). The average utilization of trucks is sixty percent and the products which the domestic growers bring to the auction within one vehicle is mostly limited to one specific type of flower or plant (EVO, 2009; Wenink, 2012). The types of sales where the products are physically sold at the auction house require more logistic actions than when only the financial part of the sale is carried out at the auction house. This is caused by the additional docking, storing and distributing which is required when the products are physically sold at the auction houses.

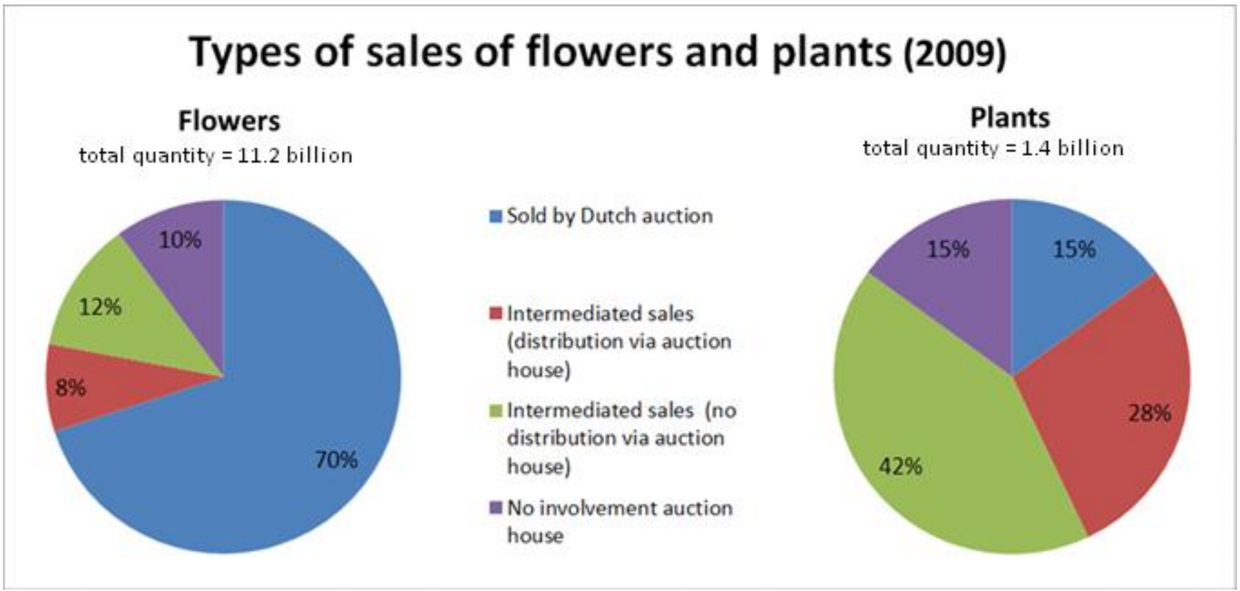


Figure 8: Types of sales of flowers and plants (adapted from VGB, 2010).

Horticultural products are also transported between the auction houses themselves. FloraHolland enables buyers to buy at all their auction houses and have the products transported to the auction house where the buyers are located. As a result, thirty percent of all products sold at auction houses have to be moved to another auction house once they are sold. This equals 1800 transport movements between the various FloraHolland action houses each day (EVO, 2009; Hubways, 2010).

Eighty percent of the total amount of exported flowers and plants is bought at auction houses. Each week, 30,000 trucks depart and arrive at the various auction houses of FloraHolland to deliver and collect the products (FloraHolland, 2012). Consequently, approximately one out of ten trucks on the Dutch roads contains horticultural products. This number increases to one out of four trucks on the A4 highway near the Westland-Oostland greenport (Hubways, 2010).

3.3.2 Wholesalers

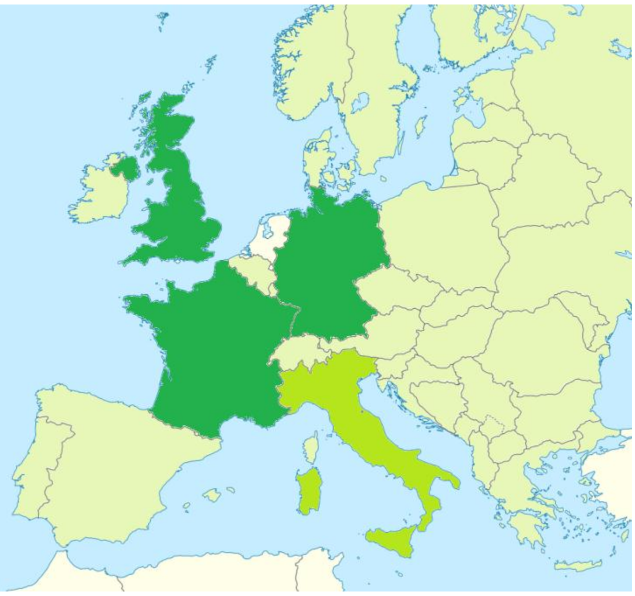
Wholesalers carry out the great majority of both export and import of horticultural products. The export and import of plants, flowers, fruits and vegetables are analyzed below to establish the physical flows of these products.

Export of flowers and plants

Wholesalers carry out 92 percent of the export of flowers and plants (VGB, 2010). Table 4 shows the export value of flowers and plants on a national, European and global level. A more detailed table, among others with breakdowns per region for the three main export destinations, is included in appendix A. The export value can be used to determine the relative magnitude of international flows of flowers and plants. Figure 9 visualizes that most plants and flowers are exported to Germany, the United Kingdom and France (HBAG Bloemen & Planten, 2012).

Table 4: Export value (in thousands of euros) of Dutch flowers and plants per main destination in 2011 (adapted from HBAG Bloemen & Planten, 2012).

	Flowers		**Plants**	
Destination	*Absolute value*	*Percentage*	*Absolute value*	*Percentage*
Germany	910,620	28,4	661,915	32,5
United Kingdom	570,152	17,8	173,906	8,5
France	434,543	13,6	247,941	12,2
Italy	158,701	5,0	163,326	8,0
Russia	147,726	4,6	51,082	2,5
Belgium	105,766	3,3	121,465	6,0
Europe	3101,917	96,8	2023,841	99,3
World	3204,042	100,0	2038,648	100,0



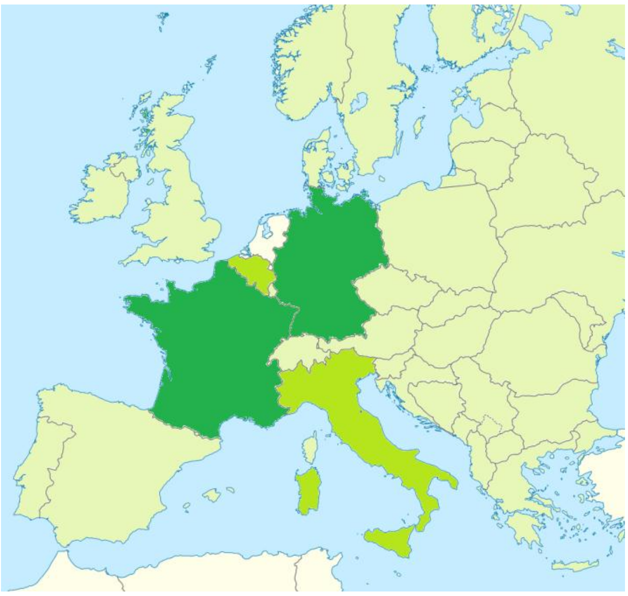
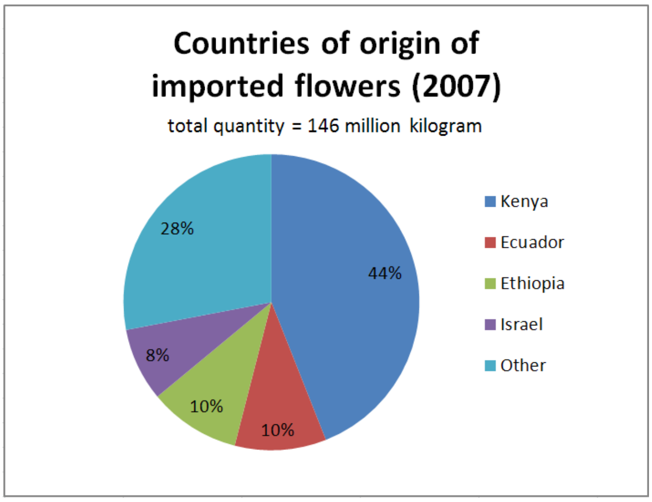


Figure 9: Market share of the destinations of flowers (left) and plants (right) export, varying from more than ten percent (dark green) to less than five per cent (light green) (adapted from HBAG Bloemen & Planten, 2012).

Import of flowers and plants

The value of total imports of flowers is approximately 400 million euros and includes 146 million kilogram. Figure 10 shows that most flowers are imported from Kenya, Ecuador and Ethiopia to the Netherlands (HBAG Bloemen & Planten, 2009; VGB, 2010).



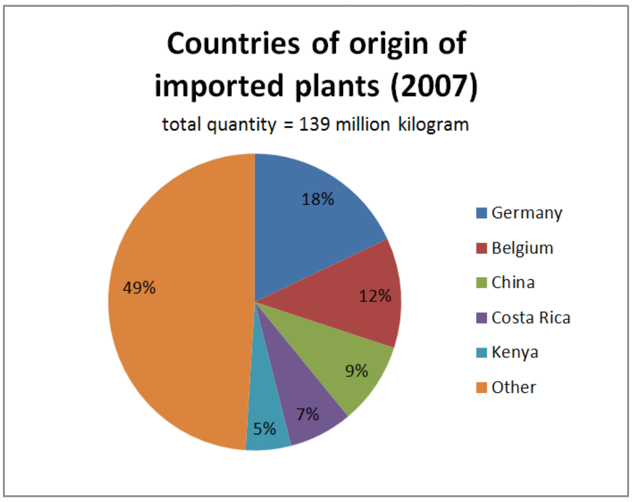


Figure 10: Countries of origin of imported flowers and plants (adapted from HBAG Bloemen & Planten, 2009; VGB, 2010).

The value of total imports of plants is approximately 350 million euros and includes 139 million kilogram. Figure 10 also shows that most imported plants are of European origin, namely from Germany and Belgium (HBAG Bloemen & Planten, 2009; VGB, 2010).

Export of vegetables and fruit

In 2010, the total exported volume of vegetables from the Netherlands was 4.1 billion kilogram, with a value of 4.2 billion euros. The total exported volume of fruit was 2.5 billion kilogram, with a value of 2.7 billion euros. Table 5 shows the exported volume of vegetables and fruit of Dutch origin. This quantity is approximately half of the total exported volume. The other half is re-export of products which were initially imported to the Netherlands. Since the Dutch production of fruit is limited, re-export mainly includes fruit. Figure 11 visualizes that most vegetables and fruit are exported to Germany, the United Kingdom and Russia (CBS, 2008; Frugi Venta, 2012).

Table 5: Export volume (in tonnes) of vegetables and fruit of Dutch origin (excluding re-export) per main destination in 2011 (adapted from Frugi Venta, 2012).

	Vegetables		**Fruit**	
Destination	Absolute value	Percentage	Absolute value	Percentage
Germany	771,077	29,6	57,425	18,1
United Kingdom	385,286	14,8	45,633	14,4
Russia	130,097	5,0	61,899	19,5
France	114,077	4,4	20,145	6,4
Sweden	99,239	3,8	23,212	7,3
Europe	2089,288	80,3	308,75	97,5
World	2601,741	100,0	316,763	100,0

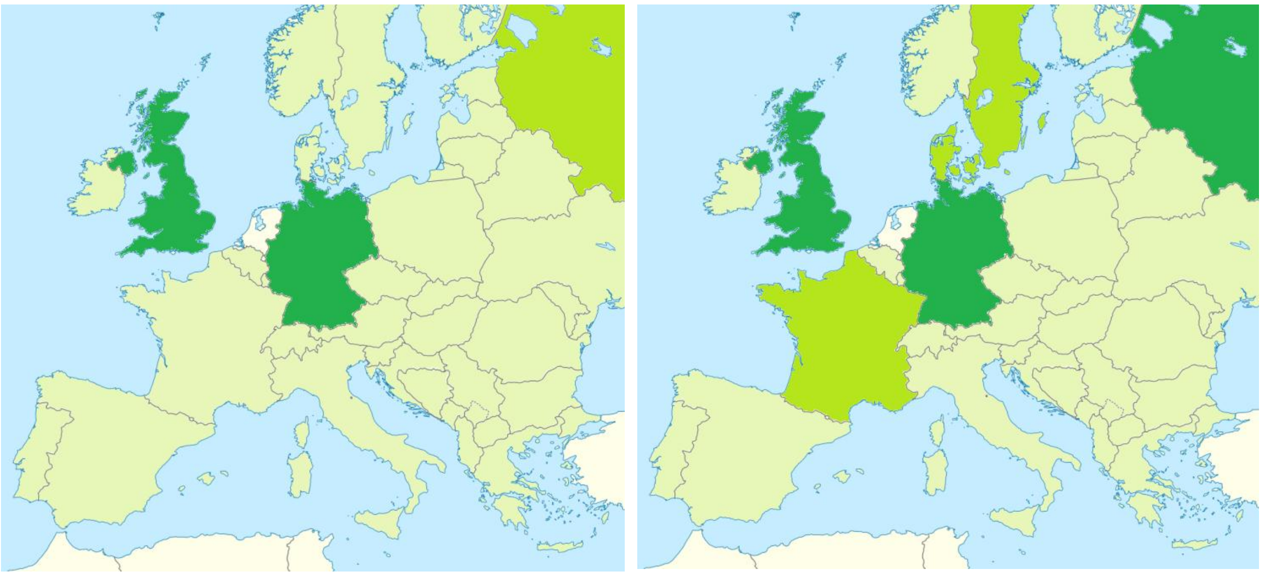


Figure 11: Market share of the destinations of vegetables (left) and fruit (right) export, varying from more than ten percent (dark green) to less than five per cent (light green) (adapted from Frugi Venta, 2012).

Import of vegetables and fruit

In 2010, the total imported volume of vegetables was 1.2 billion kilogram, with a value of 1.1 billion euros. Figure 12 shows that most imported vegetables come from Spain and Belgium. The imported volume of vegetables was 3.1 billion kilogram, with a value of 3 billion euros. Figure 12 also displays that most imported fruit comes from South-Africa and Spain (Frugi Venta, 2012).

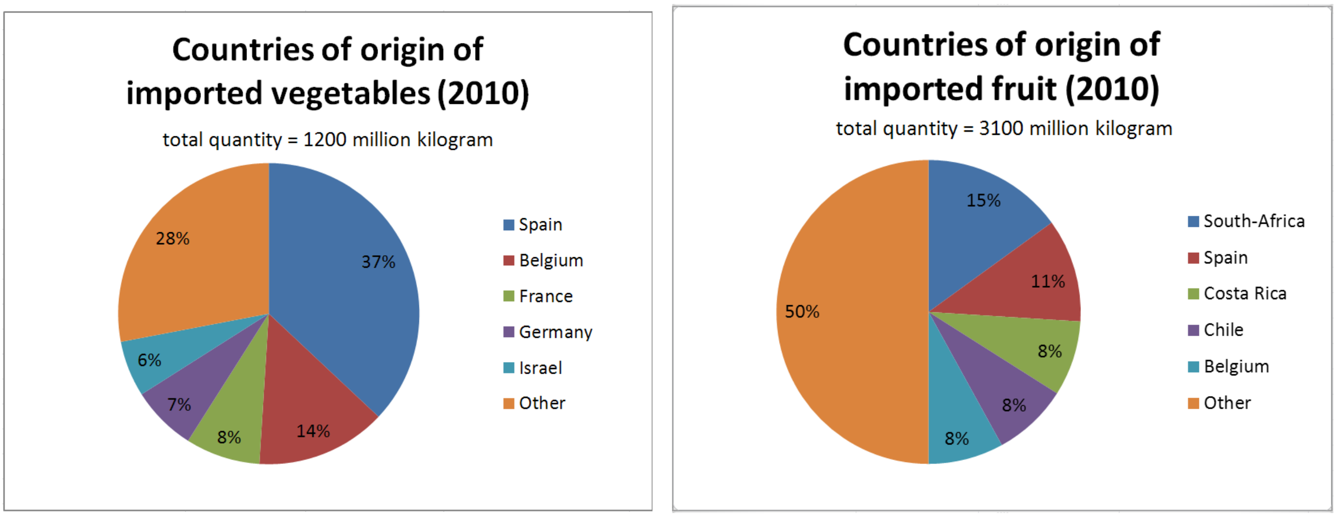


Figure 12: Countries of origin of vegetables and fruit which is imported to the Netherlands (adapted from Frugi Venta, 2012).

Logistics of wholesalers

Most wholesalers are located at or near auction houses. Once the horticultural products are bought and transported to these locations, the products are mixed, bundled and prepared based on the demands of the customers. Afterwards, the products are transported to the buyers. This occurs mostly on the same day as the products arrive. Depending on the destination of the products, transport arrives within two (in West and South-European countries) to four days (in East-European countries) (NEA, 2010; Wenink, 2012). Traditionally, the modal share of trucks for transport was low. Figure 13 displays that rail was the most common modality for transport to for example Germany in the sixties, but that this changed quickly in the years that followed (VGB, 2009).

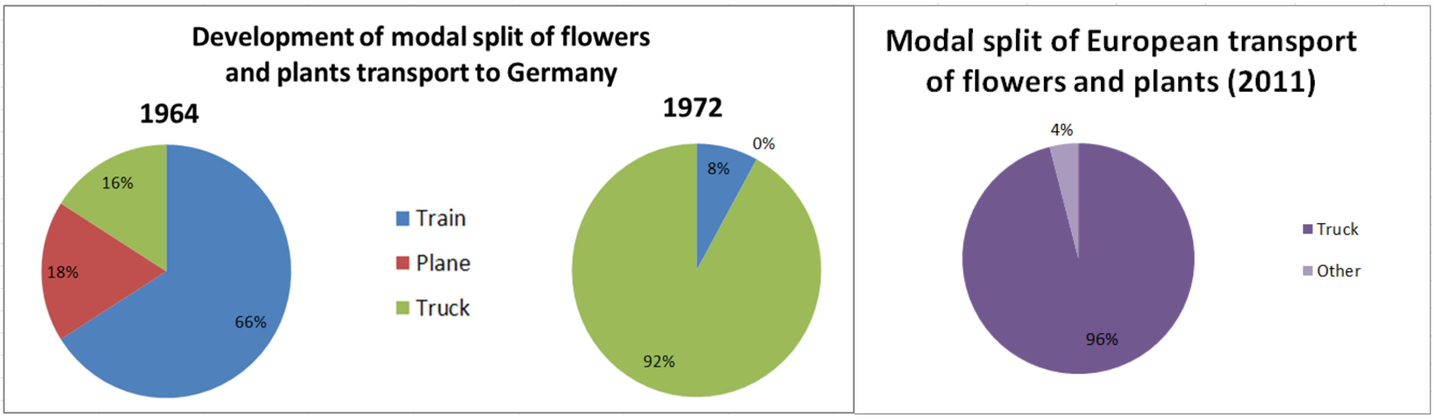


Figure 13: The development of the modal split of flower and plant transport to Germany and Europe (adapted from VGB, 2009).

Figure 13 also shows that nowadays 96 percent of flowers and plants are transported to European destinations by truck. This equals 15,000 to 20,000 truck movements each week. Planes are utilized to reach destinations on the borders and outside of Europe. The modal share of trains is very limited but has been increasing since 2008, when FloraHolland and VGB started with successful rail projects for the transport of plants (FloraHolland, 2012; VGB, 2010; Wenink, 2012).

Fruits and vegetables which are transported to or from European locations are mostly transported by trucks as well. Ships are most frequently utilized to transport the vegetables or fruit are imported from countries outside of Europe. When the ships arrive in the port, the containers are moved to the locations of the wholesalers by truck. Products which are more perishable, and thus require a shorter transport time, are transported by plane. Trucks are also utilized to transport the imported vegetables and fruit from the airport to the wholesalers (Slim fruit, 2004).

3.3.3 Retailers

The product flows and logistic processes which are related to retailers are discussed below.

Product flows of retailers

In 2009, 1.75 billion kilogram of vegetables and fruit was sold in the Netherlands by various types of retailers. Most of the vegetables are of Dutch origin, whereas most of the fruit is imported (PT, 2011). Most plants are grown in the Netherlands as well and an increasing quantity of flowers originates from foreign markets (Kenlog, 2009; VGB, 2010). Figure 14 shows that the type of retailer which is most important for the sales of horticultural products depends on the type of product. Most fruit and vegetables are sold at supermarkets, whereas most flowers and plants are sold through specialized channels (PT, 2011).

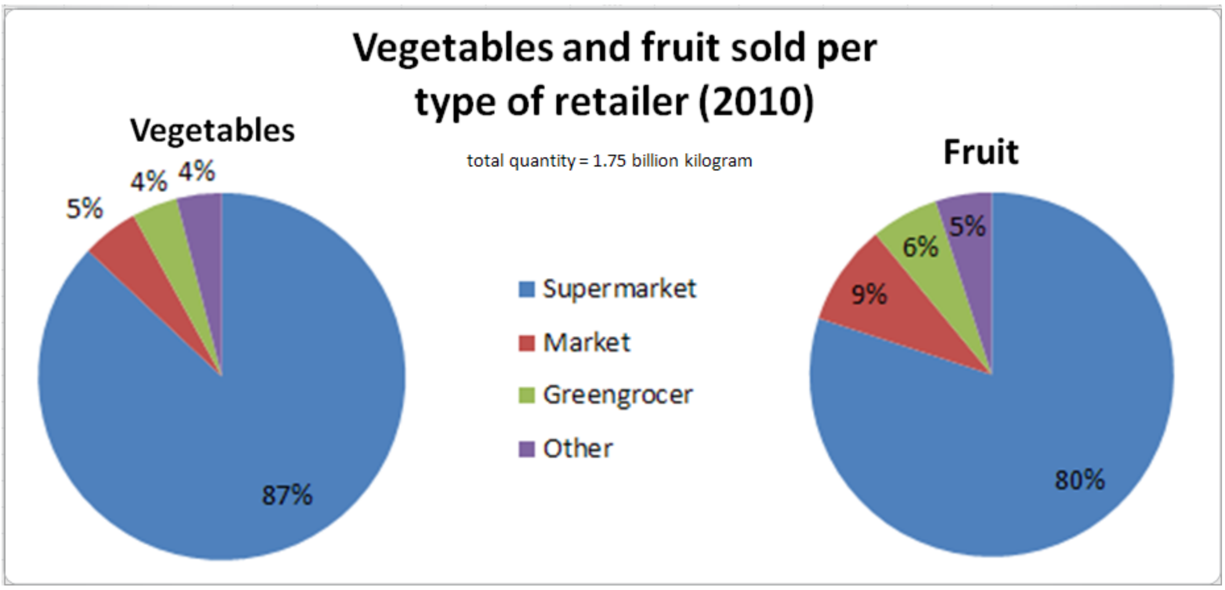


Figure 14: Distribution of fruit and vegetables sold in the Netherlands in 2010 by the various types of retailers.

Logistics of retailers

Retailers have concentrated their logistic activities in distribution centers. The horticultural products are collected there and spread over the local stores. Smaller retailers, especially those which aren't part of franchises, receive the products directly from wholesalers or growers. Both types of delivery require specialized, reliable door-to-door transport for which only trucks are used. The large number of retailers causes the product flows to become more fragmented at this point in the supply chain. The frequency of deliveries increases as well and the quantity of products per order decreases. This complicates transport and lowers efficiency (EVO, 2009; Kenlog, 2009; VGB, 2010). Transport costs per product are relatively high for horticultural products. Consumer prices for paprikas include on average eighteen percent transport costs, which is higher than for most other grocery products (Platform Agrologistiek, 2009).

3.4 Conclusion

The third chapter is focused on the second research question: *What are the main flows of horticultural products to and from the Westland-Oostland greenport?* The volume of the horticultural products which are grown and traded in the greenport needs to be established in order to answer this question. The tasks of the stakeholders ought to be determined as well before can be concluded which flows of horticultural products to and from the greenport can be distinguished. Three supporting research questions are used to answer these questions. The results are elaborated below.

Chapter 3.1 provides the answer to the fourth supporting research question: *Which types and quantities of horticultural products are grown and traded in the greenport?* Six million tonnes of horticultural products are grown in the greenport each year. Flowers, plants and vegetables account for the great majority of this quantity. Companies in the greenport don't only trade and handle products which originate in the greenport itself, but also from other parts of the Netherlands and other countries. The total quantity of vegetables and mostly fruit which is traded in the greenport exceeds nine million tonnes, of which the majority isn't produced in the greenport itself.

Chapter 3.2 answers the fifth supporting research question: *What are the roles and characteristics of the stakeholders in the greenport?* Suppliers provide the input which is needed to grow the products. Growers sell a variety of horticultural products to wholesalers and retailers, possibly with an auction house as an intermediary. Consumers buy the products at retailers and have increasing demands with regards to the quality of the products. Due to the transition from a push-based to a pull-based supply chain, the traditional roles of the stakeholders are changing. To avoid products from perishing, quality control during transport and storage becomes more important.

Chapter 3.3 provides an answer to the sixth research question: *Which flows of horticultural products from and to the Westland-Oostland greenport can be identified?* The main flows are the export of flowers, plants and vegetables, and the import of fruit. Table 6 provides an overview of the countries of destinations and origins of the flows.

Table 6: Overview of the origins and destinations of the largest product flows to and from the Westland-Oostland greenport.

Flowers	Plants	Vegetables	Fruit
to Germany	to Germany	to Germany	from South-Africa
to the United Kingdom	to France	to the United Kingdom	from Spain
to France	to the United Kingdom	from Germany	from Costa Rica
to Italy	to Italy	to Russia	from Chile
from Kenya	to Belgium	to France	from Belgium

The second research question can be answered at this point. The main flows of horticultural products to and from the Westland-Oostland greenport are:

- Exported flowers to Germany, to the United Kingdom and to France;
- Exported plants to Germany, to France, to the United Kingdom and to Italy;
- Exported vegetables to Germany, to the United Kingdom and from Germany;
- Imported fruit from South-Africa and Spain.

The flows are potentially suitable for synchromodal transport due to their magnitude.

4. Synchromodal corridors

The fourth chapter is focused on the third research question: *What are the characteristics of potential synchromodal transport for the Westland-Oostland greenport?* Four synchromodal corridors are selected, characteristics of the organization of synchromodal transport are presented and the extent to which shippers fulfill the requirements for synchromodal transport is analyzed.

4.1 Selection of synchromodal corridors

Chapter 4.1 is focused on the seventh supporting research question: *What are potential corridors for the implementation of synchromodal transport?* One corridor is chosen for each of the four main types of horticultural products which are transported to and from the greenport. The selected corridors are the basis for the analysis of the extent to which shippers meet the requirements for synchromodal transport.

The corridors are selected based on the three requirements relating to the connectivity of synchromodal transport:

- Volume: the selected corridors require the supply of sufficient volume to optimize the use of infrastructure and vehicle capacity. The largest flows of horticultural products are already selected in chapter 3.
- Availability: the corridors have to include multi-modal infrastructure and services to enable the parallel availability of modalities.
- Responsiveness: the corridors have to include multi-modal hubs to enable switching between modalities.

There are two additional requirements of synchromodal corridors which are taken into account:

- The corridors have to cross distances of at least several hundred kilometers to make the utilization of trains and barges financially attractive.
- Both the origin and the destination of the corridor should be in proximity of one of the included hubs in order to limit pre-haulage and end-haulage costs.

In order to explore synchromodal transport to a variety of destinations, the diversity of the corridors is taken into account as well. All of the corridors are focused on another country and region.

4.1.1 Synchromodal corridor for export of flowers

The selected synchromodal corridor for flowers connects the greenport with the Rhône-Alpes region in the south of France. This corridor is selected for the following reasons:

- France is one of the main destinations for exported flowers, ensuring a large potential volume of products. Within France, the second largest quantity of exported flowers is sold in the south.
- The distance between the greenport and the Rhône-Alpes region is approximately 800 kilometers, which gives trains and barges a potential cost advantage over trucks.
- The tri-modal hub Lyon Vénissieux, which is connected to terminals in the port of Rotterdam, is located within Rhône-Alpes.

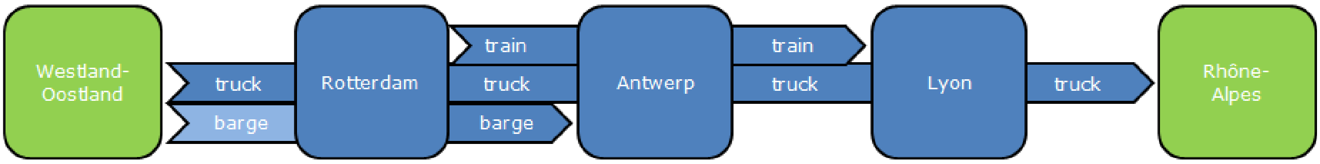


Figure 15: The hubs and modalities of a synchromodal corridor between the greenport and the Rhône-Alpes region.

Figure 15 visualizes the modalities which can be selected and the hubs which are part of the corridor. The corridor enables three different possibilities for transport:

- The entire distance between the greenport and Rhône-Alpes can be crossed by trucks. Transport by trucks is offered by a variety of specialized carriers and provides a high level of flexibility, but the supply of services is limited when aggregated demand is low. Under regular circumstances it takes trucks two days to reach the south of France.
- The transport between the port of Rotterdam and Lyon can be carried out by train. The transport from the greenport to the train terminal of departure and from the train terminal of arrival to the final destination in Rhône-Alpes can be done by truck. Trains from Rotterdam to Lyon currently depart once or twice a day and arrive two to three days later (Kombiverkehr, 2012; Rail Cargo, 2012).
- The distance between Rotterdam and Antwerp can be crossed by barges, which depart on a daily basis and arrive at the same day or one day later

(for example Danser, 2012). Beyond Antwerp, inland waterways are unsuitable for barge transport. The flowers can continue the journey in Antwerp either by truck or by train. A current pilot explores the possibility of creating a barge connection in Hoek van Holland, which is in terms of travel distance 50 kilometers closer to the greenport than the port of Rotterdam (BVB, 2011). This provides a direct potential connection between the greenport and Antwerp.

4.1.2 Synchromodal corridor for export of vegetables

The selected synchromodal corridor for vegetables connects the greenport with Mannheim and the surrounding area in the south-west of Germany. This corridor is selected for the following reasons:

- Germany is the main destination for exported vegetables, which provides the corridor with the largest potential product volume.
- The distance between the greenport and Mannheim is approximately 400 kilometers, which gives trains and barges some potential cost advantage over trucks.
- The tri-modal hub Ludwigshafen am Rhein is located next to Mannheim. Because the hub borders on three large regions which covers approximately a fourth of all of Germany, the city of Mannheim and the area surrounding it is selected in order to include parts of all three regions without including areas which require extensive end-haulage.

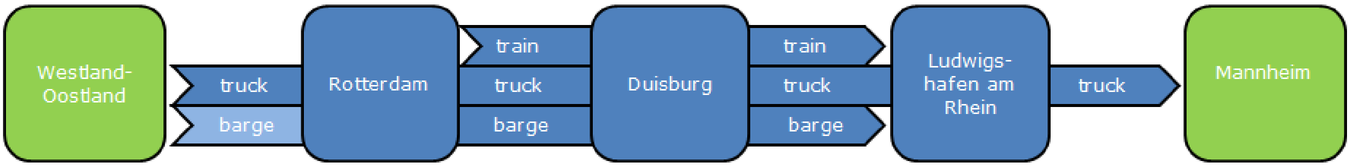


Figure 16: The hubs and modalities of a synchromodal corridor between the greenport and Mannheim.

Figure 16 visualizes the modalities which can be selected and the hubs which are part of the corridor.

The corridor enables three different possibilities for transport:

- The transport between the greenport and Mannheim can be carried out by trucks. If a truck leaves the greenport in the morning, it usually arrives in the Mannheim area at the same day.
- The lane between the port of Rotterdam and Ludwigshafen am Rhein can be crossed by train. Trains from Rotterdam to Ludwigshafen am Rhein currently depart several times a day and arrive one to two days later (Rail Cargo, 2012). Pre-haulage and end-haulage can be done by truck.
- The distance between Rotterdam and Ludwigshafen can be crossed by barges, which depart on a daily basis and arrive two and respectively three days later (for example Alcotrans, 2012). Pre-haulage and end-haulage is carried out by truck. The potential barge connection in Hoek van Holland could also be part of the corridor, which would enable a direct inland waterway connection between the greenport and the Mannheim area.

4.1.3 Synchromodal corridor for export of plants

The selected synchromodal corridor for plants connects the greenport with the Lombardy region in the north of Italy. The corridor is selected for the following reasons:

- Italy is one of the main destinations of exported plants, which provides the corridor with a large potential volume.
- The distance between the greenport and Lombardy is approximately 1000 kilometers, which gives trains and barges a potential cost advantage over trucks.
- There are several multi-modal hubs around Milan which connect Lombardy with Rotterdam, such as Novara and Melzo.

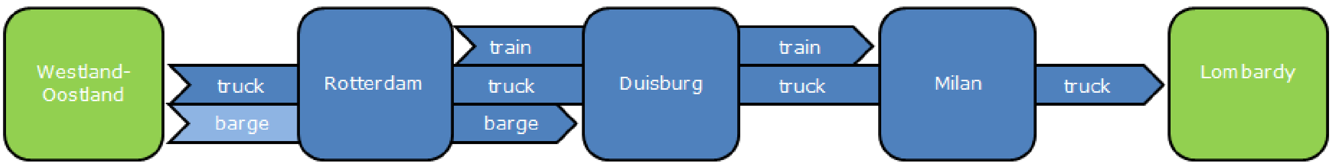


Figure 17: The hubs and modalities of a synchromodal corridor between the greenport and Lombardy.

Figure 17 shows the modalities which can be selected and the hubs which are part of the corridor. The corridor enables three different possibilities for transport:

- The distance between the greenport and Lombardy can be crossed by trucks in its entirety. Under regular circumstances it takes trucks two days to reach the north of Italy.
- The transport between the port of Rotterdam and Milan can be carried out by train. The transport from the greenport to the train terminal of departure and from the train terminal of arrival to the final destination in Lombardy can be done by truck. Trains from Rotterdam to Milan currently depart several times a day and arrive two to three days later (Kombiverkehr, 2012; Rail Cargo, 2012).
- Barges can be utilized for the part of the corridor between Rotterdam (or potentially Hoek van Holland) and Duisburg. Barges currently depart daily from Rotterdam and take two to three days to reach Duisburg (for example Rhinecontainer, 2012).

4.1.4 Synchromodal corridor for import of fruit

The selected synchromodal corridor for fruit connects the greenport with the Valencia region in the east of Spain. The corridor is selected for the following reasons:

- Spain and Valencia in particular is by far the main European origin of imported fruit, which ensures a large potential product volume for the corridor.
- The distance between Valencia and the greenport is approximately 1500 kilometers, which gives trains and barges potential cost advantage over trucks.
- Tri-modal possibilities in Spain are limited due to the lack of inland waterways. The rail hub Barcelona is located in proximity of Valencia. In and around Barcelona are various terminals from where Rotterdam can be reached in three to six days (Kombiverkehr, 2012).

Figure 18 visualizes the modalities which can be selected and the hubs which are part of the corridor. The corridor enables three different possibilities for transport:

- The entire distance can be crossed by truck, which usually takes two day.
- The lane between Barcelona and Rotterdam can be crossed by train, which takes three to six days (Kombiverkehr, 2012). Trains depart daily from terminals such as Morrot and Tarragona.
- Between Mannheim and Rotterdam, and potentially Hoek van Holland, barges can be utilized as well. They depart daily and take one to two days to arrive (for example Danser, 2012).

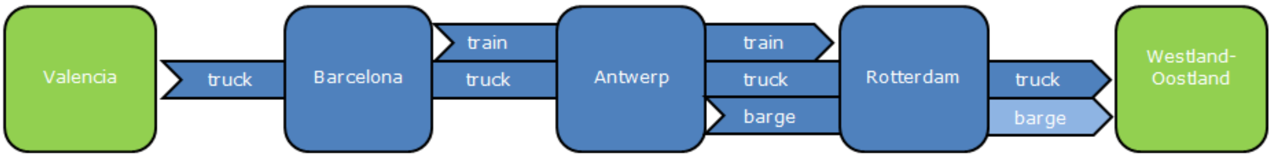


Figure 18: The hubs and modalities of a synchromodal corridor between Valencia and the greenport.

4.2 Organization of synchromodal corridors

Chapter 4.2 is dedicated to the eighth supporting research question: *What are the characteristics of potential organization of transport within the synchromodal corridors?* The characteristics are based on the theoretical requirements of the organization of synchromodal transport. Because the research is focused on the shippers and not the operational side of the supply of transport, the characteristics aren't analyzed beyond their theoretical feasibility. Instead, they serve as an example of potential supply of synchromodal transport for each corridor in chapter 4.3.

4.2.1 Management

The level of management of the transport of horticultural products is currently limited to the planning of individual carriers, which leads to suboptimal utilization of the available infrastructure and services. Synchromodal transport requires orchestration on a larger scale. Stakeholders such as carriers or shippers themselves can organize this, but orchestration can also be done by a third party such as a logistic service provider. A non-asset based logistic service provider is the type of orchestration which is selected for the synchromodal corridors, for the following reasons:

- Shippers don't want to cooperate with other shippers with regard to transport of their products, because this would require them to share sensitive information about customers with their competitors.
- Non asset-based logistic service providers are in principle neutral, which prevents them from favoring either shippers or carriers. This means that they don't benefit from treating the shippers unequally and from having a bias against modalities they don't operate themselves (Lamers, 2012).
- Most interviewed shippers state that they don't want to be involved in the organization of transport and prefer to leave as many transport related activities as possible to another party.

4.2.2 Scope

Because synchromodal transport has a higher chance of success when already existing infrastructure and services are utilized, the four corridors include modalities and hubs which are currently operational.

4.2.3 Pricing

The selected pricing mechanism for the four synchromodal corridors is a model which is based on the cost savings that are achieved. This mechanism includes a maximum transport price, for example like the one which occurs in the current situation, when no financial benefits are accomplished. If synchromodal transport leads to any cost savings, those benefits are divided among the stakeholders.

4.2.4 Real time planning

GPS tools are used in the synchromodal corridors to measure the key performance indicators. The indicators are input for a virtual dashboard which visualizes the progress of transport. The dashboard is additionally fed with data on the available capacity and demand for transport, so a match between the two can be made. Shippers have digital access to information on the progress of the transport of their products.

4.2.5 Cooperation

The pricing mechanism which is selected distributes the benefit of cost savings among the stakeholders. Dedicated and motivated stakeholders are included to ensure commitment.

4.2.6 Paperwork

Stakeholders have access to an extended single window. They are thus able to conveniently perform any required procedures, such as customs and insurance.

4.3 Requirements for shippers in synchromodal corridors

Chapter 4.3 is dedicated to the ninth supporting research question: *To what extent do shippers meet the requirements for synchromodal transport?* If shippers meet the requirements, synchromodal transport could be an attractive transport solution for shippers in the Westland-Oostland greenport. The analyzed requirements include the lead time of orders, the perception of synchromodal transport and the urgency to innovate transport. The price of synchromodal transport is taken into account as well, because it can affect lead times and the perceived attractiveness of synchromodal transport.

The requirements which shippers have to meet are compared to the current transport needs of shippers in the four selected corridors. The results are based on interviews with shippers of the various types of horticultural products. Table 7 provides an overview of the interviewed shippers, including the name and the type of company they work for, and their function at the companies.

Table 7: Overview of the interviewed shippers.

Name	Company (type)
Stephan van Maldegem	Oudendijk (import of flowers)
Peter Kap	Javado (export of plants)
Niels van Schie	Hamiplant (export of plants)
Sabine Berendse	Anaco Greeve (import of vegetables and fruit)
Susan Troost	H. Troost & Zn. BV (export of vegetables and fruit)
Roy Vijverberg	Hamifleurs (export of flowers)

4.3.1 Synchromodal corridor for export of flowers

The shippers' requirements regarding lead time, price, perception of synchromodal transport and urgency of innovation are explored below. Unless stated otherwise, the analysis is based on interviews with Stephan van Maldegem (of flower import company Oudendijk) and Roy Vijverberg (of flower export company Hamifleurs).

Lead time

Shippers describe lead time as one of the most important requirements of synchromodal transport. Shippers currently sell approximately ninety percent of all flowers to their customers at the same day as the customers buy them. Only supermarkets work with contracts on a longer term, thus providing predictability of demand, but the market share of flowers sold at supermarkets averages in France at only fifteen percent (PT, 2010). The utilization of contracts or other arrangements for the sales of flowers are complicated for two reasons:

- The production of flowers which aren't grown in greenhouses can be irregular and unpredictable due to its dependency on the weather. Consequently, the flowers aren't necessarily ready to be sold when a contract is due.
- Roughly ninety percent of flowers is sold and bought at auction houses. Such sales are characterized by considerable price fluctuations from day to day. Wholesalers include the fluctuations in their own price and their customers prefer to order no more than one or two days in advance with the purpose of taking these fluctuations into account.

The lack of long term sales complicates synchromodal transport in the sense that it prevents predictability of ordered products. Currently, the customers of the shippers in the Rhône-Alpes region receive the flowers usually two days after ordering them, which tends to be the day after the transport commences. Customers don't object to incidental delays of a few hours, especially not if these are occurred when the stores are closed for consumers at that time. In contrast, they don't agree with the flowers regularly arriving just one day later than they currently do. This leaves in principle little possibilities for any utilization of trains and barges. Additionally, both the wholesaling shippers and their retail customers profit if flowers arrive early: the sooner the flowers can be sold, the sooner the retailer runs out of stock and the sooner the retailer will order again.

Because customers order on such short notice, transport can't commence earlier to accommodate deadlines while also making more optimal use of all available modalities in the corridor. However, there is a basis of certain types of flowers in the aggregated demand of customers. Such flowers tend to be ordered each time and thus add some predictability to the sales after all. This steady flow could provide a promising basic for a synchromodal corridor, because it could be send for transport several days before it's actually ordered. Advancing transport by one or two days would suffice to enable rail transport.

Long term transport is for the quality of the flowers themselves no issue. As long as they are sufficiently cooled at all times, the flowers can be transported for weeks without considerable decrease in quality. Continued cooling throughout the entire transport process can be achieved by putting the flowers in reefer containers. The extent to which the flowers endure differs however among species. Similarly, the ideal temperature isn't the same for all species and these species have to be separated during long term transport. The initial quality of the flowers, before transport commences, has to suffice as well.

Price

Although the shipper's customer isn't necessarily billed directly by the transport provider, the customer is the stakeholder paying the transport which the shipper organizes on their behalf. The selected gain sharing model enables shippers – and thus their customers - to profit from the cost savings that synchromodal transport could achieve. Shippers require their customers to profit from such cost savings, describing financial benefit as one of the main potential advantages of synchromodal transport. They also indicate that some of their customers might be willing to negotiate a tradeoff between lower transport costs and the additional transport time which can be necessary to achieve them.

Perception of synchromodal transport

Shippers are in general positive towards the utilization of trains for the transport of their flowers. Due to longer transport time both aboard the ship and at terminals, the suitability of barges within a synchromodal corridor to the south of France is questioned. Specifically, shippers are interested in the potential efficiency increases which could be achieved with synchromodal transport. Shippers don't object to their flowers being bundled with products of other companies or even their direct competitors, because this currently already happens to a large extent. They do put emphasis on the trust which they require to give a third party full control over the modal choices.

Urgency of innovation

Synchromodal transport could potentially reduce road congestion, but shippers describe that they don't face any significant issues due to road transport delays. Sustainability is no reason for them to innovate either, because the role of sustainable transport is limited in the industry, especially for foreign customers in times of financial difficulty. Although shippers aren't directly looking for ways to improve transport itself, they do actively aim to improve the documentation which is related to it. Most required documents are still processed manually and information flows are hardly separated from physical product flows. Shippers are aware of the increase of efficiency which digitalization can bring and attempt to achieve such benefits. Synchromodal transport includes the optimization of information flows and could thus play a significant part in accomplishing such improvements.

4.3.2 Synchromodal corridor for export of vegetables

The required lead time, price, perception and urgency for shippers of vegetables is analyzed below. Unless stated otherwise, the information is based on interviews with Sabine Berendse (of fruit and vegetable import company Anaco Greeve) and Susan Troost (of fruit and vegetable export company H. Troost & Zn. B.V.).

Lead time

The required lead time differs among the type of customers of the shippers. Approximately eighty percent of sales to importing wholesalers and independent retailers is sold at the same day as transport starts, thus strongly limiting lead time. A part of this flow is however repetitive. Since the importing wholesalers and small retailers demand to receive the vegetables as quickly as possible once they have ordered them, delaying the time of delivery is not an option for them. Hence, sufficient speed of the transport services is one of the main requirements of shippers for synchromodal transport.

But most supermarkets, especially those which are part of franchises, work with contracts for a term of a few weeks (WUR, 2009), thus providing early insight into ordered vegetables. Since close to ninety percent of vegetable is sold at supermarkets (PT, 2011), the latter provides a significant steady flow. The additional time between the moment of the order and the date of delivery could enable the utilization of synchromodal transport.

Although not all types of vegetables are equally suitable for long term transport, most of them can successfully endure being underway for several weeks if they are inside reefer containers. Tools are available to monitor the development of the temperature within the container during transport.

Price

The price is for the shippers in this corridor one of the main requirements of synchromodal transport. When the speed of delivery remains the same, their customers are not willing to pay more for transport than they currently do, and prefer to pay less. Interestingly, shippers indicate that their customers would be willing to pay slightly more for transport if the vegetables were to arrive earlier.

Perception of synchromodal transport

Considering modalities in general, shippers have a positive bias towards road transport and question the effectiveness of trains and especially barges on the relatively short distance to Mannheim. In terms of synchromodal transport specifically, they perceive synchromodality to be incapable of transporting the vegetables quickly enough to their customers. Shippers also mention the trust it requires to let a third party make transport decisions on their behalf and doubt the benefits which synchromodal transport could achieve for shippers which have small product flows. Smaller shippers however already outsource transport and are familiar with bundling, whereas shippers which achieve more volume tend to carry out their own transport. Due to their ownership of trucks, the latter is expected to be biased against the flexible utilization of modalities.

Urgency of innovation

Shippers indicate that road congestion is not an issue. Sustainability doesn't play a significant role in the industry and is secondary to profitability. Shippers do wish for improved communication with carriers and experience the benefits which they have already achieved by digitalization, but they state that their current transport is satisfactory.

4.3.3 Synchromodal corridor for export of plants

The requirements regarding lead time, price, perception of synchromodal transport and urgency of innovation are explored below. Unless stated otherwise, the analysis is based on interviews with Peter Kap (of exporting company Javado) and Niels van Schie (of exporting company Hamiplant).

Lead time

The type of retailers selling plants impacts the lead time of the shipping wholesalers. Retailers such as florists and market salesmen generally don't plan their purchases ahead and demand the plants to be delivered as soon as possible once they've ordered them. Currently, there are usually three days between the moment an order is received and the moment the vegetables are delivered in the north of Italy. Under normal circumstances, this speed can't be matched by other modalities in this distance. Such retailers often are independent and frequently order small volumes of plants. In contrast, retailers such as garden centers, hardware stores and supermarkets are mostly part of franchises which aggregate orders, with larger quantities of plants demanded as a result. The larger retailers also tend to contract the shippers to deliver predetermined quantities of plants at certain dates which are possibly still months away. Such contracts lead to predictability and allow transport to take longer without the plants arriving late at their destination. The contracts also involve large quantities of ordered plants. The market share of both types of retailers is in Italy approximately equal (PT, 2010), which implies that roughly half of all plants sold have a sufficient lead time for synchromodal transport. Additionally, the flows going to smaller and independent retailers is predictable to some extent in the sense that the aggregated flow is somewhat similar each time. Such a steady flow could also be suitable for synchromodal transport, because the shippers can be quite certain that the plants are going to be demanded before the customers have actually ordered them.

Plants are perishable, just like other horticultural products. The conditions and a particularly the duration of transport have to be taken carefully into account. Under regular conditions, plants lose quality more slowly than flowers, but most plants can't be cooled as much as flowers without damaging them. The higher temperature under which the plants have to be kept also means that they don't endure long transport times as well as flowers and that transport which takes longer than five or six days should be avoided. Different species of plants are characterized by different levels of endurance and different optimal temperatures. This makes it difficult to combine several small flows, because the temperature which is required for one species can be damaging for another. The utilization of compartmentalized containers to keep such species separated could be a solution.

Price

The price of transport is an important requirement for shippers. Although shippers arrange transport, their customers pay for it. A slight increase in (transport) costs is likely to cause the customer to buy from other wholesalers in the future. On the other hand, a decrease in transport costs is attractive to some customers to the extent that they are willing to negotiate a tradeoff between later deliveries and lower costs. This has already been achieved in the GreenRail project, in which plants are transported by rail to a variety of European destinations. The objective of cost savings is for shippers the main appeal of synchromodal transport. Consequently, it's of importance that shippers profit from any financial gains that synchromodal transport could accomplish.

Perception of synchromodal transport

Shippers perceive transport by train as a satisfactory alternative for road transport, especially if they already make use of rail transport. The performance of barges, particularly with regards to speed and handle time, is questioned. With regards to synchromodal transport in particular, shippers have no objection against their transport being handled by a logistic service provider. They are also in favor of bundling, which currently already occurs extensively on the initiative of carriers. Shippers are particularly enthusiastic about the cost savings and improved supply of information which synchromodal transport could achieve. They emphasize that flexibility and responsiveness to unforeseen circumstances has to be ensured and that their customers aren't willing to take any “out of stock” risks which might occur when changing to a new type of transport.

Urgency of innovation

Shippers of plants point out that increasing road congestion doesn’t cause noteworthy delays. Sustainability is no motivation for innovation either; shippers are willing to operate in a more sustainable way but fear that they’ll lose customers if this leads to any additional costs. Although rail transport of plants already occurs, the utilization of this more environmentally friendly modality can’t be used as a “green” marketing instrument because sustainability doesn’t play a role for the wholesalers’ customers. The urgency to improve logistic performances is based on achieving cost savings and accomplishing more efficiency with regards to information.

4.3.4 Synchromodal corridor for import of fruit

The requirements regarding lead time, price, perception of synchromodal transport and urgency of innovation are explored below. The analysis is based on interviews with Sabine Berendse (of importing company Anaco Greeve) and Susan Troost (of exporting company Troost & Zn. B.V.).

Lead time

The lead times for the import of fruit are short. Importing wholesalers frequently have sold the fruit already to their customers before the products arrive in the Netherlands and the remaining products are sold on the day that they arrive. The customers are retailers and wholesalers. They want the ordered fruit to be delivered as quickly as possible. Consequently, shippers demand the transport from the fruit to the greenport to take as little time as possible. This is for shippers the most important requirement for synchromodal transport. Currently, all transport between Spain and the greenport is carried out by truck and takes approximately two days. Delays longer than a few hours aren't acceptable to the shippers and their customers. This makes the utilization of modalities other than trucks unfeasible, which in turn greatly lowers the potential for synchromodal transport.

Fruit is perishable and has to be transported under specified conditions. Some types of fruit are capable of enduring longer transport times than others. Sufficient cooling in reefer containers allows for most types up to four weeks of transport without considerable quality loss. Such containers are already utilized for the import of fruit from overseas.

Price

According to shippers, synchromodal transport should at worse be of the same price as current transport, and preferably cheaper. Price is not described by shippers as a main requirement for synchromodal transport, but any costs which could potentially be saved are valued.

Perception of synchromodal transport

Fruit from countries outside of Europe is currently imported by ship and the performance of this modality is perceived as satisfactory, except for the long handling time of up to three days when containers are moved from one ship to another. In contrast, shippers perceive rail and inland waterways unsuitable for transport within Europe. With regards to synchromodal transport specifically, shippers don't object to the bundling of their products with those of other importing wholesalers, since this is a common practice already. However, synchromodal transport is perceived as unsuitable for providing the fast and reliable transport which the shippers demand.

Urgency of innovation

Shippers are mostly satisfied with their current transport arrangements and express no wish or reason to change them. They don't experience any considerable issues due to road congestion and the role of sustainability in the industry is limited due to the focus on profitability. The only current logistic issue currently faced is the lack of insight into transport progress and the sometimes lacking communication with carriers.

4.4 Conclusion

The fourth chapter is focused on the third research question: *What are the characteristics of potential synchromodal transport for the Westland-Oostland greenport?* The requirements of synchromodal transport with regards to connectivity, organization and shippers for four corridors are analyzed.

Chapter 4.1 answers the seventh supporting research question: *What are potential corridors for the implementation of synchromodal transport in the greenport?* A synchromodal corridor is selected for each of the four main types of horticultural products of the greenport. Corridors are considered suitable when they meet the infrastructure and services related requirements of synchromodal transport. The requirements for selection are based on connectivity and distance. The four selected synchromodal corridors are:

- Export of flowers from the greenport to the Rhône-Alpes region in the south of France, with hubs in Rotterdam, Antwerp and Lyon.
- Export of vegetables from the greenport to Mannheim and its surrounding areas in the south-west of Germany, with hubs in Rotterdam, Duisburg and Mannheim.
- Export of plants from the greenport to the Lombardy region in the north of Italy, with hubs in Rotterdam, Duisburg and Milan.
- Import of fruit from the Valencia region in the east of Spain to the greenport, with hubs in Barcelona, Mannheim and Rotterdam.

Chapter 4.2 provides an answer to the eight supporting research question: *What are the characteristics of potential organization of transport within the synchromodal corridors?* The determined characteristics meet the requirements for the organization of synchromodal transport. They serve as an example of synchromodal organization that can be implemented in the four corridors. Six characteristics are identified:

- A neutral logistic service provider orchestrates synchromodal transport;
- The corridors includes already existing infrastructure and services whenever possible;
- Transport prices are based on a model in which any cost savings are deducted from an original, maximum price;

- A virtual dashboard processes and displays all required information;
- Achieved profits are distributed among the stakeholders;
- An extended single window facilitates all required paperwork procedures.

Chapter 4.3 answers the ninth supporting research question: *To what extent do shippers meet the requirements for synchromodal transport?* The requirements which shippers have to meet are confronted with the current transport needs of shippers. Four requirements are taken into account:

- Lead time of ordered products
- Price of synchromodal transport
- Perception of synchromodal transport
- Urgency of innovation

Table 8 provides a schematic overview of the four requirements with regards to the extent to which the different types of shippers fulfill them and what is needed to get closer to meeting the requirements. The column labeled 'score' indicates to which degree the shippers currently meet the requirements on a scale from 'not at all' (--) to 'very much so' (++).

The third research question can now be answered. The selected potential synchromodal transport for the Westland-Oostland greenport include four corridors, namely to Rhône-Alpes, Mannheim, Lombardy and from Valencia. The organization of transport is characterized by a logistic service provider, the utilization of already existing infrastructure and services, prices based on cost savings, a virtual dashboard, sharing of profits and an extended single window. Shippers have to meet requirements regarding lead time, perception and urgency. Price plays an important role as well. The extent to which they meet the requirements varies, depending on the horticultural products they sell and the related market they are part of.

Table 8: Overview of the extent to which shippers meet the requirements for synchromodal transport.

Flowers

Requirement	Relevant aspects	Score	Necessary measures	Bottlenecks
Lead time	Timing of orders	+/-	Implementation of long term contracts	Dependency on weather; price variety
	Quality control	+	Utilization of reefer containers*	Mix of different types of flowers
Price	Transport costs	+	Tradeoff costs and delivery time	Dependency on last minute orders
Perception	Modalities	+	Mental shift*	Doubt performance barges
	Organization	+	A-modal booking, bundling*	Trust in logistic service provider
Urgency	Road congestion	-	Innovation to avoid road congestion	No considerable delays reported
	Sustainability	-	Sustainability equal to profitability	Related (perceived) costs
	Efficiency	+	Digitalization	Development of necessary software

Vegetables

Requirement	Relevant aspects	Score	Necessary measures	Bottlenecks
Lead time	Timing of orders	+	Use of long term orders*	Not all types of retailers use contracts
	Quality control	+	Utilization of reefer containers*	Mix of different types of vegetables
Price	Transport costs	+/-	Tradeoff costs and delivery time	Cost savings less important than speed
Perception	Modalities	-	Mental shift	Positive bias for road transport
	Organization	+/-	A-modal booking, bundling*	Trust in logistic service provider
Urgency	Road congestion	-	Innovation to avoid road congestion	No considerable delays reported
	Sustainability	-	Sustainability equal to profitability	Related (perceived) costs
	Awareness	+	Real time insight transport progress	Lacking communication with carriers

Plants

Requirement	Relevant aspects	Score	Necessary measures	Bottlenecks
Lead time	Timing of orders	+	Increased use of long term orders*	Not all types of retailers use contracts
	Quality control	+/-	Utilization of reefer containers*	Much cooling is damaging; mix of types
Price	Transport costs	+	Tradeoff costs and delivery time*	Increase of last minute orders
Perception	Modalities	++	Mental shift*	Doubt performance barges
	Organization	+	A-modal booking, bundling*	Possible “out of stock” risk
Urgency	Road congestion	-	Innovation to avoid road congestion	No considerable delays reported
	Sustainability	-	Sustainability equal to profitability	Related (perceived) costs
	Efficiency	++	Digitalization	Development of necessary software

Fruit

Requirement	Relevant aspects	Score	Necessary measures	Bottlenecks
Lead time	Timing of orders	-	Implementation of long term contracts	Contracts aren’t traditionally used
	Quality control	+	Utilization of reefer containers*	Mix of different types of fruit
Price	Transport costs	+/-	Tradeoff costs and delivery time	Cost savings less important than speed
Perception	Modalities	-	Mental shift	Positive bias for road transport
	Organization	+/-	A-modal booking, bundling*	Perceived as taking too much time
Urgency	Road congestion	-	Innovation to avoid road congestion	No considerable delays reported
	Sustainability	-	Sustainability equal to profitability	Related (perceived) costs
	Awareness	+	Real time insight transport progress	Lacking communication with carriers

Measures marked with an asterisk* are already taken or wouldn’t require much deviation from current practices. Unmarked measures should be taken in order to accommodate synchromodal transport.

5. Conclusion

The fifth chapter briefly summarizes the content of the thesis so far in order to provide an answer to the main research question. Afterwards, several recommendations are offered and the limitations of the research are discussed.

5.1 Research results

The pressure on the Dutch logistics industry is rising due to decreasing performance and increasing demand. This also threatens other industries, such as the horticulture industry, which depends on the efficient and affordable supply of transport services. Synchromodality is a newly developed logistics concept which aims to provide more efficient transport for lower costs. Before these objectives can be achieved, several requirements have to be fulfilled. This thesis is dedicated to identifying the requirements and determining to which extent they are currently met by shippers in the horticulture industry. Hence, the main research question is formulated as follows: *To what extent do shippers in the Westland-Oostland greenport currently fulfill the requirements for synchromodal transport?*

The definition of synchromodality used in the thesis focuses on the flexibility and reliability which could be achieved by optimally assigning loads to the available infrastructure and services: "*Flexible and reliable transport for which at least two modalities are simultaneously available; the modal choice is no longer pre-determined; all infrastructure, services and stakeholders are adapted to one another; and product flows are bundled, in such a way that the most suitable modality can be chosen given both the requirements of each individual order and the aggregated demand for transport.*"

The requirements which have to be fulfilled to implement synchromodal transport successfully can be divided into three different types:

- the connectivity provided by infrastructure and services;
- the organization of synchromodal transport;
- requirements regarding shippers.

Four potential flows of horticultural products for synchromodal transport have been identified based on requirements relating to the magnitude of the flows. Four synchromodal corridors are selected to include the potential flows based on two additional requirements, namely the availability and responsiveness of at least two modalities. These are the selected synchromodal corridors:

- Export of flowers from the greenport to Rhône-Alpes in France;
- Export of vegetables from the greenport to Mannheim in Germany;
- Export of plants from the greenport to Lombardy in Italy;
- Import of fruit from Valencia in Spain to the greenport.

There are six key characteristics of the supply of synchromodal transport, which are based on the theoretical requirements relating to organization:

- A neutral logistic service provider carries out the orchestration tasks;
- The corridors include existing infrastructure and services;
- Prices are based on achieved cost savings;
- A virtual dashboard includes all necessary information;
- Cost savings are distributed among the stakeholders;
- An extended single window facilitates all necessary paperwork procedures.

There are three requirements which shippers have to meet to make the implementation of synchromodal transport possible:

- Sufficient lead time of orders;
- A positive perception of synchromodal transport;
- An urgency to innovate current transport arrangements.

Although attractive pricing is a requirement which synchromodal transport itself has to meet, it is taken into account as well because it can affect the lead times and the shipper's perception of synchromodal transport.

The main research question can be answered at this point. The extent to which the shippers in the greenport currently meet the requirements for synchromodal transport depends on the horticultural products they sell and the related market they are part of. The extent to which they fulfill the requirements is determined by confronting the synchromodal requirements for shippers with the current transport needs of the shippers in the greenport.

The main results of this analysis are summarized below, specified for each of the four corridors and types of products.

Shippers of flowers meet most of the requirements for synchromodal transport:

- The lead time of actual orders doesn't suffice for synchromodal transport, but a part of the aggregated product flow is predictable due to its regularity and is thus a potential basis for synchromodal transport.
- The cost savings which synchromodal transport aims to achieve might be used by shippers to negotiate a tradeoff between transport costs and delivery time with some customers.
- Shippers have a positive perception of multi-modal initiatives such as synchromodal transport.
- Shippers are actively seeking to improve efficiency related to transport information.

Shippers of vegetables meet some of the requirements for synchromodal transport:

- The majority of orders are based on contracts which predict orders on a scale from several weeks to several months.
- Maintaining the speed of transport which is currently achieved is more important than lowering current transport costs.
- Shippers express a positive bias towards road transport and perceive synchromodal transport to be unsuitable for their transport needs.
- Shippers would like to have better insight into the progress of transport.

Shippers of plants meet all requirements for synchromodal transport:

- A minority of orders is based on contracts which establish orders on a scale from several weeks to several months and the remaining product flows are partly predictable.
- The cost savings which synchromodal transport aims to achieve can be used by shippers to negotiate a tradeoff between transport costs and delivery time with some of their customers.
- Shippers have a positive perception of multi-modal initiatives such as synchromodality and some of them already have positive experiences with rail transport.

- Shippers are actively seeking to improve efficiency relating to transport information.

Shippers of fruit fulfill few requirement of synchromodal transport:

- The lead time of almost none of the orders is sufficient for synchromodal transport and there is no sufficient predictability in transport needs.
- Maintaining the speed of transport which is currently achieved is more important than lowering current transport costs.
- Shippers express a negative perception of multi-modal initiatives such as synchromodal transport for distances within Europe.
- Shippers would like to have better insight into the progress of transport.

5.2 Recommendations

Several recommendations which are based on the research are discussed below. The recommendations are related to future research and policy.

5.2.1 Recommendations for future research

Synchromodality is a recently developed topic which is currently being development both in research and in practice. There are several essential aspects of synchromodality which aren't fully developed yet, such as a functional cost and gain sharing model or an extended single window which facilities all required paperwork procedures. Gaining more knowledge and knowhow regarding such issues would add greatly to the development of synchromodal transport.

This research is focused on the demand side of synchromodal transport, namely the shippers in the horticulture industry. The operational side of the supplying parties isn't fully taken into account, whereas this is obviously an essential part of synchromodal transport. Future research is needed to gain more insight into the operational implications and requirements of synchromodal transport.

This thesis is focused a very specific types of shippers. Shippers of other backgrounds aren't included in the research, but it would be interesting to see if similar results would be found in other industries.

5.2.2 Policy recommendations

The availability and quality of at least two parallel modalities is a key aspect of synchromodal transport. Whereas the actual transport services are the responsibility of the market, the Dutch government invests in the infrastructure which could be included in synchromodal corridors. By (continuing to) actively develop tri-modal infrastructure in the Netherlands, the government can improve and expand corridors for synchromodal transport.

The implementation of synchromodal transport requires a variety of planning tools and information systems. Some of them aren't fully developed yet and involve a variety of stakeholders. The government could support the development by facilitating and possibly subsidizing the cooperation between the relevant stakeholders and the necessary research.

5.3 Research limitations

Limitations of the research are discussed below.

Firstly, the available literature on the topic of synchromodal transport is almost non-existent so far. This makes it impossible to anchor the research in a theoretical framework. The number of published reports on synchromodal transport is currently limited as well. Consequently, the theoretical argumentation in the research is based on a relatively small number of references.

Due to time restraints and (lack of) availability of sources, the focus on the operational aspect of synchromodal transport is limited, particularly in the four selected corridors. Instead, the research focuses on the shippers and mostly presumes that the supply of synchromodal transport is fixed and meets the requirements for the organization of synchromodal transport. In practice this is of course not the case and it influences the attractiveness of synchromodal transport for shippers in a way which is not considered in this thesis.

Conducted interviews are an essential part of the research. Based on two shippers per corridor, the thesis aims to give insight into the current transport situation of the industry of which the shippers are part. Due to practical reasons such as time restraints and limited availability of companies who are interested in participating in interviews, no more than two shippers per corridor could be interviewed. Although an attempt was made to select representative companies, they are not necessarily typical examples of shippers in the horticulture industry. As a result, some conclusions of the research may hold only limited truth in practice.

Finally, synchromodality is a new concept which is currently implemented in practice on only a limited scale. Many shippers, especially more traditional ones like those in the horticulture industry, aren’t familiar with it yet. Still, the thesis assumes both that four synchromodal corridors are fully functional and that the shippers have knowledge of them. Consequently, the results of the research are quite hypothetical.

6. References

Literature

Allen, 1999. Transaction costs. *Encyclopedia of law and economics*. Chelthenham: Edward Elgar Publishing Limited.

Beamon, B.M., 1999. System reliability and congestion in a material handling system. *Computers & industrial engineering*, Vol. 36, issue 3, p. 673 – 684.

Bell, M.G.H., 1999. Measuring netework realiability: a game theoretic approach. *Journal of advanced transportation,* Vol. 33, p. 135 – 146.

Blauwens, G., De Baere, P. & Van de Voorde, P., 2008. *Transport economics*. Antwerpen: De Boeck.

Borger, B. de & Mayeres, I., 2004. *Taxation of car ownership, car use and public transport*.

Buck Consultants International, Agrotechnology & Food Innovations & TNO, 2003. *Bundelen doe je zo!*

Buck Consultants International, 2011. *Synchromodal transport: efficient en duurzaam via netwerkregie.*

Bureau Voorlichting Binnenvaart, 2011. *Verladersinfo.*

CBS, 2008. *Glasgroenten: van grond tot mond.*

CBS, 2011. *Internationale handel; in- en uitvoer naar goederengroepen.*

CBS, 2012. *Groenteteelt: oogst en teeltoppervlakte per groentesoort.*

Cruijssen, F., Dullaert, W. & Fleuren, H., 2007. Horizontal cooperation in transport and logistics: a literature review. *Transportation journal*, Vol. 46, issue 3, p. 22-39.

Danser, 2012. *Vaarschema's.*

Dekker, R., Bloemhof, J. & Mallidis, I., 2012. Operations research for green logistics – an overview of aspects, issues, contributions and challenges. *European Journal of Operational Research,* vol. 219, p. 671 – 679.

Ecorys, 2010. *Landelijke capaciteitsanalyse binnenhavens.*

Eng-Larsson, F. & Kohn, C., 2012. Modal shift for greener logistics – the shipper's perspective. *International journal of physical distribution & logistics management*, Vol. 42, issue 1, p. 36- 59.

European Commission, 2012. *Statistical pocketbook 2012.*

European Container Terminals, 2011. *The future of freight transport*.

European Container Terminals, 2012. *European Gateway Services.*

EVO, 2009. *Besparen in ketens – sierteeltsector*.

FloraHolland, 2012. *How the flower supply chain is developed.*

Forkenbrock, D.J., 1999. External costs of intercity truck freight transportation. *Transportation research,* Vol. 33, p. 505 - 526.

Frugi Venta, 2012. *Jaarverslag 2011.*

The Greenery, 2012. *Jaarverslag 2011*.

Greenport Nederland, 2010. *Strategische agenda mainport 2010 – 2013.*

Greenport Westland-Oostland, 2008. *Integrale visie greenport Westland-Oostland 2020.*

Hinterhuber, A., 2002. Value chain orchestration in action and the case of the global agrochemical industry. *Long range planning,* Vol. 35, p. 615 – 635.

Hoofdbedrijfschap Agrarische Groothandel Bloemen en Planten, 2009. *Kengetallen 2008*.

Hoofdbedrijfschap Agrarische Groothandel Bloemen en Planten, 2012. *Kengetallen 2011*.

Hoofdbedrijfschap Agrarische Groothandel Groenten en Fruit, 2012. *Kengetallen 2011*.

Hubways, 2010. Greenports in control.

Institute for Energy and Environmental Research & Research Association for Intermodal Transport, 2009. *Comparative Analysis of Energy Consumption and CO2 Emissions of Road Transport and Combined Transport Road/Rail.*

Kenlog, 2009. *De sierteeltketen in 2020.*

Kombiverkehr, 2012. *Timetable information.*

Lodewijks, G. et al., 2005. *Multimodaal transport in de tuinbouwdelta.*

Maddison, D., 1996. *The true costs of road transport*. London: Clays.

Ministerie van Infrastructuur en Milieu, 2012a. *Multimodale achterlandknooppunten in Nederland.*

Ministerie van Infrastructuur en Milieu, 2012b. *Verklaring reistijdverlies en betrouwbaarheid op hoofdwegen 2000 – 2010.*

NEA, 2006. *Freight flows in an enlarging Europe: from facts to visuals.*

NEA, 2010. *Logistiek van agro, food en feed producten.*

Nijkamp, P. et al, 2010. *Vitaal tuinbouwcluster 2040.*

Notteboom, T., 2008. Bundling of freight flows and hinterland network development. In: Konings, R., Priemus, H., Nijkamp, P. *The future of intermodal freight transport, operations, technology, design and implementation*, p. 66-88. Cheltenham: Edward Elgar Publishing Limited.

Organisation for Economic Co-operation and Development, 2002. *Key issues for transport beyond 2000.*

Organisation for Economic Co-operation and Development, 2010. *Improving reliability on service transport networks.*

Organisation for Economic Co-operation and Development, 2012. *Transport outlook 2012.*

Palma, A. de, Lindsey, R., Quinet, E. & Vickerman, R., 2011. *A handbook for transport economics*. Cheltenham: Edward Elgar Publishing Limited.

Platform Agrologistiek, 2009. *De agrologistieke kracht van Nederland.*

Productschap Tuinbouw, 2010. *Marktbeeld tuinbouw.*

Productschap Tuinbouw, 2011. *Marktmonitor groenten en fruit*.

Productschap Tuinbouw, 2012. *De consumenten van bloemen en planten*.

Provincie Zuid-Holland, 2007. *Greenports 2020.*

Provincie Zuid-Holland, 2011. *Van Mainport-Greenport naar Growport.*

Rail Cargo, 2012. *Rail scout*.

Rhinecontainer, 2012. *Sailing plan.*

Rodrigue, J.-P., 1999. Globalization and the synchronization of transport terminals. *Journal of transport geography*, Vol. 7, p. 255-261.

Sánchez-Silva, M., Daniels, M., Lleras, G. & Patiño, 2005. A transport network reliability model for the efficient assignment of resources. *Transportation research part B: methodological*, Vol. 39, issue 1, p. 47-63.

SEOR, 2007. *EVD sectoronderzoek Nederlandse tuinbouwsector.*

Slikker, M., 2010. *Game theory with applications to supply chain management.*

Slim fruit, 2004. *Groenten- en fruitkeuringen op een nieuwe manier.*

Strategisch Platform Logistiek, 2010. *Brief aan informateur Opstelten.*

Stuurgroep synchromodaliteit, 2012. *Synchromodaal vervoer in 2020: definitie, kansen en perspectieven.*

Texas Transportation Institute, 2012. *Modal comparison of domestic freight transportation effects on the general public: 2001 – 2009.*

TNO, 2010. *Verkenning synchromodaal transportsysteem.*

TNO, 2011a. *IDVV spoor 3 maatregel 10 Kennis- en visiedocument.*

TNO, 2011b. *Implementatieroadmap synchromodaliteit.*

TNO, 2012a. *Lange termijn perspectief spoorgoederenvervoer.*

TNO, 2012b. *Synchromodality pilot study: identification of bottlenecks and possibilities for a network between Rotterdam, Moerdijk and Tilburg.*

Topteam Logistiek, 2011. *Partituur naar de top*.

Topteam Logistiek, 2012. *Dinalog jaarevent.*

Topteam Tuinbouw en Uitgangsmaterialen, 2011. *Bron voor groene economie.*

Verereniging van Groothandelaren in Bloemkwekerijproducten, 2009. *Toenemende transportmodaliteit*.

Verereniging van Groothandelaren in Bloemkwekerijproducten, 2010. *Typisch groothandel.*

World Bank, 2005. *The European horticulture market.*

World Bank, 2007. *Connecting to compete 2007: trade logistics in the global economy*.

World Bank, 2010. *Connecting to compete 2010: trade logistics in the global economy*.

World Bank, 2012. *Connecting to compete 2012: trade logistics in the global economy*.

Woxenius, J., 2012. Directness as a key performance indicator for freight transport chains. *Research in transport economics*, p. 1 – 10.

Wageningen University & Research Centre, 2009. *Prijsvorming in de tuinbouwsector.*

Wageningen University & Research Centre, 2011. *Verduurzaming voedselproductie: transportbewegingen van het Nederlandse voedsel*.

Interviews

Name	Company (type)
Edwin Wenink	FloraHolland (auction house)
Albert Veenstra	TNO (research organisation)
Stephan van Maldegem	Oudendijk (import of flowers)
Peter Kap	Javado (export of plants)
Niels van Schie	Hamiplant (export of plants)
Sabine Berendse	Anaco Greeve (import of vegetables and fruit)
Susan Troost	H. Troost & Zn. BV (export of vegetables and fruit)
Rob Lamers	e-Logistics Control (logistic service provider)
Roy Vijverberg	Hamifleurs (export of flowers)

Appendix

Detailed tables with information on the export value of flowers and plants and export volume of vegetables and fruit than the ones used in the main text are displayed here.

Export value (in thousands of euros) of flowers and plants from the Netherlands (2011)

Destination		**Flowers**		**Plants**	
		Absolute value	*Percentage*	*Absolute value*	*Percentage*
Germany		***910,620***	***28,4***	***661,915***	***32,5***
	N.R. Westphalia	286,458	8,9	314,549	15,4
	East	168,778	5,3	48,001	2,4
	North-west	158,324	4,9	67,847	3,3
	South-west	87,861	2,7	29,755	1,5
	South	209,200	6,5	201,763	9,9
United Kingdom		***570,152***	***17,8***	***173,906***	***8,5***
	South-east	323,575	10,1	105,440	5,2
	Middle-west	74,253	2,3	30,698	1,5
	North	132,504	4,1	29,942	1,5
	Scotland	32,284	1,0	6,645	0,3
	N. Ireland	7,536	0,2	1,182	0,1
France		***434,543***	***13,6***	***247,941***	***12,2***
	Paris region	130,402	4,1	72,970	3,6
	North	90,752	2,8	51,596	2,5
	West	73,856	2,3	43,718	2,1
	Central	43,913	1,4	24,454	1,2
	South	95,619	3,0	55,203	2,7
Italy		158,701	5,0	163,326	8,0
Russia		147,726	4,6	51,082	2,5
Belgium		105,766	3,3	121,465	6,0
Poland		82,097	2,6	55,038	2,7
Denmark		73,264	2,3	43,070	2,1
Switzerland		87,246	2,7	66,268	3,3
Austria		70,010	2,2	76,238	3,7
Sweden		60,422	1,9	68,666	3,4
Spain		49,000	1,5	48,575	2,4
Ireland		36,311	1,1	10,431	0,5
Chech republic		54,510	1,7	35,126	1,7
Norway		38,619	1,2	26,199	1,3
Romania		24,449	0,8	17,203	0,8
Greece		18,432	0,6	10,820	0,5
Hungary		19,601	0,6	23,134	1,1
Finland		29,858	0,9	20,952	1,0
Portugal		14,474	0,5	15,772	0,8
Ukraine		14,521	0,5	13,784	0,7

Slovakia	21,989	0,7	14,188	0,7
Lithuania	11,418	0,4	4,683	0,2
Slovenia	10,228	0,3	8,771	0,4
Latvia	9,171	0,3	4,896	0,2
Croatia	6,240	0,2	6,691	0,3
Estonia	5,834	0,2	2,965	0,1
Other European countries	36,715	1,1	30,736	1,5
Europe	**3101,917**	**96,8**	**2023,841**	**99,3**
North America	63,342	2,0	0,149	0,0
Far East	19,877	0,6	1,654	0,1
Middle East	15,266	0,5	8,717	0,4
Middle & South America	1,789	0,1	2,369	0,1
Africa	1,327	0,0	1,918	0,1
Oceania	0,524	0,0	0,000	0,0
World	**3204,042**	**100,0**	**2038,648**	**100,0**

Adapted from HBAG Bloemen & Planten, 2012

Export volume (in tonnes) of vegetables and fruit of Dutch origin (excluding re-export) from the Netherlands

	Vegetables		**Fruit**	
Destination	*Absolute value*	*Percentage*	*Absolute value*	*Percentage*
Germany	771,077	29,6	57,425	18,1
United Kingdom	385,286	14,8	45,633	14,4
Russia	130,097	5,0	61,899	19,5
France	114,077	4,4	20,145	6,4
Sweden	99,239	3,8	23,212	7,3
Poland	85,509	3,3	10,456	3,3
Italy	84,889	3,3	3,021	1,0
Belgium/Luxembourg	74,149	2,8	13,854	4,4
Czech Republic	62,582	2,4	3,181	1,0
Denmark	38,930	1,5	16,192	5,1
Norway	29,141	1,1	12,542	4,0
Spain	36,662	1,4	4,116	1,3
Ireland	25,067	1,0	5,444	1,7
Finland	21,541	0,8	10,725	3,4
Lithuania	17,464	0,7	6,832	2,2
Switserland	17,441	0,7	0,848	0,3
Austria	15,752	0,6	0,514	0,2
Latvia	13,013	0,5	4,862	1,5
Romania	10,366	0,4	0,755	0,2
Hungary	8,800	0,3	0,058	0,0
Slovakia	7,927	0,3	0,514	0,2
Estonia	6,257	0,2	1,190	0,4
Greece	5,977	0,2	0,331	0,1
Other European countries	28,045	1,1	5,001	1,6
Europe	**2089,288**	**80,3**	**308,750**	**97,5**
United States	29,173	1,1		
Malaysia	20,193	0,8		
Brazil	16,841	0,6		
Indonesia	11,176	0,4		
Other countries	435,070	16,7	8,003	2,5
World	**2601,741**	**100,0**	**316,763**	**100,0**

Adapted from Frugi Venta, 2012