MASTER

Optimization of reverse logistics by cooperation between export companies in the floricultural sector

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Award date:
2012

Eindhoven, November 2012

Optimization of reverse logistics by cooperation between export companies in the floricultural sector

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BEng Human Mechanical Engineering - 2009
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in partial fulfillment of the requirements for the degree of

Master of Science
in Operations Management and Logistic

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TUE. School of Industrial Engineering.
Series Master Theses Operations Management and Logistics

Subject headings: Cooperation, Containers reusable, Floricultural, Logistics, Packaging, Reverse Logistics, RTI, Transport.

Abstract

In this master thesis project the possibilities of cooperation between exporting companies in the floriculture sector are investigated. This project is executed at the project department of the VGB in Aalsmeer, the Netherlands. The main objective of the research is to give an indication of the current RTI process at the export company and the logistic service provider, and what savings could be achieved by cooperation between export companies. In order to determine the change of the improved processes a simulation model (Enterprise Dynamics) of the current en improved situations is developed. These improved scenarios are based on cooperation between the exporting companies in the floriculture supply chain.

Management summary

The VGB initiated a project to determine what savings can be achieved if export companies (EC's) in the floricultural sector cooperate on RTI (Returnable transport items) management. For most of the export companies the RTI process is not their core business and encounter problems in the processing of packaging and export trolleys. These problems consist of peak moments at docks, disturbance of warehouse logistics, high RTI stocks, many handling procedures, problems with administration. The following problems are indicated for the logistic service provider; many counting moments in the reverse logistic flow, much time involved in sorting of export trolleys, high transportation cost involved in delivering the RTI's to the export companies (unloading, administration, transport between EC's). In order to improve the reverse logistics in the floriculture supply chain this research is focused on the below formulated research question:

"How can empty RTI's in the reverse logistics of the floricultural supply chain, be managed in an effective way by cooperation between export companies, and lead to a cost reduction?"

The following sub-questions are formulated:
"*What will be the savings for the export companies, and what will be the cost per export trolley in the improved situation."*
"What will be the savings for the logistic service providers, and what will bet the cost per export trolley in the improved situation."

A simulation model of the reverse logistics processes is made in the simulation software 'Enterprise Dynamics'. The main conclusion from the analysis of the current RTI processes at are the following;

- Head of expenses of the RTI process at the <u>export company</u> consist of trolley expenses, warehouse expenses, salary cost and transport cost, which account for 39%, 29%, 27% and 5% respectively.
- Total cost per year of the RTI process at an export company with an export trolley turnover of 24.400 per year accounts for €310.000. These cost are determined without export trolley expenses because of the high variability in this head of expenditure between EC's. This accounts for an cost per export trolley movement of €12,66.
- Head of expenses of the RTI process at <u>the logistic service provider</u> which is located on a distance of approximately 100 km from the auction location are, transport cost, handling and equipment cost and salary cost, which account for 55%, 34% and 11% respectively.
- The total cost per year of the RTI process at the logistic service provider, scoped from delivery at the cross-dock of the LSP towards auction location Aalsmeer, and a total export trolley turnover of 56.000 serving six EC's at auction location Aalsmeer is determined on €465.000. This accounts for an cost per export trolley movement of €8,32

In order to improve the existing situation two scenarios are designed based on existing literature, previous conducted research by TNO (Handiger omgaan met bloemenexportkarren, TNO, 2011) and interviews with experts in the sector. The following scenarios are defined;
<u>Scenario 1</u>, a central depot system where EC's can take advantage of economies of scale. At the central depot the RTI of cooperating EC's are unloaded and the same RTI process takes place as at the individual EC's, only on a bigger scale.
<u>Scenario 2</u>, a pool system, the pool system operates in the same way as the central depot, the difference is that a pool of export trolleys is implemented.

<u>Results from the analysis of the central depot scenario</u> are the following;
- In a setting of six EC's with an ET turnover of 24.400 a decrease per <u>export company</u> of the following head of expenditures is achieved. Salary cost decrease with 27%, warehouse expenses decrease with

16% and transport cost decrease with 57%. Based on an export company with an export trolley turnover of 24.400 the total saving per year determines 24%. This saving account for an yearly saving of €73.700. The sensitivity analysis shows that the throughput of ET's at the central depot ranges from 78.000 to 276.000 a saving per export trolley movement of 22% to 25% respectively is achieved.

- At the RTI process of the logistic service provider salary cost stay the same, handling and equipment cost decrease with 25% and transport cost decrease with 11%. Based on a LSP with a total export trolley turnover of 56.000 serving six EC's at auction location Aalsmeer the total savings per year are 6%, which accounts for a yearly amount of €25.500 euro. The saving for larger LSP's will be higher than for smaller ones, the analysis indicates an increasing of the saving percentage based on ET movements.
- The total amounts of ET's moving through the system is the leading factor for the saving incorporated. In the saving the investment cost for an ICT system is not taken into account. The payback period of the investment is based on the number of EC's cooperating and ET movements per year. In order to give a detailed answer on the payback period more information is needed on the cost of the ICT system and the exact EC's cooperating.

Results from the analysis of the pool system are the following:

- An analysis is made based on pre-conditions specified by a previous research on the new type of export trolley. Based on these pre-conditions the savings of the pool system are analyzed. These savings are also achieved by the improvements of the central depot scenario.
- Based on the same settings as at the central depot scenario the analysis of the pool system scenario indicated the following savings per export company. Salary cost decrease of 30%, warehouse expenses decrease with 35% and transport cost decrease with 60%. The total saving per ET movement for the EC is 38%, this is an saving of €115.700 per year.
- At the RTI process of the logistic service provider salary cost decrease with 16%, handling and equipment cost decrease with 28% and transport cost decrease with 15%. Based on an LSP as described previously the total savings per year are 16%, which accounts for an yearly amount of €81.400 euro. The saving for larger LSP's will be higher than for smaller ones, the analysis indicated an increasing of the saving percentage based on ET movements.
- In this saving the investment in a new type of trolley is not taken into account. This is because of no indication of the price is available. In the determination of the profitability of the pool system several factors have to be taken into account which are; the price of the new export trolley, total size of the pool, actual specification of trolley, the payback period.

Determined on the results of both analysis the following is recommended:

- *More in depth analysis of the RTI handling process design within the central depot.*
- *Further analysis on the cost of implementing an information management system.*
- *Detailed information about EC's cooperating and determine the savings based on this configuration.*
- *Initiate an analysis on the savings for the EC and LSP based on the pool system.*
- *Locate the central depot nearby FH at the specific auction location*
- *At the starting point for the project it is recommended to initiate a central depot with EC's cooperating of average ET turnover sizes, which are approximately 24.500 ET's per year per EC.*
- *Determine the appropriate service fee for EC's cooperating at the central depot.*

Preface

This master thesis is the result of a graduation project executed at the 'Vereniging van Groothandelaren in Bloemkwekerijprodukten'. It is the concluding work of the master study Operations Management & Logistics at the sub department Operations, Planning, Accounting and Control at the Eindhoven University of Technology. During the past months I had the opportunity to get familiar with the horticultural sector. I gained numerous new insights and knowledge about the logistic aspects in this sector. The time at the VGB and several companies related to the project where very enjoyable for me.

I would like to thank Tom van Woensel, my first university supervisor, for the regular short, but effective meetings, and for motivating and keeping me on the right track every time. Also I would like to thank Remco Dijkman, my second university supervisor, for the few meetings we had, especially on modeling and the simulation.

I would like to thank my company supervisor Robbert van Willegen from the VGB, for the regular meetings and discussions we had about the projects and for the practical view on the project Also I would like to thank Lars de Kuijer of the VGB who was involved at the initial phase of the project, for his support to let me get acquainted with the floricultural sector. Thanks go to Anton Brill of the VGB to give me the opportunity to execute my master thesis project at the VGB. Also I would like to thank Rinie Ravensbergen from ………………. for his support on information and his flexibility with meetings.

To conclude this preface I would like to thank the students of the N-corridor for their support and discussions on the project. Also I would like to thank my family for their support during my study, and special thanks to Ilse for her support during my study.

Daniël Akkers

Eindhoven, November 2012

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1. Introduction

This master thesis is executed at the VGB which has started a project to improve the reverse logistic flow of returnable transport items (RTI's), in the floricultural supply chain of wholesalers/export companies (EC's). These RTI's consist of export trolleys (ET's) and packaging, which is explained more in detail further on in this rapport. In the floricultural supply chain several parties are involved, which will be highlighted later on in this report. In this chapter an introduction is given concerning the supply chain in the floricultural sector to get an understanding of the background of the project.

1.1 Floricultural supply chain

The floricultural supply chain characterizes itself by a wide variety of parties involved, the majority is active as grower or as wholesaler/exporter. Beside this other parties are active in the field of multiplication and upgrading or specific services. Also within the sector a significant number of specialized logistic service providers are represented. The auction takes a central place within the sector, this because of the fact that the supply of growers and the demand from wholesaler is brought together at this point. A major differentiation within the horticulture sector can be made between flowers and plants. Strong influences of peak demand is characterizing the trading of flowers (e.g. Valentine's day and mother's day) and also the high cycle times because of perishability of the products is a major factor. Concerning plants there is a more constant flow of products with less time pressure. The horticultural sector delivers a substantial contribution towards the Dutch export and has a major share in the total volume concerned road transport.

Figure 1 shows the logistical flows in the horticultural chain. Within the complete chain similar activities take place. Concerned with internal logistics these are the following steps; inbound, checking, storage, distribution, processing and outbound. Concerned external logistics the following steps take place; supply/outward transport and inter-auction transport (Eindrapportage Besparen in Ketens –Sierteeltsector, EVO, 2009).

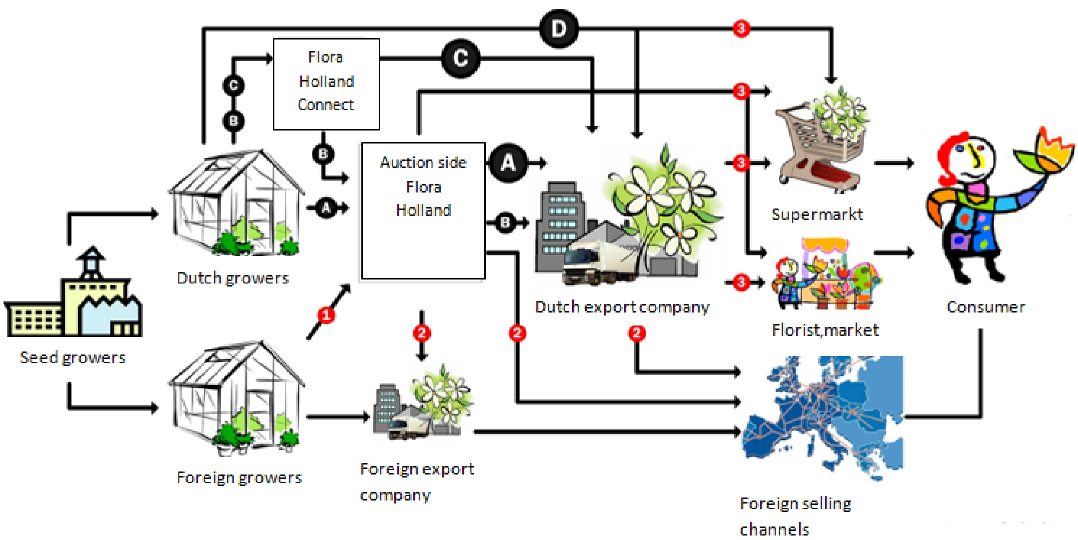


Figure 1 Floriculture supply chain (Eindrapportage Besparen in Ketens –Sierteeltsector, EVO, 2009)

Within the Dutch horticulture chain from grower to wholesaler four logistical flows are distinguished. These flows are indicated by the following letters A, B, C and D:

A. Clock flow: Products are delivered at the auction side, stored, checked, sold on the clock, distributed and delivered at the wholesaler.
B. Intermediary Flora Holland connect: Wholesaler (buyer) indicates which products at what time and under what delivery conditions are necessary. These products will not be included in the clock auction process, but are delivered by the auction center.
C. Bypassing of the auction distribution process; products are not delivered, stored and distributed at the auction side, but are directly delivered at the wholesaler/exporter. The purchase process and payment is done via Flora Holland connect.
D. Completely bypassing Flora Holland. Products are directly delivered at the wholesaler/exporter, the purchase process and payment is not done via Flora Holland connect (Eindrapportage Besparen in Ketens –Sierteeltsector, EVO, 2009).

In the figure also a distinction is made between the import and export flows. These numbers are defined as following;

1. import
2. export
3. Dutch sales

1.2 Development of markets

With a market share of approximately 30%, Germany is for many years the biggest export market, with on close distance followed by the UK and France. An increasing trend is visible in the export towards East-European countries like Poland and Russia, these have been growing substantial in the last years, see Table 1.

	2005	2006	2007	2008	2009	2010	2011	% 2011	% 05-11
Duitsland	1.531	1.506	1.514	1.475	1.530	1.599	1.573	30,0%	3%
Verenigd Koninkrijk	810	849	907	745	656	704	744	14,2%	-8%
Frankrijk	650	652	679	664	646	671	682	13,0%	5%
Italië	333	341	337	330	323	331	322	6,1%	-3%
België	187	191	206	216	212	238	227	4,3%	21%
Rusland	100	127	151	177	136	154	199	3,8%	99%
Denemarken	135	132	147	143	135	148	154	2,9%	14%
Polen	73	89	109	143	128	142	146	2,8%	100%
Zwitserland	132	143	139	137	135	138	137	2,6%	4%
Oostenrijk	135	137	138	135	133	119	116	2,2%	-14%
Overig	773	847	907	932	846	900	943	18,0%	22%
Totaal	**4.859**	**5.014**	**5.234**	**5.097**	**4.880**	**5.144**	**5.243**	100%	8%

Table 1 Most significant floriculture export markets (€ billion), (HBAG bloemen en planten 2011)

The Dutch export companies have moved their focus in recent years more and more on Europe as sales region. There are a lot of reasons for this shift, like as for example unfavorable exchange rates, phytosanitary demands, production movements and high export costs towards far destinations. A combination of these factors resulted in the fact that export towards countries outside Europe decreased rapidly. Over 97% of all export nowadays is focused on regions within Europe. In Figure 2 the growth / decrease, concerning floriculture products at the several export destinations within Europe is visualized. Within the European export market the products are mainly transported by means of transport via road. In 70% of all cases the floricultural products are transported on RTI's. These RTI's have high deposit fees, so all of these have to be returned at the right sender, which are the exporting companies. In the following section more explanation will be given on the different types of export companies.

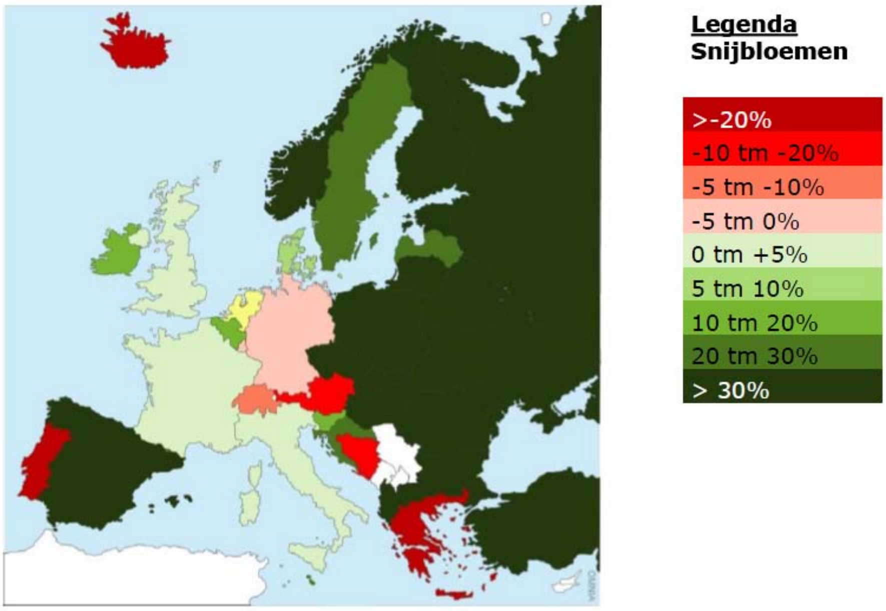


Figure 2 Export developments floriculture products Europe 2002 – 2011, (Typisch groothandel 2005 - 2011, VGB)

Specialism within export companies

Specialization is defined as the focus on a particular type of customer by a wholesale company. This analysis is based on horticulture products, so both plants and flowers are incorporated into the results. The wholesale companies are divided in terms of type of customers. There is a distinction between the following customers:

- Supermarkets,
- Garden centre's (Lumberyard) as retail chain stores,
- Garden centre (Lumberyard) independent,
- Florists as retail chain stores,
- Florists independent,
- Wholesaler (operating abroad),
- Cash-and-carry,
- Trade grower,
- Direct purchases by foreign companies at FH,
- Remainder / unknown.

A remarkable conclusion which is found by the VGB is that the number of companies has decreased in turnover category 1 and 2, in the period stretching from 2005 up unit 2011. The following tendency can be seen;

- Turnover category 1: € 0 – 5 billion: from 799 (2005) to 546 (2011) nr. of companies,
- Turnover category 2: € 5 – 40 billion: from 164 (2005) to 155 (2011) nr. of companies,
- Turnover category 3: > €40 billion: from 17 (2005) to 28 (2011) nr. of companies.

A strong decrease of the number of companies in category 1 can be seen. This concerns primarily companies that supply independent florists and importing wholesalers abroad. In the other two categories there's minor change. In Figure 3 the average turnover per wholesale company divided into specialized customer is shown.

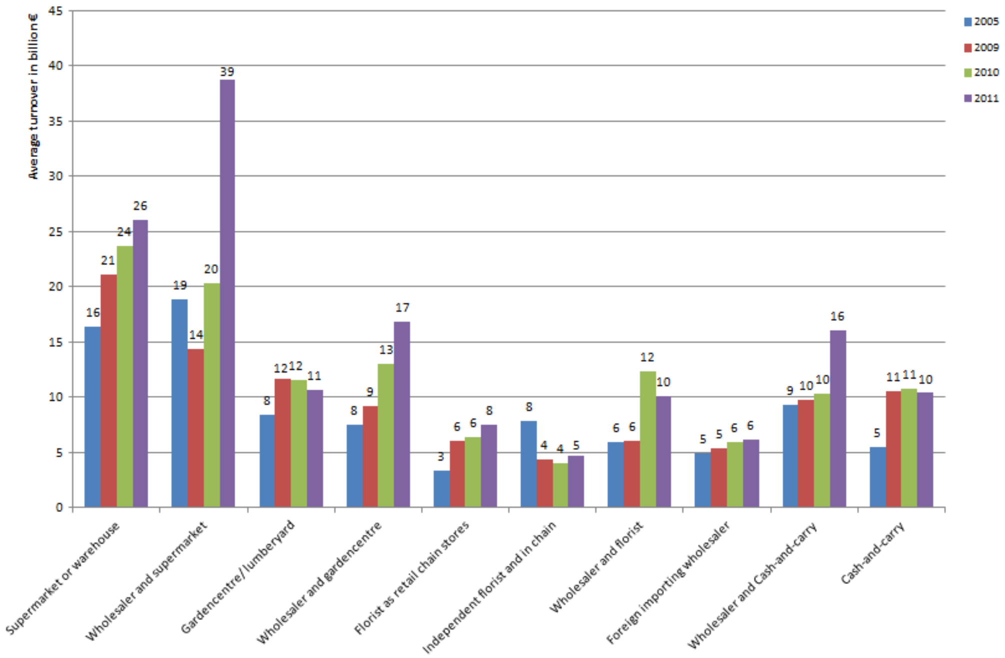


Figure 3 Average turnover per wholesale company divided into specialized customer type, (Typisch groothandel 2005 - 2011, VGB)

Research focus
As can be concluded from the previous sections billions of flowers are exported every year to a wide variety of countries, which are approximately 140 countries all over the world. Approximately 700 Dutch flower exporting companies are responsible for a total exporting value of more than 5 billion euro, from which 98% stays within Europe. Flowers are transported in 70% of all cases on RTI's, these RTI's consist of flower buckets, boxes (further referred as packaging in this report) and trolleys (see Appendix A). This research focuses on two types of trolleys, namely FH trolleys and export trolleys. The export trolleys are owned by export companies and the packaging by SiVePo. This is a subsidiary of FH which owns and manages the packaging. Thousands of customers receive their products on these RTI's, the challenge is to improve the retour logistical process of these different RTI's.

1.3 Stakeholders

In this research project several stakeholders are involved, these parties consist of the Vereniging van groothandelaren in bloemkwekerijprodukten (VGB), FloraHolland (FH), export companies (EC's) and logistic service providers (LSP's). A study group has been created by the VGB in which five wholesalers are involved and one LSP. In the following sections a description is given of the several parties which are involved in the project.

VGB
The VGB is the branch association for wholesalers in floriculture products. This association is representing more than sixty five percent of the total turnover from Dutch flower and plant wholesalers. They are involved in several projects which defends the interest of their members. Many VGB initiatives take care of crucial and innovative developments in the floriculture sector. In the this sector the VGB mainly takes a leading role, primarily on the interest of trade. The association is involved in different kind of projects in several areas like logistics, ICT and quality management.

FloraHolland/SiVePo
FH is the biggest floriculture auction cooperative in the Netherlands. It was founded on the first of January 2008 through a merger of 'Verenigde Bloemenveilingen Aalsmeer' and 'Flora Holland'. Currently FH has five

auction locations nationwide (Aalsmeer, Bleiswijk, Eelde, Naaldwijk, Rijnsburg) and one joint-venture in Germany (Rhein-Maas). FH also owns one mediation organization which is operating on national scale and has an international import department. Everyday around 120.000 transactions are made with an annual turnover of 4.1 billion Euros. The involvement of FH Holland at the project is not an active role, but in the reverse flow of the supply chain FH is an important stakeholder concerning trolleys and packaging. SiVePo is a subsidiary company from FH which is responsible for the management of the packaging.

Logistic service providers
The logistical service provider takes care of the transport activities for the wholesalers, FH and the growers. A differentiation is made between supply and delivery transport. The supply transport is mainly defined as the transport from the grower towards the auction side, and from the auction towards the wholesaler/exporter. The delivery transport is defined as the transport from the wholesaler/exporter toward the purchaser (Eindrapportage Besparen in Ketens –Sierteeltsector, EVO, 2009).

Wholesalers/export company in Floricultural products
The wholesaler or exporter is the link between grower or auction and the buyer of floricultural products, further referred in this report as export company (EC). The EC buys the products via the clock, or direct at the grower and sells them after processing or preparation. In 2011 729 floricultural export companies where registered in the Netherlands and responsible for a total export value of 5.243 billion euro. From this total export value almost 97% stays within Europe. Of the in total registered wholesaler in 2011, 458 delivered their products to Germany, 235 to France and 209 to the United Kingdom. The total number of exporting wholesalers has decreased in the last years with 5,3%. Within the floriculture sector there is a high diversity within the different types of wholesalers. Under these wholesalers the following distinction can be made (Typisch groothandel 2005 - 2011, VGB);

- Shipment exporters, sends products which are ordered directly to their customers within the Netherlands or foreign countries. These types of export companies are responsible for approximately 85% of the total export value.
- Line-drivers, offers products towards florists from their truck and visits customers directly at the door.
- Importing companies, import products from foreign countries and sells these primarily via the auction or wholesaler.
- Trade growers, this type of wholesaler grows his own assortment and completes it by purchasing other floriculture products. These products can be sold immediately or bred for a longer time.
- Commission agents, this are intermediate bureaus who do the purchasing of floricultural products for other companies.
- Cash- and carry's, are purchase centre's only for florists and retailers.

1.4 Structure of the report

The following sections of the report are structured as follows. In chapter 2 the research project is described, with the problem encountered in the reverse logistics of RTI's, the research question, scope and model. Also the inefficiencies and possible causes are analyzed. In chapter 3 the RTI process is described more in detail for both the export company and the logistic service provider. In chapter 4 the model development of the processes is described. In this chapter conceptual and black box models are described, also performance indicators and an analysis of the data is performed. Within chapter 5 the current situation is analyzed and the performance is quantified based on performance indicators of a simulation model. Chapter 6 highlights the redesign scenario's established on existing literature on RTI management. Also in this chapter these redesign scenario's are analyze based on the output of a simulation. In the final chapter the conclusion and recommendations are given. The reading guides and appendices are added at the end of the report.

2. Research project

This master thesis project focuses on RTI management in the reverse logistical process of the floricultural distribution chain, so other floricultural processes are excluded in this project. This chapter describes the project context in more detail and also the formulated research question is explained. As a starting point the project will be described in the following section.

2.1 Project description

An important process in the flower supply chain is the restacking of floriculture products. This restacking process is performed at the different EC's, here floricultural products which are stacked in the packaging on FH trolleys are unloaded and reloaded on ET's. These ET's are used for the transport towards the customers. The ownership of these ET's is divided over several exporting companies, so each one possesses its own trolleys. These trolleys are of the same type and dimensions, the only aspects in which they differ are quality, displaying of the company name and equipped with a barcode or without. The horticultural growers supply their products, usually on FH trolleys when the products are auctioned or by direct delivery, the products are transported towards the wholesalers, this is usually done on FH trolleys. At the wholesaler these trolleys are normally not used for export because of high rental costs. This means that no universal chain trolley is incorporated in the exporting process of floricultural sector. The packing in which the flowers are transported, are in comparison to the trolleys interchangeable. Every exporting company pays deposit and receives flower buckets and boxes retour. So the distribution process that takes place during export is also included in the reverse logistics of RTI's. In Figure 4 the flow of RTI's and information is visualized in the supply chain.

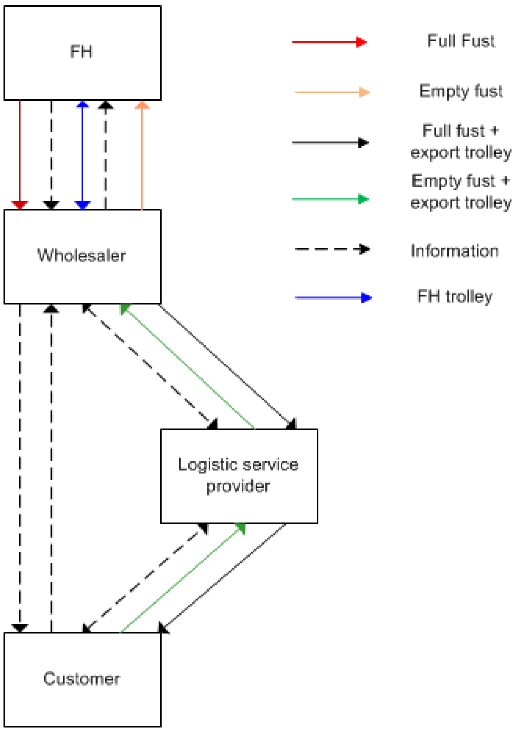


Figure 4 Flow of RTI's and information

Multiple relations

Different relations exist between the parties in the floriculture chain. In Figure 5 these relations are visualized, this indicates that several EC's can make use of the same LSP, and also serve the same end customers. An important issue in the retour process lies in the fact that every type of trolley has to be brought back to the right wholesale company. So LSP's have to put a lot of time and effort into the processing of these export trolleys and packing. The VGB wants to have investigated conceptual solutions relevant to the opportunity of improving the reverse flow process of empty RTI's in the floriculture supply chain.

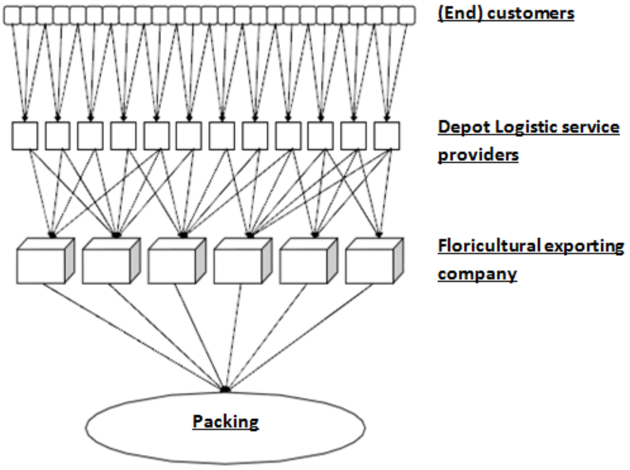


Figure 5 Schematic representation of RTI flow, (Handiger omgaan met bloemenexportkarren, TNO, 2011)

2.2 Problem description

Due to the fact of high RTI values and property rights, wholesalers as well as logistic service providers are forced to invest a high amount of resources in the reverse flow of RTI's. Every export company independently organizes their handling, administration, settlement and stock management. Export companies as well as logistic service providers encounter inefficiencies in their processes concerning empty RTI flows in the floricultural supply chain. Previous conducted research by TNO (Handiger omgaan met bloemenexportkarren, TNO, 2011) which is validated by interviews held at export companies as well as LSP's highlighted several causes, which lead to inefficient management of RTI's. These possible causes are structured in an Ishikawa (Ishikawa, 1990) diagram, these can be found in Appendix B, the diagrams are split up for both the wholesaler as well as the LSP.
From the Ishikawa diagram the main causes are structured for the wholesaler and the LSP, these will be explained more in detail in the following sections. The main causes indicated at the export companies are:

- Docks at the wholesaler are not utilized optimal. Peak moments at the docks are normal due to the fact that LSP's unload the empty RTI's at the moment they load floricultural products. Normally the peak of loading takes place at the wholesaler between 10 o'clock in the morning up until 14:00. The unloading of empty RTI's can consist of full freights or only a couple of export trolleys.
  Due to this peak moment at the docks waiting rows build up for loading and unloading. In some cases EC's have a separated dock to unload empty RTI's.
- Disturbance of the warehouse logistics. As a result of the peak moments for loading of full trolleys and unloading of empty ones, the docks at the EC fill up with empty RTI's and full trolleys with floricultural products. Due to these cross-streams the supply chain in the warehouse is disturbed which leads to problems as; lack of space, disturbed supply process of full trolleys, increased loading times.
- High RTI stocks. Due to limitations in storage capacity export companies have to process the empty packing and export trolleys every day. This implies that the empty packing has to be restacked on FH trolleys, and the export trolleys have to be nested together in packages of 4 up to 6 trolleys if not reloaded again.
- Many handling procedures. For the processing of empty packing and export trolleys a lot of physical handling procedures by employees are required. Also the utilization of employees for processing is not optimal because this is done if time is available beside the process of the supply chain. Export companies mainly see the processing of empty RTI's not as their core business.

- Problems with administration. Due to high deposit amounts for empty RTI's, a lot of time is involved in the administration. Administration takes place at the docks when RTI's are unloaded. One employee counts the amounts of packing and export trolleys, and does the necessary administration. At the example company the administration has to be checked and balanced with the outstanding amount per customer.

The main causes indicated for the LSP's:
- Many counting moments are incorporated in the reverse flow of empty RTI's. This is because of high deposit amounts for empty RTI's, mistakes have to be minimized to avoid los of deposit credits. Truck drivers can make mistakes when loading at the customers, to minimize these, packing and export trolleys are recounted at the cross-dock of the LSP.
- Sorting out export trolleys per EC. Due to different owners of export trolleys a lot of time has to be incorporated in sorting out these on specific owner. This sorting out has to be done at the customer as well as at the cross-dock of the LSP
- Lot of time involved retour flow of RTI's due to combined freights, (docking moments, administration). In 80% of the truckloads from the cross-dock towards the EC's, freights are combined with empty export trolleys of 2/3 EC's. These combined freight result in higher unloading times due to the fact that every stop at an EC involves a docking moment, unloading and administration.

The following main causes are identified for both the wholesaler as well as the LSP:
- Different owners of export trolleys. Trolleys are owned by different EC's, therefore a lot of time has to put into sorting out the trolleys on the right owner. For the LSP much time is also involved in unloading at the EC's in several stops. Also EC's don't cooperate in the supply chain by renting ET's to each other.
- Many counting moments in process. As explained before.
- Many handling procedures in process. As explained before.
- No cooperation between EC's. Because there is no cooperation between EC's, the LSP has to unload at different stops, which is time consuming. At the RTI process for the EC no scale economies can be incorporated because of no cooperation initiatives between EC's are started.
- Small scale of empty RTI management. The EC's don't see the RTI process as their core business, therefore no effort is made to improve and optimize the process. These small process have also an effect on the logistic process of the LSP.

2.3 Research question

Based on previous research conducted by TNO (Handiger omgaan met bloemenexportkarren, TNO, 2011), interviews and the analysis of the Ishikawa diagram the focus will be directed on cooperation at the wholesalers on RTI management. Both the wholesalers as well as the logistic service providers see opportunities to separate the physical flow of RTI's apart from the informational flow. Exporting companies are willing to separate the management of empty RTI's from their main activities. Due to the characteristics of export trolleys the research is not focused on increasing of load factors, this is explained later on in chapter 3. Out of the previous analysis the following research question is formulated. The research question will focus on returnable transport items used in the international trade flows of Dutch flower exporters. The following research question is formulated:

How can empty RTI's in the reverse logistics of the floricultural supply chain, be managed in an effective way by cooperation between export companies, and lead to a cost reduction?

The following sub-questions are formulated:

What will be the savings for the export companies, and what will be the cost per export trolley in the improved situation.
What will be the savings for the logistic service providers, and what will bet the cost per export trolley in the improved situation.

2.4 Research scope

In this chapter the scope of the research is defined to assign boundaries to the project. The scope of this project is focused on the retour flow of empty RTI's in the flower supply chain, so other floriculture products are left out of scope. The trolleys which are considered are the export trolleys (cage trolleys) which are owned by the different wholesalers, so other types of trolleys are not taken into account.

The scope is defined by the following points:

- Only empty RTI's are considered,
- Only trolleys from export companies are considered (cage/export trolleys),
- Trays within the trolleys are not taken into account, they are assumed to be enclosed in the trolley per amount of three.
- RTI's (packaging) considered are the following (see Appendix A) ;
    - 6 flower crates,
    - 2 facing racks,
    - 3 flower boxes.
- RTI process starts when RTI's are unloaded at LSP,
- Only Dutch wholesalers/export companies,
- Increase of loading factor is not incorporated due to the fact that export trolleys are not ideal for nesting, explained more in detail in the following chapters,
- Processes will be analyzed at the exporting company,
- Processes will be analyzed at the logistic service provider.

2.5 Research model

The model from (Mitroff, Betz, Pondy, & Sagasti, 1974)shown in Figure 6 is based on the initial approaches used when operational research emerged as a field. Within this model the operational research approach consists of a number of phases:

1. Conceptualization,
2. Modeling,
3. Model solving,
4. Implementation.

During the conceptualization phase, decisions have to be made about the variables that need to be included in the model, and the scope of the problem and which model to be addressed.

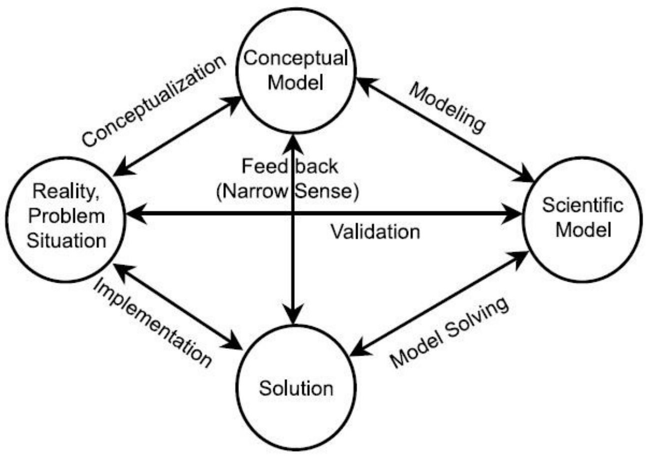


Figure 6 Research model by Mitroff et al. (1974)

This conceptual model description should use as much as possible concepts and terms that are accepted as standards published in scientific OM literature on the subject (Bertrand & Fransoo, 2002).
In the second phase the quantitative model will be build, this incorporates defining causal relationships between the variables.
During the third phase mathematics usually play a dominant role. In this phase there has to be determined which mathematical techniques and/or which simulation techniques have to be used to gain the optimal solution. In axiomatic normative research the model solving part stands central in the research process (Bertrand & Fransoo, 2002).
The last phase the implementation phase, within the scope of the research a detailed implementation plan of the proposed solutions is not included. The last phase consist of a recommendation part, without further execution of the solutions.

Mitroff et al. argue that a research circle can begin and end at any of the phases in the cycle, provided that the researcher is aware of the specific parts of the solution process that he/she is addressing and, consequently, of the claims he/she can make based on the results of his/her research. Mitroff et al. put forward the notion of shortcuts in the research cycle that are often applied and that lead to less than desirable research designs. The authors also indicate that the research types described in previous section can be positioned in the model. This research will be axiomatic normative based, where the model solving process is the central research process. In many axiomatic normative researches articles the modeling process is also included (Bertrand & Fransoo, 2002)

Computer simulation

Because of the fact that the existing situation cannot be derived mathematical a simulation program is used which is called 'Enterprise dynamics'. As described by (Banks, 1999) simulation is used to describe and analyze the behavior of a system, ask "what if" questions about the real system, and aid in the design of real systems. Both existing and conceptual systems can be modeled with simulation (Banks, 2000). The analysis of the current situation will serve as the base case model in order to compare the redesign scenarios.

The simulation of the process is set up as described by (Ottjes, Veeke, Duinkerken, Rijsenbrij, & Lodewijks, 2007). The authors describes the "process interaction method" as a modeling technique for a logistical process. This method is a combination of event scheduling and activity scanning. It consists of identifying the system elements and describing the sequence of actions for each one. Each type of handling can be modeled both aggregated and in detail by a composition of the following elementary functions:

- A transport function for the transport of empty trolleys and packing
- A handing function for the unloading/restacking of trolleys and packing
- A storage function for inventory of empty trolleys and packing

The relationships between the three elementary functions is shown in Figure 7. For each export trolley, at least one handling function must be executed. This handling function can be coupled to both a transport function and a storage function. The RTI processes in the floricultural supply chain of can be represented by a composition of connected elementary functions.

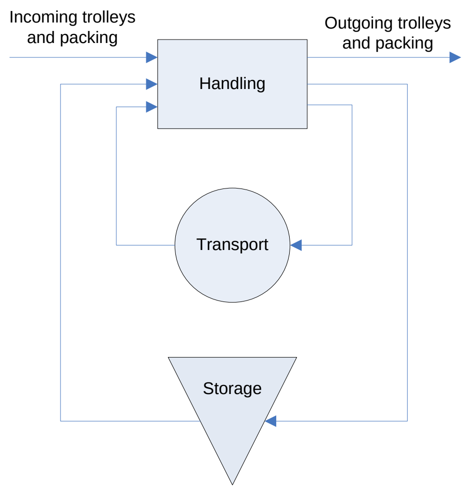


Figure 7 Relationship between elementary functions as described by Ottjes et al. (2007)

In order to build up the simulation model the methodology and steps of the reader Business Process Simulation (Pels et al. 2012) is used in combination with the steps in a sound simulation model described by Law et al. (1991). In the reader a 7-step methodology is adopted in order to design and execute a simulation study, these steps are shown below. In this 7-step model the data collection is left out, this is added at step 2 based on the simulation steps described by Law et al. (1991). The steps are explained more in detail at the specific chapter where they are applied. The simulation steps and the research phases as indicated by Mitroff et al. (1971) are shown in Figure 8, the simulations steps consist of the following:

Step 1. The project definition; formulation of the problem of the object system and the research questions of the study.
Step 2. Conceptual model and assumption; Conceptual modeling is the process of abstracting a model from a real or proposed system.
Step3. Black box and data collection; representation of the system which will be simulated as a black box, with the relevant control-, environmental and output variables.
Step 4. Build the executable model in the simulation software; Define the appropriate variables and attributes to control the flow of the process and to collect the required output data.
Step 5. Validation; check that the behavior of the simulation model corresponds to that of the object system studied.
Step 6. Experiments and results; run the experiment and summarize the results of the simulation.
Step 7. Conclusions; Draw conclusions; explain results and how the research questions is answered, recommendations/advice.

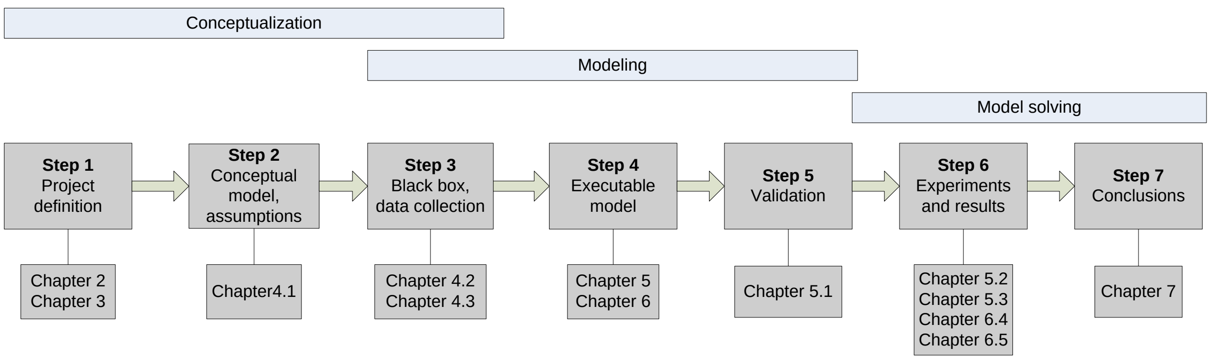


Figure 8 Simulation steps and research phases

3. RTI process description

In this chapter the current situation concerning RTI flows within the floricultural chain is described. Several aspects influence the profitability of using RTI's, therefore it is important to analyze the current process. A number of factors affect the system cost, including the type of packaging used, transportation characteristics, handling, labor, and disposal costs (Mollenkopf et al., 2005). The goal of this chapter is to get insight in the current situation and to analyze the current situation more in detail. The analysis starts with a description of the reverse flow of empty RTI's in the flower supply chain. This is followed by a description of the RTI process at the EC and the LSP.

3.1 Logistic process of RTI's

The reverse flow of empty RTI's in the flower supply chain starts after the floriculture products are delivered at the customer. At this point the empty export trolleys and packing which are in stock at the customer are picked up for the retour transport. The LSP usually only picks up the amount of RTI's which are transported previously by that particular transport company, this is because of retour transport is already paid in the supply transport of floriculture products. See Appendix D for a schematic representation of the export trolley process.

In Figure 9 a simplified model is shown of the logistic chain of empty packing and export trolleys. Exporting companies make use of several LSP's of different sizes. Large LSP's serve several exporting companies. For example EC1 and EC2 make use of the same LSP's, namely C and D, these may as well deliver the floricultural products to the same end customers. In theory it should be a possibility for these two to cooperate in combining export trolleys with RTI's in the reverse chain. But in practice this is not done, because of transport of an empty trolley already is paid in the supply transport price. So every LSP loads the amount of export trolleys which is paid in advance by the specific EC. In the current situation every LSP has to sort out export trolleys on specific export company, which takes into account a lot of time.

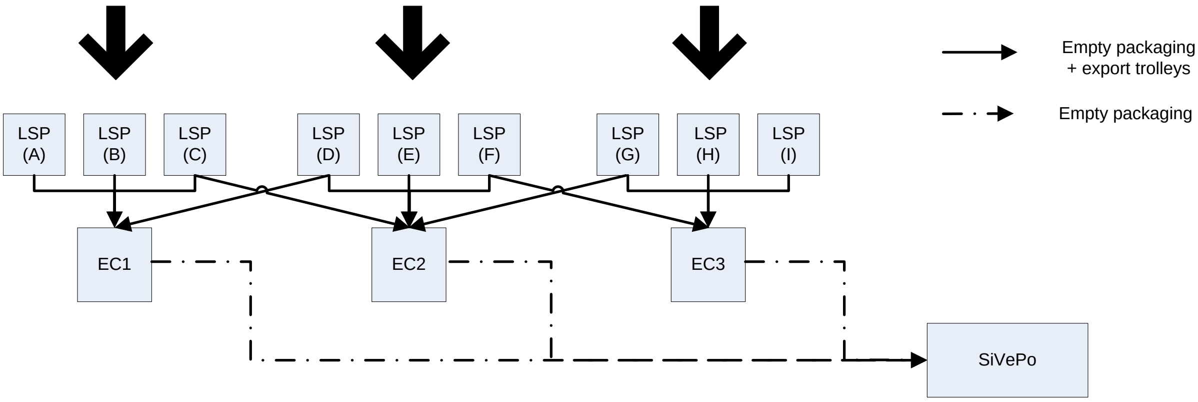


Figure 9 Simplified arrival process of packing and export trolleys.

3.1.1 Deposit fee

When (end)customer order floricultural products they are billed by the EC with a deposit for the packing and export trolleys. This is approximately €4,- per packing type, and €250 euro per export trolley. Some EC 's also charge a fee for usage of packing and export trolleys . When export trolleys and packing are returned at the EC company the (end)customer receives the amount of deposit, the term of payment can consist of 54 days. EC's themselves are billed by FH with a deposit for the usage of packing, when packing is returned towards FH the EC receives the deposit minus a fee for usage. Due to the large amount of deposits per truckload, counting of packing and export trolleys is crucial in order to avoid expensive mistakes for the (end)customer, LSP as well as the export company. This prudence with empty RTI's also results in no initiatives to cooperate between LSP's. In Figure 10 a schematic representation of the deposit system is shown.

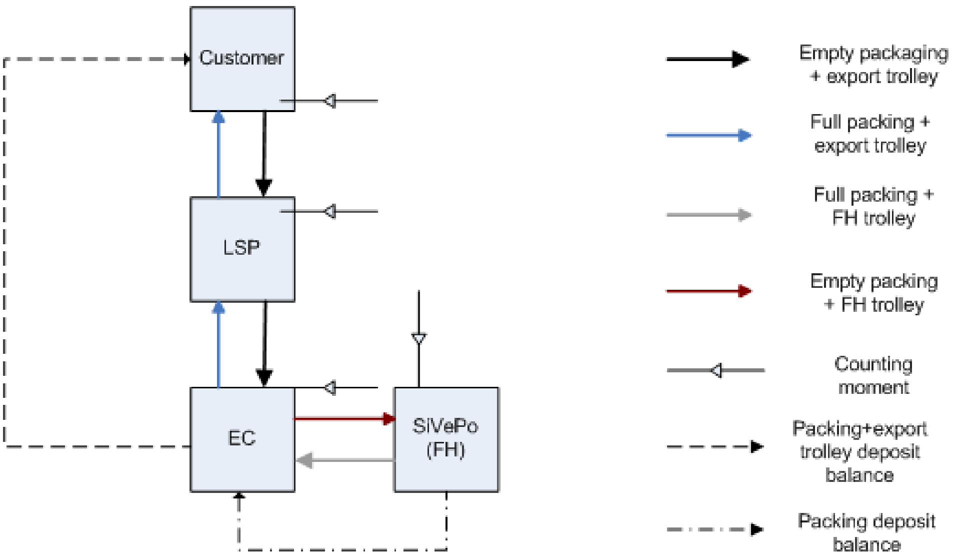


Figure 10 Schematic representation RTI structure.

3.1.2 Transportation characteristics export trolley

The cost of most of the operations involved in a RTI process are influenced by the packing characteristics (Mollenkopf et al., 2005). The export trolleys used by the EC's all have the same dimensions (100 x 120 cm). The only aspect in which they may differ is quality and brand name, which normally is displayed on the export trolleys. An export trolley consists of a bottom part with four wheels and has three upstanding facing racks which can be removed, also included with a trolley are three trays which can be stacked at different levels. Nesting of export trolleys, which is stacking up to five export trolleys into one takes into account a lot of time. Conducted measurements showed an average time of 15 minutes for nesting three trolleys into one. Previous conducted research by TNO ((Handiger omgaan met bloemenexportkarren, TNO, 2011) indicated the following characteristics of the export trolley:

- Trolleys are not ideal for nesting.
- Nesting brings hazardous situations with it.
- If every export trolley would be nested, a lot of time is needed in un-nesting at EC.
- The LSP will be charged with many handling procedures.

Because of these characteristics, increasing of the load factor in the reverse chain is not incorporated into the research.

3.2 Process at EC

………………… is taken as an example company to analyze the current process at the exporting company. The empty RTI's process starts when export trolleys are delivered by the LSP at the EC. The first step at the wholesaler is the unloading of the export trolleys. These ET's loaded are stacked with empty packaging, and a percentage of the empty export trolleys are nested together to increase the loading volume. Ones the export trolleys with packing are unloaded at the cross-dock of the EC, an employee counts the number of each type of

packaging and the number of export trolleys. After the amount has been approved, a document is made which has to be signed by the driver of the LSP who confirms the amount of RTI's delivered. From the cross-dock the RTI's are transferred to a processing area where the packing will be unloaded from the export trolleys, at some companies this will be done at the cross-dock itself.
The processing consist of unloading the packing from the export trolleys, and sorting out the packing by type. After the unloading the packing is restacked onto FH trolleys and transported back to the nearest auction side of FH. The empty export trolleys will be nested in packages of four for storage, or transferred to the processing area to be reloaded again with floricultural products. See Appendix D for a model of the total process.

3.3 Process at LSP

In the analysis of the process ………………. located in the Netherlands is taken as example company. This LSP is one of the larger companies who serve several export companies in the floricultural sector. Their main transportation area is focused on France.
The reverse flow of empty RTI's starts when the LSP loads the empty packing and trolleys at the customer. At the customer the packing and trolleys have to be counted by the truck driver, these amounts are documented and have to be agreed by the customer with a signature. Most of the time the driver makes a trip along several customers, in order to unload flowers and pickup empty trolleys. Also full freights are delivered and empty trolleys are picked up directly. Normally empty RTI's are loaded at the end of the week due to the cause of no available payload.
The full trucks with empty trolleys and packing are transported towards the cross-dock in the Netherlands. Here the export trolleys are unloaded and counted again by a warehouse employee, also the export trolleys are sorted on specific owner. This sorting and recounting is done to avoid expensive mistakes. Full freights with export trolleys and packing are loaded again at the cross-dock and brought back towards these specific companies. In 80 percent of the truckloads, a full freight consists of export trolleys of 2/3 EC, so they have to be unloaded in multiple stops. See Appendix C for a process model.

3.4 Summary of RTI description process

The current RTI process in the floricultural supply chain is quit complex due to the fact that many EC's and LSP's are involved in the reverse logistics. Due to high RTI costs and deposit fees many counting moments are incorporated in the process. In order to analyze the processes at both the EC and the LSP several assumptions and simplifications have to be made. The example company which is analyzed in order to understand the process at the EC is …………………. This export company is located at auction location Aalsmeer and is of average size compared to the project group members. The example company which is analyzed to understand the process at the LSP is ………… which is located in ………….. in the south of the Netherlands. Based on interviews with experts in the sector and company visits, simplified process representations are made to build an understanding of the process which takes place in the reverse flow of RTI's. Due to the characteristics of the current ET in use, increasing of the load factor is not profitable for the LSP. Determined on previous conducted research and meetings with experts inefficiencies at the current processes are highlighted. In order to improve the current processes, the research is focused on cooperation between EC's.

4. Model development

Based on the previous chapters, interviews and measurements, the base system model is build. As described by Banks (1999) the base system is the existing system of the process. This base system model will represent the existing situation at both the EC and the LSP. In the simulation model the processes of the LSP and the EC are split up in order to keep the model simple, as described by (Pidd, 1999).

4.1 Conceptual models

In this section step 2 of the simulation model development is executed which is conceptual modeling, also assumptions are made on the development of the model. The conceptual model is used to make a simplified representation of the real world to provide communication among clients, modelers and domain experts. The conceptual model is not dependent on the simulation method, tool or software. Conceptual modeling only addresses the problem situation and results in a definition of what and how it should be modeled. Conceptual modeling is also described as the process of abstracting a model from a real or proposed system. It is almost certainly the most important aspect of a simulation project. The design of the model impacts all aspects of the study, in particular the data requirements, the speed with which the model can be developed, the validity of the model, the speed of experimentation and the confidence that is placed in the model results (Robinson, 2007). In the first section a conceptual model is made of the total RTI process, which is followed up by the models of the EC and the LSP

Total RTI process
In Appendix D the conceptual model of the total RTI process within the defined scope is visualized. The conceptual model of the total process is made in order to simplify the understanding and the communication of the process. The building of the conceptual model is done iteratively by taking small steps at a time, which consists of modeling, documenting, and validating. This is done based on interviews, and measurements at the different processes. As described by Robinson (2007) the content of the conceptual model consist of the components that are represented in the model and their interconnections. This content can be split up into four dimensions which are the scope of the model, the level of detail, assumptions and simplifications.

The scope of the model:

- Start of the model; model starts at the cross-dock of the LSP, here empty ET's and packing are loaded by the LSP.
- End of the model; the model ends at the EC where ET's are stored or loaded again for supply.

The level of detail; in a simulation the determination must be made what aspects of a complex real-world actually need to be incorporated into the simulation model and at what level of detail, and what aspects can be safely ignored. The entity moving through the simulation model does not always have to be the same as the entity moving through the corresponding system (Law et al., 1991). The level of detail is explained in the following sections

Assumption and simplification; while making decisions about the content of the model, various assumptions and simplifications are normally introduced. Assumptions are made either when there are uncertainties or beliefs about the real world being modeled. Simplifications; are incorporated in the model to enable more rapid model development and use, and to improve transparency (Robinson, 2007). Assumptions and simplifications are explained in the following sections.

4.1.1 Conceptual model of EC

The conceptual model which visualizes the process of the export company is shown in Figure 11. This model functions as a road map in building of the actual simulation model. It describes the different activities, stock points and control moments within the process. The conceptual model of the EC is described based on the four points as indicated by (Robinson, 2007).

The scope of the model:

- Start of the model; unloading of export trolleys at warehouse of the export company.
- End of the model; the model ends at the EC where ET's are stored for reuse or used for supply.

The level of detail;

- Export trolleys are treated as entities.
- Packing is modeled as one type.
- Handling activities are modeled.
- Truckloads are modeled into three different classes, which is explained in section 4.3.1.

Assumptions;

- Packaging is un-stacked at different area than cross-dock (as in example company), at some export companies the un-stacking of packaging is done at the cross-dock.
- RTI storage is in same building as loading/processing area of floricultural products, at the example company the storage of ET's and processing of packaging is performed at a different location. At most of the EC's this is done at the same location.
- Nested trolleys consist of 3 trolleys into 1. From measurements and interviews with experts is indicated that the average nesting amount is 4.
- Warehouse employees haven an utilization rate of 50% on the described process due to different other tasks. This utilization rate is determined based on measurements, and interviews with experts.
- Per ET it is assumed that these are loaded with 27 pieces of packaging, this is based on interviews with experts and previous conducted research.
- Packaging is stacked with an average amount of 105 pieces per FH trolley, this determined based on experts opinion. The simulation output is checked with historical data of outgoing FH trolleys, in order to adjust to the average amount of packaging stacked on FH trolleys.
- 20% of the incoming export trolleys are nested in packages of four, this number is assumed based on measurements and interviews with experts.

Simplifications;

- Packing is treated as one type, because of no data availability.
- Trays which are included on export trolleys in amounts of three are excluded.
- Storage is not taken into account, due to the fact of no data of ET demand for the different EC's.

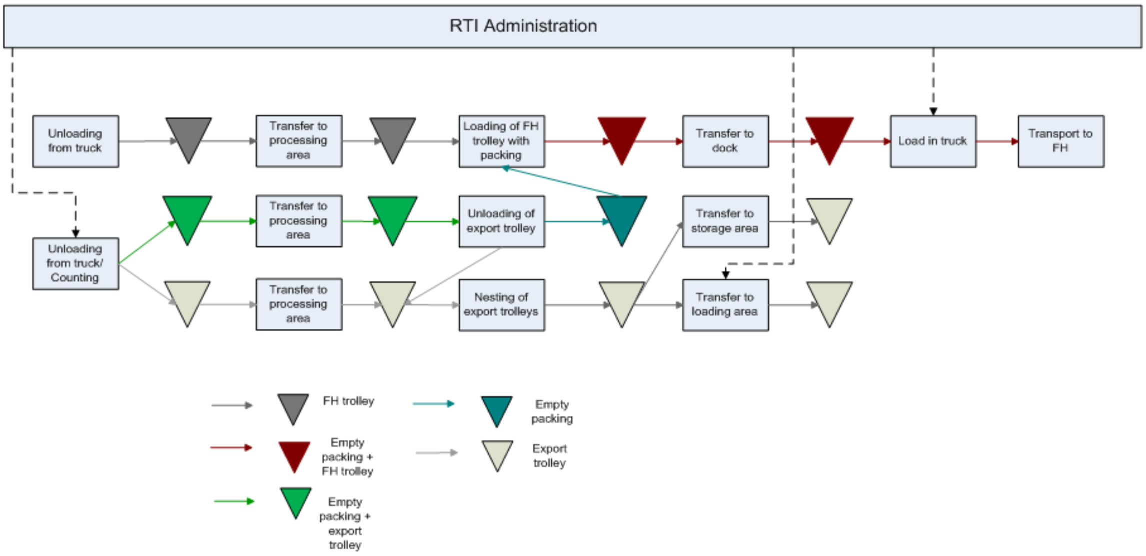


Figure 11 Handling process at exporting company

4.1.2 Conceptual model of LSP

The conceptual model which visualizes the process of the LSP is shown in Figure 12. This model functions as a road map in building of the actual simulation model. It describes the different activities, stock points and control moments within the process. The conceptual model of the LSP is described based on the four points as indicated by (Robinson, 2007)

The scope of the model:

- Start of the model; The model starts when export trolleys are unloaded at the cross-dock of the LSP.
- End of the model; the model ends at the warehouse of EC, where export trolleys are unloaded.

The level of detail:

- The level of detail is narrowed down onto export trolleys.
- Packing is treated as one type, because of no data availability.

Assumptions;

- Loading times are assumed based on estimations and opinions of experts.
- Counting times at the cross-dock are assumed based on estimations and opinions of experts.
- Sorting times at cross-dock are assumed based on estimations and opinions of experts.
- 20% of incoming export trolleys are nested, this is assumed based on measurements and opinions of experts.

Simplifications;

- Packaging is treated as one type.
- In the conceptual model as example three export companies are used, in practice LSP's server several customers.
- Truckloads only consist of export trolleys and packaging.
- LSP's have several customers (EC's), all EC's are located at the same auction location.
- In the simulation model the LSP serves six customers at auction location Aalsmeer.
- Storage cost are not taken into account, because cross-dock situation at the LSP will not change.

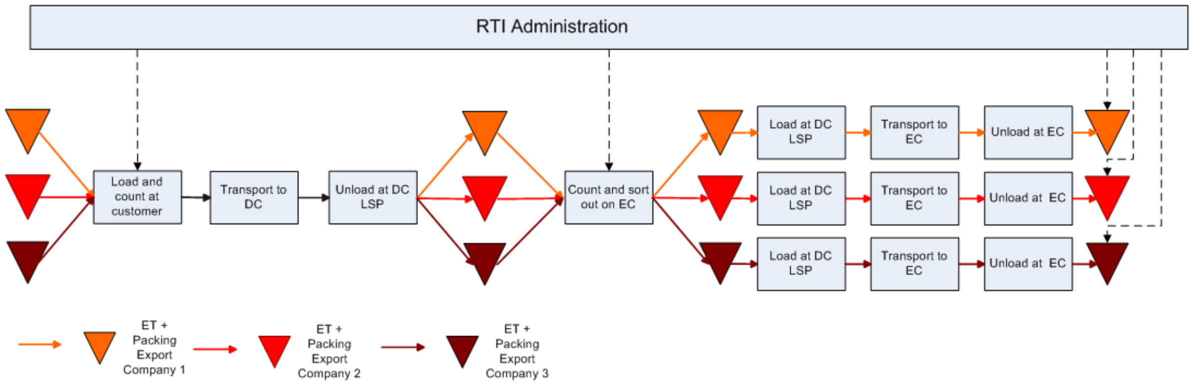


Figure 12 Conceptual model of LSP

4.2 Black box representation

In the following sections step 3 of the of the simulation steps is performed, which consist of the black box representation and data collection. In order to build up the simulation model input variables are needed. There can be distinguished two types of input variables, these are the following;

- Environmental variables: Variables which can't be modified and that are a result of the environment of the system.
- Control variables: Variables which can be controlled or changed.

In Figure 13 and Figure 14 the black box representations of the model for the EC and the LSP are shown. In Appendix E more detailed black box representations of the simulation models are shown. These models are used to construct both models in the simulation software package.

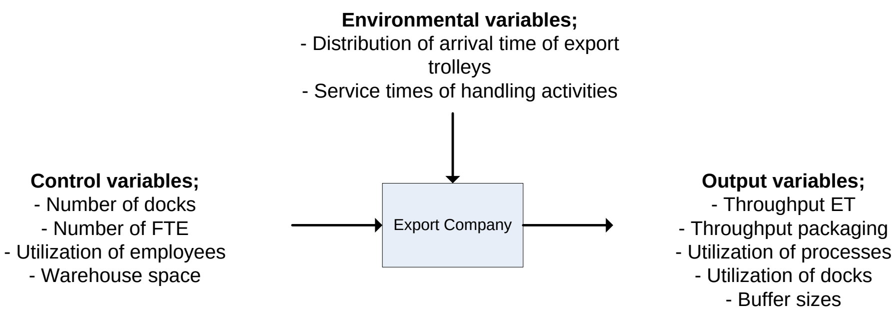


Figure 13 Black box representation of EC

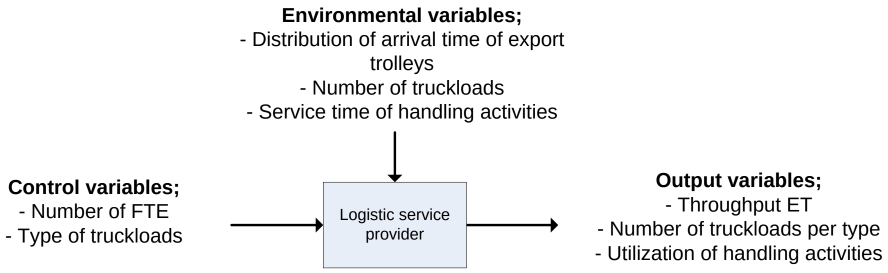


Figure 14 Black box representation of LSP

4.3 Performance indicators and data analysis

The current return logistical process of empty RTI's is quantified based on several performance indicators. These performance indicators are subdivided into indicators specific for the EC and indicators for the LSP. In the following sections, more in detail is explained how every performance indicator is defined.

Data of input variables is gathered and analyzed, the data is needed for three purposes: for building the conceptual model, for validating the model, and for performing experiments with the validated model (Sargent, 2005). In a simulation project, data is usually required to build the simulation model, to set the initial level of various factors in the model, and also to validate the model once built. Data usually falls into one of three categories:

1. Available
2. Not Available, but Collectable
3. Not Available and Not Collectable

In order to deal with the third category, the data may need to be estimated. The data can be estimated by using the experience of people who are familiar with the operation and by referring to manufacturers' specifications (Mehta, 2000). Input data can be collected based on conversations, observations, theory and intuition. These data and viewpoints are discussed with people who understand the process, also on regular bases meetings are scheduled with the manager of the RTI process of the EC. First the performance indicators and data of the LSP is treated and in the section following the ones of the EC. Formulas for the calculations can be found in Appendix F.
Several performance indicators are used to measure the process at both the EC and LSP. The performance indicators are based on the cost figures indicated by (Kroon & Vrijens, 1995). As described by the authors these consist of distribution costs, collection costs, relocation costs, and the fixed costs of the depot.

4.3.1 Performance indicators and data for EC

Several performance indicators are used to measure the process at the EC, these are explained more in detail below. The performance indicators consists of the following; m² of warehouse capacity, output of export trolleys, output of FH trolleys with packaging, number of FTE at warehouse, transport costs, salary cost, warehouse cost, total cost per year, cost per ET movement. The input variables consist of; number of incoming ET's, type of truckloads. First the input variables are discussed followed by the performance indicators. The equations to calculate the indicators not explained below can be found in Appendix F.

Input variables

Number of incoming export trolleys: As described by Kroon & Vrijens (1995) necessary input data into the model is data representing the expected number of yearly container/export trolley movements from the possible senders (S) to the possible recipients (r). Within the scope of the research the empty RTI flow starts when customers send the RTI back toward the EC, so the senders represent the customer and recipients are the EC's. Data of export trolley movements is made available by the example company. The data shows the number of export trolleys which are returned weekly at this specific company. Graph 1 shows the weekly incoming amount of ET's.

By making use of the statistical software program 'Statgraphics centurion' the distribution of the data is determined. The goodness of fit test indicated a gamma distribution, which is shown in Appendix H. The distribution has an of scale (r) …… and an shape (λ) of ……. The mean and the standard deviation can be calculated by the following formulas

Mean; $\mu = r/\lambda$, = ……… ET/week

standard deviation; $\sigma = \sqrt{r/\lambda^2}$ = ……..ET/week

At the example company a total of 4500 ET's are in use of which 1500 operational are used. The export trolleys have an average cycle time of 16 days (Handiger omgaan met bloemenexportkarren, TNO, 2011). The cost of the ET process is calculated per export trolley moving through the process.

Confidential

Graph 1 Export trolleys 2011

Type of incoming truckloads: ET's trolleys are transported by different LSP's, data of all freights in 2011 are analyzed based on LSP (see Appendix G). This analysis shows that 20% of the LSP's are responsible for 80% of all ET movements. These 20% of LSP's visit the EC several times a week, ranging from one time a week up until four times. Based on this data it is assumed that 20% of the incoming truckloads are fully loaded with a capacity of 34 ET's, 40% of the truckloads loaded with 20 ET's and 40% loaded with 10 ET's, see Table 4. These different truckloads have different unloading times which influence the unloading process at the EC.

Performance indicators

M² of warehouse capacity: The square meters of warehouse capacity is an indicator for the current process. The warehouse capacity is needed for unloading, processing of export trolleys and packing, also extra stock of export trolleys have to be stored in the warehouse.

The current process has an cross-dock surface of 180 m^2 and an process area of equal size. Every export company organizes the processing and storage of RTI's in an different way, so the assumption is made that for an amount of 24.500 incoming ET's per year a total warehouse capacity of 360m² is necessary.

The number of docks is incorporated in the m² of warehouse capacity needed. The utilization of the loading docks is an important indicator for the process. At the current process of the example company three docks are used for (un)-loading of empty RTI. Peak moments are normal at the docks from 10:00 – 14:00, this is due to the fact that LSP's want to unload empty RTI's before loading of full ET. The utilization of the docks is difficult to measure due to usage of these docks for unloading of other RTI's. By making use of the simulation program this utilization is will be displayed more in detail.

Output of export trolleys: The number of export trolleys is an indicator for the performance of the process. Export trolleys leave the RTI process if they are loaded again with floricultural products, or if they are stored at the warehouse .

Output of FH trolleys with empty packaging: As explained before the empty packaging is stacked onto FH trolleys, these trolleys are transported back towards FH. A full truckload for transport toward FH consists of 34 FHT, the hourly rate is €75. The average cost per truckload, which incorporates loading, transport to FH and unloading is €120. The trucks are normally not fully utilized, but loaded with an average amount of 30 FHT. The average transport cost per FHT is €4,-.

Number of FTE needed: As described by Mollenkopf et al. (2005) the labor cost of a reusable container system varies because each system requires a different set of activities. The total cost are based on the handling times of the RTI's at each handling procedure. The number of FTE needed at the process of the EC is determined based on the handling activities described in the following sections. No data of process times were available, in order to retrieve the data which is necessary to analyze the process, measurements within the process are conducted. The number of measurement per handling procedure within the specified error range are calculated within a 95% confidence interval with the formula 3.1. The margin of error and sample sizes per variable are shown in Table 2.

$$n = \left[\frac{z_{\alpha/2}.\sigma}{E}\right] \tag{3.1}$$

n = sample size
E = margin of error
$z_{\alpha/2}$ = critical value = 1,96
σ = standard deviation of population

	handling activity	variable	unit	deviation	mean	σ	E (sec.)	n
EC	transfer	t	sec./ET	normal	49	7,5	5	9
	un-stacking	us	sec./ET	normal	221	67	40	11
	stacking	s_{fh}	sec./FHT	normal	222	74	50	9
	nesting	nt	sec./4ET's	normal	802	24	30	3

Table 2 Handling times at EC

Calculations for the handling activities in the processes are explained in the following sections, formulas can be found in Appendix F. In order to determine the deviations of the handling procedures, the data has been analyzed with 'Stratgraphics Centurion', results can be found in Appendix H. The type of handling activities with variables, durations and deviations are shown in Table 2.

Transfer time: At the example company export trolleys loaded with packaging are transferred towards an area where the ET are un-stacked of packing and nested. The transfer time per export trolley is measured and the data is analyzed, see Appendix H.1.

Un-stacking of packaging: Packing is un-stacked from export trolleys at the processing area of the EC. The un-stacking time per export trolley is measured and the data is analyzed, see appendix H.2.

Stacking of packaging on FH trolleys: The empty packaging is stacked per type on FH trolleys, afterwards these trolleys are transported towards FH. The total handling time per stacked FHT is measured and the data is analyzed, see appendix H.3

Nesting of export trolleys: Export trolleys which are not nested are nested in the processing area. This process incorporates breaking up export trolleys, which consist of taking out the three trays and take of the 3 sides. Three of these un-assembled trolleys are than placed into one export trolley. Nesting times are measured and this data is analyzed, see appendix H.4

4.3.2 Performance indicators and input data for LSP

Several performance indicators are used to measure the process at the LSP, also input is determined. In the sections below these performance indicators and input data is explained more in detail. These indicators are based on the indicators described by Mollenkopf et al. (2005) and by Kroon & Vrijens (1995). The performance indicators consist of the following; number of truck movements, transport cost, number of FTE at cross-dock, salary cost, output of export trolleys, cost per year and cost per ET movement. The input variable is; number of incoming ET's. The equations to calculate the indicators not explained below can be found in Appendix F. First the input variable is discussed, followed by the performance indicators.

Input variables

Number of incoming export trolleys: As described by Kroon & Vrijens (1995) necessary input data into the model is data representing the expected number of yearly container/export trolley movements. Because of no availability of data at the LSP it is assumed that ET's arrive at the cross-dock of the LSP with the same deviation as at the EC. In practice this will be different, but because the data is not available and cannot be gathered this assumption is made. ET's arrive with full truckloads at the cross-dock of the LSP, which consist of 34 ET's.

Performance indicators

Number of truck movements: The number of EC's served by the LSP for auction location Aalsmeer is assumed to be six in the simulation model. For these EC's amounts of ET movements per year are estimated based on turnover information. Because EC's make use of several LSP's an estimation of the number of ET movements by the specific LSP has to be made. An analysis of the incoming transport data of ET is made, the results are shown in Appendix G. Here can be seen that the example company is responsible for 22% of all ET movements. In the simulation the assumption is made that the LSP transports 22% of all ET movements for these six EC's. In Table 3 the amounts of ET's transported by the LSP included in the simulation are shown.

	average turnover	number of ET's/year	ET transported by LSP
EC1	€63.529.237	49.380	29.600
EC2	€22.689.011	24.690	5.300
EC3	€22.689.011	24.690	5.300
EC4	€22.689.011	24.690	5.300
EC5	€14.747.857	18.518	3.500
EC6	€14.747.857	18.518	3.500

Table 3 Sizes of EC's included in simulation

Transport costs: As indicated by Mollenkopf et al. (2005) transportation cost is a performance indicator of the RTI system. In order to determine the transport cost the number of truck movements has to be determined. As indicated by the RTI manager at the LSP, 40% of the total truckloads per year from the cross-dock towards the EC consists of trolleys of three EC's, 40% of two EC's and the other 20% are freights with ET's of one EC. All truckloads are assumed to be loaded with a amount of 34 ET's. The type of truckloads is subdivided into three types, these are shown in Table 4. The actual number of truckloads per type is given as output variable in the simulation model. As indicated by (Mollenkopf et al., 2005) the transport cost depends on the number of stops. At freight type 1, three stops are made, type 2 two stops and type 3 one stop is made for unloading. In the analysis the transport cost are based on the specified type of freights with determined (un)loading times and transport times between the cross-dock of the LSP and the EC, and transport times between several EC's.

v	ρ	R	λ (%)	UT (min.)	φ (min.)
1	0,3	10	40	20	20
2	0,6	20	40	15	20
3	1	34	20	10	0

Table 4 Truckload variables

v = truckload type
ρ = load factor
R = number of export trolleys per EC, total load consists of 34 export trolleys
λ = percentage of total truckloads per year
UT = unloading time at EC per truckload type
φ = transport time between two export companies

Transport cost are calculated based on a calculation for transport cost from the cross-dock of the EC towards the EC obtained from Transport and Logistiek Nederland (TLN). Transport costs can be addressed per driven kilometer or by a hourly rate. For transport from the LSP toward the EC a price per kilometer is used, for transport at the auction location the hourly rate is used.The following costs prices are calculated, see Appendix I for detailed cost calculation.
p = transport cost per kilometer; €1.22.
TC_h = transport cost per hour; €50,78.

Number of FTE at cross-dock: As described by Mollenkopf et al. (2005) the labor cost of a reusable container system varies because each system requires a different set of activities. The total cost are based on the handling times of the RTI's at each handling procedure. The number of FTE needed at the cross-dock of the LSP is determined based on the handling activities described in the following sections. Because of no availability of data from the processing times, and no options to measure data, assumptions of the process times are made. These deviation and times are discussed with an expert of the VGB who is known with the logistical processes, in order to get reliable assumptions. These assumptions are also made on an interview with the RTI manager of the LSP. The processes and calculations of handling times are explained in the following sections, the formulas can be found in Appendix F . The variables with times and deviations are shown in Table 5.

	handling activity	variable	unit	deviation	mean	SD
LSP	docking	d	sec./TL	normal	300	180
	Loading at LSP	l	sec./ET	normal	900	300
	unloading at LSP	u	sec./TL	normal	1200	300
	sorting	s	sec./ET	normal	300	120
	counting	c	sec./ET	normal	300	120

Table 5 Handling times at LSP

Loading time: The total loading time is divided by two, based on the assumption that unloading takes place by the truck driver and one warehouse employee.

Unloading time: The time is divided by 2 based on the assumption that the truck drivers and one warehouse employee unload trolleys. Unloading times are assumed and validated based on opinions of experts.

Sorting : Export trolleys have to be sorted out at the cross-dock of the LSP. These sorting times are assumed and validated based on opinions of experts.

Counting : At the cross-dock of the LSP every ET is counted with the number of packing included. This is done to avoid expensive mistakes due to the fact of high deposit fees on packaging and ET's.

4.4 Summary of model development

In this chapter the conceptual models, black box representation and the performance indicators and data analysis is discussed. These aspects are all of importance in order to build up the simulation model. In the conceptual model section the scope, level of detail, assumptions and simplification are determined. The conceptual model functions as a road map in building of the actual simulation model. It describes the different activities, stock points and control moments within the process.
The black box representation shows how input is given in the model, and which variables are incorporated. Also the output variables are displayed in more detail. Data of input variables is gathered and analyzed, the data is needed for three purposes: for building the conceptual model, for validating the model, and for performing experiments with the validated model. Determined on this model development section the actual simulation model is build in the software package 'Enterprise Dynamics'.

5. Analysis of current situation

In the previous chapter the development of both models for the EC and LSP is described. In this chapter the performance of the current RTI processes at the EC and LSP is described. In this chapter step 4 of the simulation steps is performed, which is based on the model development in previous chapter. The simulation model is build in the simulation software program 'Enterprise Dynamics', see Figure 15 for a snapshot of the software program. The first section, which is 5.1 describes the simulation models verification and validation, which is simulation step 5. In section 5.2 and 5.3 the simulation output is analyzed. From the results of the simulation output and incorporated calculations, the performance and cost of both processes is shown, which is step 6 of the simulation steps.

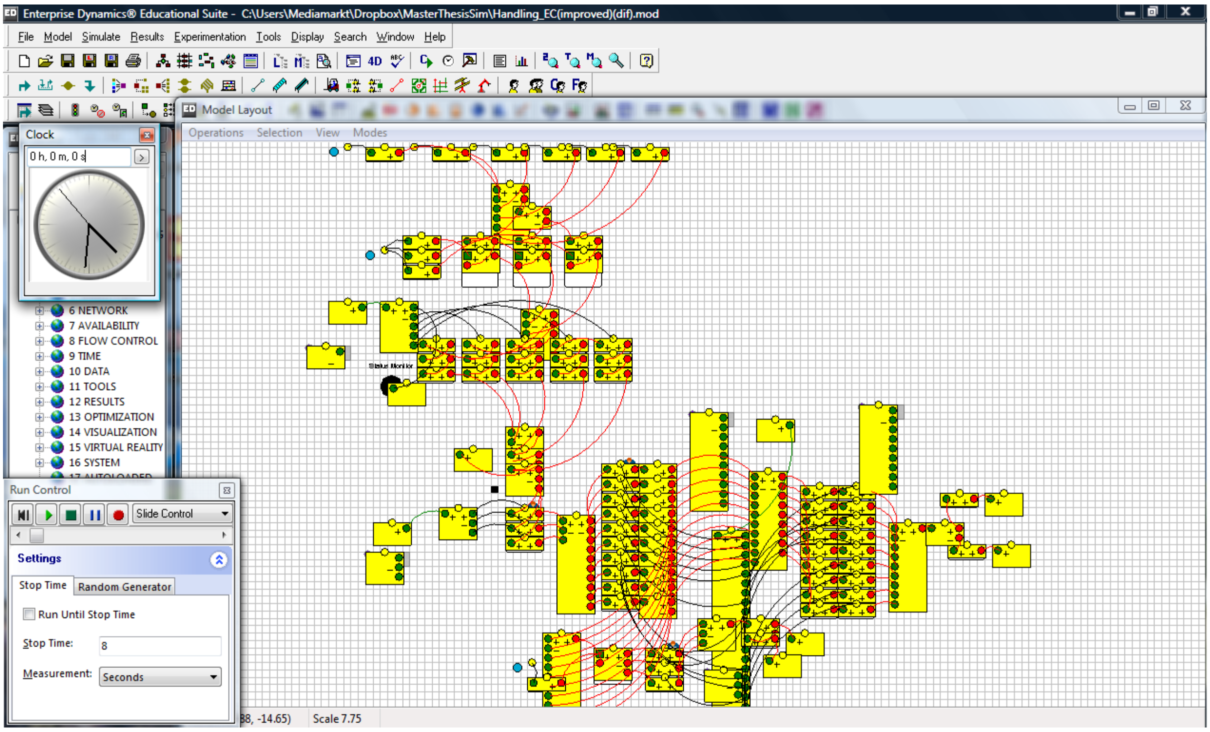


Figure 15 Snapshot Enterprise Dynamics, EC model

5.1 Simulation model verification and validation

One of the most difficult problems facing a simulation analysis is that of trying to determine whether a simulation model is an accurate representation of the actual system being studied, i.e., whether the model is valid (Law et al., 1991). As described by Banks (1999) Verification concerns the operational model. Is it performing properly? Validation is the determination that the conceptual model is an accurate representation of the real system. Can the model be substituted for the real system for the purposes of experimentation?

Verification

Model verification is defined as ensuring that the computer program of the computerized model and its implementation are correct (Sargent, 2005). Enterprise dynamics is a widely used and specialized software program, which is mainly designed for logistic and production simulation, verification is already performed. Small verification steps in the software are made by designing simple layouts in order to check if output is as expected.

Validation

Validation of the model should be performed on completion of the model. This 'validation' should test the overall accuracy of the model and the ability to meet the project objectives (Mehta, 2000). As described by (Sargent, 2005) a combination of techniques is generally used. In the following sections the performed validation of the EC and the LSP is described.

Validation of EC model:

Historical data validation is described by Sargent (2005) as testing (test) whether the model behaves as the system does. Mehta (2000) described historical data validation as an ideal way to validate the simulation model is to compare its output to that of the existing system. The simulation model is validated based on comparison of the amount of FHT leaving the system compared to historical data of 2011. In Table 6 historical data of number of outgoing FH trolleys with packaging is checked versus output of FH trolleys of the simulation model. The difference between the historical data and the simulation data is 2,3% which indicates an accurate output of the simulation model.

	FHT/year
Historical data	6528
Simulation data	6379
Difference	2,3%

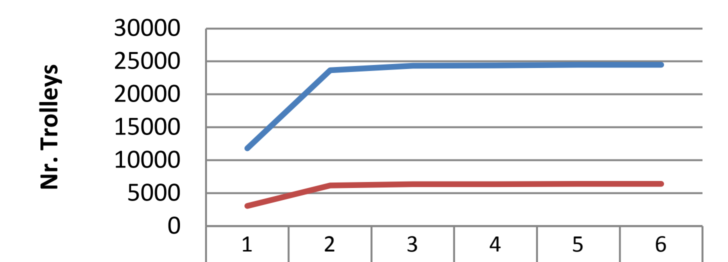
Table 6 Historical data validation

Face validity is described by Sargent (2005) as asking individuals knowledgeable about the system whether the model and/or its behavior are reasonable. This testing of face validity is performed by talking with experts about the simulation and the generated output. The conceptual model of the process at the EC is discussed with an employees of the VGB and with the manager of the RTI process at the EC. These are familiar with the processes at the EC's, and are capable of validating the conceptual model. Assumptions and simplifications of the simulation are discussed with experts as well, this is done with an employee of the VGB and with the manager of the RTI process at the EC. As indicated by these experts the simulation model performs in the same way as the actual process, based on output variables and FTE needed for the handling activities.
No output data of the process at the EC is available or could be measured, as indicated by experts all ET's which enter the EC process have to leave the process for storage or to be reused at the supply chain. In Table 7 the average input of ET for 2011 is shown with the output of ET per year in the simulation. Based on opinions of experts the ET process simulation can handle approximately the same amount of ET's per year, so no large buffers of ET's are build up in the simulation model.

	ET/year
average 2011	24690
Simulation output	24368
Difference	1,3%

Table 7 Export trolley output

By holding conversations with experts the number of FTE's needed for the processing of RTI's is determined on 3 FTE for the processing and 1FTE controlling. In the actual situation also 1 FTE is assigned with administration, this is not incorporated in the simulation. By conducting several runs with multiple amounts of FTE, assigned with processing of packaging output is generated of the number of ET and FHT. In Graph 2 the output of ET and FH is plotted against the number of FTE on the horizontal axes. The output amount of trolleys is stabilizing at a number of 3 FTE, if more employees are added in the simulation model no substantial amount of extra output is generated. The total number of FTE needed for the handling procedures at the EC process is determined on 3 in the simulation. This amount of FTE is also needed in the actual process, which is indicated by the manager of the RTI process. Based on face validity the conclusion is made that the simulation is a good representation of the actual process.



	1	2	3	4	5	6
ET/Year	11813	23668	24368	24416	24472	24486
FHT/year	3093	6200	6379	6387	6410	6415

Graph 2 Simulation trolley output based on nr. of FTE

Validation of LSP model: Historical data validation is not applicable for the process of the LSP, this because of the fact that no data is available at the LSP. Data of the LSP is mainly documented on paper, and is therefore labor intensive to analyze. Also the gathering of data is an issue at LSP's, because of the fact that transportation is their core business, and giving insight in all cost aspects can be an sensitive issue. Although an estimation of the number of truckloads towards auction location Aalsmeer from the cross-dock is given by the RTI manager at the LSP. On average 31 full truckloads towards Aalsmeer take place every week, in the simulation the average number of truckloads per week is 31,6. The model is validated based on face validity, this is done by holding conversations with experts of the VGB. Numbers of truckloads and processing times are discussed with the focus on reliable results.
Extreme condition validation is performed by giving extreme input variables at the simulation model. An analysis is made if the model gives unlikely combination of levels of factors in the system. Number of truckloads and buffer sizes in the simulation model are monitored in order to see if unlikely outputs are given. If the number of FTE's at the cross-dock is set on five and the ET amount is increased, high buffer sizes build up at the cross-dock. When the number of ET is decreased the utilization of the FTE's is reduced, which indicates an overcapacity of FTE's.

5.2 Simulation parameters

A simulation experiment may be terminating or non-terminating, depending on whether there is an obvious way for determining the replication length (Law et al., 1991). The simulation experiment in this research is an non-terminating simulation, which means that it has no natural event to specify the length of a run. As described by Law et al. (1991) this often occurs when a new system is designed or changing an existing one. The following simulation parameters have to be determined;

- *duration of the warm-up period*
- *length of a replication*
- *number of replications*

5.2.1 Warm up period simulation

The warm up period is described as the amount of time that a model needs to run before statistical data collection begins. It is the part of the simulation until the point in time that outcome seems to be stable (steady-state). The warm up period can be estimated through experimentations with moving averages (flow times, throughput) and time series (WIP: work in process, buffer sizes) (Mehta, 2000). If the level of WIP is plotted on a graph, the plot rises steeply at the start of the model run and gradually reaches a relatively stable level representing the 'typical' condition. The time taken by the plot to get stable can be recorded as being the system's warm-up period (Law et al., 1991).

Warm up period EC
The warm up period is determined based on the stabilization of the buffer sizes. In Appendix J graphs are shown of the buffer sizes at the cross-dock and the process place of the exporting company. These graphs indicated that the buffers, which are the cross-dock and the process place fill up within 7 days, and stay stable in the weeks after. It should be mentioned that stochastic processes for most real systems do not have steady-state distributions, since the characteristics of the system change over time (Law et al., 1991).

Warm up period LSP
In order to determine the warm up period for the simulation of the LSP, the buffer sizes on the cross-dock is plotted in a graph, this graph is shown in Appendix J. On the vertical axes the number of export trolleys are represented and on the horizontal axes the time in seconds. From this graph can be seen that the buffer size starts to stabilize after 1.382.400 seconds, which is 16 days. As described by (Mehta, 2000) it is always better to have a warm-up period that is too long rather than one that is too short. For this reason a warm up period of 21 days is chosen for the simulation of the process of the LSP.

5.2.2 Replication length

Once the model has warmed up, run length of the model has to be decided. One method for deciding this is inspecting the random numbers sampled. As a rule of thumb, a minimum of 15 to 20 random numbers from each random number stream should be used in the model (Mehta, 2000). Because of the fact that peak moments are incorporated in the ET data, the replication length will be set on one year plus the determined warm up period.

5.2.3 Number of replications

Replication is defined as executing the same model a number of times, but with different random numbers in each run. As a rule of thumb, a modeler should always perform at least three to five replications for each experiment. Burghout (2004) concludes from the literature that usually a number of five to ten replications are taken for each experiment. Simulation software Enterprise Dynamics used in the research offers the experimentation wizard option. This can be used to setup the right amount of replications, and confidence intervals on the results of the simulation. The number of replications based on literature is set on 5, with an confidence interval of 95%.

5.3 Performance of the current process

In this section the output of the simulations results are analyzed. Both processes are analyzed and serve as the base model. The base model is a hypothetical complete explanation of the real system, which is capable of producing all possible input-output behaviors (Robinson, 2007). From the results of the simulation of the base case the costs of the current processes are analyzed. In this section the results of the simulation are shown. Based on the simulation output a cost calculation is made, which determines the performance of the current process. In the first section the process at the EC is analyzed, which is followed up by the analysis of the LSP process. In Appendix K the simulation outputs are shown.

5.3.1 Performance of RTI process of EC

In Figure 16 the head of expenses are shown of the current RTI process at the EC. The costs consist of salary of the employees, warehousing, transport and trolley costs. As can be seen trolley expenses, warehouse expenses and salary cost make up the biggest cost factor, followed up by transport cost. Transport cost only account for five percent of the total cost. At the example company export trolley expenses are substantial high because of the fact that they have a large amount of trolleys namely 4500, of which 1500 are operationally used. At the cost calculation, depreciation of the trolleys is taken into account at the price of new trolleys, which is €260 . For a detailed cost allocation on depreciations of ET's more information is needed on the current age of the export trolley stock. For this base model the depreciation cost are not of high importance because of the fact this is different for every EC, and not comparable in the optimized situation.

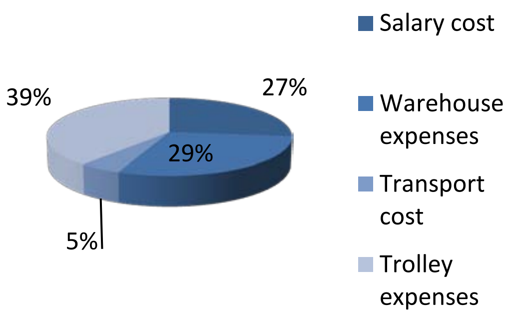


Figure 16 Cost allocation of ET process at EC.

As can be seen in Figure 16 warehousing cost are high at the example company (29% of total), this is because they have the availability of an extra warehouse besides the main location. Other export companies normally organize the RTI management on their main location, which incorporates different inefficiencies. The third head of expenditure are salary costs, which accounts for 27% of the total costs of the RTI process at the EC. Transport costs account for the smallest part, namely 5% of the total cost.

In Table 8 the detailed cost allocation is shown. Based on the predefined utilization rate (50%), the output of the simulation resulted a minimum of 3 FTE for handling procedures, 1 FTE as team leader and 1FTE administration. The total salary cost per year are determined on €135.000. The warehousing costs are calculated on assumptions of the m² at the existing situation, the cost per m² is determined on €84 (Handiger omgaan met bloemenexportkarren, TNO, 2011). Because of the fact that the example company has an extra warehouse capacity for RTI's, the area used for processing is a good representation of the area needed based on the amount of incoming RTI's. The EC's has the availability of three docks with an total area of 180m². Storage capacity is calculated based on the total area needed after trolleys are nested. Transport costs consists of truckloads from the EC towards FH with FHT's loaded with packing. At the current situation the EC pays an amount of €125,- per full truckload. The truckload have an maximum capacity of 34 FHT, on average the trucks are loaded with 30 FHT, which results in a total transport cost per year of €25.516. The total cost of the RTI process at the EC, within the defined scope is €505.839 per year. The simulation resulted an output of 24.416 ET's per year, and 6380 FH trolleys loaded with packaging per year. The cost per rotating export trolley in the supply process is calculated at a cost of €20.72/ET/year.

Salary		nr. FTE	cost/FTE		cost
	warehouse	3	€25.000		€75.000
	team leader	1	€30.000		€30.000
	administration	1	€30.000		€30.000
				total	€135.000
warehouse		m²	cost/m²/year		cost
	Cross-dock	180	€84		€15.120
	processing area	180	€84		€15.120
	docks	390	€84		€32.760
	storage	1.020	€84		€85.680
				total	€148.680
Transport		FHT/year	cost/FHT		cost
FHT	to FH	6.379	€4		€25.516
				total	€25.516
Trolleys		FHT/year	cost/FHT		
	repair	-	-		€10.000
	loss	75	€260		€19.500
		nr. trolleys	value	period years	depreciation/year
	depreciation	4.500	€1.170.000	7	€167.143
				total	€196.643

Total cost	**€505.839**
number of ET's	**24.416**
cost/ET	**€20,72**

Table 8 Detailed cost allocation of RTI process at EC, base case

In order to compare the base model with improved situations, the trolley costs expenses will be left out of scope, as described before this is because of the fact that every EC has different amounts of ET's with including safety stocks. Also these means of transport have different age's, which results in other depreciation costs. In Figure 17 the cost allocation of the RTI process without trolley expenses is displayed. In Table 9 the total cost per year of the ET process without trolley expenses is shown, the cost per ET movement is €12,66

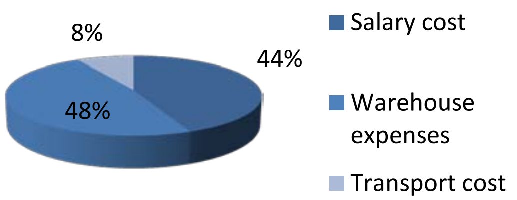


Figure 17 Cost allocation at EC without trolley expenses , base case.

Total cost without trolley expenses/year	**€309.196**
number of ET's/year	**24.416**
cost/ET	**€12,66**

Table 9 cost of RTI process without trolley expenses at EC

Cost current process at LSP

In Table 10 the detailed cost allocation of the RTI process is shown, formulas used for the calculations can be found in Appendix F. The head of expenditures consist of transport, handling and equipment/ salary costs. As can be seen in Figure 18 transport costs are the biggest expenses for the RTI process at the LSP.

The transport costs consists of the transport from the cross-dock to the EC, and transport between several EC's when RTI's of multiple EC's are transported. At the example company the transport costs from the cross-dock towards the EC are relatively high because the cross-dock is located in the south of the Netherlands. For other LSP's which are located more close to the auction location the transport cost will decline.

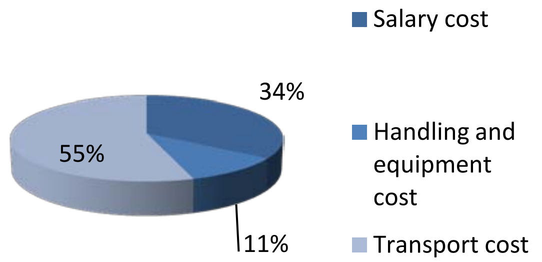


Figure 18 Cost allocation of RTI process at LSP, base case

Salary cost account for the second biggest head of expenditure, at the current process four FTE are assigned with unloading, sorting, and counting of RTI's. Also one team leader and one employee for administration are assigned to the process. Handling and equipment cost consist of the expenses made by loading and unloading of RTI's. In this head of expenditure equipments cost of the truck with driver are incorporated. These costs are calculated based on the hourly rate which is determined in section 4.3.2.
The total cost of the RTI process for the LSP within the defined scope and without warehouse expenses is determined on €465.321 per year. These costs are based on the assumption that the LSP servers six customers (EC's) auction location Aalsmeer, with turnovers as described in Table 10, of which 20% is transported by the specific LSP. The cost per export trolley for the LSP within the defined scope is €8,32.

	average turnover	number of ET's/year	ET transported by LSP
EC1	€63.529.237	49.380	29.600
EC2	€22.689.011	24.690	5.300
EC3	€22.689.011	24.690	5.300
EC4	€22.689.011	24.690	5.300
EC5	€14.747.857	18.518	3.500
EC6	€14.747.857	18.518	3.500

Table 10 ET turnover amounts in simulation

Salary		nr.	cost/FTE		cost
FTE at cross-dock	employees	4	€25.000		€100.000
	team leader	1	€30.000		€30.000
	administration	1	€30.000		€30.000
				Total	**€160.000**
Handling and equipment costs	v	nr.	total UT (hr)	cost/hr	cost
Loading	1,2,3,	1.645	206	€51	€10.487
Unloading	1	323	108	€51	€5.491
	2	659	330	€51	€16.805
	3	663	332	€51	€16.907
				Total	**€49.689**
Transport	v	nr.	dij	cost/km	cost/year
from LSP to auction location	1,2,3,	1.645	117	€1,22	€234.807
	v	nr.	total UT (hr)	cost/hr	cost
transport between EC's	1	-	-		-
	2	612	204	€51	€10.404
	3	613	204	€51	€10.421
				Total	**€255.632**

Total cost	**€465.321**
number of ET's	**55.930**
cost/ET	**€8,32**

Table 11 Detailed cost allocation RTI process at LSP

5.4 Summary of analysis current situations

The reverse flow of empty RTI is a process which is quit complex to model, this because of the fact that many export companies and logistic service providers organize their RTI process in a different way or setting. Some export companies have an extra warehouse facility ,while the majority executes the handling and storage of RTI's within their main warehouse. In Table 12 an overview of the head of expenses is shown for both the EC as well as the LSP. For the EC the cost are shown for the analysis with export trolley expenses and without. The example company ……………… at Aalsmeer has a yearly incoming amount of export trolleys of 24.416 and is of average size compared to other export companies at Aalsmeer. The analyzed company has the availability of an extra warehouse for RTI processing. The handling procedures within this facility are analyzed, which results process models with incorporated processing times. In order to determine the cost and throughput of the existing process at the EC and LSP, a simulation analysis is performed. The head of expenditures for the export company consist of salary , warehousing, transport and trolley expenses. Results from the simulation output and calculations indicate a yearly cost of €505.839 with an export trolley throughput of 24.416. This results a cost rate per export trolley movement of €20,72. In order to compare the improvement of the process based on new scenario's, trolley expenses are left out. This because of the fact that every export company has other amounts, quality and ages of export trolley inventory. The cost per year at the example company without trolley expenses is determined on €309.196, which results in a cost rate per export trolley of €12,66.

In order to analyze the RTI process at the LSP an example company in …………. has been analyzed which is …………. Because of the fact that minimum data is available at this company, the simulation analysis is mainly based on assumed data, which has been validated by experts who are familiar with the process. In the development of the model it is assumed that the LSP serves six customers at auction location Aalsmeer of different turnover sizes. The starting point of the process analysis is set at the moment export trolleys are unloaded at the cross-dock in …………. The head of expenditures for the LSP consist of salary, handling and equipment, and transport cost. Results from the simulation output and calculations indicate a yearly cost of €465.321 with an export trolley throughput of 55.930. This results a cost rate per export trolley movement of €8,32. Although the RTI processes is differently organized or of different scale at each LSP or EC, a indication of the current cost of the process can be given. Established on this base case model improvements of the existing process can be compared to these indications.

RTI process at EC	current situation with trolley expenses	current situation, no trolley expenses	**RTI process at LSP**	current situation
Salary cost/year	€135.000	€135.000	Salary cost/year	€160.000
Warehouse expenses/year	€148.680	€148.680	Handling and equipment cost/year	€49.689
Transport cost/year	€25.516	€25.516	Transport cost/year	€255.632
trolley expenses	€196.643	-	-	-
Total cost/year	€505.839	€309.196	**Total cost/year**	€465.321
ET movements/year	24.416	24.416	ET movements/year	55.930
Cost/ET movement	€20,72	€12,66	**Cost/ET movement**	€8,32

Table 12 Summary of cost allocation current situation at EC and LSP

6. Redesign scenario's

In the previous chapter the current RTI process is analyzed, this process will serve as the benchmark model for the improved scenario's. In this section redesign scenario's for the existing RTI process are described, these scenarios are determined on bases of existing literature, previous conducted research by TNO and interviews with experts in the sector. In the first section an overview of the existing literature on RTI management, the following section describes the two redesign scenario's. In section 6.2 and section 6.3 the selected scenario's are described more in detail.

6.1 Literature review

Several authors focused their research on the topic of RTI management. Already in 1996 by Rosenau (1996) the trend was detected that contracts with carriers where made in order to provide third-party logistics service, including container sorting, return and tracking. In this kind of systems, the package users pay a fee for each day of container use.

Design
According to Twede & Clarke (2005) 3PL providers have a growing role in container management. A third party should be able to better manage such assets, minimize the investment and reduce operating costs, since container management is the service provider's core business. Twede & Clarke distinguished three types of 3PLs providing reusable packaging services namely;

- Lead logistics providers,
- Container management companies,
- Container rental companies.

Lead logistics providers (LLP)
Since many firms have already adopted a carrier based LLP as part of their inbound supply chain management efforts, they find that it is a relatively straightforward matter to include package repositioning in these negotiations. In some cases, the carrier only provides return transportation. The LLP is efficient because it has its own network of consolidation facilities and transportation movements, and can coordinate returns with other freight (Wieclaw & Carlson (1997) as referenced in Twede & Clarke (2005)).

Container management companies
These companies, provide a specialized service dealing only with the empty containers, but with no responsibility for inbound transportation of full containers.

Container rental companies
This type of third party company purchases the containers and rents them to users, similar to pallet rental programs. There are two types of rental arrangements.

- In the first, the third party organizes return logistics (or replenishment) and the deposit or credit/ debit system for controlling the containers; the shipper pays the third party for the total service.
- In the second type only containers are rented; logistics and control are the responsibility of the regular members of the distribution channel.

As described by Twede & Clarke (2005) managing a fleet of reusable containers is harder than it looks. Containers are routinely misdirected, inappropriately reused or lost, and they are rarely tracked in system-wide information systems (McKerrow, 1996 as referenced in Twede & Clarke 2005).

Kroon and Vrijens (1995) described a reverse logistic system for returnable containers in the following way. Suppose a sender **s** intends to send goods to a specific recipient **r**, and wants to use returnable containers for packaging these goods. The information and goods flows related to this shipment are represented in Figure 19. First, the sender notifies Agency **A**, of the fact that he wants to use returnable containers (1). Then the agency notifies the logistics service organization (2). Next, the logistics service organization distributes the desired number of containers from the nearest container depot **d1** to the sender (3). After having packed the goods to be sent in the containers, the sender sends the goods to the recipient. This shipment may be handled by the logistics service organization, but it may also be carried out by another carrier (4). After the recipient has received a certain number of containers, he notifies the agency of this fact (5). Next, the logistics service organization is notified by the agency (6). Then the logistics service organization collects the containers from the recipient and takes them to the nearest container depot **d2** (7). Before the containers can be used again, they are cleaned, and, if necessary, also maintained in this container depot (Kroon & Vrijens, 1995).

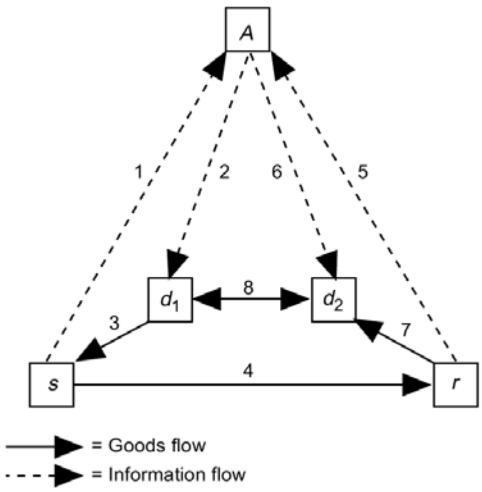


Figure 19 The flow of information and goods (Kroon and Vrijens, 1995).

Kroon & Vrijens pointed up that for the agency the most important questions relate to the number of containers and the appropriate service, distribution, and collection fees. For the logistics service organization the main questions concerns the number of container depots, their locations and the appropriate distribution and collection fees (Kroon & Vrijens, 1995).

Control strategy

According to Lützebauer, as referenced in Kroon and Vrijens (1995) three main types of control strategies exist for RTI systems; (1) *a switch-pool system*, (2) *a transfer system* and (3) *a depot system*.

- In the *switch-pool system*, every participant is allocated a share of the RTI fleet for which the participant is responsible. A switch takes place at every exchange of RTIs, e.g. when loaded RTIs are delivered the recipient gives the sender a corresponding number of empty RTIs in return.
- In the *transfer system*, the sender has full responsibility for tracking, administering, maintaining and storing RTIs, while in the depot system, RTIs are maintained and stored in depots by the central agency. The sender is provided with RTI's from the depot, and after having been transported to the recipient, empty RTIs are collected and returned to the depot.
- *Depot systems*, in this system the containers that are not in use are stored at container depots. From a container depot the sender is provided with the number of containers he needs. After having been transported to the recipient, the empty containers are collected and returned to a container depot.

Here the containers are cleaned and maintained, if necessary. Within this system, Lützebauer again distinguishes two variants:

- Book system. The essence of this system is a detailed control of the flow of containers by the central agency. The sender has an account with the agency. When a number of containers are delivered to the sender, the quantity involved is debited in the sender's account. When the sender sends the containers to a recipient, the quantity involved is credited in the sender's account, and debited in the recipient's. Therefore the sender has to submit to the agency all the necessary data for each shipment, including the name and address of the recipient, and the number of containers involved. This allows the agency to monitor the movements of the containers.
- Deposit system. In this system the sender pays the agency a deposit for every container he uses. The deposit equals at least the value of the containers. The sender debits his recipient for this deposit, who does the same with his recipient, and so on. The moment the containers reach their final destination in the logistic chain, they are collected by the agency. At this point, the agency refunds the deposit to the party from which the containers were collected. The deposit finances loss and theft of the containers. So, a tracking and tracing system to control the flow of containers is unnecessary in this case. Finally the deposit also stimulates the quick return of the containers, so the rate of circulation with be high (Kroon & Vrijens, 1995).

According to Hellstrom & Johansson (2010) the choice of control strategy has a major impact on the investments and operating costs of an RTI system. In the case study conducted in their research they found the following conclusions;

- The switch-pool design would reduce the investment cost in RTI's by almost 34% and the total cost by 25% compared to a base scenario.
- The transfer system could reduce operating costs by approximately 52% and the total costs can be reduced by 35% if tracking data are coupled with the correct managerial action. The 2% cost increase for the tracking system is minor in comparison.

According to Kroon & Vrijens (1995) for designing a good reverse logistics system, a planning process has to be incorporated. Examples of important questions within this planning process, both for the agency and the logistics service organization, are the following:

- How many containers should be available in the system ?
- How many container depots should there be and where should they be located ?
- How should the distribution, collection, and relocation of the containers be organized ?
- What are appropriate service, distribution and collection fees?

Kroon & Vrijens pointed up that for the agency the most important questions relate to the number of containers and the appropriate service, distribution, and collection fees. For the logistics service organization the main questions concerns the number of container depots, their locations and the appropriate distribution and collection fees (Kroon & Vrijens, 1995).

6.2 Scenario 1: Central Depot

In this section the first scenario of the redesign is further explained. For the first scenario based on the literature and interviews with experts in the sector is chosen for the central depot. The central depot scenario is simular to the depot system as described by Kroon & Vrijens (1995). Lützebauer, as referenced in Kroon and Vrijens (1995) describes within the depot system two variants, which are the *book system* and the *deposit system*.

The essence of the *book system* is a detailed control of the flow of containers by the central agency. This variant is not suitable for the floricultural sector because of the fact that giving detailed information about customers and locations is confidential.

The second variant of the *depot system* is the deposit system, at this system the EC's have to pay the agency a deposit for every container in use.

For scenario 1 is chosen for a depot system which makes use of the current inventory of export trolleys of each EC. This decision is based on the high investments already made by the EC's. Some of these have an export trolley stock at a value of €1.200.000. At the central depot scenario design the sender/export company stores its own export trolleys at the depot. So every export company has its own storage area for their specific export trolleys. The depot supplies the EC with the amount of export trolleys needed per day.

Process

At the central depot the same process takes place as at the exporting company, only the scale of the process is extend towards the number of EC's that cooperate in the new process. At this central depot the empty RTI's are unloaded from the trucks, counted, sorted out, unloaded with packing, nested and stored per export company or transported towards the EC. Due to the high purchasing cost of the export trolleys, and deposit fees on the packing, it is important to have a minimal loss rate. The need for an efficient information management system in the new scenario to manage the rotation of RTI's is therefore important as described by the following authors (Kopicki, 1993; Maloney, 1999; Witt, 2000; Randall, 1998 as referenced in Kärkkäinen et al., 2001).

As described in section 3.1 every EC organizes its own RTI process, see Figure 20 for schematic representation. At the central depot scenario several EC's, depending on the number collaborating, organize the RTI process at a bigger scale. In Figure 21 a schematic representation of the central depot scenario is shown. At the top of the figure several LSP's are shown, at these LSP's the export trolleys arrive and are redistributed towards the central depot. From this central depot nested ET's are transported to the EC's owning them, empty packaging is transported on FHT towards SiVePo.

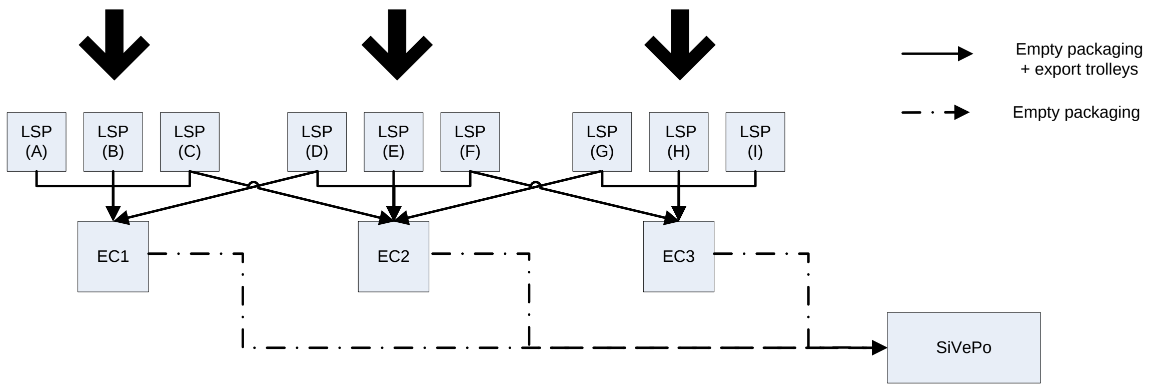


Figure 20 Current situation

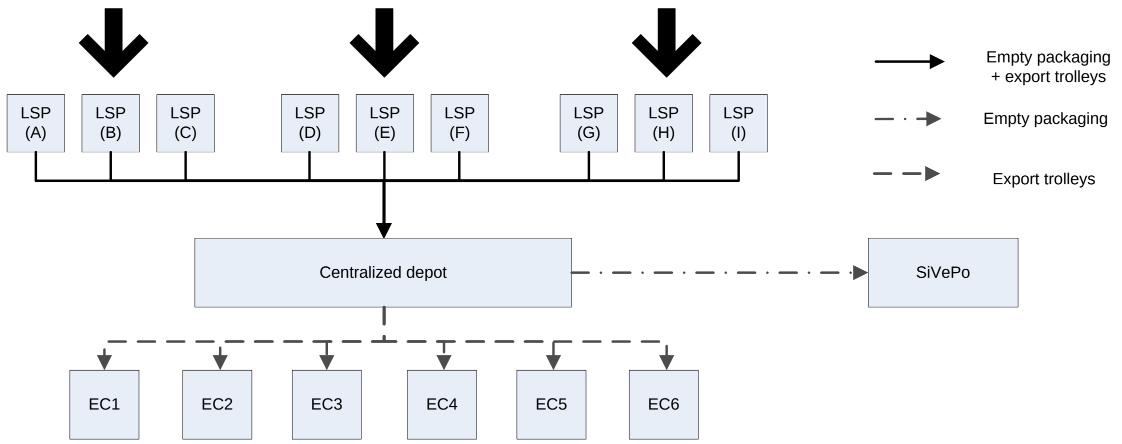


Figure 21 Schematic representation of scenario 1; centralized depot

Improvements for EC

At the central depot scenario several efficiency improvements are applied for the EC, these consist of the following:
Utilization of employees at the base case scenario have an assumed utilization rate of 50%, because of different other parallel tasks at the warehouse. At the central depot scenario employees are assumed to have an utilization rate of 85%. This assumption is made on the fact that the handling procedures for ET's and packaging is the only task of the employees.
At the base case situation 3 docks are available at the example company, at these docks several other products and RTI's have to be (un)-loaded. At the central depot scenario the docks are only used for unloading of ET's and FH trolleys with packaging.
In the current situation FH truckloads consist of an average amount of 30 FHT, the maximum capacity is 34 trolleys. In the new scenario trucks can be fully loaded. The current hourly cost rate at for the transport is €75. Based on high number of truckloads from the centralized depot towards FH, lower hour rates can be arranged. Based on the hourly rate of €50 which is calculated, this rate is substantially lower than the current rate at the example company. Extra transport cost are made at the central depot scenario by the fact that empty ET's have to be transported towards the EC's owning them. At the base case scenario is assumed that this transport is unnecessary, because of ET processing is executed at the main location .

Improvements for LSP

For the LSP several advantages are incorporated which are the following:
When ET's are transported retour towards the central depot only one docking and unloading moment is incorporated in the retour process. At the current situation in 40% of the freights the unloading consist of two unloading moments and one transport action between EC's. 40% of the truckloads consist of three unloading moments and two transport actions between EC's. Unloading of full truckloads at one location is more efficient than unloading in multiple stops, as can be seen in the base case analysis. By unloading at one stop also administration moments per truckload are minimized, because per unload handling RTI's have to be counted and documents have to be signed. At the central depot scenario only one administration and counting moment is incorporated. At the cross-dock of the LSP sorting out of export trolleys can be minimized because the trolleys have to be unloaded at one central point.

6.3 Scenario 2: Pool system

The second scenario is that of the pool system in which still a central depot is used, but which operates as a ET pool system. This pool system has all the improvements as described before in scenario 1, the differences between the both scenarios is that the central depot uses trolleys from EC's. At the pool system an investment is made in a new type of trolley, which is used by all cooperation EC's. The pool system can be designed as a container rental company as described by (Twede & Clarke, 2005). This type of third party company purchases the containers and returns them to users, similar to pallet rental programs. At this type of pool system the logistics and control are the responsibility of the members of the distribution channel, which are the EC's. At the pool system scenario also the processing of empty packaging is performed similar as in scenario 1. The schematic representation is the same as in scenario 1, see Figure 21. This scenario is based on interviews with experts from the sector, to implement this scenario first scenario 1 has to be set up. This pool system requires a big investment in a new type of export trolley. TNO previously conducted a research on the new type of export trolley (Handelsexportkar bloemen, TNO ,2008). All parties involved in the project recognize that the current ET is not the most ideal trolley. Also at the EC, LSP and customer there is a lack of space, so ET's have to be nested but it is quit dangerous and a time consuming process. TNO indicated that the new ET has to be more flexible in use, which consists of easier an higher amount of nesting, and the size of the ET has to be adjusted. The research indicated that a pool system can decrease the administration cost for the EC's, and a possible saving on transportation cost by increasing the efficiency at the LSP. From the conclusions of the research the following pre-conditions of the new ET are indicated;

- 25% reduction in nesting time.
- Nesting of packages consisting of 7 ET's.
- Similar loading capacity of trolley.
- Lifespan > 5 year.

Improvements for EC

At the central depot scenario the same improvements will be incorporated as previously described at scenario 1, because of the fact that the same intern process will be incorporated as at the central depot. The main improvements for the EC will be a reduction in total nesting time by the new type of trolley. This will lead to a lower amount of FTE's needed for the nesting handling procedures. By the higher amount of trolleys per nested package, storage costs can be reduced which lead to lower warehouse costs.

Improvements for LSP

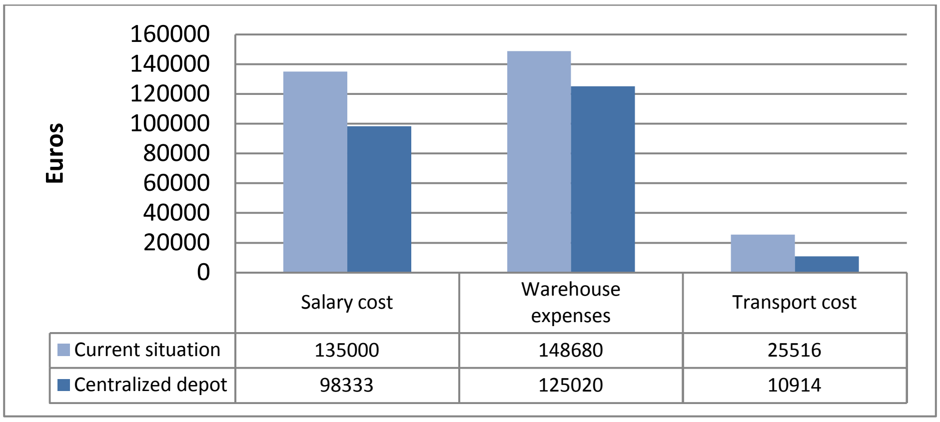
At the central depot scenario the same improvements for the LSP will be incorporated as previously described at scenario 1. The improvements at scenario 2 for the LSP are increasing of the load factor from the cross-dock of the LSP towards the EC. At the base case scenario and the central depot scenario a full truckload is assumed to consist of 34 ET's. Based on the pre-conditions a full truckload is assumed to consist of 38 ET's, this will lead to an decrease of transport cost.

6.4 Performance scenario 1: Central Depot

In this section step 6 of the simulation steps is executed, which are the experiments and results for the central depot scenario. The performances of the RTI processes for both the EC and the LSP is analyzed based on scenario 1, which is the central depot. This analysis is performed based on the simulation models as described in chapter 4. These models have been adjusted to create the situation as shown in Figure 21 chapter 6.2. In order to analyze the performance of the new scenario, the output is compared to the base case scenario. First the process analysis at the EC is treated, followed by the process at the LSP. The results are analyzed based on the head of expenses per year as described in the base case scenario. The improvement of the process is calculated per ET movement. The improvement calculation is based on this indicator because of the fact that ET output is different for both scenario’s.

6.4.1 Results of scenario 1 for EC

In Graph 3 the different head of expenses of the RTI process per EC are shown for scenario 1. In the graph the costs of the current situation (base case) and the centralized depot (scenario 1) are shown. The costs at the central depot scenario are divided per EC, at the simulation run is chosen for 6 EC’s of equal size, all with a total amount of approximately 24.300 ET’s per year. The input variable of ET’s per EC is determined on an average of 442 per week with a standard deviation of 94 ET’s A detailed cost allocation and performance indicators of the RTI process for scenario 1 can be found in appendix L.1. In the cost calculation assumptions are made for the FTE needed for administration and the necessary warehouse capacity. Both these cost factors are multiplied based on the scale increasing of the existing situation. Due to the fact that the example companies has an extra warehouse capacity for RTI storage and processing, reliable indications can be given on these factors.
As can be seen in Graph 3 salary cost decline with an amount of €36.667 per year, which is 27% of the base case salary cost. This saving is realized due improvement of the RTI process by increasing the scale of the process and the utilization rate of employees.
Warehouse expenses decrease per year with an amount of €23.660, which accounts for 16% of the base case warehouse expenses. This cost reduction is caused by higher utilization of the loading docks at the warehouse. The simulation results showed an capacity of five loading docks for an central depot of this scale.
The transport cost for the centralized depot decreased with €14.602 per year, which accounts for 57% of the base case transport costs. This saving is mainly caused by increasing of the loading factor of freights with FHT toward FH. Also the assumed reduction in hourly rate for transport cost leads to an significant saving.



Graph 3 Analysis of scenario 1, cost comparison RTI process at EC

In Table 13 the savings are shown based on scenario 1 compared to the base case scenario at the EC. The savings are calculated for the total cost per year and for the cost per ET movement. Because of the fact that the throughput amount per EC stays similar at both cases, savings per ET have the same percentage. The savings for the EC if scenario 1 is implied are 24% per ET movement per year. Which is an total saving of €74.235 on yearly bases for one EC with an ET turnover of approximately 24.500 trolleys per year.

	current	scenario1	savings
Total cost	€309.196	€234.267	24%
number of ET's/year	24416	24331	-
cost/ET movement	€12,66	€9,63	24%

Table 13 Savings RTI process EC scenario 1, analysis 1

In order to test the sensitivity of the analysis a simulation run has been performed with a central depot on a much larger scale. At this run six equal EC's are centralized with an ET amount of 46.000/year/EC. The input variable of ET's per EC is determined on an average of 884 per week with a standard deviation of 178 ET's. The results of this simulation run are shown in Table 14. The savings at this setting are calculated per ET movement because of the fact that EC's in scenario 1 are of much larger scale than at the base case scenario. The savings based on this setting are 25% per moving ET per year, which is an total amount of €145.840 per year for one EC.

	current	scenario1	improvement
Total cost/year	€309.196	€438.245	-
number of ET's/year	24.416	46.152	-
cost/ET movement	€12,66	€9,50	25%

Table 14 Savings RTI process EC scenario 1, high ET turnover, analysis 2

Also a simulation run has been performed with a setting of six EC's with an ET amount of 13.000 per year, which is a small scale EC. The input variable of ET's is determined on an average of 250 per week and a standard deviation of 50 ET's. In Table 15 the result of this simulation run are shown, the savings based on this setting are 22%, which is an total amount of €36.790 per year for one EC.

	current	scenario1	savings
Total cost/year	€309.196	€128.020	-
number of ET's/year	24.416	13.019	-
cost/ET movement	€12,66	€9,83	22%

Table 15 Savings RTI process EC scenario 1, low turnover, analysis 3

In order to determine the sensitivity of the central depot scenario an simulation model is setup to analyze the performance of the scenario if EC's are used of different sizes. In this analysis in total six EC's are included with three different export trolley amount per week as described above. These are two EC's with an average ET input of 250 per week, two EC's with an average ET input of 884 per week and two EC's with an average ET input of 442 per week. In Table 16 the results of the analysis is shown which is 24% per ET movement. For the two small EC's this is an saving of €38.870 per year, for the two EC's of medium size a saving of €73.255 per year can be achieved and for the two larger EC's a saving of €137.540 can be accomplished.

	current	scenario1	savings
Total cost/year	€309.196	€269.368	-
number of ET's/year	24.416	27.846	-
cost/ET movement	€12,66	€9,67	24%

Table 16 Savings RTI process EC scenario 1, combined ET turnovers

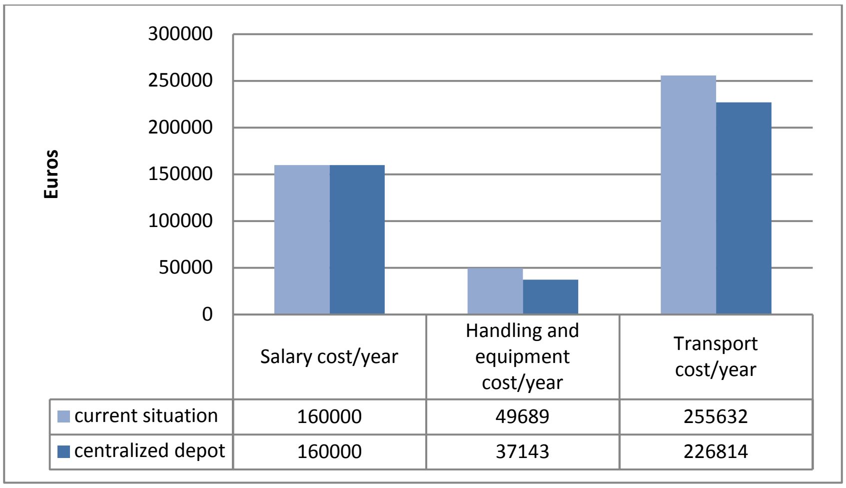
Several factors are of influence on the performance of the central depot, these factors consist of the number of EC's cooperation, average amount of incoming RTI's per EC and the standard deviation of incoming RTI's. As can be seen in Table 17 the total amount of ET's moving towards the central depot is leading for the saving which can be achieved. At the setting of analysis 4 with different sizes of EC's the saving is approximately of the same size as at analysis 1.

	number of ET movements/ year	nr. of EC's	total ET movements at central depot	cost/ET movement	saving compared to current situation	saving/year/EC
analysis 3	€13.000	6	78.000	€9,83	22%	€36.790
analysis 1	€24.400	6	146.400	€9,63	24%	€74.235
analysis 2	€46.000	6	276.000	€9,50	25%	€145.840
analysis 4	€13.000	2	166.800	€9,67	24%	€38.870
	€24.400	2				€73.255
	€46.000	2				€137.540

Table 17 summary of analysis with different settings at central depot

6.4.2 Results scenario 1 for LSP

The simulation model of scenario 1 for the LSP is constructed with six EC's with an yearly export trolley turnover of 24.500. The LSP is responsible for 20% of the ET trolley movements of these EC's. The EC's which are cooperating at the central depot, are of the same sizes as described in the base case scenario. For detailed information see table 3 in chapter 4.2.1. Concluded from the sensitivity analysis of scenario 1 for the EC this setting is chosen to be analyzed. Adjusting of the sizes of EC's does not have any significant influence on the improvement of the process, the most important factor is the total amount of ET's running through the process. The main efficiency improvements for the LSP is reduction of unloading moments, with counting and administration moments involved. For a detailed cost allocation with performance indicators of the central depot scenario, see appendix L.2. In Graph 4 the cost comparison per head of expenditure is shown for both situations. Salary cost stay the same for scenario 1, this is because of the fact that the same handling procedures within the cross-dock of the LSP have to be performed. Handling and equipment cost have decreased with €12.546, this is the result of minimizing the unloading moments per truckload. This accounts for a saving of 25% compared to the current situation. Transport costs declined with €28.818 per year, which is an saving of 11% compared to the current situation. This saving is the result of removal of the transport between several EC's to unload ET's, by unloading at one point.



Graph 4 Analysis of scenario 1, cost comparison RTI process at LSP

In Table 18 the total cost, number of ET outputs and savings are shown. The central depot scenario results an saving of 6% for the LSP. Compared to the base case scenario a reduction of €0,47 per ET movement is realized. On an average ET turnover of 56.000 per year for an central depot of six EC's, this leads to an saving of €26.320 yearly for the LSP.

	current	scenario1	savings
Total cost	€465.321	€423.957	-
number of ET's/year	55.930	54.026	-
cost/ET movement	€8,32	€7,85	6%

Table 18 Savings RTI process at LSP, scenario 1

6.5 Performance scenario 2: Pool system

In this section step 6 of the simulation steps is executed, which are the experiments and results for the pool system scenario. As indicated by (Kroon & Vrijens, 1995) for designing a good reverse logistics system, several important questions have to be answered. The main question indicated is how many containers should be available in the system. This will depend on the number of exporting companies cooperating in the pool system. To conduct a simulation analysis on this scenario detailed information about the EC's cooperating is needed. Also data of the supply chain of the involved EC's in the pool is needed. When this information is gathered the amount of trolleys and the safety stock can be determined. For the analysis of scenario 2 more information is needed on the new type of export trolley. Previous conducted research by TNO (Handelsexport kar, TNO, 2008) indicated the following pre conditions of the new trolley;

- 25% reduction in nesting time
- Nesting of packages of 7
- Similar loading capacity of trolley

Determined on these pre assumptions at which the new export trolley has to be designed, an analysis is made on the possible savings if the pool system is implemented. In this analysis the total pool size is not taken into account due to the fact that many factors are still unknown about the size of the cooperating EC's and the specifications of the new ET.

6.5.1 Results scenario 2 for EC

Based on above mentioned pre conditions the nesting time is adjusted in the simulation model. The input variables of the different handling procedures can be found in Table 19. The savings incorporated based on these pre conditions result in an decreasing of 1 FTE needed for nesting, and a reduction in transport cost from the central depot towards the EC. This reduction of transport costs is achieved by nesting the export trolleys in amounts of 7 instead of 4. Also storage cost decrease with a factor of 1,75 of the total area needed. Based on the first two mentioned pre conditions the simulation of the process at the EC is analyzed.

	handling activity	variable	unit	deviation	mean	σ	E (sec.)	n
EC	transfer	t	sec./ET	normal	49	7,5	5	9
	un-stacking	us	sec./ET	normal	221	67	40	11
	stacking	s_{fh}	sec./FHT	normal	222	74	50	9
	nesting	nt	sec./7ET's	normal	1053	32	-	-

Table 19 Adjusted handling times at EC

In appendix L.3 a detailed cost allocation and performance indicator table can be found of the pool system. In Graph 5 the head of expenses of the RTI process per EC for scenario 2 can be seen. In this graph the cost of the current situation (base case) and the pool scenario (scenario 2) are shown. The cost of the pool scenario are divided per EC, because in the simulation setting six EC's of equal size are used, as described before in the analysis of scenario 1. The salary cost decrease with an amount of €40.833 per year, which account for 30% of the cost of the salary cost at the current situation. This reduction is realized by the assumption of the pre condition that the nesting time will be reduced by 25%, and a total of 7 ET's can be nested together. Based on this increased nesting amount also the warehouse expenses decrease with an amount of €60.380 per year, which accounts for 41% of the warehouse expenses at the current situation. The reduction of transport cost at the pool scenario is €15.266 per year, which is a decline of 60%.

	Salary cost	Warehouse expenses	Transport cost
Current situation	135000	148680	25516
depot scenario	94167	88300	10250

Graph 5 Analysis of scenario 2, cost comparison of RTI process at EC

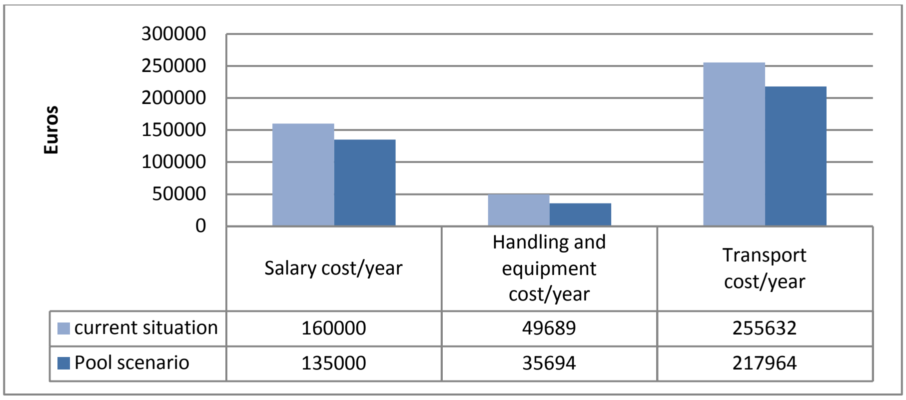
In Table 20 the total cost, number of ET outputs and savings are shown. The pool system scenario results an saving of 38% compared to the current situation. Compared to the current situation a reduction of €4,75 per ET movement is realized. On an average ET turnover of 24.500 per year at an setting of six EC's in the pool system, the scenario results an saving of €116.375 per year.

	current	scenario2	Improvement
Total cost	€309.196	€192.717	38%
number of ET's/year	24.416	24.354	-
cost/ET	€12,66	€7,91	38%

Table 20 Savings RTI process at EC, scenario 2

6.5.2 Results scenario 2 for LSP

Based on the mentioned pre conditions of the new export trolleys, the simulation model has been adjusted. The same setting is used as in the analysis of scenario 1, which is with six customers of equal size at auction location Aalsmeer. In the simulation model the loading factor of the nested export trolleys is adjusted which leads to an decreasing of the total truckloads from the cross-dock of the LSP to the EC. In appendix L.4 a detailed cost allocation and performance indicator table can be found for the pool system. In Graph 6 the head of expenses are shown of the pool system compared to the current situation. Salary cost decrease with an amount of €25.000 per year, which accounts for 16% of the salary cost at the current situation. This saving is achieved by decreasing the total loading and unloading time per year. This is decline is accomplished by decreasing of the number of truckloads by increasing the load factor. Handling and equipment cost decrease with €13.995 per year, which is 28% compared to the expenses of the current situation. The cause of the saving results from the saving in total unloading time at the EC. Transport costs are decreased with an amount of €37.668 per year, which accounts for 15% of the transport cost at the current situation.



Graph 6 Analysis of scenario 2, cost comparison of RTI process at LSP

In Table 21 the total cost, number of ET outputs and savings are shown. At the pool system scenario an saving of 17% can be realized for the process at the LSP. Compared to the current situation a reduction of €1,44 per ET movement can be achieved. This will result in an average saving of €80.640 per year for the LSP based on the setting as described with an ET turnover of 56.000 per year. At the process of the LSP much more can be saved if the total reverse logistic is analyzed from customer up to EC's. Due to the fact that increasing of the load factor was not within the scope of this research, and no data was available concerning transportation movements from customer to EC. In practice the savings for the LSP will be much more if a new ET is incorporated in the process which is more easier to nest. This nesting can be done at the customer to increase the load factor and decrease the transportation cost per export trolley movement.

	current	scenario2	savings
Total cost	€465.321	€388.658	-
number of ET's/year	55.930	56.499	-
cost/ET movement	€8,32	€6,88	17%

Table 21 Savings RTI process at LSP, scenario 2

6.6 Summary of redesign scenario's

The purpose of this chapter is to give insight in the savings which can be realized by implementing the different scenario's. In Table 22 the summary of the savings for the different scenario's of the process at the EC is given. These savings are based on a setting of six EC's cooperating at a central depot, with an average ET turnover of 24.500 per year. The savings based on the total cost of scenario 1 compared to the current situation is 24%, at scenario 1 the cost per moving ET is €9,63 which at the current situation is €12.66. Scenario 1 leads to an saving of €74.235 per year based on an ET turnover of 24.500 per year. The savings at scenario 1 are realized by increasing of the efficiency at the handling procedures, which is assumed based on increasing the utilization of warehouse employees with 35%. Utilization of the docks for the ET process also leads to an extra saving in warehouse expenses. Transport cost of FHT trolleys towards SiVePo can be reduced by increasing the average truckload amount. At the current situation the average truckloads consist of 30 FHT while the maximum capacity is 34. Due to the fact of increasing the amount of truckloads at the central depot towards SiVePo, hourly rates for transport cost can be decreased. The current hourly rate determines €75, the cost calculation of €50 is added for hourly rate which is more acceptable. These two improvements lead to an substantial reduction in transport cost for the EC at scenario 1. As concluded from the sensitivity analysis the leading factor in the savings which can be achieved is the total amount of ET's moving through the central depot. Other factors as the average ET movements per EC and standard deviation are not strongly influencing the performance indicators.

Scenario 2 accounts for a saving on the total cost of 38% compared to the current situation. The cost per moving ET is €7,91 which is compared to scenario 1 an extra saving of 18%. Scenario 2 leads to an saving of €116.375 per year compared to the current situation based on an ET turnover of 24.500 per year. Compared to scenario 1, an extra saving of €42.140 is realized. These extra savings at scenario 2 are realized by decreasing of the total nesting time of ET,s and increasing of the load factor for ET trolley transport towards the EC. Storage cost at the EC are reduced substantial with a factor of 1,75 due to the fact of higher storage space utilization. In the analysis of scenario 2 the cost of the new export trolley is not taken into account. There is no specific price available on the new type of export trolleys, so in practice the saving will be decreased by the investment of the export trolleys. One important factor of the total investment is the total pool size, which cannot be determined at this point.

RTI process at EC	current situation	improvement at scenario 1	improvement at scenario 2	difference between scenario's
Salary cost	€135.000	27%	30%	3%
Warehouse expenses	€148.680	16%	41%	25%
Transport cost	€25.516	57%	60%	3%
Total cost	€309.196	24%	38%	13%
	current situation	scenario 1	scenario 2	difference between scenario's
Cost/ET movement	€12,66	€9,63	€7,91	18%
saving per ET	-	24%	38%	

Table 22 Summary results of savings at RTI process of EC

In Table 23 the summary of the savings of the different scenario's at the process of the LSP is given. These savings are based on a setting of six EC's cooperating at a central depot, with an ET turnover of 24.500 per year. The LSP is responsible for 20% of all ET movements at the EC's. The savings based on the total cost of scenario 1 compared to the current situation result in 9% per year. At scenario 1 the cost per moving ET is €7,85 compared to €8,32 at the current situation. Scenario 1 leads to an saving of €26.320 yearly based on an ET turnover per year for an central depot with six EC's with an total turnover of 56.000 per year. The savings for the LSP at scenario 1 are realized by reduction in unloading times at EC's and transport between these. For other LSP's this saving on the total cost can be higher, because of the fact that the example company has a high transport cost percentage due to the cross-dock location.
Scenario 2 accounts for a saving on the total cost of 16% compared to the current situation. The cost per moving ET is €6,88, which accounts for an extra saving of 12% compared to scenario 1. Scenario 2 leads to an saving of €80.640 per year compared to the current situation, based on a setting of six EC's with an total ET turnover of 56.000 per year. These savings for the LSP are caused by increasing the load factor of nested trolleys. At the example company this saving is quite substantial because of long transport distances with empty packaging towards the auction location. The total savings for the LSP will be much higher because of the fact that increasing the nesting amount of ET's leads to cost reduction in the total reverse logistics of the floricultural supply chain. In this research this is left out of scope

RTI process at LSP	current situation	improvement at scenario 1	improvement at scenario 2	difference between scenario's
Salary cost	€160.000	0%	16%	16%
Warehouse expenses	€49.689	25%	28%	3%
Transport cost	€255.632	11%	15%	3%
Total cost	€465.321	9%	16%	8%
	current situation	scenario 1	scenario 2	difference between scenario's
Cost/ET movement	€8,32	€7,85	€6,88	12%
saving per ET	-	6%	17%	

Table 23 Summary results of savings at RTI process of LSP

7. Conclusions and recommendations

In this last chapter of this thesis the main conclusion, recommendations and further research is discussed.

7.1 Conclusions

Every year a billion flowers are exported from the Netherlands to approximately 140 countries all over the world. Flowers are transported in 70% of all cases on RTI's. An important process in the flower supply chain is the restacking of floriculture products. This process takes place at the wholesaler and incorporates the restacking of products from trolleys owned by Flora Holland onto export trolleys which are owned by the different wholesalers. The ownership of these export trolleys is divided over several exporting companies, so each one possesses its own trolleys. These trolleys are of the same type and dimensions, the only aspect in which they differ is quality, and in most cases the name of the exporting company is displayed. This means that no universal chain trolley is incorporated in the exporting process. The packing in which the flowers are transported, are in comparison to the trolleys interchangeable. Every exporting company pays an amount of deposit and receives flower buckets and boxes retour. So the distribution process that takes place during export is also included in the reverse logistics of RTI's

Different relations exist between the parties in the floriculture chain, which are the export companies and the logistic service providers. This indicates that several export companies can make use of the same LSP, and also serve the same end customers. Due to the fact of high RTI values and property rights, wholesalers as well as logistic service providers are forced to invest a high amount of resources in the reverse flow of RTI's. Every export company independently organizes their handling, administration, settlement and stock management. Export companies as well as logistic service providers encounter inefficiencies in their processes concerning empty RTI flows in the floricultural supply chain. In order to improve the reverse logistics in the floriculture supply chain this research is focused on the below formulated research question.
"How can empty RTI's in the reverse logistics of the floricultural supply chain, be managed in an effective way by cooperation between export companies, and lead to a cost reduction?"

The following sub-questions are formulated;
"*What will be the savings for the export companies, and what will be the cost per export trolley in the improved situation."*
"What will be the savings for the logistic service providers, and what will bet the cost per export trolley in the improved situation."

As a starting point the current situation of the RTI process has been analyzed, this analysis is split up in an analysis at the EC and at the LSP. Both process are modeled and a simulation is established in order to determine the base cases. The analysis of the RTI process at the EC is based on an export company with an average ET turnover per year of 24.400. Several performance indicators are calculated which are summarized below:

- The average utilization of employees at the handling procedures at the EC is 50 %.
- A total number of 4 FTE is needed for the handling activities at the EC, one FTE as team leader and for administration activities 1 FTE is necessary.
- The salary cost per year account €135.000, warehouse expenses €148.680 and transport cost €25.516. The total cost of the RTI process sum up to €309.196
- The number of export trolley output per year accounts 24.416, the FH trolley output per year accounts 6379.
- Cost per ET movement is €12,66

The analysis of the RTI process at the LSP is based on a LSP that serves six EC's at auction location Aalsmeer. It is assumed that these EC's vary in export turnover, the total ET movement by the LSP towards the EC's at Aalsmeer is 55.900. Several performance indicators are calculated which are summarized below:

- The number of truck movements per year to auction location Aalsmeer account 1645.
- The total transport cost per year account for €255.632.
- The total cost of the RTI process at the LSP per year is €465.321.
- The number of FTE needed at the cross-dock is 4, and 1 FTE for administration, which accounts for an yearly cost of €160.000.
- The number of export trolley output per year is 55.930.
- Cost per ET movement is €8,32

In order to improve the current situation two scenarios are determined based on cooperation between export companies. The following scenario's are developed:

- Scenario 1, a central depot system where EC's can take advantage of economies of scale. At the central depot the RTI's of cooperating EC's are unloaded and the same RTI process takes place as at the individual EC's, only on a bigger scale.
- Scenario 2, a pool system, the pool system operates in the same way as the central depot, the difference is that a pool of export trolleys is implemented.

The results of the analysis of these scenario's at the EC can be found in Table 24. The saving at the EC when scenario 1 is applied is 24% compared to the current situation, which is an saving of €73.723 per year. For scenario 2 a saving of 38% can be achieved compared to the current situation, these savings are also achieved by the improvements already incorporated at scenario 1. The total saving per year is based on scenario 2 is €115.682.

RTI process at EC	current situation	scenario 1	scenario 2	difference between scenario's
Salary cost per year	€135.000	€98.333	€94.167	
savings compared to current situation		27%	30%	3%
Warehouse expenses per year	€148.680	€125.020	€88.300	
savings compared to current situation		16%	35%	19%
Transport cost per year	€25.516	€10.914	€10.250	
savings compared to current situation		57%	60%	3%
Total cost per year	€309.196	€234.267	€192.717	
savings compared to current situation		24%	38%	13%
ET output per year	24.416	24.331	24.354	
Cost/ET movement	€12,66	€9,63	€7,91	
savings compared to current situation		24%	38%	14%
saving per year		€73.723	€115.682	€41.959

Table 24 Comparison of current situation and scenario's at EC

The results of the analysis of these scenario's at the LSP can be found in Table 25. The saving at the LSP when scenario 1 is applied account for 6% compared to the current situation, which is an saving of €25.524 per year. For scenario 2 a saving of 17% can be achieved compared to the current situation, these savings are also achieved by the improvements already incorporated at scenario 1. The total saving at the RTI process at the LSP is €81.397 per year. When the pool system is implemented the savings for the LSP will be much higher because of the fact that increasing of the load factor is possible. In this research transport from end customers toward the cross-dock of the LSP is not taken into account.

RTI process at LSP	current situation	scenario 1	scenario 2	difference between scenario's
Salary cost per year	€160.000	€160.000	€135.000	
savings compared to current situation		0%	16%	16%
Handling and equipment expenses per year	€49.689	€37.143	€35.694	
savings compared to current situation		25%	28%	3%
Transport cost per year	€255.632	€226.814	€217.964	
savings compared to current situation		11%	15%	3%
Total cost per year	€465.321	€423.957	€388.658	
savings compared to current situation		9%	16%	8%
ET output per year	55.930	54.026	56.499	
Cost/ET movement	€8,32	€7,85	€6,88	
savings compared to current situation		6%	17%	12%
saving per year		€25.524	€81.397	€55.874

Table 25 Comparison of current situation and scenario's at LSP

When one of these scenario's will be implemented an information system is needed in order to manage the flows of trolleys and packaging of the EC's cooperating. As described by Kärkkäinen et al. (2004) efficient information management systems are needed to manage the rotation of RTI's. When implementing an information management system administration cost can be reduced. In the analysis of the improved scenarios the cost of this system is not taken into account, this will result in higher total cost for both scenarios. In Table 26 an indication is given of the payback period in months based on the investment cost of an ICT system and the total amount of ET movements at the central depot.

In the analysis of scenario 2 the cost of the new export trolley is not taken into account. There is no specific price available on the new type of export trolleys, so in practice the saving will be decreased by the investment of the export trolleys. One important factor of the total investment is the total pool size, which cannot be determined at this point.

Payback period in months		Total ET movements per year at central depot		
		78.000	146.000	276.000
investment cost in euro	20.000	1,1	0,5	0,3
	30.000	1,6	0,8	0,4
	40.000	2,2	1,1	0,6
	50.000	2,7	1,4	0,7
	60.000	3,3	1,6	0,8
	70.000	3,8	1,9	1,0
	80.000	4,3	2,2	1,1
	90.000	4,9	2,4	1,2
	100.000	5,4	2,7	1,4

Table 26 Indication payback period ICT system

7.2 Recommendations

- *In depth analysis of the RTI handling process design within the central depot*. One conclusion of the current RTI process at the EC is that the utilization of employees is 50%, because of different other tasks which have to be performed. In the improved situation the assumption is made that this utilization can be increased up until 85%. By implementing a good design for the handling process within the central depot this utilization can be reached. Further research has to be performed on the actual design of this process.

- *Further analysis on the cost of implementing an information management system.* The analysis in the research does not take into account the investment which has to be made for an ICT system. Both scenario's in the analysis describe a central depot, in order to manage the RTI's in a structured way an information management system has to be implemented. This system has to keep track of incoming and outgoing ET's and packaging of the several EC's cooperating at scenario 1. For scenario 2 a different system has to implemented which keeps track of the rented export trolleys at the different customers. At both scenario's this system is important to divided the cost over the different EC's cooperating.

- *Detailed information about EC's cooperating and determine the savings based on this configuration.* Determine the exact number and sizes of the export companies cooperating at the central depot scenario. Because only specific data of incoming ET's is available of one EC's, the data of the other EC's cooperating at both scenario's are assumed. Based on the fact that no detailed information is available it is hard to give a detailed saving indication. When an initial pilot project is started an analysis of the EC's and turnover amount of export trolleys have to be made. If these turnover amounts differ very strongly from the ones in the analysis it is recommendable to re-run the simulation analysis to give a more detailed indication of the savings which can be achieved at scenario 1.

- *Further analysis on the savings for the EC and LSP based on the pool system.* In order to determine the savings at the EC and LSP at the pool system scenario, a more detailed analysis has to be made. If the specifications of the new trolley allow a higher nesting amount the storage cost at the EC can be reduced. For the LSP a higher nesting amount will result in increasing of the load factor of truckloads.

This increasing of the load factor can lead to significant savings over longer distances towards customers.

- *Locate the central depot nearby FH at the specific auction location.* In order to save more on transport cost at the central depot, this has to be located nearby FH. Due to the fact of a large amount of truckloads with FH trolleys with packaging towards FH, the cost can be reduced by minimizing the transport distance. The option of organizing the transport from the central depot to FH with an electrical tug truck, which are used on the auction itself, has to be determined.

- *At the starting point for the project it is recommended to initiate a central depot with 4-6 EC's cooperating of average ET turnover sizes, which are approximately 24.500 ET's per year per EC.* The total amount of incoming export trolleys has to lie between 78.000 and 276.000 ET's per year, in the analysis is shown that for these amounts a saving can be achieved between the 22% and 25% per ET movement. In the initial phase it is recommended that EC's of medium or larger size cooperate in the central depot, this in order to reach a high throughput of ET's. Also the investment cost of an ICT system has to be taken into account, the payback period of this system is highly depended on the total amount of ET throughput of the depot. For scenario 2 further research has to be conducted on the minimum pool size at which this scenario will be profitable.

- *Determine the appropriate service fee for EC's cooperating at the central depot.* For the central depot an important questions relate to the number of ET's and the appropriate service/distribution fees. The fee per EC can be based on a fixed cost per year and a variable cost factor determined on the number of ET's per EC moving through the central depot. This service fee has to be determined more in detail.

7.3 Further research

- *A limitation of this research is that the data of incoming export trolleys is only analyzed at one EC.* The data of other EC's is assumed based on extrapolation. In order to give more detailed results on the savings which can be achieved at the different scenario's, more in depth analysis is necessary on export trolley data at EC's cooperating. Due to variability in the average ET turnover and standard deviation per week, the improved processes has to be designed in a more flexible way to cooperate with fluctuating ET input.

- *A limitation of this research is the fact that no actual data was available at the LSP.* The analysis of the RTI process at the LSP is primarily based on assumptions of the data. A possibility for further research is to retrieve exact data at the LSP based on the RTI flows in the reverse logistics. From this data a more exact analysis can be made on the transport cost of empty RTI's from the loading point (customers of EC) towards the EC. A possibility for this data analysis can be to scan the barcodes which are located on the ET's when they are received. For the new type of export trolley implementing RFID could be useful in order to collect more specific data, and to accurately assign the cost per specific EC.

- *A possibility for further research is to determine the exact specifications of a new type of export trolley and which savings can be achieved by implementing this trolley.* Given the absence of specific data on a new type of trolleys, the pre-conditions which are specified in a research conducted by TNO (Handelsexportkar bloemen, TNO ,2008) are used in the analysis of scenario 2. In order to perform a more in depth analysis of the pool system more information about the new type of export trolley has to be know. When specifications of the new type are available a detailed analysis can be made on the handling and storing cost at the EC's and an analysis on transport flows for the LSP.

- *A limitation of this research is that packing is not analyzed in detail because of no availability of data.* A possibility for future research is to extract data of packaging in the reverse logistics. Due to the fact that EC's export different type of products different flow of packaging types is incorporated in the flows. These packaging types need different transportation space in the reverse flow. When small amounts of packaging are used in the transportation to customers over long distances, nesting of ET's can save transport costs.

- *Another possibility for future research is that the analysis of storage capacity of empty ET's is not taken into account.* In order to determine the storage cost in detail the demand of ET's in the supply chain has to be incorporated in the analysis. Data of export trolley amounts at the EC's cooperating have to be analyzed in order to give accurate insight in storage cost in the improved situation. Based on this factor and the safety stock of ET's which are used by the specific EC's a conclusion can be generated on the storage capacity needed. Future research can included these cost in the analysis, in the analysis conducted storage cost are determined on the base case scenario and multiplied by the scale increasing

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Reading guides

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List of abbreviations

FH	FloraHolland
FHT	FloraHolland trolley
FTE	Full time equivalent
EC	Export company
ET	Export trolley
LSP	Logistic service provider
OM	Operations management
RTI	Returnable transport items
VGB	Vereniging van groothandelaren in bloemkwekerijprodukten

Content of appendices

Appendices

Appendix A Types of RTI's

Picture A-1 Export/Cage trolley

Picture A-2 Flora Holland trolley

Picture A-3 Types of flower crates and racks

Picture A-4 Type 519 Flower box examples

Appendix B Ishikawa diagrams

B.1 Ishikawa diagram LSP

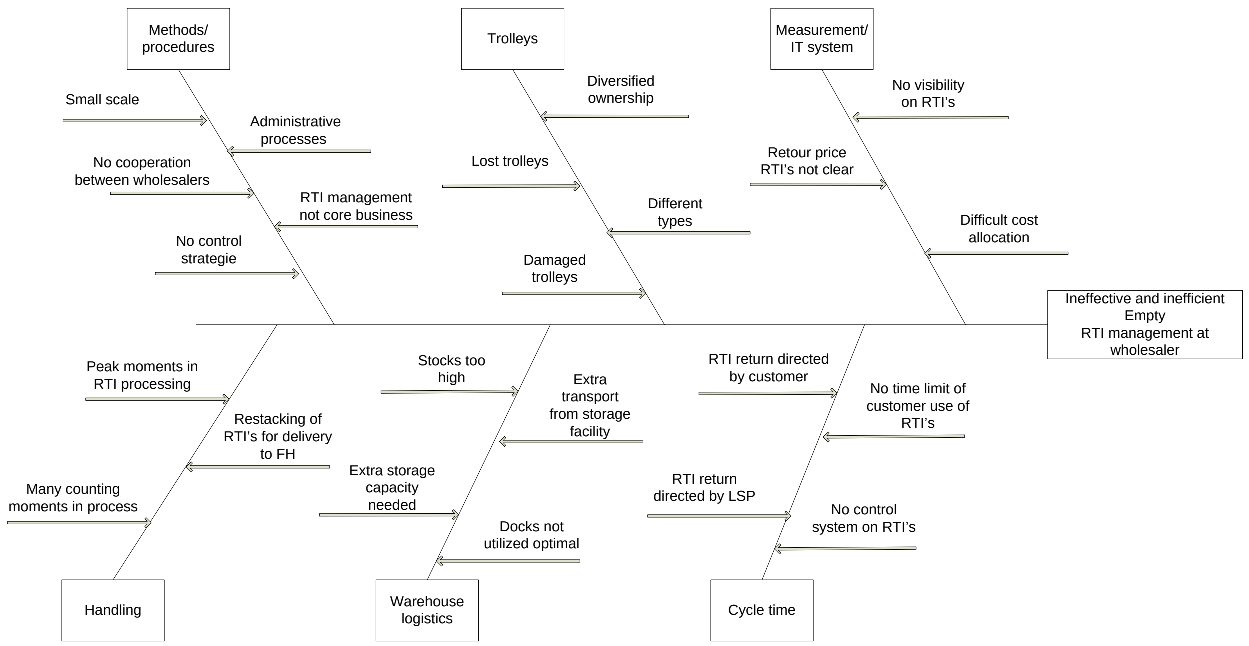

Figure B.1 Ishikawa diagram for possible causes at LSP

B.2 Ishikawa diagram EC

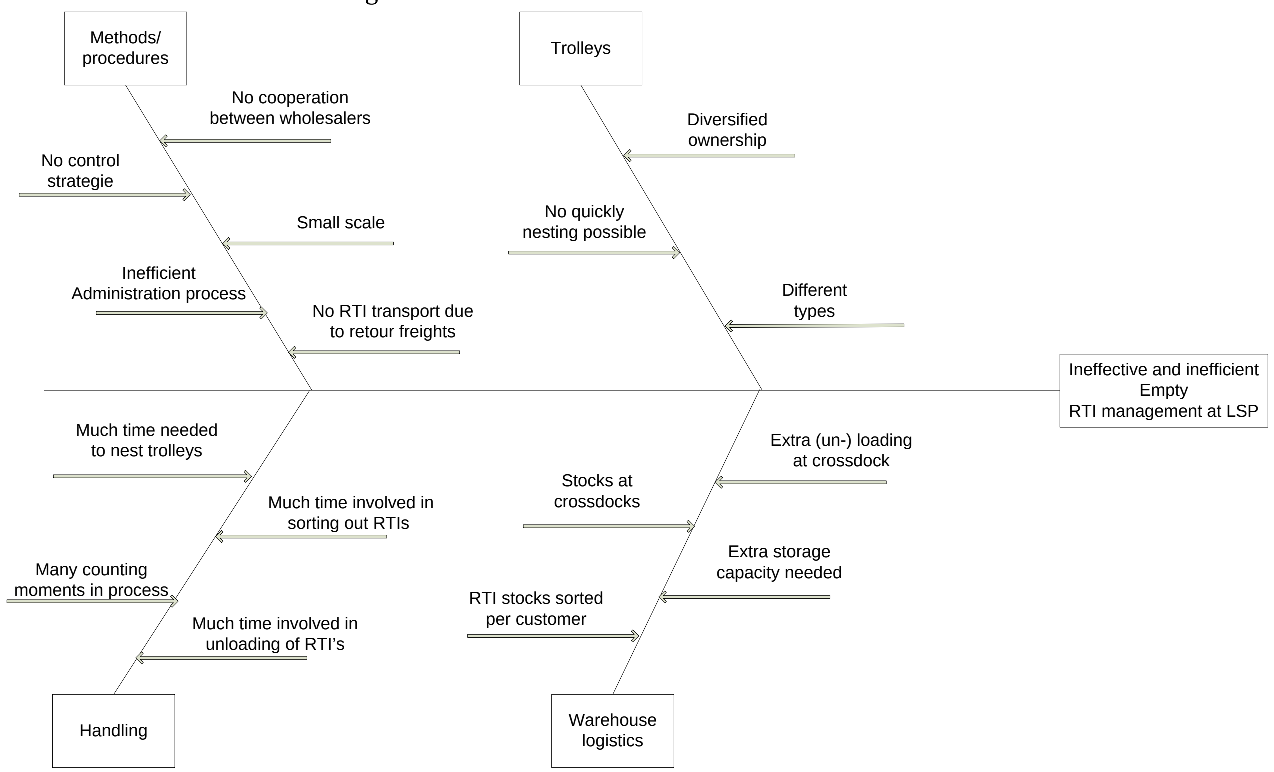

Figure B.2 Ishikawa diagram for possible causes at LSP

Appendix C Process models

C.1 Process model of EC

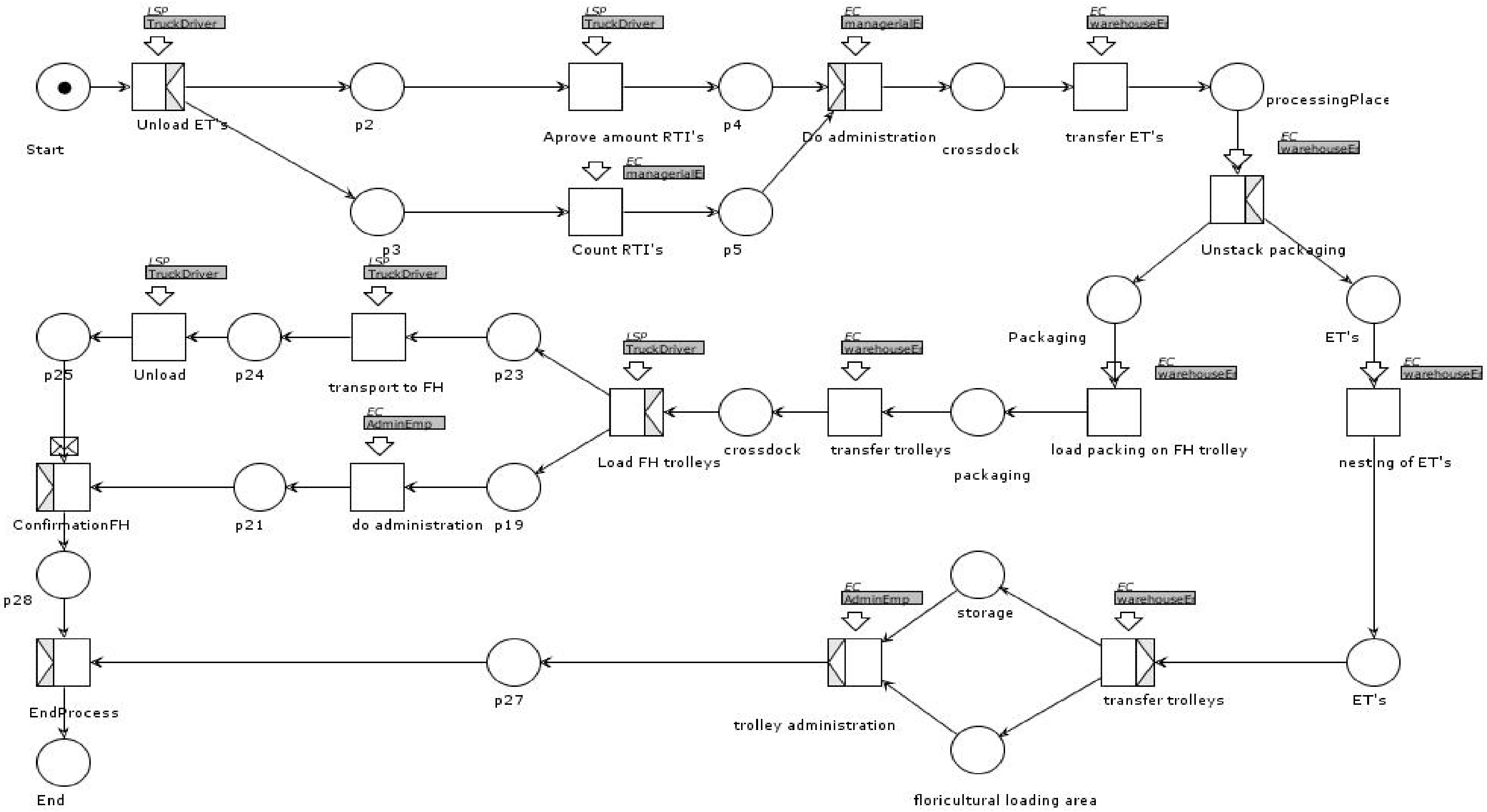

Figure C.1 process model of EC

C.2 Process model of LSP

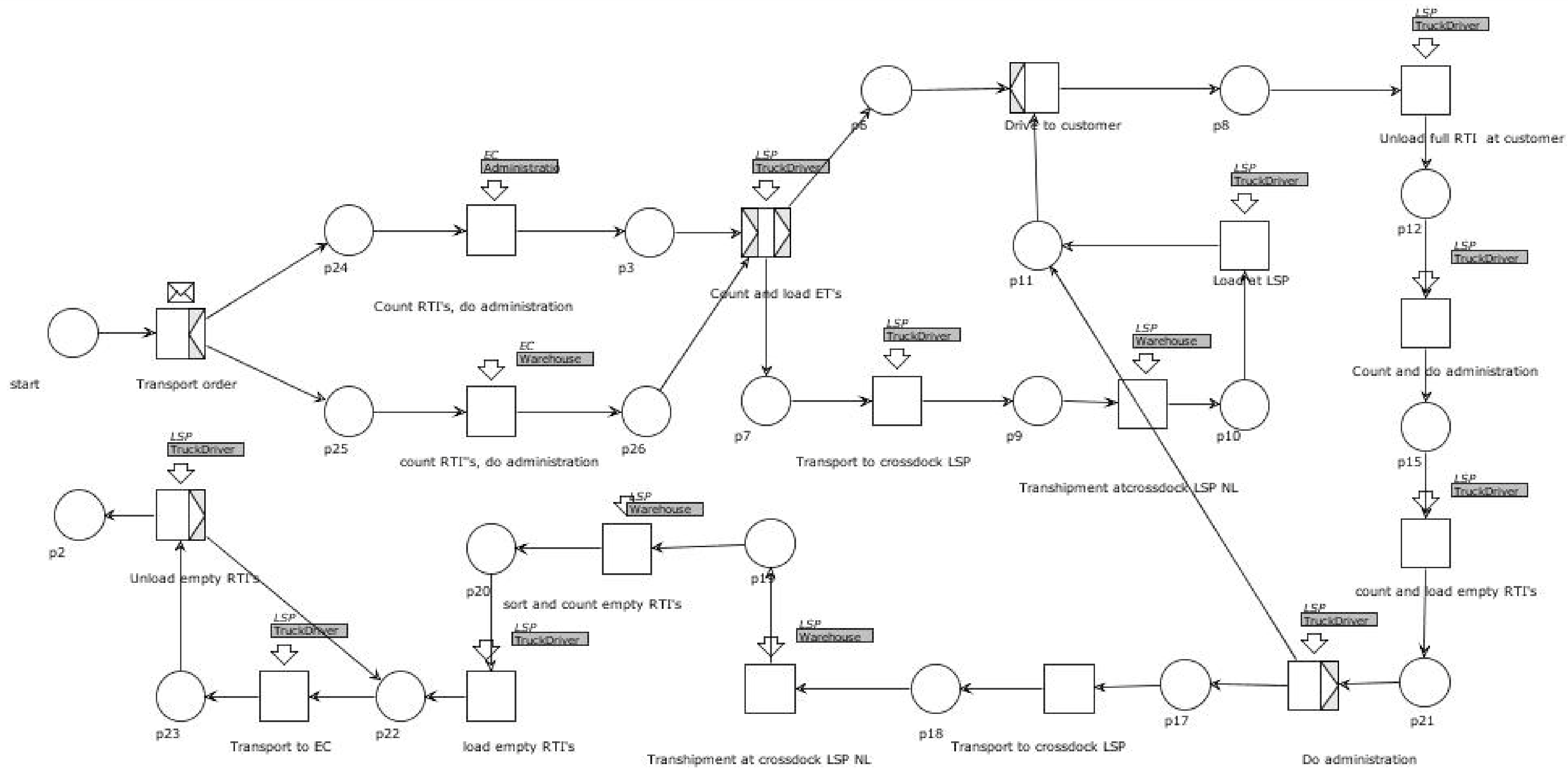

Figure C.2 process model at LSP

Appendix D Conceptual model of total RTI process

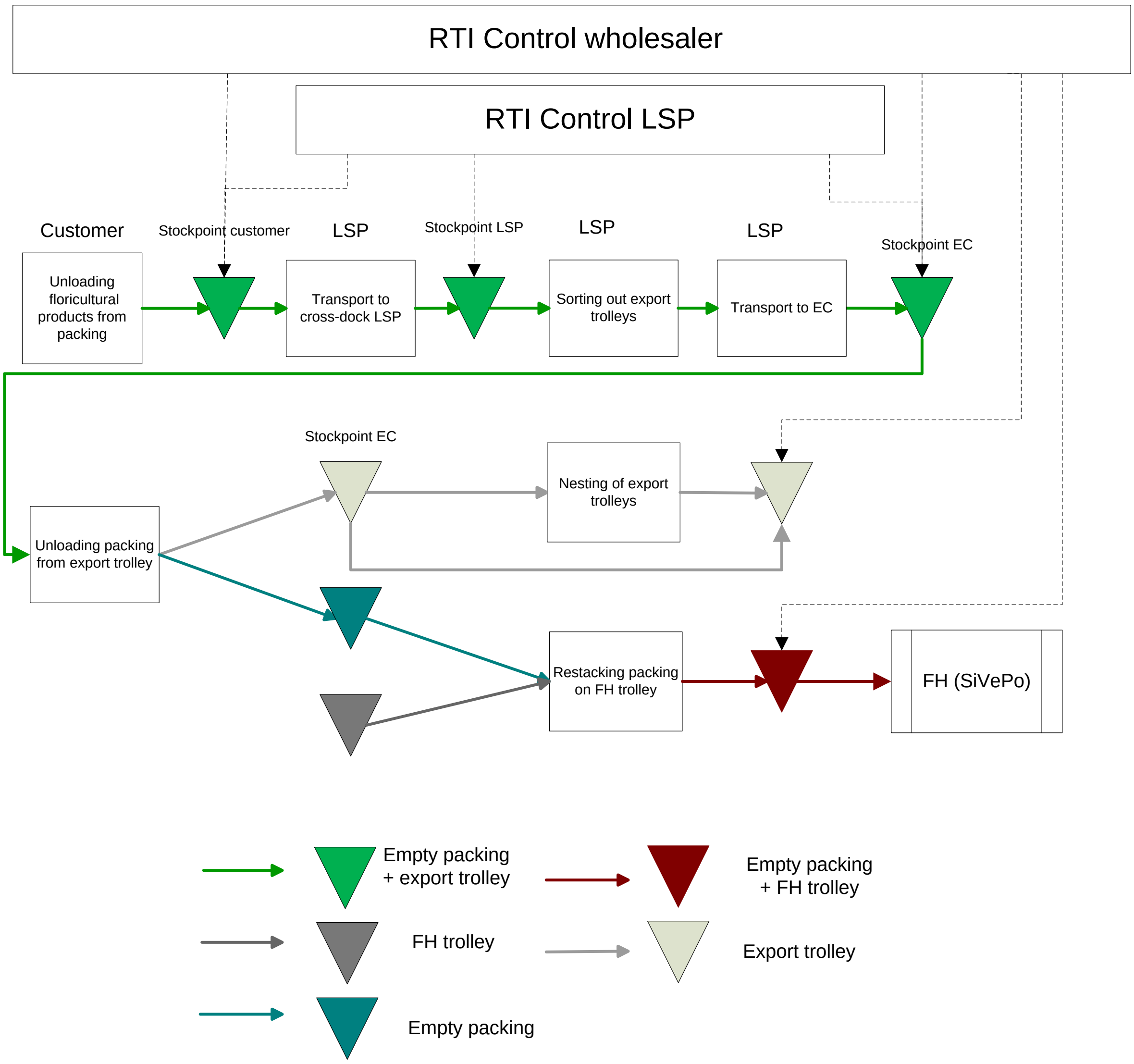

Figure D.1 Conceptual model of total RTI process

Appendix E Detailed black box representations

E.1 Process at EC

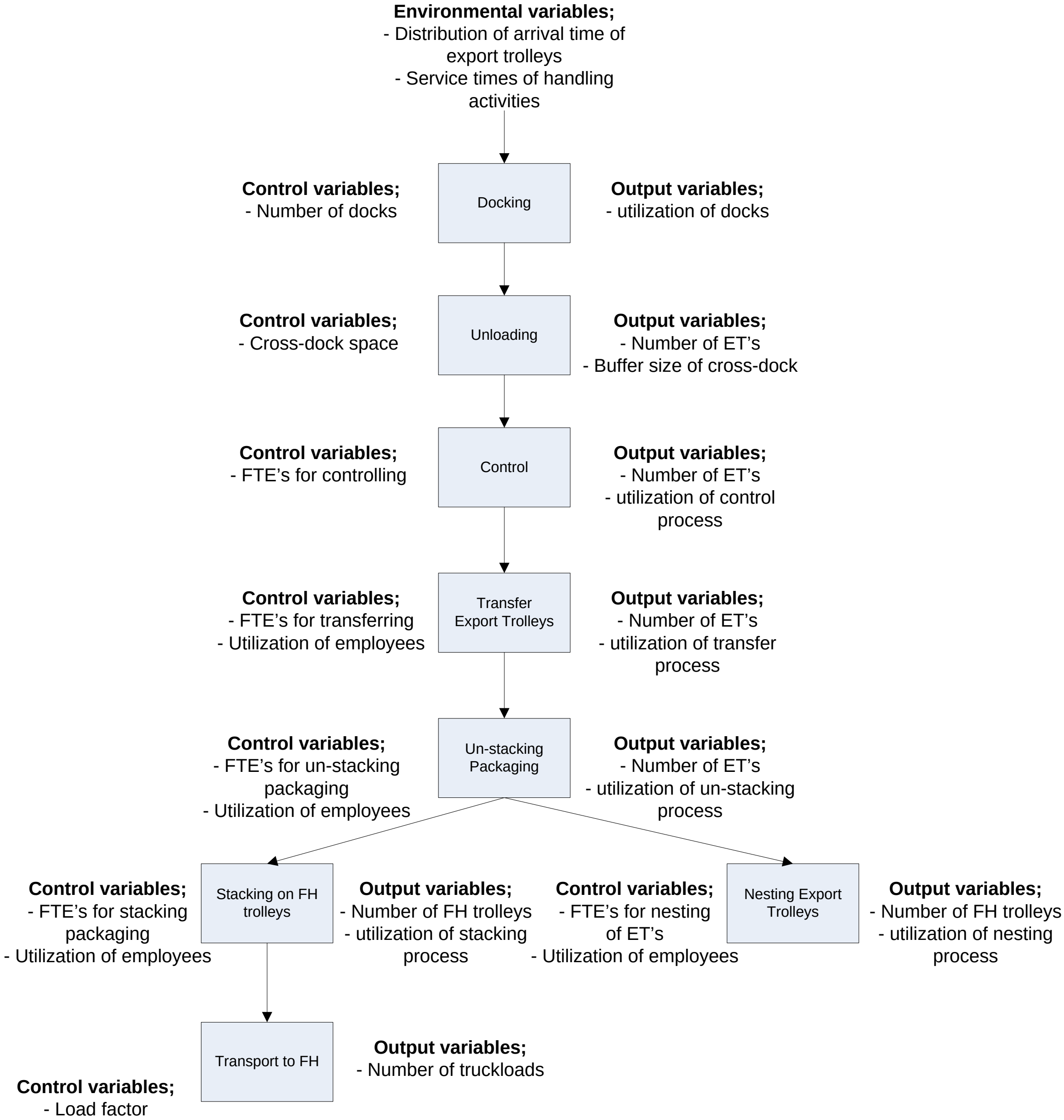

Figure E.1 Detailed black box representation of process at EC

E.2 Process at LSP

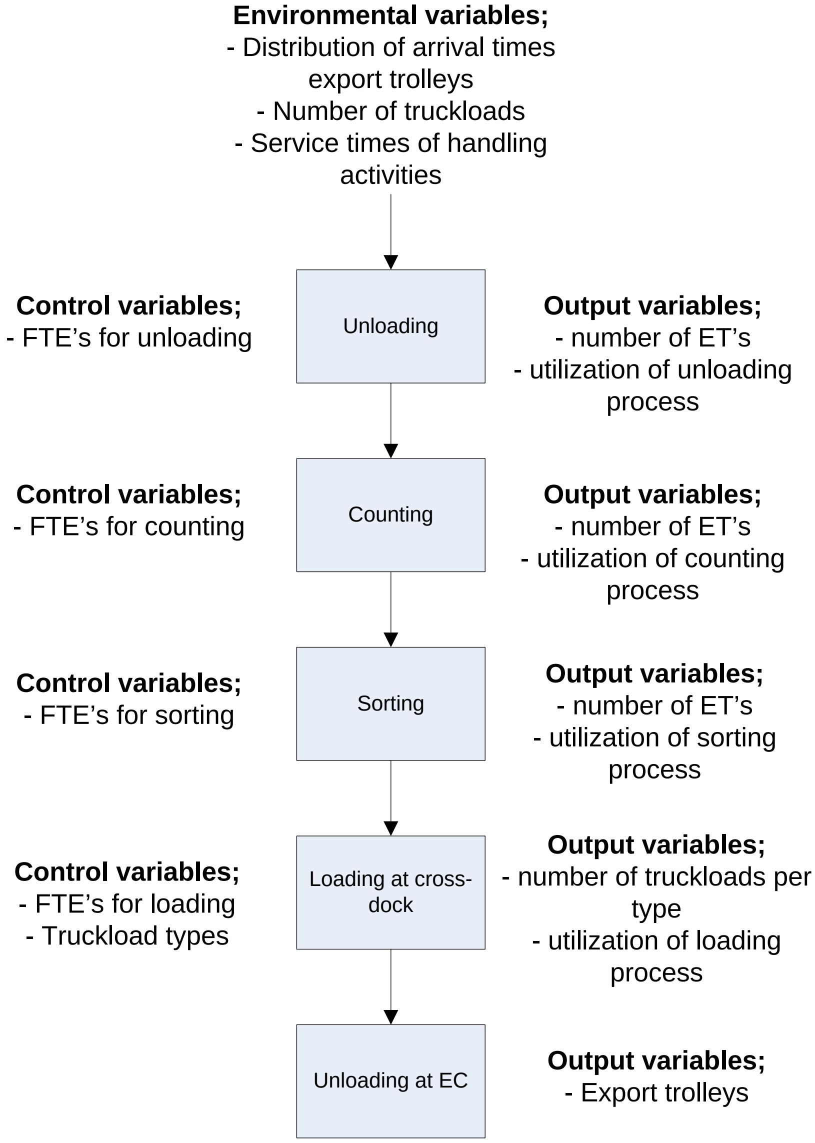

Figure E.2 Detailed black-box representation of process at LSP

Appendix F Formulas for process calculations

F.1 Calculations for process at LSP

$$V_{ij} = \frac{\sum_c \sum_e ET_{ce}}{ca\ .\rho 1} .\lambda 1 + \frac{\sum_c \sum_e ET_{ce}}{ca\ .\rho 2} .\lambda 2 + \frac{\sum_c \sum_e ET_{ce}}{ca\ .\rho 3} .\lambda 3 \quad (3.1)$$

V_{ij} = Total number of truckloads between cross-dock and export company
ET_{ce} = yearly export trolley movements between customer and export company
ρ = load factor
ca = maximum amount of empty export trolleys
λ = percentage of total truckloads
c = customer
e = export company

$$T_c = (\sum_{v1} V_{ij}\ .UT_1 + \sum_{v2} V_{ij}(2\ .UT_2 + (\varphi_2\ .TC_h)) + \sum_{v3} V_{ij}(3\ .UT_3 + (\varphi_3\ .TC_h)))\ .TC_h + V_{ij}.d_{ij}.p \quad (3.2)$$

T_c = Total transport cost per year
v = truckload type (combinations of ET's of number of EC's)
UT = unloading time at EC on truckload type
φ = transport time between two export companies
TC_h = transport cost per hour
d_{ij} = distance between LSP and EC
p = transport cost per km,

$$L_{et} = \frac{\sum_c \sum_e ET_{ce}\ .\ l}{2} \quad (3.3)$$

L_{et} = Total time per year (in seconds) needed for loading of export trolleys
ET_{ce} = yearly export trolley movements between customer and export company
l = loading time (in seconds) per trolley

$$U_{et} = \frac{\sum_s \sum_r ET_{ce}\ .u}{2} \quad (3.4)$$

U_{et} = Total time per year(in seconds) needed for unloading of export trolleys
ET_{ce} = yearly export trolley movements between customer and export company
u = unloading time per trolley (in seconds)

$$S_{et} = \sum_s \sum_r ET_{ce}\ .s \quad (3.5)$$

S_{et} = Total time per year (in seconds) needed for sorting of export trolleys
ET_{ce} = yearly export trolley movements between customer and export company

$s =$ sorting time per trolley (in seconds)

$$C_s = \sum_s \sum_r ET_{ce} \,.\, c_{et} \quad (3.6)$$

C_s = Total time per year (in seconds) needed for sorting of export trolleys
ET_{ce} = yearly export trolley movements between customer and export company
$c_{et} =$ counting time per trolley (in seconds)

F.2 Calculations for process at EC

$$T_{et} = \sum_c ET_{ce} \,.\, t \quad (3.8)$$

T_{et} = Total time per year (in seconds) needed for transfer of export trolleys within the warehouse
ET_{ce} = yearly export trolley movements between customer and export company
$t =$ transfer time per trolley (in seconds)

$$US_{et} = \sum_c ET_{ce} \,.\, us \quad (3.9)$$

US_{et} = Total time (in seconds) needed for un-stacking of packaging from export trolleys
ET_{ce} = yearly export trolley movements between customer and export company
$us =$ un-stacking time per export trolley (in seconds)

$$S_p = \frac{\sum_c ET_{ce} \,.\alpha}{\lambda} \,.\, s_{fh} = \frac{\sum_c ET_{ce} \,.\, 27}{105} \,.\, s_{fh} \quad (3.10)$$

S_p = Total time (in seconds) per year needed for stacking of packaging on FH trolleys
ET_{ce} = yearly export trolley movements between customer and export company
$\alpha =$ number of packaging per export trolley, 27
$\lambda =$ number of packing per FH trolley, assumed 105
$s_{fh} =$ stacking time (in seconds) of FH trolley

$$N_{et} = \frac{\sum_c ET_{ce} \,.nt}{4} \quad (3.11)$$

N_{et} = Total time (in seconds) needed for nesting of export trolleys
ET_{ce} = yearly export trolley movements between sender (customer) and receiver (EC)
$nt =$ nesting time (in seconds) of four export trolleys

$$TL_c = FHT.C_{fht} \quad (3.12)$$

TL_c = Total transport cost for FHT movements
Fht = total truckloasd with FH trolleys
$C_{fht} =$ transport cost per truckload for FHT transport

Appendix G Analysis of LSP's at example EC

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Table G.1 Analysis of LSP's at EC

Appendix H Statistical analysis of data

H.1 Transfer time

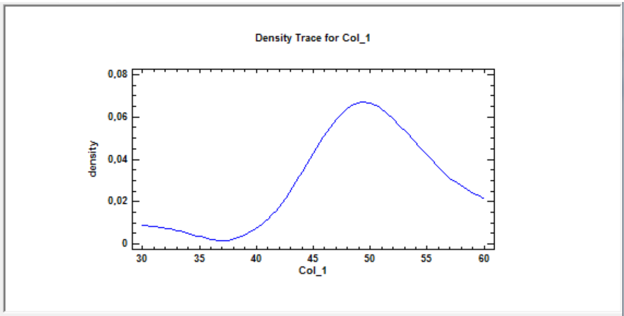
Uncensored Data - Col_1
Data variable: Col_1

13 values ranging from 30,0 to 60,0

Fitted Distributions

Erlang	*Exponential*	*Gamma*	*Normal*
shape = 41,0	mean = 49,5385	shape = 40,5389	mean = 49,5385
scale = 0,82764		scale = 0,818333	standard deviation = 7,46788

The StatAdvisor
This analysis shows the results of fitting 4 distributions to the data on Col_1. The estimated parameters of the
You can test whether the distributions fit the data adequately by selecting Goodness-of-Fit Tests from the list o
visually how well the distributions fit by selecting Frequency Histogram from the list of Graphical Options. Ot
you to compute and display tail areas and critical values for the distribution. To select a different distribution, p
select Analysis Options.



Goodness-of-Fit Tests for Col_1
Kolmogorov-Smirnov Test

	Erlang	*Exponential*	*Gamma*	*Normal*
DPLUS	0,0000224139	0,297846	0,0981366	0,114724
DMINUS	0,897332	0,519902	0,21446	0,194759
DN	0,897332	0,519902	0,21446	0,194759
P-Value	0,0	0,00177384	0,588219	0,70755

The StatAdvisor
This pane shows the results of tests run to determine whether Col_1 can be adequately modeled by various dist

P-values less than 0,05 would indicate that Col_1 does not come from the selected distribution with 95% confid

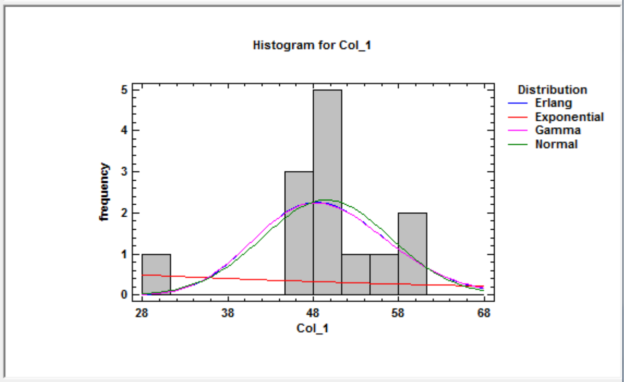


Figure H.1 Output of 'statgraphics centurion', transfer time data

H.2 Un-stacking of packaging

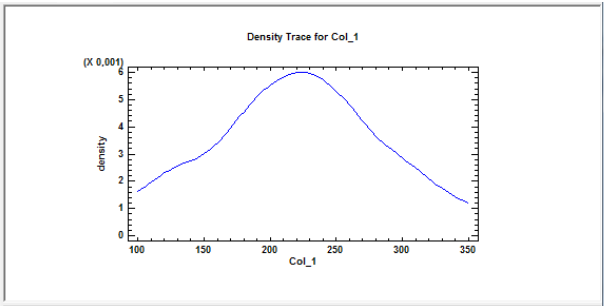
Uncensored Data - Col_1
Data variable: Col_1

14 values ranging from 100,0 to 350,0

Fitted Distributions

Erlang	*Exponential*	*Gamma*	*Normal*
shape = 11,0	mean = 221,429	shape = 10,7447	mean = 221,429
scale = 0,0496774		scale = 0,0485247	standard deviation = 66,7783

The StatAdvisor
This analysis shows the results of fitting 4 distributions to the data on Col_1. The estimated parameters of the
You can test whether the distributions fit the data adequately by selecting Goodness-of-Fit Tests from the list o
visually how well the distributions fit by selecting Frequency Histogram from the list of Graphical Options. Ot
you to compute and display tail areas and critical values for the distribution. To select a different distribution, p
select Analysis Options.



Goodness-of-Fit Tests for Col_1
Kolmogorov-Smirnov Test

	Erlang	*Exponential*	*Gamma*	*Normal*
DPLUS	0,0	0,205842	0,0772976	0,091788
DMINUS	1,0	0,397181	0,186447	0,146339
DN	1,0	0,397181	0,186447	0,146339
P-Value	0,0	0,024139	0,71519	0,925254

The StatAdvisor
This pane shows the results of tests run to determine whether Col_1 can be adequately modeled by various dist

P-values less than 0,05 would indicate that Col_1 does not come from the selected distribution with 95% confid

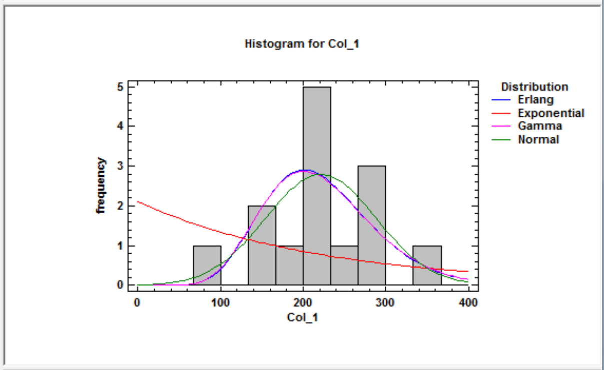


Figure H.2 Output of 'statgraphics centurion', unstacking of packing data

H.3 Restacking time packing on FH trolley, time per full FH trolley

Uncensored Data - Col_1
Data variable: Col_1

9 values ranging from 100,0 to 324,0

Fitted Distributions

Erlang	*Exponential*	*Gamma*	*Normal*
shape = 9,0	mean = 222,333	shape = 8,7519	mean = 222,333
scale = 0,0404798		scale = 0,0393639	standard deviation = 73,6767

The StatAdvisor
This analysis shows the results of fitting 4 distributions to the data on Col_1. The estimated parameters of the
You can test whether the distributions fit the data adequately by selecting Goodness-of-Fit Tests from the list o
visually how well the distributions fit by selecting Frequency Histogram from the list of Graphical Options. Ot
you to compute and display tail areas and critical values for the distribution. To select a different distribution, p
select Analysis Options.

Goodness-of-Fit Tests for Col_1
Kolmogorov-Smirnov Test

	Erlang	*Exponential*	*Gamma*	*Normal*
DPLUS	0,0	0,232871	0,115772	0,104285
DMINUS	1,0	0,371025	0,200938	0,158673
DN	1,0	0,371025	0,200938	0,158673
P-Value	3,046E-8	0,167892	0,860536	0,977253

The StatAdvisor
This pane shows the results of tests run to determine whether Col_1 can be adequately modeled by various dist

P-values less than 0,05 would indicate that Col_1 does not come from the selected distribution with 95% confid

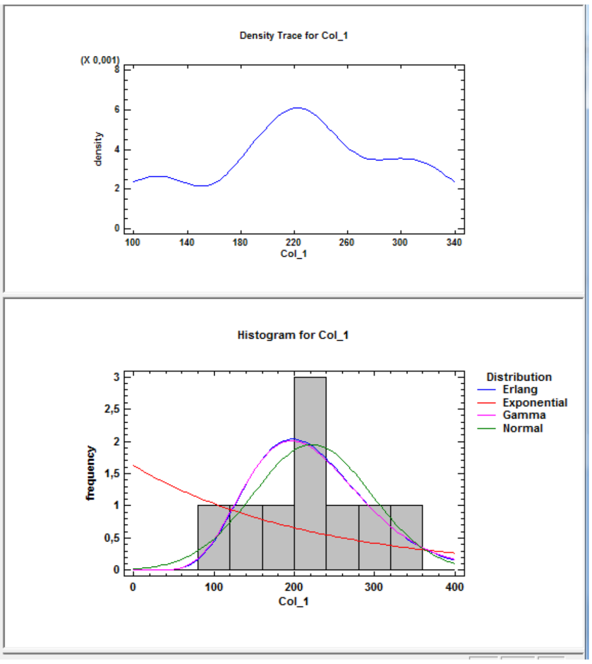


Figure H.3 Output of 'statgraphics centurion', restacking time packing on FH trolley

H.4 Nesting of export trolleys

Uncensored Data - Col_1
Data variable: Col_1

5 values ranging from 780,0 to 840,0

Fitted Distributions

Erlang	*Exponential*	*Gamma*	*Normal*
shape = 1363,0	mean = 801,8	shape = 1363,26	mean = 801,8
scale = 1,69993		scale = 1,70025	standard deviation = 24,4377

The StatAdvisor
This analysis shows the results of fitting 4 distributions to the data on Col_1. The estimated parameters of the
You can test whether the distributions fit the data adequately by selecting Goodness-of-Fit Tests from the list o
visually how well the distributions fit by selecting Frequency Histogram from the list of Graphical Options. Ot
you to compute and display tail areas and critical values for the distribution. To select a different distribution, p
select Analysis Options.

Goodness-of-Fit Tests for Col_1
Kolmogorov-Smirnov Test

	Erlang	*Exponential*	*Gamma*	*Normal*
DPLUS	1,0	0,350764	0,20608	0,193805
DMINUS	6,79517E-9	0,621981	0,159149	0,186178
DN	1,0	0,621981	0,20608	0,193805
P-Value	0,0000907999	0,0417752	0,983693	0,991885

The StatAdvisor
This pane shows the results of tests run to determine whether Col_1 can be adequately modeled by various dist

P-values less than 0,05 would indicate that Col_1 does not come from the selected distribution with 95% confid

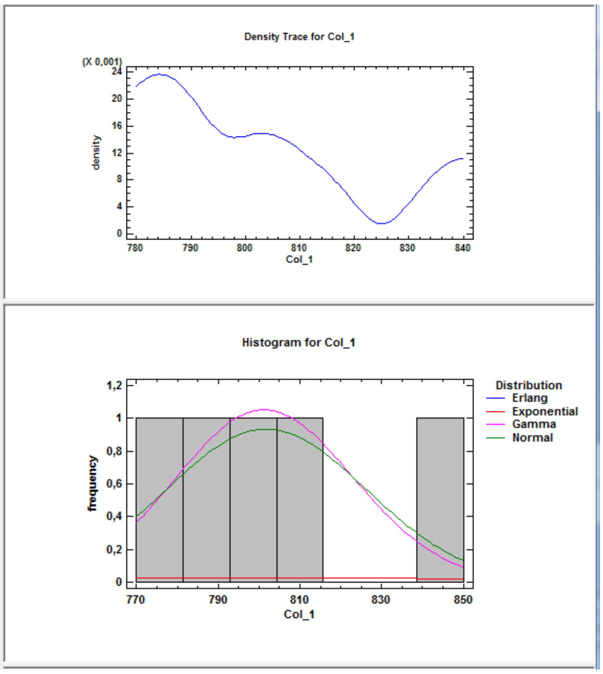


Figure H.4 Output of 'statgraphics centurion', nesting of export trolley data

H.5 Export trolley data

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Figure H.5 Output of ‘statgraphics centurion’, export trolley data

Appendix I Transport cost calculation for truck with trailer

In this appendix the cost calculation is showed based on a truck and trailer combination. This tool is accessible for members and is used to determine the cost price per hour and per km. Below the calculation sheet is shown.

Web Kostprijscalculatie
Calculatie: Trekker oplegger combinatie NL
Gebaseerd op lonen en premies per: CAO 01-01-2012

ALGEMENE GEGEVENS	Calculatie voor 2012
Ziekteverzuim-verzekering Percentage	2,00
ARBO-dienst per jaar	100,00
WIA gediff. premiepercentage	0,30
Dieselprijs Nederland	0,8000
Dieselprijs Buitenland	0,0000
Percentage buitenlandse diesel	0,00
Algemene kosten Bedrag	750,00
Rente percentage	5,00
Opslag winst & risico percentage	7,00

CHAUFFEUR GEGEVENS	D-5 chauffeur
Functieschaal en trede	D05
Uren 100% per week	40,00
Uren 130% per week	10,00
Uren 150% per week	0,00
Uren 200% per week	0,00
Ploegentoeslag %	0,00
Ploegentoeslag per jaar	0,00
overige bruto loonvergoeding / week	0,00
Vakantiedagen per jaar (excl.ATV)	25,00
Ziektedagen per jaar	5,00
Wachtdagen werknemer per jaar	1,00
Ziekte-uitkering per jaar	1.000,00
Onbelaste vergoeding per week	100,00
Overige kosten per jaar	1.000,00
Bijrijder	0

TREKKEND VOERTUIG	Daf 85	GETROKKEN VOERTUIG	1360 huif oplegger 3 asser
Nieuwprijs	75.000,00	Nieuwprijs	30.000,00
Restwaarde	7.500,00	Restwaarde	3.000,00
Gebruiksduur in Jaar	7,00	Gebruiksduur in Jaar	10,00
Jaarkilometrage	100.000,00	Verzekering per jaar	500,00
Productieve uren per jaar	2.400,00	Verzekering: - casco aantal jaren	0,00
Dieselverbruik per 100 km	33,00	Verzekering: - premie casco	0,00
MRB per jaar	864,00	Aantal banden (incl. reserve)	7
Eurovignet per jaar	1.250,00	Prijs van een band	350,00
Verzekering per jaar	1.500,00	Levensduur band in km	200.000,00
Verzekering: - premie WA	0,00	Reparatie per km	0,0260
Verzekering: - eigen risico WA	0,00	Smeermiddelen per km	0,0000
Verzekering: - casco aantal jaren	0,00	Overige kosten per jaar	1.000,00
Verzekering: - premie casco	0,00	Opbouw getrokken voertuig	0
Aantal banden (incl. reserve)	6		
Prijs van een band	400,00		
Levensduur band in km	250.000,00		
Reparatie per km	0,0350		
Smeermiddelen per km	0,0000		
Overige kosten per jaar	1.500,00		
Opbouw trekkend voertuig	0		

ALGEMEEN KOSTENOVERZICHT	TRK/MW	OPBOUW	OPL/AH	OPBOUW	COMBI
VAR. AUTOKSTN/KM	0,3070	0,0000	0,0365	0,0000	0,3435
- Brandstof	0,2640	0,0000	0,0000	0,0000	0,2640
- Smeerolie	0,0000	0,0000	0,0000	0,0000	0,0000
- Banden	0,0080	0,0000	0,0105	0,0000	0,0185
- Reparatie & Onderhoud	0,0350	0,0000	0,0260	0,0000	0,0610
- Afschrijving	0,0000	0,0000	0,0000	0,0000	0,0000
VASTEKOSTEN/JR	16.477	0	4.780	0	21.257
- Brandstof	0	0	0	0	0
- Reparatie & Onderhoud	0	0	0	0	0
- Afschrijving	9.300	0	2.455	0	11.755
- Verzekering	1.500	0	500	0	2.000
- Mrb	864	0	0	0	864
- Eurovignet	1.250	0	0	0	1.250
- Rente	2.063	0	825	0	2.888
- Overig	1.500	0	1.000	0	2.500
PERSONEEL/JR	57.548	0	0	0	57.548
- Loon	51.656	0	0	0	51.656
- Verblijf	4.800	0	0	0	4.800
- Overig	1.092	0	0	0	1.092
ALG.KSTN/JAAR	750	0	0	0	750
WINST & RISICO	7.383	0	590	0	7.973
TOTALE KOSTEN	**112.857**	**0**	**9.020**	**0**	**121.877**

KOSTEN PER UUR		plus	KOSTEN PER KM	
- Autokosten	8,86		- Autokosten	0,3435
- Personeelskosten	23,98		- Algemene kosten	0,0000
- Algemene kosten	0,31		Subtotaal	0,3435
Subtotaal	33,15		- Winst & Risico	0,0240
- Winst & Risico	2,32		TOTAAL	**0,3675**
TOTAAL	**35,47**			

TOTAAL PER UUR
50,78

TOTAAL PER KM
1,2188

KOSTENOVERZICHT PER KM, PER UUR EN PER JAAR EN IN PROCENTEN	PER KM	PER UUR	PER JAAR	%
Brandstof	0,2640	11,00	26.400	23,17
Smeerolie	0,0000	0,00	0	0,00
Banden	0,0185	0,77	1.850	1,62
Reparatie & Onderhoud	0,0610	2,54	6.100	5,36
Afschr. voertuig	0,1176	4,90	11.755	10,32
Loon & Sociale lasten	0,5166	21,52	51.656	45,35
Verblijfkosten	0,0480	2,00	4.800	4,21
Overige personeelskosten	0,0109	0,45	1.092	0,96
Verzekering	0,0200	0,83	2.000	1,76
Mrb	0,0086	0,36	864	0,76
Eurovignet	0,0125	0,52	1.250	1,10
Rente	0,0289	1,20	2.888	2,54
Overig	0,0250	1,04	2.500	2,19
Opbouw trekkende eenheid	0,0000	0,00	0	0,00
Opbouw getrokken eenheid	0,0000	0,00	0	0,00
Opslag algemene kosten	0,0075	0,31	750	0,66
Totaal excl. Winst & Risico	1,1391	47,46	113.904	100,00
Totaal incl. Winst & Risico	**1,2188**	**50,78**	**121.877**	**107,00**

OVERZICHT LOONKOSTEN CHAUFFEUR

BEREKENING LOONKOSTEN					SPECIFICATIE DIENSTUREN	
Loon 100% uren	2.048,00	*	12,97	26.562,56	Dienstuur	2.088,00
Overuren 130%	439,80	*	16,86	7.415,03	Vakantie	-200,00
Overuren 150%	0,00	*	19,46	0,00	ATV	-28,00
Overuren 200%	0,00	*	25,94	0,00	Feestdagen	-48,00
Kosten ziektedagen				625,35	Verzuim	-12,80
Aftrek wachtdagen				-125,07	Overuur 100%	0,00
Overige bruto loonvergoeding				0,00	Overuur 130%	439,80
Ploegentoeslag				0,00	Overuur 150%	0,00
Vakantiebijslag				2.158,25	Overuur 200%	0,00
Bijdrage Zorgverzekeringskosten				0,00	Ziek	-40,00
Kerstuitkering / eenmalige uitkering				0,00	Totaal	2.199,00
Bruto loon				36.636,12		
Sociale lasten				11.012,83	SOCIALE LASTEN	
Uitkering Ziektewet				-1.000,00	Pensioen	4.754,44
Ziektekosten				681,09	VUT	0,00
SUBTOTAAL				47.330,03	Prepensioen	0,00
					Zvw	2.417,86
Onbelaste vergoeding				4.398,00	WW	762,48
Overige personeelskosten				1.000,00	Wachtgeld	946,71
					WIA	1.821,91
TOTALE LOONKOSTEN PER CHAUFFEUR				52.728,03	O&O	209,43
TOTALE LOONKOSTEN PER UUR				23,9782	ARBO dienst	100,00

Kosten samenstelling	In %	Kosten ontwikkeling in %	Kosten effect in %
Brandstof	23,17	0,00	23,17
Smeerolie	0,00	0,00	0,00
Banden	1,62	0,00	1,62
Reparatie en onderhoud	5,36	0,00	5,36
Afschrijving voertuigen	10,32	0,00	10,32
Loon en sociale lasten	45,35	0,00	45,35
Verblijfkosten	4,21	0,00	4,21
Overige Personeelskosten	0,96	0,00	0,96
Verzekering	1,76	0,00	1,76
MRB	0,76	0,00	0,76
Eurovignet	1,10	0,00	1,10
Rente	2,54	0,00	2,54
Overig	2,19	0,00	2,19
Opbouw trekkende eenheid	0,00	0,00	0,00
Opbouw getrokken eenheid	0,00	0,00	0,00
Opslag algemene kosten	0,66	0,00	0,66
Totaal exclusief winst en risico	100,00		100,00
Totaal inclusief winst en risico	107,00		107,00

Appendix J Queue graph of buffer sizes at EC

J.1 Buffer size at cross-dock at EC

On the horizontal axes the time is displayed in seconds, on the vertical axes the number of ET's on the cross-dock are shown.

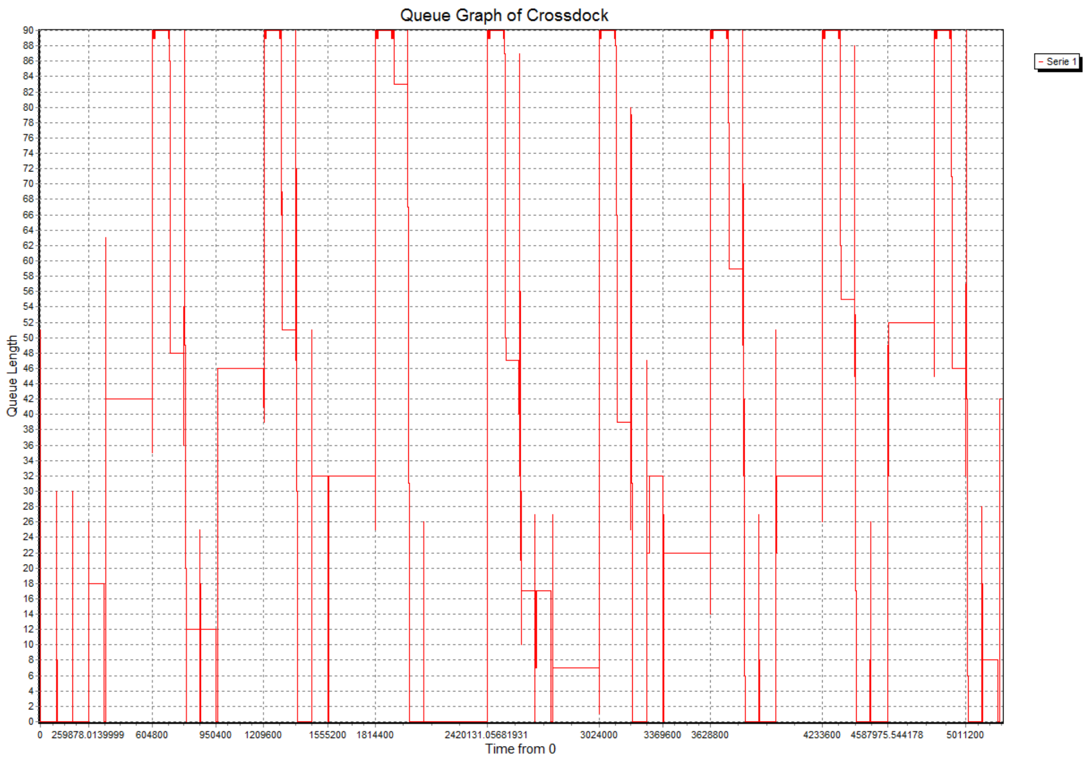

Figure J.1 Buffer sizes at cross-dock at EC

J.2 Buffer size at process place at EC

On the horizontal axes the time is displayed in seconds, on the vertical axes the number of ET's at the process place are shown.

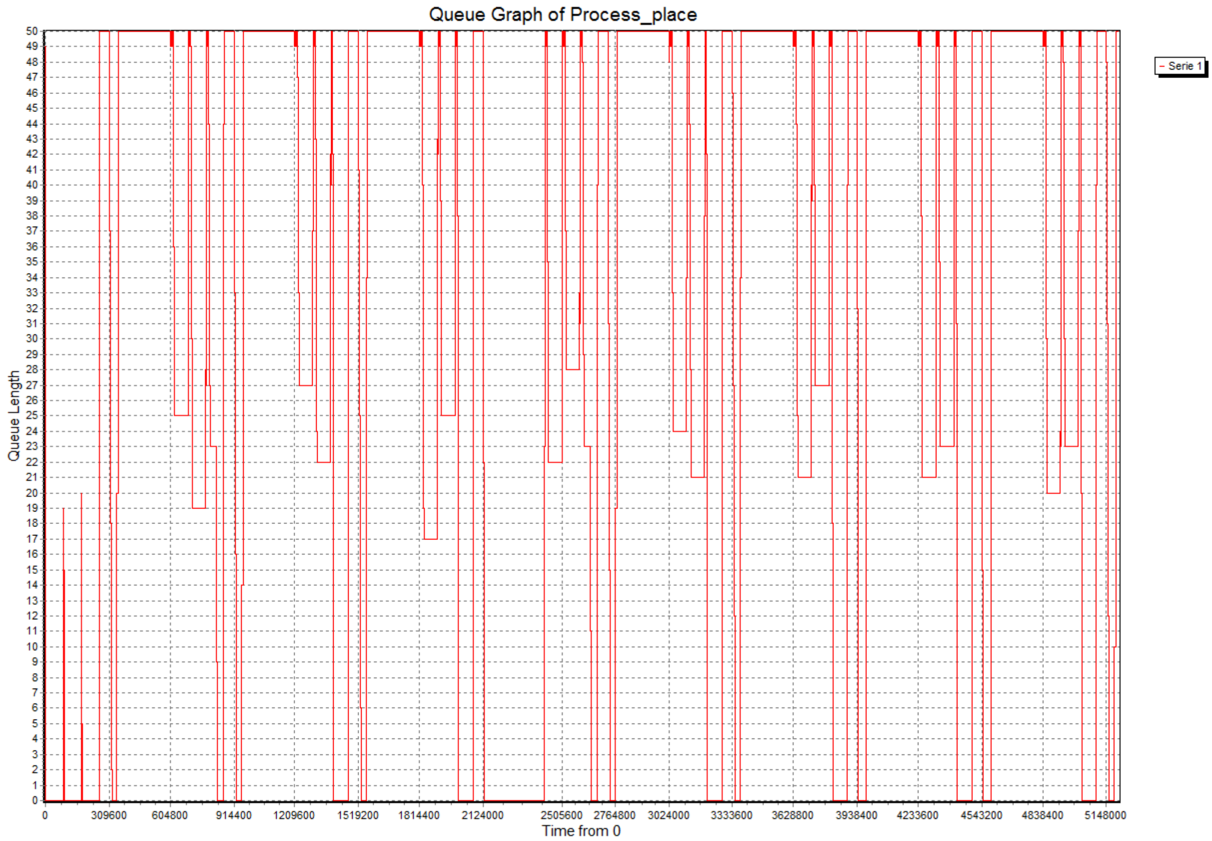

Figure J.2 Queue graph of process place at EC

J.3 Buffer size of cross-dock at LSP

On the horizontal axes the time is displayed in seconds, on the vertical axes the number of ET's on the cross-dock are shown.

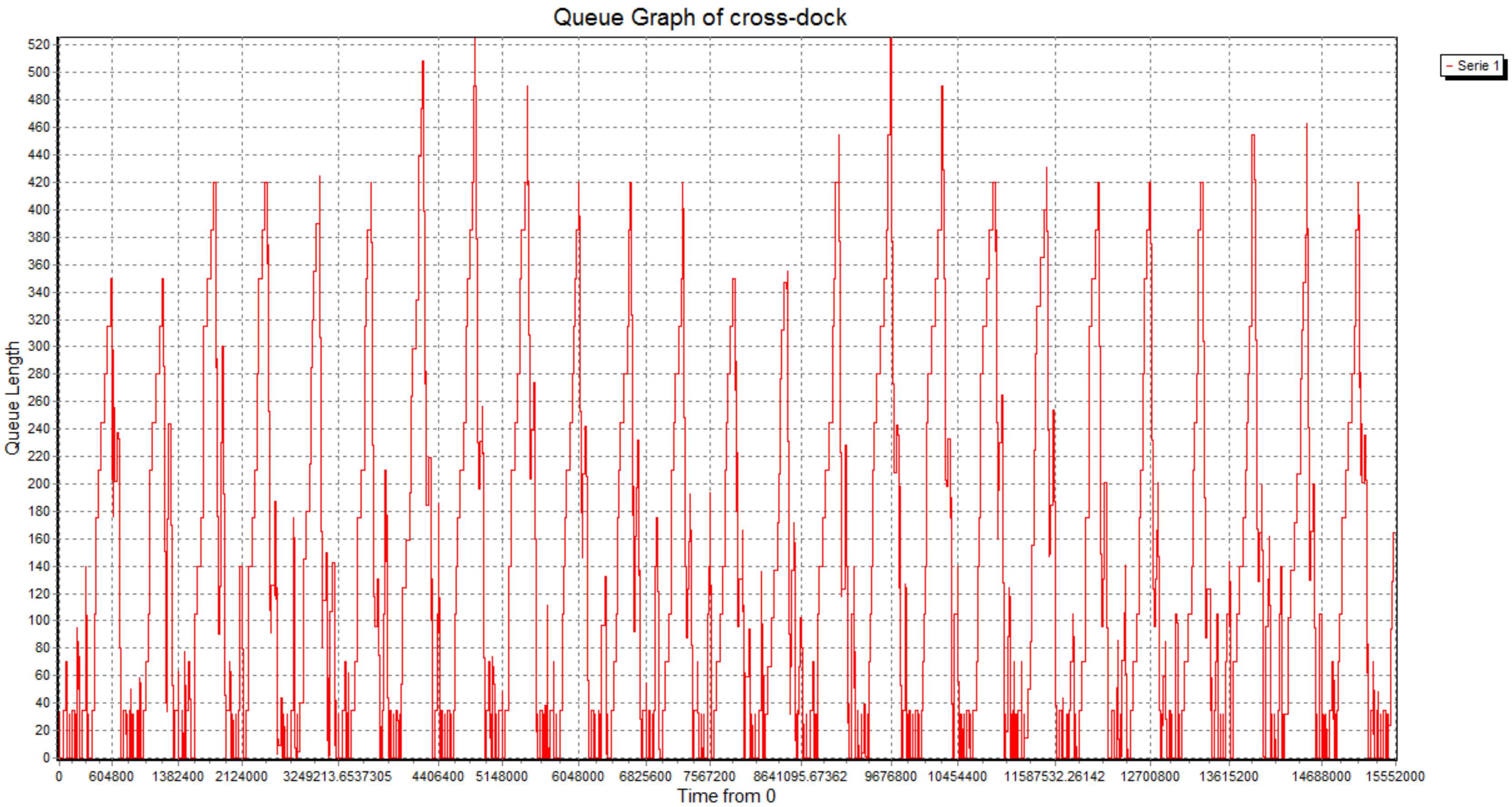

Figure J.3 Buffer size of cross-dock at LSP

Appendix K Simulation output

K.1 Output base case scenario EC

Observation period :	31536000
Warmup period :	604800
Number of observations :	5
Simulation method :	Separate runs
Description :	

Atom : EXKar

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
EXkar	24361.40	11.97	24346.53	24376.27	24344.00	24377.00

Atom : FHkarOUT

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
FHkar	6380.60	8.38	6370.19	6391.01	6368.00	6387.00

Atom : nesting1

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.06	0.00	0.06	0.06	0.06	0.06
Status Busy	0.10	0.00	0.10	0.10	0.10	0.10
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.02	0.00	0.02	0.02	0.02	0.02

Atom : nesting2

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.15	0.00	0.15	0.15	0.15	0.15
Status Busy	0.02	0.00	0.02	0.02	0.02	0.02
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.01	0.00	0.01	0.01	0.01	0.01

Atom : Stacking1

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.10	0.00	0.10	0.10	0.10	0.10
Status Busy	0.04	0.00	0.04	0.05	0.04	0.05
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.04	0.00	0.04	0.04	0.04	0.04

Atom : TLSiVePo

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLSiVePo	289.60	0.55	288.92	290.28	289.00	290.00

Atom : transfer1

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.06	0.00	0.06	0.06	0.06	0.06

Status Busy	0.02	0.00	0.02	0.02	0.02	0.02
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.10	0.00	0.10	0.10	0.10	0.10

Atom : transfer2

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.06	0.00	0.06	0.06	0.06	0.06
Status Busy	0.02	0.00	0.02	0.02	0.02	0.02
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.10	0.00	0.10	0.10	0.10	0.10

Atom : Trucks

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
trucks	64080.44	359.73	63633.68	64527.19	63619.30	64630.02

Atom : UnstackingPr1

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.07	0.00	0.07	0.07	0.07	0.07
Status Busy	0.06	0.00	0.06	0.06	0.06	0.06
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.05	0.00	0.05	0.05	0.05	0.05

Atom : unstackingPr2

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.08	0.00	0.07	0.08	0.07	0.08
Status Busy	0.05	0.00	0.05	0.05	0.05	0.05
Status Not Available	0.82	0.00	0.82	0.82	0.82	0.82
Status Waiting for Operator	0.05	0.00	0.05	0.05	0.05	0.05

K.2 Output base case scenario at LSP

Observation period :	33350400
Warmup period :	1814400
Number of observations :	5
Simulation method :	Separate runs
Description :	

Atom : truckloadsout3EC(2)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TL3(2)	176.60	3.13	172.71	180.49	174.00	182.00

Atom : sorteren

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : sorteren2

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : sorteren3

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : tellen

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : tellen2

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : tellen3

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
Status Idle	0.13	0.00	0.13	0.13	0.13	0.13
Status Busy	0.17	0.00	0.17	0.17	0.17	0.17
Status Not Available	0.70	0.00	0.70	0.70	0.70	0.70

Atom : TLin(ba)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum

TLinBA		21.40	0.55	20.72	22.08	21.00	22.00

Atom : TLin(ha)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLinHA	179.40	1.34	177.73	181.07	177.00	180.00

Atom : TLin(vi)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLinVi	21.60	0.55	20.92	22.28	21.00	22.00

Atom : TLin(x)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLinX	31.80	1.10	30.44	33.16	31.00	33.00

Atom : TLin(z)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLinZ	32.40	1.52	30.52	34.28	30.00	34.00

Atom : TLin(zu)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TLinZU	31.40	0.55	30.72	32.08	31.00	32.00

Atom : truckloads 2EC (3)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TL2(3)	130.80	1.64	128.76	132.84	129.00	133.00

Atom : truckloadsout 2EC(1)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TL2(1)	110.00	1.41	108.24	111.76	108.00	111.00

Atom : truckloadsout 2EC(2)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TL2(2)	412.80	1.92	410.41	415.19	410.00	415.00

Atom : truckloadsout 3EC (1)

	Average	St.Deviation	Lower bound (95%)	Upper bound (95%)	Minimum	Maximum
TL3(1)	479.60	0.55	478.92	480.28	479.00	480.00

Appendix L Detailed cost allocation at processes

L.1 Cost allocation at EC, scenario 1

Salary		Handling	nr. FTE	cost/FTE	cost
FTE at cross-dock	warehouse	transfer	2	€25000	€50000
		un-stacking	5	€25000	€125000
		stacking	2	€25000	€50000
		nesting	5	€25000	€125000
	team leader		2	€30000	€60000
	administration		6	€30000	€180000
					€590000

Warehouse		m²/area	m²	cost/m²/year	cost
	crossdock		1080	€84	€90720
	processing area		1080	€84	€90720
	docks	130	650	€84	€54600
	storage		6120	€84	€514080
					€750120

Transport		trolleys/year	cost/hr	cost/trolley	cost
	FHT to FH	38216	€51	€1,47	€56177
	ET to EC	24331	€51	€0,38	€9306
					€65484

	6 EC's	per EC
Total cost	**€1405604**	**€234267**
number of ET's	**145984**	**24331**
cost/ET	**€9,63**	**€9,63**

Table L.1 Detailed cost allocation of RTI process at EC, scenar

L.2 Cost allocation at LSP, scenario 1

Salary		nr.	cost/FTE		cost
FTE at cross-dock	employees	4	€25000		€100000
	team leader	1	€30000		€30000
	administration	1	€30000		€30000
				Total	**€160000**
Handling and equipment costs	v	nr.	total UT (hr)	cost/hr	cost
Loading	1,2,3,	1589	198,625	€51	€10130
Unloading	1	1589	529,67	€51	€27013
	2	0	0,0	€51	0
	3	0	0	€51	0
				Total	**€37143**
Transport	v	nr.	dij	cost/km	cost/year
from LSP to auction location	1,2,3,	1589	117	€1,22	€226814
	v	nr.	total UT (hr)	cost/hr	cost
transport between EC's	1	-	-		-
	2	0	0	€51	0
	3	0	0	€51	0
				Total	**€226814**

Total cost	**€423957**
number of ET's	**54026**
cost/ET	**€7,85**

Table L.2 Detailed cost allocation of RTI process at LSP, scenario 1

L.3 Cost allocation at EC, scenario 2

Salary		Handling	nr. FTE	cost/FTE	cost
FTE at cross-dock	warehouse	transfer	2	€25000	€50000
		un-stacking	5	€25000	€125000
		stacking	2	€25000	€50000
		nesting	4	€25000	€100000
	team leader		2	€30000	€60000
	administration		6	€30000	€180000
					€565000

Warehouse		m²/area	m²	cost/m²/year	cost
	Cross-dock		1080	€84	€90720
	processing area		1080	€84	€90720
	docks	130	650	€84	€54600
	storage		3497	€84	€293760
					€529800

Transport		Trolleys/year	cost/hr	cost/FHT	cost
	FHT to FH	38216	€51	€1,47	€56178
	ET to EC	24354	€51	€0,22	€5323
					€61501

	6 EC's	per EC
Total cost	**€1156301**	**€192717**
number of ET's	**146123**	**24354**
cost/ET	**€7,91**	**€7,91**

Table L.3 Detailed cost allocation of RTI process at EC, scenario 2

L.4 Cost allocation at LSP, scenario 2

Salary		nr.	cost/FTE		cost
FTE at cross-dock	employees	3	€25000		€75000
	team leader	1	€30000		€30000
	administration	1	€30000		€30000
				Total	**€135000**
Handling and equipment costs	v	nr.	total UT (hr)	cost/hr	cost
Loading	1,2,3,	1527	190,875	€51	€9735
Unloading	1	1527	509,00	€51	€25959
	2	0	0,0	€51	€0
	3	0	0	€51	€0
				Total	**€35694**
Transport	v	nr.	dij	cost/km	cost/year
from LSP to auction location	1,2,3,	1527	117	€1,22	€217964
	v	nr.	total UT (hr)	cost/hr	cost
transport between EC's	1	-	-		-
	2	0	0	€51	€0
	3	0	0	€51	€0
				Total	**€217964**

Total cost	**€388658**
number of ET's	**56499**
cost/ET	**€6,88**

Table L.4 Detailed cost allocation of RTI process at LSP, scenario 2