MASTER

The flowtype selection model
selecting the logic logistic structure

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Cash & Carry Nederland

The Flowtype Selection Model

Selecting the Logic Logistic Structure

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Preface

This report presents the results of my master thesis project at Metro Cash and Carry.

This report has two primary goals. First, it forms the master thesis report of my study at the Technological University in Eindhoven. Second, the report gives logistical guidance to Metro Cash and Carry. An additional goal is to inform other people, who are interested in this subject.

Readers, who want a quick impression of the highlights of this report, should read the management summary at the beginning of this report.

In addition I would like to thank some people who helped me during this project. First, I want to thank Niels Maas for giving me the opportunity to execute this master thesis project at Metro Cash and Carry. Second, I want to thank Emil Driesenaar, who was always willing to help me and to give me guidance. Third, I want to thank my supervisors of the TUE for their consultation: Rob Broekmeulen and Karel van Donselaar. And last but not least, I want to thank all my colleagues at Metro, and especially the EDI team (Jolanda Visser, Geert van der Veer, and Carolyn Mobach), who were very nice company during my time at Metro Cash and Carry.

Alex van den Heijkant

Abstract

This report describes the design of the **flowtype selection model**, which can be used to select the economic optimal logistic structure for any given non-perishable good supplier. The different logistic structures are: delivering directly from the supplier to the stores, or delivering through a platform. Finally, the report gives an indication of the preferable flowtype for all non-perishable good suppliers of Metro.

Management Summary

This section presents a summary of the master thesis report of Alex van de Heijkant at Metro Cash and Carry. First, the problem is defined. Second, the current situation and the diagnosis are described. Next, some general guidelines based on the analytical model are presented. Finally, the flowtype selection model and its results are presented.

The Problem Definition

During the first project stage the following problem was defined, formulated as an assignment:

Develop a method that determines the benefits & costs of the different flowtypes within a short amount of time, for each supplier, for the non-perishable goods, and before the end of June 2006.

Further explanation:

method:	The method should be structured and documented in such a way that someone with access to the required information can use it and will use it in the same right way.
benefits & costs:	The most relevant benefits and costs factors should be considered for both the supplier and Metro Cash and Carry.
different flowtypes:	All four basic flowtypes should be considered, but bad performing cross docking flowtypes could be excluded after the analysis phase.
short amount of time:	The exact limit cannot be stated, because half an hour longer might lead to much better results. The goal is a couple of hours.

A **flowtype** is the way that the goods flow from the supplier to the several stores. Metro uses four basic flowtypes:

- *Direct Store Delivery (DSD):* The goods are delivered directly from the supplier to the different stores.
- *Central Warehouse (CW):* The suppliers deliver the goods to a central warehouse, where the goods are stored, and shipped to a store when they order products.
- *Break-Bulk Cross-Docking (BB-XD):* The orders of the different stores are combined into one order. The supplier delivers this order to a cross docking point, where the goods on the pallets are divided and shipped directly (without storing in a central warehouse) to the stores.
- *Pre-Allocated Cross-Docking (PA-XD):* The orders of the different stores are picked separately at the supplier. Then, the different orders are loaded in one truck and shipped from the supplier to the cross docking point, where the shipment can be easily split and transported to the different stores. In comparison to the break bulk cross docking, the goods do not need any further handling at the platform.

The research model that is used to analyze the problem is shown in Figure 1. The research model is based on a model presented by Verschuren en Doorewaard (1995). The left column presents the information sources for the evaluation of the current situation. The middle column presents the comparisons. The right column displays the result.

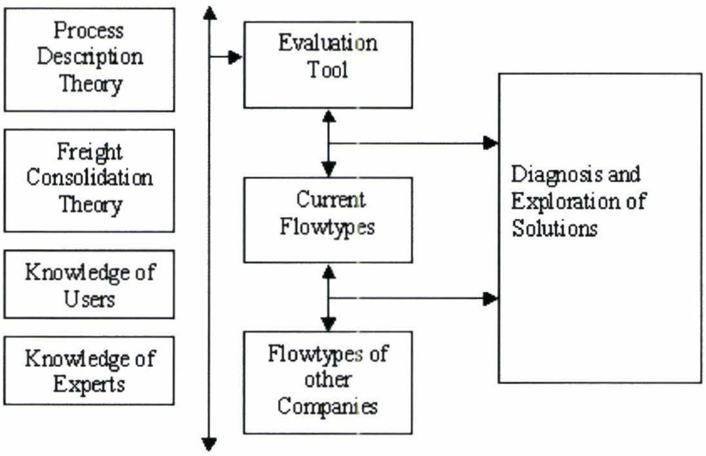

Figure 1: The Research Model for the Diagnosis

The Diagnosis

Before the diagnosis can be made, some information must be gathered about the current situation of Metro, knowledge of employees and experts, theory in the literature, and the situation in the market.

Metro Cash and Carry

The description of the different flowtype processes are based on a standard model, the Supply Chain Operations Reference (SCOR) model (Supply Chain Council 2000). This model is developed by the Supply Chain Council and constitutes a supply chain management standard. This model gives an overview and description of all the processes in the supply chain. Based on this description the relevant parts of the supply chain are determined, which are yellow coloured. Next, the different processes are linked to the different participants in the supply chain (See Figure 2).

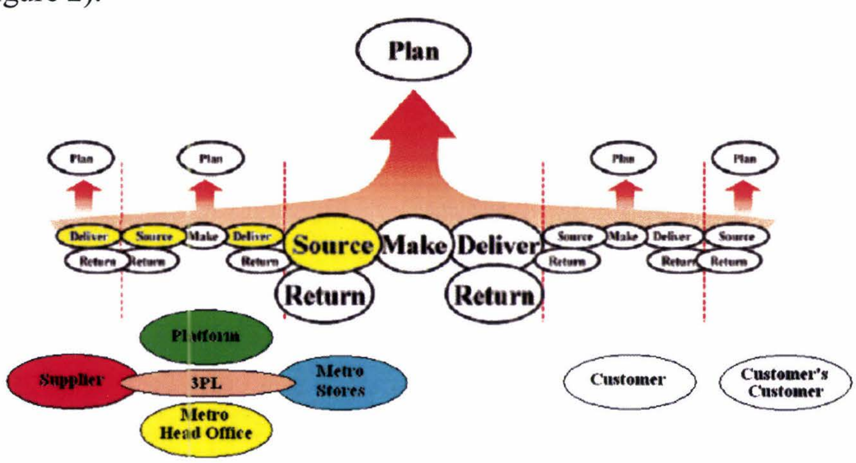

Figure 2: The SCOR Model

The current flowtypes of the non-perishable good suppliers are presented in Figure 3. A supplier delivers through a central warehouse when a supplier is willing to pay a **compensation**. Metro developed a method to make an estimation of the compensation that the supplier has to pay. This method is discussed, which lead to the following most important requirements for the flowtype selection model:

- It should be easy to use, and give a solution in a relative **short amount of time**, e.g. a couple of hours. (The exact limit cannot be stated, because half an hour longer might lead to much better results.)

- It should give an overview of the benefits and costs for the **different participants** in the supply chain. This information is needed, when the different parties have to negotiate about necessary compensations.
- It should be documented and put into a **tool**. In this way, the method is used in the same and right way and the mistakes will be reduced.
- One supplier can have **only one flowtype for all the orders**. This precondition follows from the information system that is used.

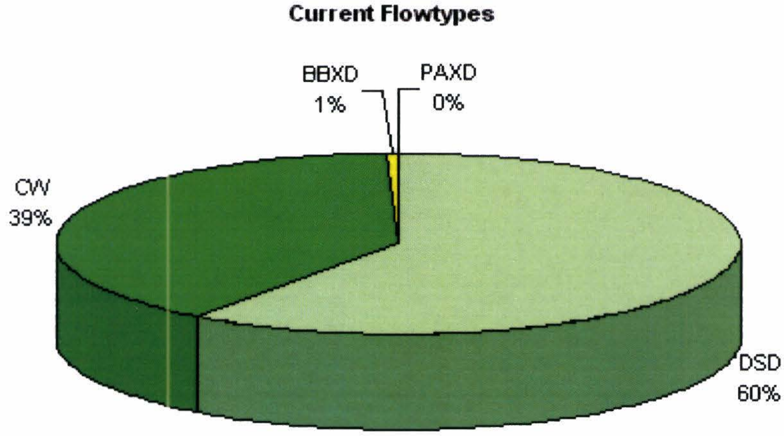

Figure 3: The Current Flowtypes of the Non-Perishable Good Suppliers

The most important reasons for a supplier to deliver through a central are investigated:
- *The location of a supplier*: If a supplier is located outside the Netherlands and the goods require additional actions, the goods are shipped over a central warehouse.
- *The total sales volume:* The benefits of consolidating goods in a central warehouse are higher when a supplier has a low total sales volume.
- *The assortment width:* A small assortment generally results in lower total sales; and, therefore, the consolidation benefits will increase. Moreover, the storage costs in the central warehouse are lower for suppliers with a small assortment.

The influence of the product value and promotion share are negligible.

The Literature
Several articles that are related to the flowtype selection are studied. One general guideline that can be derived from the literature is:

> The benefits of freight consolidation on transportation costs should outweigh the longer transportation routes, the (possibly) higher inventory level and the operating costs of the platform.

The Market Situation
The logistic structure of several similar retail chains is investigated. There are companies that have direct store delivery as the standard flowtype, such as Hanos, Metro C&C Germany, and Metro C&C Belgium. And there are companies that have the central warehouse delivery as standard flowtype, such as Sligro, Albert Heijn, and the Lidl. The reasons for central warehouse delivery are:
- *Warehouse for home deliveries*
- *Short response time*
- *Small storage space*
- *Less handling of incoming goods*

The Diagnosis

The difference in costs between the flowtypes should explain why suppliers are (not) willing to pay a compensation, which results in the "unique" situation of Metro. Therefore, the remaining of the project focuses on the total supply chain **costs**. Figure 4 shows the research model for developing the cost model. Models from the literature are matched with the situation of Metro, which leads to the flowtype selection model.

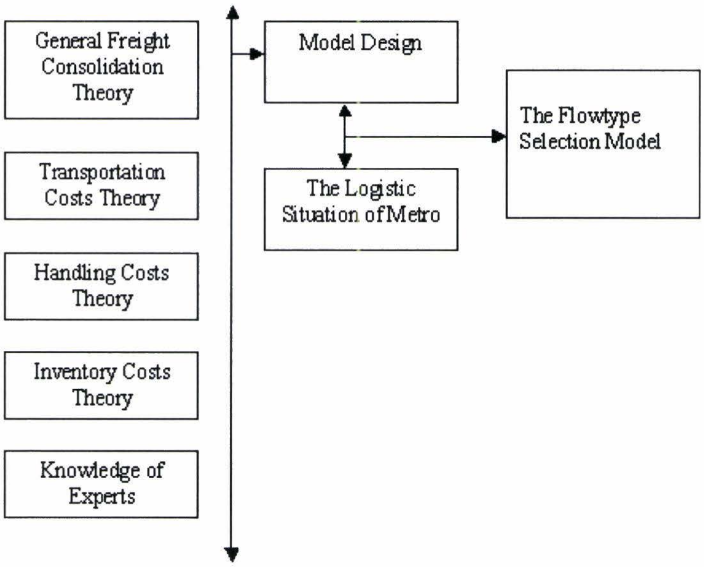

Figure 4: The Research Model for Designing the Flowtype Selection Model

The Analytical Model

First, the most relevant cost factors are determined, because it is impossible to model all the factors. Next, the pilot suppliers are selected, which are used to validate the models presented in the literature. Finally, the analytical models are formulated and some general guidelines are presented.

The Scope of the Model

A model is constructed for the five largest cost factors presented in Figure 5.

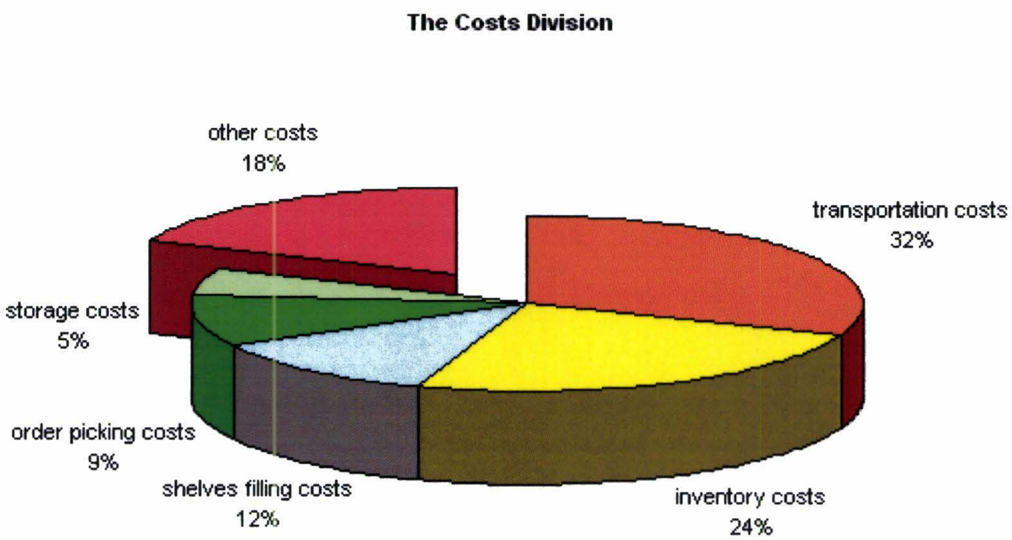

Figure 5: The Costs Division

These five costs can be combined into three:

- *the transportation costs:* including the transportation from the supplier to the store or the warehouse, and the transportation from the warehouse to the store.
- *the handling costs:* including the order picking costs, both for the supplier and in the warehouse, and the costs of filling the shelves in the store.
- *the inventory costs:* including the interest and the storage space costs at the warehouse, and the interest costs at the store.

The Pilot Suppliers

Matching the models in the literature to all 300 relevant suppliers is not realistic. Therefore, a limited number of suppliers is selected and analysed, these are the so-called pilot suppliers. (See Appendix M) These suppliers are also used during the implementation and testing phase. The suppliers are selected based on their sales volume and assortment width.

The Analytical Model

Figure 6 presents the relevant situation. One should choose between the blue and the black goods flow.

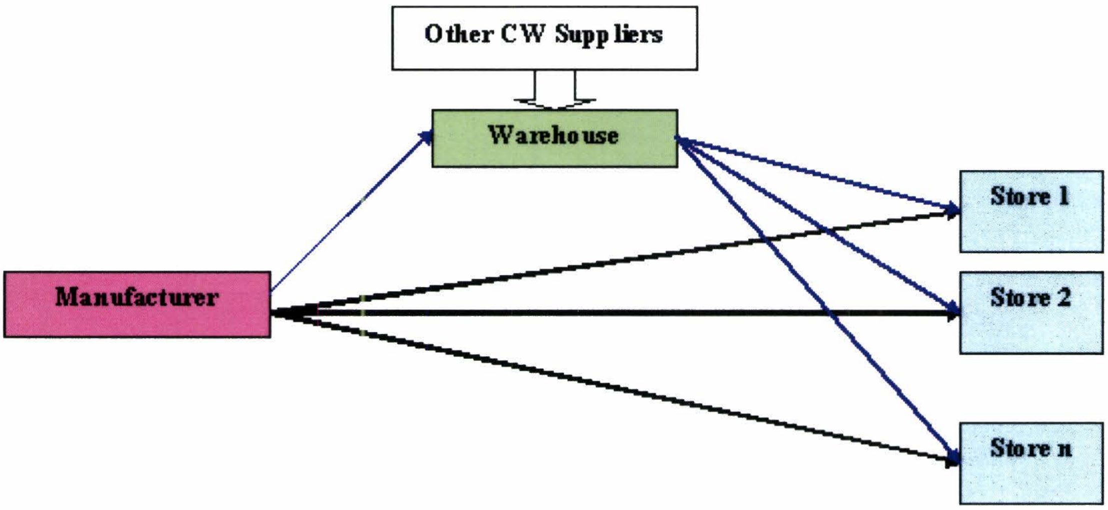

Figure 6: The Situation in the Market

To be able to make some general guidelines independent of the labour costs, the model will be made without a dimension. To construct formulas without a dimension the ratio of the three different costs are modelled. These models lead to some general guidelines. Direct store delivery becomes more beneficial, when:

- *the volume increases:* This is due to the change in transportation and storage space costs.
- *the delivery frequency from the manufacturer to the store is allowed to be significantly lower than the delivery frequency from the central warehouse to the store:* This is due to transportation costs and the line handling costs.
- *the labour costs of the supplier are low compared to the labour costs at the platform used by Metro:* This is due to both type of handling costs, line and unit costs.
- *the number of stores decreases:* This effect is due to the line handling costs.

These guidelines show that direct store delivery is more beneficial to Metro than for a supermarket chain, because of the larger sales volume, the lower delivery frequency, and the smaller number of stores.

The models also show that in most cases the handling costs are higher for the central warehouse than for direct store delivery. Moreover, the CW flowtype will probably have more inventory carrying costs, and definitely more storage space costs. So, the additional handling and inventory costs must be earned back by the savings in the transportation costs.

So:

If no savings can be made in the transportation costs a supplier should always deliver directly.

The Flowtype Selection Model

The insights gained from the analytical model are used in the development of the flowtype selection model. The flowtype selection model first calculates the costs of the activities, based on the gathered time tariffs and the productivity figures. Next, the model presents formulas to calculate the necessary data. Finally, it calculates the total costs based on the inputs and the costs per activity.

The model is applied on the pilot suppliers. The results are displayed in Figure 7. The figure shows that in most cases the most beneficial flowtype for the total supply chain is CW, but the most beneficial flowtype for Metro is DSD. If a supplier delivers to the central warehouse, the transportation costs decrease due to the consolidation benefits. However, the costs of Metro increase, because Metro has to compensate for using the platform. So, the fact that Metro asks a compensation is explicable.

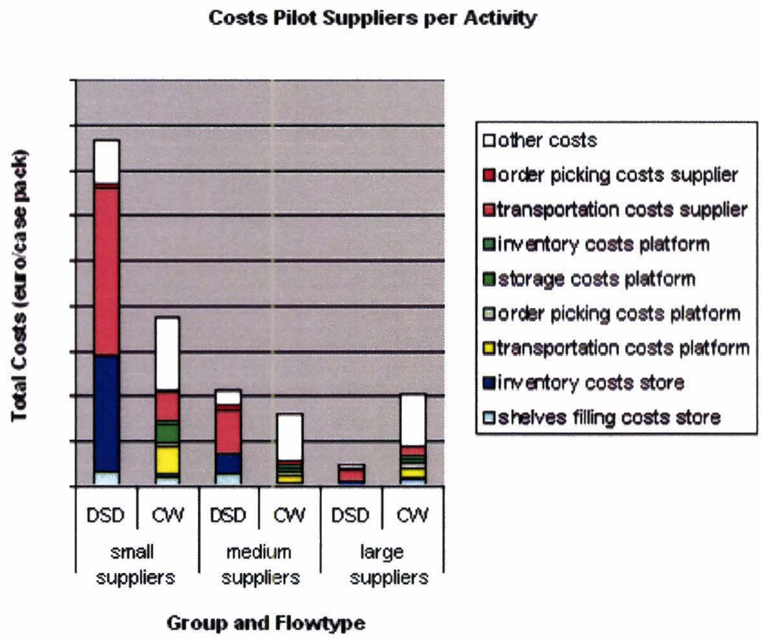

Figure 7: The Supply Chain Cost per Case Pack per Process for the Selected Suppliers

A linear regression analysis is executed to show that the results of the flowtype selection model align with the general guidelines. All the input parameters have a significant influence on the total cost ratio. The three most important input parameters and the nature of their influence are:

1. Distance ⇑ ⇒ CW
2. Volume ⇑ ⇒ DSD
3. Value ⇑ ⇒ DSD

The flowtype selection model is embedded in the organisation. A manual is produced for the use and maintenance of the model. One person is appointed to maintain of the model. In addition, the model is explained to the possible users by making some example calculations, and discussing the manual.

Finally, an overview of the suppliers and their current and preferable flowtype is presented in Figure 8. The upper flowtype represents the current flowtype, and the lower flowtype indicates the most preferable flowtype. The figure shows that most suppliers follow with their most preferable flowtype. Only four per cent of the suppliers should switch from central warehouse to direct store delivery. However, these are large suppliers, and removing them out of the warehouse will considerably lower the available consolidation volume. Therefore, it is better to:

- ➔ First focus on the group of supplier that should switch from direct store delivery to central warehouse. This list of suppliers and their current and preferable flowtype is handed over to Metro.
- ➔ Use the flowtype selection model to calculate the compensation that the supplier has to pay, to switch from direct store delivery to central warehouse delivery.

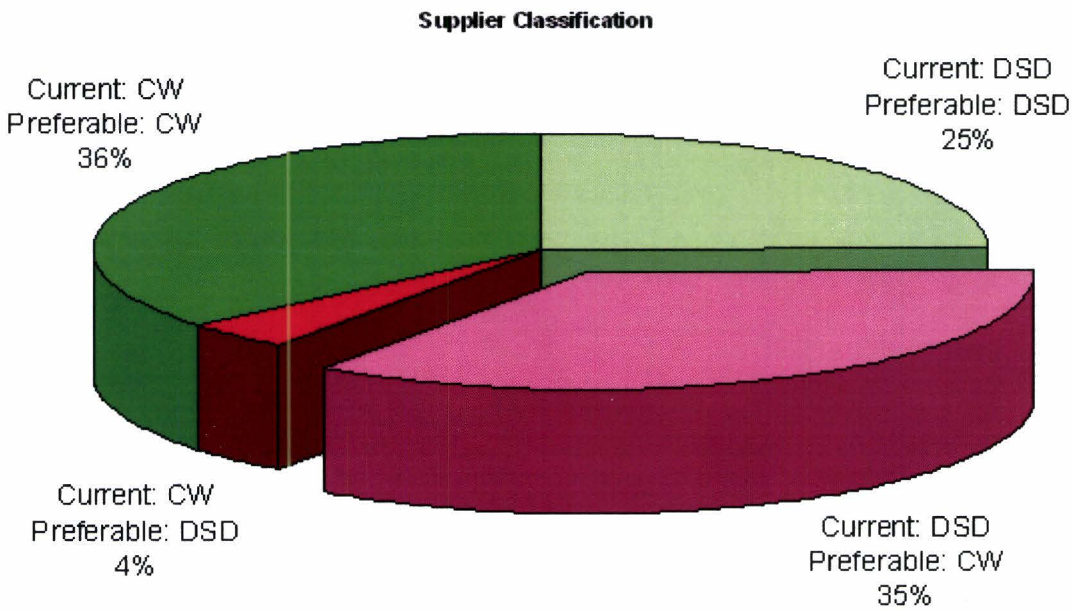

Figure 8: The Current and Most Preferable Flowtypes

A rough approximation shows that implementing this model could lead to **cost savings of over four million euro** in the total supply chain. These benefits must be divided over the different participants in the supply chain: the supplier, and Metro.

Table of Contents

Introduction

Metro Cash and Carry NL uses four logistic structures for shipping the goods from the supplier to the 16 stores. These logistic structures are called **flowtypes**. The four basic flowtypes are:

- *Direct Store Delivery (DSD):* The goods are delivered directly from the supplier to the different stores.
- *Central Warehouse (CW):* The suppliers deliver the goods to a central warehouse, where the goods are stored, and shipped to a store when they order products.
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- *Pre-Allocated Cross-Docking (PA-XD):* The orders of the different stores are picked separately at the supplier. Then, the different orders are loaded in one truck and shipped from the supplier to the cross docking point, where the shipment can be easily split and transported to the different stores. In comparison to the break bulk cross docking, the goods do not need any further handling at the platform.

Metro Cash Carry likes to have more insights in the operations and costs of these flowtypes. Based on these insights a **flowtype selection model** can be developed.

This report presents several insights and a selection model that uses these insights. The report is structured as follows:

1. *Company Description:* This chapter provides some general knowledge and background information about the company at which the project took place.
2. *Problem Definition:* This chapter gives the problem definition and the approach for solving this problem.
3. *The Problem Analysis:* In this chapter the situation in relation to the different flowtypes is analysed. Based on different information sources a diagnosis is presented.
4. *The Analytical Model:* An analytical model is developed, which provides some general guidelines in relation to the flowtype selection.
5. *The Flowtype Selection Model:* This chapter presents detailed information about the economic factors that influence the flowtype selection. Based on this information the flowtype selection model is developed.
6. *Implementation:* During the last phase of the project, the flowtype selection model is implemented. First, the implementation plan is described. Next, the flowtype selection is applied on all non-perishable goods suppliers.
7. *Conclusions and Recommendations:* This final chapter presents the most important results of the research. Moreover, this chapter gives some points of interest that are noticed during the project, but are out of the project scope.

1. Company Description

This chapter gives an overview of the company at which this project took place. It starts with the holding company, the Metro Group. Next, Metro Cash and Carry NL, the company at which the project is done, is described. The goal is to provide some general facts and background information about the company.

1.1 Metro Group

The Metro Group, also referred to as Metro AG, is a large trading group. The company was founded in 1996 by merging different smaller commercial chains. Nowadays, the company is one of the largest trading groups in the world, with over 2400 stores in more than 30 countries. (See Appendix A) The Metro brands operate in the four business units Cash & Carry, Food Retailing, Non-food Specialty Stores and Department Stores. (See Figure 1.1) In these units the Metro Brands act independently in the market. Their customers are both businesses and consumers.

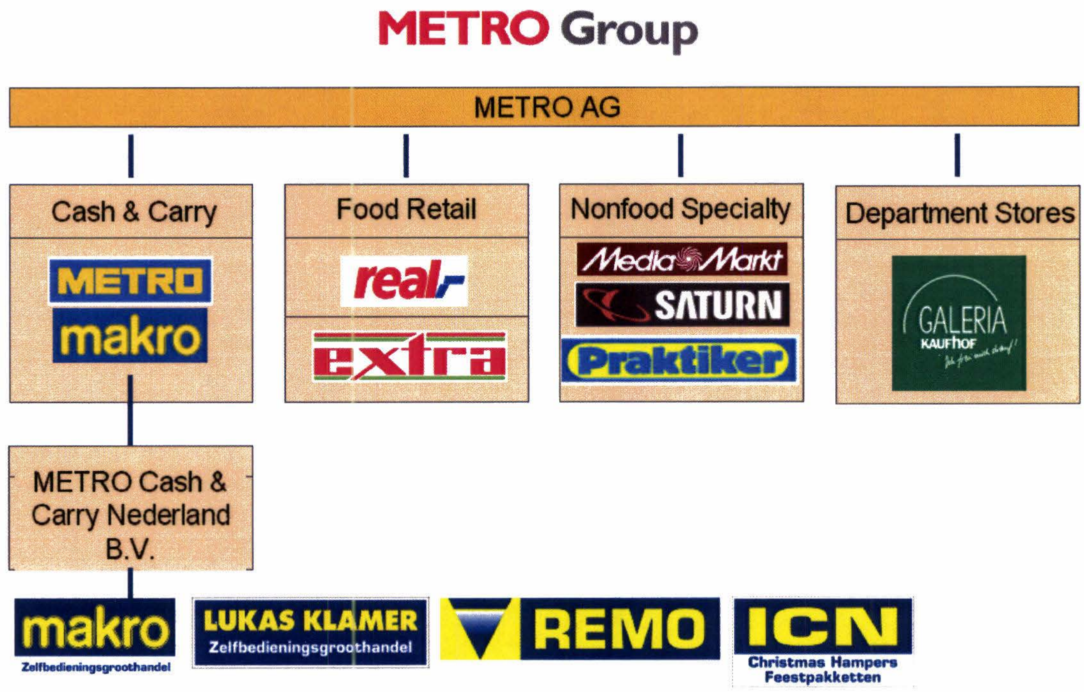

Figure 1.1: Global Organisation Structure of the Metro Group

Originally, Metro is a German company. Therefore, it has most of its stores and sales in Germany. These stores are part of several retail chains, such as:

- Metro Cash & Carry: a self-service grocery store
- Real: a supermarket chain that also delivers at home
- Media Markt: a retail chain for electronic devices (also active in the Netherlands)
- Saturn: a retail chain for electronic devices
- Praktiker: a home improvement chain
- Kaufhof: a department store

In the Netherlands, the Metro Group operates under four names:

- Makro: a self-service grocery store
- Lukas Klamer: a self-service grocery store
- Remo: purchasing company for the shoes
- ICN: responsible for the party and Christmas boxes

The difference between the two self-service grocery stores is that the Makro stores are bigger than the Lukas Klamer stores. At the moment, Metro is changing the Lukas Klamer stores into Makro stores. The reason is that they want to operate in the market under the same name with similar stores. Besides these two companies, there are two other Dutch companies part of the Metro Group: ICN, and Remo. ICN is responsible for the procurement and distribution of party and Christmas boxes. Remo is responsible for the procurement of the shoes. These two companies are out of the scope of this project. More information about the Metro Group is presented in Appendix B.

1.2 Metro Cash and Carry NL

This master thesis project is executed at Metro Cash and Carry in the Netherlands. Metro Cash and Carry NL operates in the market under two names: Makro and Lukas Klamer. These companies have been part of the Metro Group for seven years. From now on there will be referred to Metro or Metro Cash and Carry. The Metro stores are self-service grocery stores. This concept is further explained in the next section.

1.2.1 The Strategy

In the self-service grocery stores a Cash & Carry (C&C) concept is used. The term "Cash & Carry" means that customers pick their own orders, pay in cash, and carry the merchandise away. The advantages over traditional wholesale operations are the better price/performance ratio, the scope of the food and non-food assortments, the immediate availability of the merchandise and the longer business hours per week. The stores each offer a food assortment of about 15,000 items as well as some 35,000 items in the non-food segment. These two groups are further divided into fresh and non-perishable for the food products, and soft (e.g. clothes), hardware (e.g. household products) and electrical for the non-food articles.
Metro Cash and Carry is a wholesaler, that is why only registered organisations can apply for a special access card for the Metro stores. With this card you have access to the large Metro stores where people can also buy goods for private usage. At the moment, Metro has approximately 1,200,000 cardholders.

A substantial part of the Metro sales are promotional products. Metro promotes its articles by sending advertisement leaflets with special promotions to all the cardholders. Besides these leaflets, Metro also has a website for special promotions, which can only be accessed by cardholders. About 40% of the total sales are promotional sales.

1.2.2 Sales

The sales of Metro remain quite steady. In 2004 the sales decreased with about 5%. (See Table 1.1)

Sales Metro C&C NL (* 1000)

	2001	2002	2003	2004	2005
Food	616,164	658,240	642,941	619,410	613,245
Non Food	702,279	758,637	751,709	695,967	701,137
Total	1,318,443	1,416,877	1,394,650	1,315,377	1,314,382

*Table 1.1: The Sales of Metro C&C NL (*1000)*

The net income went down from about 52 million in 2004 to about 42 million in 2005. However, the sales and net income from the Metro Group are still rising.

1.2.3 Historical Overview

Metro (Makro in former times) has been operating in the Netherlands for more than 35 years and has more than 5400 employees. The company took over Lukas Klamer in 1990. The head office is located in Diemen and has 260 employees. Metro has 16 stores in the Netherlands, in Amsterdam, Barendrecht, Best, Beverwijk, Breda, Delft, Duiven, Groningen, Hengelo, 's Hertogenbosch, Leeuwarden, Nieuwegein, Nijmegen, Nuth, Vianen and Wateringen. The first store was opened in 1968 in Amsterdam. Metro is planning to expand, by opening more stores.

1.2.4 Competitors

Because of the large range of products, Metro has a lot of competitors, from electronic stores to supermarkets. However, Metro is almost unique in selling such a large assortment as a wholesaler company. Two other self-service grocery stores in the Netherlands are Sligro (43 stores) and Hanos (13 stores) These wholesalers focus more on the catering industry.
The most important competitors in food-segment are the supermarkets. Currently, a price war is going on between the supermarket chains. This trend is also affecting Metro. The customer is more and more focusing on the price of the products; therefore, it is necessary for Metro to focus on low prices. Metro can benefit from its relative low priced location and its large product packages.

The most important competitors in the non-food segment are the stores that focus on a specific part of the large assortment of Metro. For example, the electronic stores, like BCC and Media Markt are competing with the electronic products of the Metro assortment. Besides these stores, other competitors are organisations that sell their products directly on the Internet without using a wholesaler. A good example is Dell computers.

Another trend in the market are the so-called "category killers" or the branch differentiation. This means that stores are selling products that are not in the regular assortment. For example, a drugstore that sells DVD's. These category killers compete with Metro because they are selling a wider range of products at low prices. The next section presents more trends in the market.

1.2.5 Market Trends

Besides the price war and the category killers, there are some other trends in the trading business. An article of Brockmann (1999) describes 21 trends for the 21st century; the most important trends in relationship to Metro will now shortly be discussed:

- *Information technology*: the newest technology is RFID, which are small chips with product information that are attached to the products. This simplifies the control over the products, such as checking orders. Metro C&C Germany is experimenting with this technology in the so-called Future Store.
- *Cross docking*: more and more companies try to implement cross docking, to shorten delivery times and reduce the inventory levels. Metro has already implemented cross docking for some product types.
- *EDI and the Internet*: EDI is a system to interchange date between the supplier and the customer. Metro is one of the leaders in the area of EDI.
- *Third party warehousing:* the trend is to focus on the core competences and, therefore, outsource several activities. Outsourcing warehouse operations leads to e.g. a reduction in

capital assets and investment requirements. Metro also out sources the operational activities to third party logistics and warehouses.

Besides the trends discussed in this article, three more trends are:

- *Globalization of the market:* an important effect for Metro is that it is easier to transport goods between different countries. This is important because Metro is part of Metro group which is an international company. Because of global sourcing, the lead-times increase and this influences the planning.
- *Factory gate pricing:* retailers might lower the logistic costs when they pick up the goods at the supplier, instead of letting the supplier bring the goods to the retailer. (Le Blanc et al, 2005) Metro is also starting this concept.
- *Data exchange:* retailers more and more exchange data with their suppliers. For example Metro exchanges inventory information with two large suppliers. (VMI)

1.2.6 SWOT Analysis

The SWOT analysis exists of an environmental scan, which can be divided in an internal and an external analysis. The strength and weaknesses arise from the internal analysis and the opportunities and threats from the external analysis.

	Positive	**Negative**
Internal	- Strong market position - Internationalization - Large assortment - Low prices - Long opening hours - Low space costs	- High labour costs - No home deliveries
External	- Customer focuses on low prices - Globalization of the market	- Pressure on prices

2. Problem Definition

This chapter gives the problem definition and the approach for solving this problem. First, the problem is presented. Second, the relevance of the problem is described. Third, the scope of the problem is defined. Finally, the research design is presented.

2.1 The Problem Definition

During the first project stage the following problem was defined, formulated as an assignment:

Develop a method that determines the benefits & costs of the different flowtypes within a short amount of time, for each supplier, for the non-perishable goods, and before the end of June 2006.

Further explanation:

method:	The method should be structured and documented in such a way that someone with access to the required information can use it and will use it in the right way.
benefits & costs:	The most relevant benefits and costs factors should be considered for both the supplier and Metro Cash and Carry.
different flowtypes:	All four basic flowtypes should be considered, but bad performing flowtypes could be excluded after the analysis phase.
short amount of time:	The exact limit cannot be stated, because half an hour longer might lead to much better results. The goal is a couple of hours.

A **flowtype** is the way that the goods flow from the supplier to the several stores. Metro uses four basic flowtypes (see Appendix C):

- *Direct Store Delivery (DSD):* The goods are delivered directly from the supplier to the different stores. (See Appendix D for a graphical overview)
- *Central Warehouse (CW):* The suppliers deliver the goods to a central warehouse, where the goods are stored, and shipped to a store when they order products. (See Appendix E for a graphical overview)
- *Break-Bulk Cross-Docking (BB-XD):* The orders of the different stores are combined into one order. The supplier delivers this order to a cross docking point, where the goods on the pallets are divided and shipped directly (without storing in a central warehouse) to the stores. (See Appendix F for a graphical overview)
- *Pre-Allocated Cross-Docking (PA-XD):* The orders of the different stores are picked separately at the supplier. Then, the different orders are loaded in one truck and shipped from the supplier to the cross docking point, where the shipment can be easily split and transported to the different stores. In comparison to the break bulk cross docking, the goods do not need any further handling at the platform. (See Appendix G for a graphical overview)

2.2 The Relevance of the Assignment

This section provides some reasons why this assignment is relevant for Metro. The obvious objective of Metro is to gain profits. In order to gain profit it is important that the stores have a high service level at low costs. The logistic costs are an important component of the total costs of Metro; and, therefore, Metro aims to lower these costs. However, the service level to the customer should improve and should definitely not be reduced. An important decision that influences the costs and the service level is choosing the flowtype. Moreover, many suppliers want to deliver to a central warehouse or cross docking point, instead of delivering all the 16 stores separately. The suppliers want to deliver to one point, because they want to consolidate their freight and lower their costs. However, the consequences for Metro of changing a flowtype should also be examined.

2.3 The Project Scope

To limit the complexity the project scope will be restricted. The project concentrates on the logistic flow of finished products from the supplier to and in the stores. From now on this part of the supply chain will be referred to as the total supply chain. Moreover, this project makes no distinction between suppliers that use a central warehouse or deliver directly from the factory. This project considers the goods that come from one location as a separate supplier.

The project concentrates on the non-perishable goods and the detergent products. In the remaining of the project both groups will be referred to as the non-perishable goods. This group is selected, because these products account for a large volume and many suppliers (about 50% of the total sales volume). So, the biggest savings can be made for this product group. This reduces the total number of relevant suppliers from about 1700 to 300 suppliers. Besides, the insights gained in this project might be useful for the other product groups as well, and the solution could be adjusted in such a way that it can be used for the other product groups.

2.4 The Research Design

This section gives the research model for the diagnosis. (See Figure 2.1) The research model is based on a model presented by Verschuren en Doorewaard (1995). The left column presents the information sources for the evaluation of the current situation. The middle column presents the comparisons. The right column displays the result.

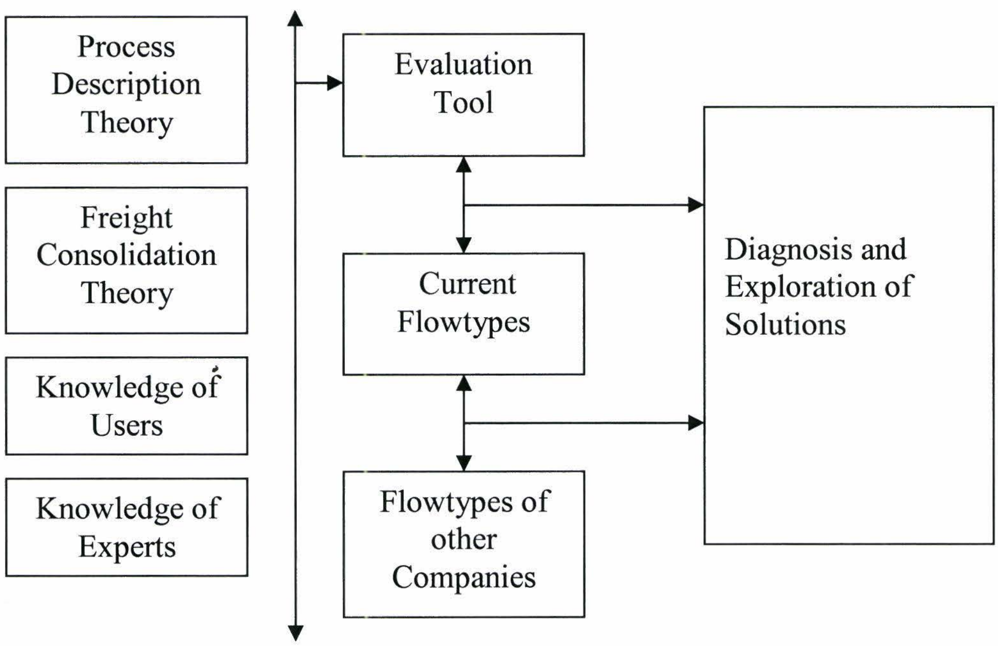

Figure 2.1: The Research Model for the Diagnosis

3. The Problem Analysis

This chapter analyses the situation in relation to the different flowtypes. Based on these different information sources a diagnosis can be stated. First, the flowtypes are described. Second, the current flowtype selection method is discussed. Third, an overview of the current flowtypes is given and explained. Fourth, a literature review is presented. Fifth, the situation in the market is described. Finally, the diagnosis can be stated.

3.1 Flowtypes Description

A flowtype is the way that the goods flow from the supplier to the several stores. This project concentrates on four different flowtypes, which are already mentioned in Section 2.1:

- Direct Store Delivery (DSD)
- Central Warehouse (CW)
- Break Bulk Cross-Docking (BB-XD)
- Pre Allocated Cross-Docking (PA-XD)

This section describes these flowtypes into further detail.

3.1.1 Process Description

A detailed description of these flowtypes is based on a standard model, the Supply Chain Operations Reference (SCOR) model (Supply Chain Council, 2000). The model is developed by the Supply Chain Council and constitutes a supply chain management standard. This model gives an overview and description of all the processes in the supply chain. First, the relevant parts of the model are determined. Next, the different processes are presented and linked to the different participants in the supply chain.

The general supply chain is shown in Figure 3.1, and has five basic management processes:

- *Plan*: balance resources and demand, and provide integration between activities and organizations.
- *Source*: acquire raw materials, and connect organizations with their suppliers
- *Make*: transform raw materials into finished goods
- *Deliver*: manage orders, deliver finished goods, and connect organizations with their customers
- *Return*: send raw materials to suppliers, and receive finished goods from customers

This project concentrates on the source and deliver processes. The planning process is excluded, because this project forms an input for the planning process. The make process is excluded too, because Metro does not transform the product. The return process is also excluded, because the report already stated that it concentrates on the flow from finished products from the supplier to and in the stores. (See Section 2.3) The relevant processes are coloured in Figure 3.1.

Five participants are operating in the relevant scope of the supply chain:

- the supplier of the goods
- a third party logistic service provider who transports the goods
- a third party logistic service provider who operates the warehouse or cross-docking point
- the head office of Metro who controls the inventory and sources the products in the central warehouse
- the Metro stores who sell the products in the stores.

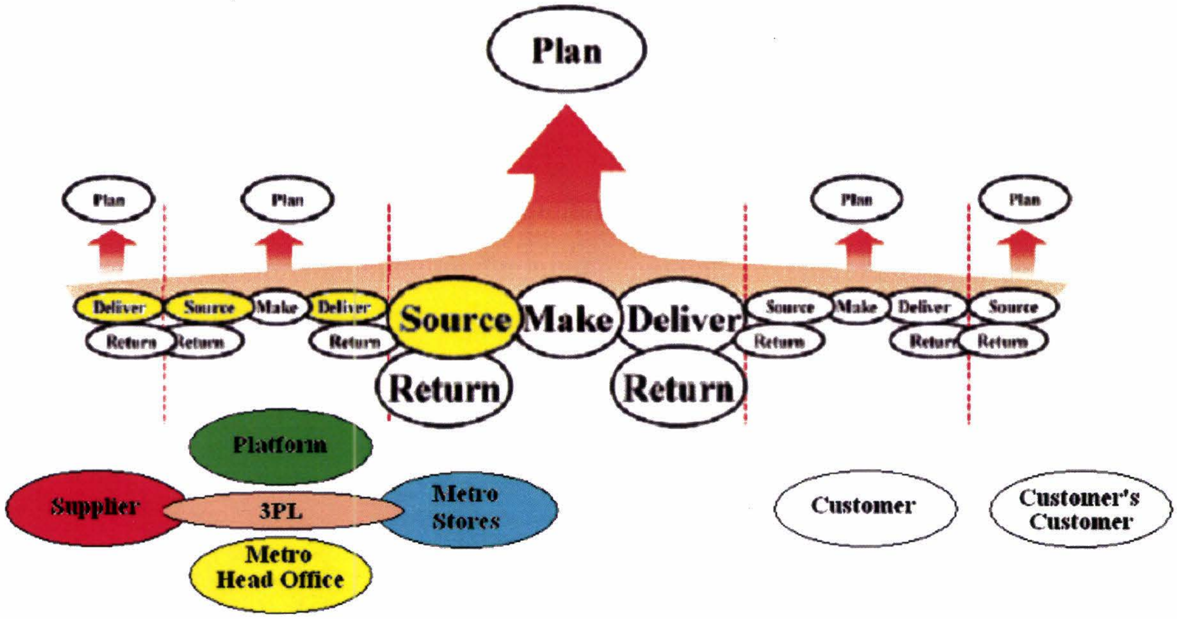

Figure 3.1: The Five Basic Management Processes in the Supply Chain

The SCOR model splits the basic management processes into smaller processes. This report gives the separate steps for the source and deliver processes in Appendix H. The different colours of the steps represent the different participants in the supply chain. The DSD flowtype excludes the processes of the first "source" and second "deliver". The CW flowtype includes all the processes. For the BB-XD flowtype the picking step must be replaced by a bulk-breaking step. The PA-XD flowtype excludes the picking step. Further details about the different steps can be found in Section 5.1 and the SCOR Model (Supply Chain Council 2000).

3.1.2 The Platforms

Metro operates with five platforms:

- a central warehouse for the frozen goods located in Tuitjenhorn.
- a central warehouse for the clothes located in Nijmegen
- a central warehouse for the hardware, which is located in Zaandam.
- a platform in Zeewolde, which is a cross dock platform for fresh and non-perishable products, and a central warehouse for the detergent products.
- a central warehouse for non-perishable goods located in Moerdijk.

Appendix I gives an overview of the platform locations.

Metro has 314 suppliers of non-perishable goods. 188 of these 314 suppliers deliver directly to the stores, this is 59.9%. Only two suppliers deliver BB-XD (0.6%). These suppliers deliver BB-XD, because the shelf life of the goods of these suppliers are short. So, it is not wise to store these goods in a warehouse. The remaining 124 suppliers (39.5%) deliver through a central warehouse. The PA-XD flowtype is not applied for the non-perishable goods at the platforms of Metro.

The 124 CW suppliers are divided as follows over the two platforms: four of the five large detergent suppliers deliver to Zeewolde and the remaining 120 suppliers deliver to the central warehouse in Moerdijk. The warehouse in Moerdijk is split in three "sub" warehouses:

- *AGP*: for the wine and liquor supplier
- *P&G*: for Procter and Gamble
- *Non-AGP*: for the remaining suppliers

These groups are picked separately, but shipped together. Zeewolde delivers the stores two or three times a week, and Moerdijk four or five times a week depending on the size of the stores. (the larger stores more frequently)

3.2 The Flowtype Selection Method

This section describes the current flowtype selection method. First, the history in relation to the flowtypes is described. Next, the current selection method is described. Finally, based on the properties of the current method, the requirements for the preferred method are presented.

3.2.1 The History

When Metro Cash and Carry started, more than 35 years ago (Makro in those days), all the suppliers delivered directly to the stores. So, direct store delivery was the only flowtype used. The company used only this flowtype because the stores are comparable with warehouses. The stores are large and have high turnover rates. Therefore, suppliers can deliver large quantities to a Metro store and freight consolidation would not be beneficial.

In 1982, Metro first started using a central warehouse for the electronic products. Metro started using the central warehouse because more and more suppliers from electronic products delivered from outside the Netherlands. If the transportation time is longer it is more beneficial to consolidate the freight and in this way lower the transportation costs (see Section 3.4.3). A second reason is that, otherwise, the stocks in all the stores need to be higher to prevent out of stocks during the lead-time. Then, it is better to aggregate the demand uncertainty in a central warehouse to reduce the inventory level.

About nine years ago, the first warehouse was used for the non-perishable goods. The central warehouse started with the liquor and the wine suppliers. First, most of the liquor and wine suppliers are international suppliers with long lead-times, so freight consolidation is beneficial. Second, the excise taxes over these products are high and they only have to be paid when the products leave the central warehouse and not when they are imported. So, it is beneficial to pay these taxes as late as possible. Third, importing wine and liquor requires additional actions, such as repacking and import issues. It is cheaper to centralize these activities.

About eight years ago, other non-perishable goods were added in the central warehouse. The suppliers initiated this. Procter and Gamble started this movement by paying Metro a compensation for the use of the central warehouse. Other suppliers followed when they were willing to pay the necessary compensation calculated by Metro. So, the suppliers started the process of using a central warehouse flowtype.

About two years ago, another central warehouse was used for some non-perishable products. Metro Cash and Carry did a tender for this product group and the warehouse in Zeewolde won this tender. As a result, Metro C&C uses two central warehouses for the non-perishable goods, one in Moerdijk and one in Zeewolde.

Nowadays, the standard flowtype still is direct store delivery because Metro believes it is the cheapest delivery method for Metro Cash and Carry. However, they cannot ground this belief with actual data. This project should give more insights in this matter.

3.2.2 The Current Selection Method

Currently, the purchasing department negotiates with the supplier about the flowtype. However, this decision is made in close consideration with the supply chain department. The supply chain department should give insights in the economic factors that influence the decision.

The logistic department calculates the flowtype costs as follows. As already discussed, the standard flowtype is direct distribution and, therefore, the costs of this flowtype are set at neutral. The suppliers can switch to delivering through a central warehouse, when they pay a compensation to Metro for the costs of using a central warehouse. Metro uses the tariffs of the third party who owns and operates the warehouse to calculate the compensation (see Appendix J). So, when a supplier wants to change from direct store delivery to central warehouse delivery, he must pay a compensation to Metro that is at least equal to the price that Metro pays for using the central warehouse.

Some good properties of this method are:
- It is a relatively simple method, because it only includes the standard tariffs from the warehouse for the calculations.
- It calculates a compensation that the supplier has to pay and this can be used in the negotiation.

Some points for improvement could be:
- It excludes the influence of the flowtype on the service level.
- It excludes some cost factors that might have an important influence on the total logistic costs, and this could lead to a wrong flowtype choice. For example, the influence on the inventory and transportation costs is excluded.
- It does not include cross docking. The two basic flowtypes based on cross docking might lead to lower costs and better service levels.
- It is not documented and this may lead to mistakes in using it.

3.2.3 The Preferred Selection Method

The preferred method should have the following properties:
- It should include the most important cost factors and benefits. If the most important factors are included the best flowtype can be chosen.
- It should give an overview of the benefits and costs for the different participants in the supply chain. This information is needed, when the different parties have to negotiate about necessary compensations.
- It should be easy to use and give a solution in a relative short amount of time, e.g. a couple of hours. (The exact limit cannot be stated, because half an hour longer might lead to much better results.)
- It might include flowtypes based on cross docking if this could lead to lower total costs.
- The preferable method should consider the influence of the flowtype on the service level.
- It should be documented and put into a tool. In this way, the method is used in the consistent right way and the mistakes will be reduced.

Besides these requirements, there are some preconditions for the method:
- One supplier can have only one flowtype for all the orders. This precondition follows from the information system that is used. If different products from one supplier are allowed to have different flowtypes, the supplier should be split up. However, this will reduce the consolidation benefits. So, splitting up suppliers is not further investigated.
- The parameter values that will be used in the solution method should be variable. This is necessary to keep the solution method up to date; for example, to update the labour costs.
- The user should be able to determine the parameter values based on the available data.
- It should be possible to implement the method in a relative simple software program. This simplifies the use and the maintenance of the method.

3.3 The Current Flowtypes

In this section, the current DSD suppliers are compared with the CW warehouse suppliers. Metro has 314 suppliers of non-perishable goods. 188 of these 314 suppliers deliver directly to the stores, this is 59.9%. This section looks for underlying reasons why suppliers are delivering directly to the stores or through a warehouse. First, the influence of the sales volume is examined. Second, the influence of the assortment width is investigated. Third, the influence of the location and the lead-time of the supplier is investigated. Fourth, the influence of the average product value of the supplier is examined. Fifth, the influence of the promotions is investigated. Finally, a conclusion about the underlying reason for selecting a flowtype is given.

3.3.1 The Influence of the Total Sales Volume

Delivering directly to the stores is more suitable for suppliers with a high total sales volume, because this means that suppliers can deliver (almost) full trucks to the stores. This leads to the following hypothesis:

> Hypothesis 1: The average sales volume is higher for DSD suppliers than for CW suppliers.

The difference of the sales volume between the DSD and CW suppliers is tested. A one side t-test is run to compare the means of the two samples. The results of the t-test show that the total sales volume is statistically significant higher for the DSD suppliers at a 95% confidence level. Therefore, Hypothesis 1 is not rejected.

3.3.2 The Influence of the Assortment Width

The assortment width is the number of article types of a supplier. An article type will also be referred to as a stock-keeping unit (SKU). Delivering directly to the stores is more suitable for suppliers with a higher sales volume per SKU. A higher sales volume per SKU means that suppliers can deliver more full pallets to the stores. So, the following hypothesis can be formulated:

> Hypothesis 2: The average sales volume per SKU is higher for DSD suppliers than for CW suppliers.

The difference in sales per SKU between the DSD and CW suppliers is tested. A t-test is run to compare the means of the two samples. The results of this t-test show that the sales volume per SKU is statistically significant higher for the DSD suppliers at a 95% confidence level. Therefore, Hypothesis 2 is not rejected. One remark that should be made is that this result might be influenced by the fact that suppliers with a higher sales volume per SKU have a higher total sales volume. (This is also tested with a linear regression.) Therefore, the underlying reason for the fact that more suppliers with a high sales per SKU deliver directly to the stores might be the larger total sales volume.

3.3.3 The Influence of the Lead-Times

The influence of the lead-time could also be investigated. Suppliers with long lead-times are more suitable for delivering through a central warehouse, because it is more beneficial to consolidate the freights, when the distance is longer. A second reason is that, otherwise, the stocks in all the stores need to be very high to prevent out of stocks during the lead-time. (see Section 3.4.4) Then, it is better to aggregate the demand uncertainty in a central warehouse. Therefore, the hypothesis is formulated as follows:

> Hypothesis 3: The lead-time is higher for CW suppliers than for DSD suppliers.

The data for a proper analysis are not available. Moreover, most of the non-perishable good suppliers are located in the Benelux. So, the lead-times will not differ substantial. One statement that can be made is that all of the international wine and liquor suppliers deliver through a central warehouse. This is also due to the tax benefit and the additional requirements of the goods (see Section 3.1.1). The wine and liquor suppliers form almost half of the CW suppliers.

3.3.4 The Influence of the Average Product Value

The influence of the average product value is now examined. Delivering through a central warehouse could be more suitable for suppliers with a low average product value, because a central warehouse will (in most cases) lead to more inventory, and the higher the product value the higher the inventory carrying costs. So, the following hypothesis can be formulated:

Hypothesis 4: The average product value is higher for DSD suppliers than for CW suppliers.

This hypothesis is rejected by data of Metro. The t-test shows the opposite of the expected, namely that the average product value is statistically significant higher for suppliers that deliver through a central warehouse. This might be explained by the fact that a supplier is more willing to pay a compensation for the central warehouse, when the product value is high. For these suppliers the compensation in relation to the selling price is lower. Another explanation is the fact that the product value of the wine and liquor suppliers (which are all in the central warehouse) is high. If the wine and liquor suppliers are removed from the analysis, the samples have no statistical difference.

3.3.5 The Influence of the Promotions

This subsection discusses the influence of the promotions on the flowtype choice. This influence is discussed because a considerable share of the total sales is caused by promotions. In total about 40 % of the sales is promotion, and for the non-perishable goods 26.3% of the goods is sold during a promotion.

Promotions cause large volumes in a short amount of time; and, therefore, direct store delivery would be preferable. However, due to the information system only one flowtype can be selected for a longer period of time. So, a supplier cannot switch from central warehouse to direct store delivery during a promotion. Therefore, the following hypothesis is formulated:

Hypothesis 5: The promotion share is higher for DSD suppliers than for CW suppliers.

This hypothesis is also rejected by data of Metro. Again, comparing the samples leads to the opposite of the hypothesis. This result can be explained by the fact that the wine and liquor suppliers (which are all in the central warehouse) have many promotions. If the wine and liquor suppliers are removed from the analysis, the samples have no statistical difference.

3.3.6 Conclusion

Section 3.2 stated that a supplier delivers through a central warehouse when a supplier is willing to pay a compensation. This section investigated factors that could influence this flowtype choice:

- The most important reasons for a supplier to deliver through a central warehouse is the location and type of goods. If a supplier is located outside the Netherlands and the goods require additional actions, the goods are shipped over a central warehouse.

- The second reason to ship goods over a central warehouse is a low sales volume. The benefits of consolidating goods in a central warehouse are higher when a supplier has a low total sales volume.
- The third reason of delivering goods over a central warehouse is a lower sales volume per SKU. A lower sales volume per SKU generally results in lower total sales; and, therefore, the consolidation benefits will increase.

The influence of the product value and promotion share is negligible.

3.4 Literature Review

This section gives a literature review about flowtypes. An important aspect of the flowtype selection is consolidation in the freight transportation. Consolidation is defined as combining goods in the transportation, with the view to reduce the transportation costs. First, an overview is given of some published literature about consolidation. Second, the influencing cost factors for the flowtype selection are mentioned. Third, some literature related to transportation costs is discussed. Fourth, three articles related to the inventory costs are described. Finally, a total cost perspective is derived from the literature.

3.4.1 Consolidation

Using a platform is a type of freight consolidation. The literature presents four different types of consolidation. Different authors used different terms for quite the same types of consolidation. Summarizing, the four types are:

- *Inventory consolidation / Temporal consolidation*: products that are produced at different moments are combined in one shipment.
- *Product consolidation*, determining which products to combine in one shipment.
- *Vehicle consolidation / Spatial consolidation / Shipment consolidation / Vehicle routing*: picking-up and dropping-off products at different origins and destinations.
- *Terminal consolidation / Network consolidation*: products from different origins are brought to a single location where they are sorted, loaded onto new vehicles, and taken to different destinations.

This project focuses on the last form of consolidation.

3.4.2 Influencing Factors

Van Goor et al (1999) stated that there are three factors that influence the basic logistic structure decision:

- *External factors*, such as required customer service;
- *Economic factors*, such as the total logistic costs;
- *Organizational factors*, such as accounting systems.

This project will mainly focus on the second factor. Next, some articles based on the economic factors are discussed.

3.4.3 Transportation Costs

Daganzo (1988) studied the trade-off involved in shipping items directly from the origin to the destination versus shipping the goods through a consolidation centre. The study tries to minimize the total distance travelled by all trucks and provides guidance for determining: which items from each origin should be combined together to form each load, the routing of each of these shipments (either direct or to the terminal), and the composition of shipments from the terminal to the destination. The research shows that shipping through a consolidation terminal can reduce the total travel distance by making good use of the capacity of the trucks.

More recently some authors emphasize that the transportation costs depend on the drop size (Lapierre et al, 2004; and Simchi-Levi et al, 2005). Van der Vlist and Broekmeulen (2006) developed a model that includes the fact that the costs depend on the drop size. Moreover, the model includes the fact that the empty space in a truck can be filled up with goods of other destinations. Van der Vlist and Broekmeulen stated that the decision to use a terminal for freight consolidation shipment depends on:

- *The capacity of the transportation equipment*, the higher the capacity the more beneficial it is to consolidate the freight in a platform.
- *The location of the hub relative to the location of the sourcing units and the DC*, the further the location of the platform is away from the direct route between the supplier and the store, the lower the benefits of consolidation.
- *The volume that will be available at the hub for consolidation towards the DC*, the higher the available volume for consolidation, the more beneficial it is to deliver the freight through a platform.
- *The cost function or rate structure for less than truckload shipments*, the higher the costs of LTL shipments compared to FTL, the more beneficial it is to deliver the products indirect.

However, these four issues only consider the transportation costs. The additional costs of operating a warehouse and the influence of the flowtype choice on the total inventory should also be examined.

3.4.4 Inventory Costs

Van Donselaar (1990) investigated the influence of demand variability on the total stock position of different types of supply chains. He concluded that in most cases the total inventory level in the supply chain increases, when a central warehouse is used. The demand variability must be very high, to make it beneficial to aggregate the demand variability in a central warehouse.

Yang and Hill (1999) also investigated the influence of demand variability on the total stock position of different supply chains. The same conclusions were made as van Donselaar. Yang and Hill also studied the influence of other factors on the inventory level in the total supply chain. They concluded that keeping stock in a central warehouse leads to a lower total inventory level when the lead times of the supplier are long. This phenomenon is called the risk pooling effect over supplier lead times.

Waller et al (2005) compared the inventory position of delivering through a central warehouse with cross docking. The inventory at the platforms disappears when the flowtype changes from central warehouse to cross-dock. The inventory position in the stores will increase when one changes to cross docking, because of the longer lead times. A formula is derived to calculate the possible benefits for cross docking on the inventory position. The article shows a relation between the cross docking benefits and the number of stores. The benefit of cross docking increases when the number of stores decreases.

Summarising the articles about the inventory levels; the direct store delivery has the lowest total inventory in most cases, except for suppliers with a long lead-time. In general break bulk cross docking has less inventory than central warehouse, when the number of stores is low. Central warehouse will have the highest inventory position in most cases.

3.4.5 Total Costs

The factors above leads to the following general guideline for indirect delivery: the benefits of freight consolidation on transportation costs should outweigh the longer transportation routes, the (possibly) higher inventory level and the operating costs of the platform. Some articles tried to make such a total costs analysis.

Blumenfeld et al (1985) determine the optimal shipping strategies (i.e. routes and shipment sizes) between origins and destinations by analyzing trade-offs that exist between transportation, inventory and production set-up costs. The article derives formulas to calculate the total costs for three types of networks: direct, via a consolidation terminal, and a combination, which allows both direct and via a terminal. For direct shipment a formula is derived to determine the optimal shipment size. The resulting formula is quite similar to the EOQ formula. A point for improvement is the fact that no optimal shipment size is determined for the other two network types. Moreover, the different types of networks are not compared. Finally, that article assumes that the transportation costs are proportional and do not depend on the drop size.

3.5 The Market Situation

This section gives an overview of the situation in the market in relation to the flowtypes. Some similar companies as Metro C&C NL are investigated to get an overview of the situation in the market. The studied companies are Metro C&C Germany, Metro C&C Belgium, Hanos, Sligro, and two large Dutch supermarket chains, Albert Heijn and Lidl. The first three companies operate quite similar to Metro C&C NL. The other companies send almost all products over a central warehouse. A detailed description of this investigation is presented in Appendix K. Here, only the most important results are presented.

3.5.1 Retail Chains with Standard Flowtype DSD

Metro C&C Germany operates quite similar to Metro C&C Netherlands. The standard flowtype is DSD and, therefore, most suppliers deliver directly to the stores. There are two differences with Metro C&C NL. First, a lot more of the non-perishable goods are delivered through a cross docking platform. Second, all suppliers deliver at most once a week, which leads to freight consolidation over time for suppliers with a large sales volume, the so called temporal consolidation (see Section 3.4.1).

Metro C&C Belgium also operates quite similar to Metro C&C Netherlands, except for the fact that they are able to make an estimation of the benefits of the supplier.

Hanos is another self-service grocery store, which has 12 stores in the Netherlands and one store in Belgium. Hanos has his logistic operations under her own administration. Hanos operates one central warehouse in Apeldoorn. Depending on the throughput volume and the minimum order quantity at the supplier, a supplier delivers through a central warehouse or directly to the stores. If the volume is high, a supplier delivers directly to the store. So, the flowtype choice depends on the volume in relation to the minimum order quantity.

3.5.2 Retail Chains with Standard Flowtype CW

Sligro is also a self-service grocery store, and has 43 stores in the Netherlands. Almost all suppliers of Sligro deliver through a central warehouse. Break bulk cross docking is only applied for a few suppliers, and only the day fresh suppliers and the very large suppliers, such as Heineken and Coca Cola, deliver directly to the stores. Sligro sends most of the goods through a central warehouse, because Sligro also makes home deliveries. These home deliveries are sent from the central warehouse to the customer.

Albert Heijn is the largest supermarket chain in the Netherlands. The biggest difference in the formula between Metro C&C and Albert Heijn is that Albert Heijn has more but smaller stores which are located closer to the customer. Therefore, Albert Heijn has less storage and shelf space and less sales per store. This difference has its consequences for the logistics. All the suppliers of Albert Heijn deliver to a central warehouse. Albert Heijn has several reasons for this decision. First, by delivering through a central warehouse, Albert Heijn is able to respond quickly to the needs of the store. Second, the stores have small storage space and, therefore, small order quantities. Shipping directly from the supplier to the stores would lead to high transportation costs because of these small order quantities. Finally, delivering the stores from a central warehouse means much less handling of incoming goods at the stores. Moreover, Albert Heijn uses a composite distribution centre which combines all the product groups, and this leads to consolidation benefits in the transportation.

The Lidl is also a large supermarket chain in the Netherlands. The biggest difference with Albert Heijn is the fact that Lidl has a smaller assortment and, therefore, more storage space in the stores. However, this difference has no consequences for the logistic structure. Just like Albert Heijn, all the suppliers deliver to a central warehouse. The Lidl has the same reasons for this choice as Albert Heijn. This means that the storage space in the Lidl stores is still not big enough to deliver such high quantities to the stores, to make it beneficial to deliver directly to the stores.

3.6 Conclusion

This chapter discussed different aspects of the flowtypes: the literature, the situation in the market, and the current situation at Metro. The literature provides insights in how the important cost factors influence the flowtype change. The situation in the market illustrates that the situation of Metro differs from other companies. The current situation at Metro shows that the received compensation is an important factor in the flowtype choice. In summary:

The difference in costs between the flowtypes should explain why suppliers are (not) willing to pay a compensation, which results in the "unique" situation of Metro.

The next chapter introduces an analytical model, to get more insights in the influence of the costs on the flowtype choice. Figure 3.2 shows the research model for developing the model. Models from the literature are matched with the situation of Metro, which leads to the flowtype selection model.

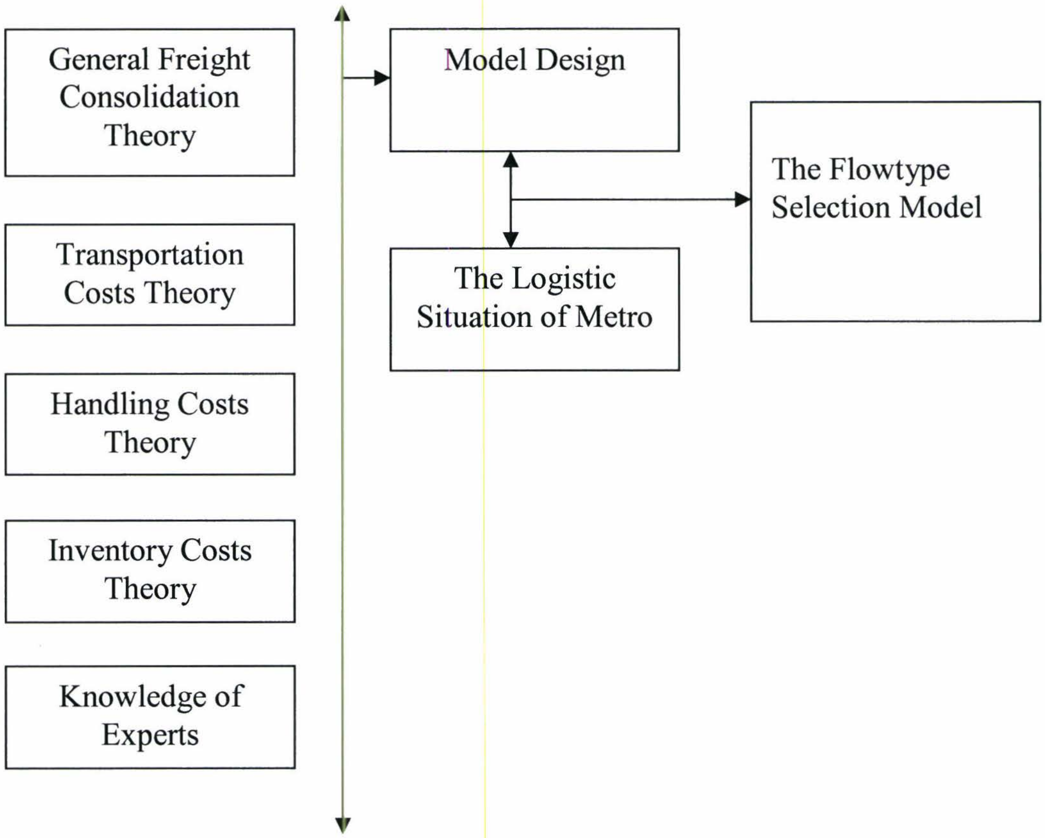

Figure 3.2: The Research Model for Designing the Flowtype Selection Model

4. The Analytical Model

This chapter presents an analytical model that provides some general guidelines in relation to the flowtype selection. First, the scope of the model is defined, because it is impossible to model all the factors. Next, the pilot suppliers are selected, which are used to validate the models presented in the literature. Finally, the analytical models are formulated and some general guidelines are presented.

4.1 The Most Relevant Cost Factors

This section presents an indication of the most relevant cost factors. This indication is based on a rough analysis at a high level of abstraction over the year 2005. This rough approximation is justified by the aim of this analysis, which is to determine the most relevant cost factors, and not the exact value of that cost factor. Unfortunately, the costs of the supplier are not known; therefore, the costs of the central warehouses are used to give an indication of the supplier costs. The different participants in the supply chain are individually discussed.

4.1.1 The Stores

The cost estimation of the stores is based on productivity figures measured by an external company. Metro needed these data for a staff planner project. These data can be used for this project as well by multiplying the productivities with the labour costs. Appendix L.1 shows the results. The inventory costs are based on the average inventory value at the stores multiplied with the interest and depreciation ratio. The products that need to be verified are a quarter of the total products, because only 25% of the goods are verified. The fill process also includes the internal transportation and opening the case pack.

4.1.2 The Head Office

The cost estimation of the head office is based on the labour costs of the relevant departments. Appendix L.2 presents the results. The inventory costs are based on the average inventory value at the warehouse multiplied with the interest and depreciation ratio. The relevant share indicates the number of employees of the department that is occupied with the non-perishable goods. For the order department the relevant share is four of the eight employees. For the payment department the share of non-perishable suppliers (314 of the 1700 suppliers) is used to determine the relevant share.

4.1.3 The Platforms

The cost estimation of the platforms is based on the contract and bills of the relevant platforms. Both platforms distinguish between the fixed costs, handling costs, and transportation costs. These cost factors will, therefore, be individually discussed (see for more information Appendix L.3). Most of the fixed costs are storage space costs, and most of the handling costs are order-picking costs.

4.1.4 The Suppliers

The cost estimation of the suppliers is based on the tariffs of the platforms. Assumed is that the suppliers that deliver over a platform, pick the goods on full pallets. The suppliers that deliver directly to the store, pick the same percentage of the goods on full pallets as in the central warehouse. Another assumption is that an average pallet contains 60 case packs. The costs are shown in Appendix L.4.

4.1.5 Total Overview

This section integrates the calculated costs of the previous section. The order picking costs and of the supplier and the platform are summed, as well as their transportation costs. The resulting cost division is presented in Figure 4.1.

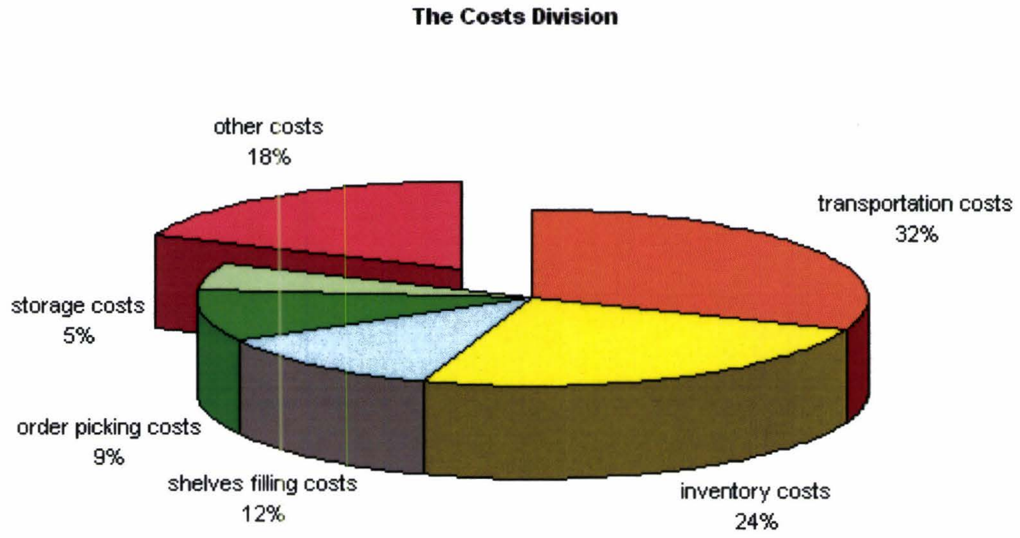

Figure 4.1: The Costs Division

To validate this analysis, the results are compared with similar investigations. The Council of Logistics Management (CLM) (Drumm, 2005) also investigated the average division of the logistic costs in the supply chain including all branches. However, this research did not include the operations in the store.

The result is shown in Figure 4.2, the order picking and facility costs together form the warehouse costs. This figure also shows that the most relevant costs are the transportation costs, the picking costs, the facility costs, and the inventory costs. The costs of filling the shelves are not mentioned, because the store operations were excluded.

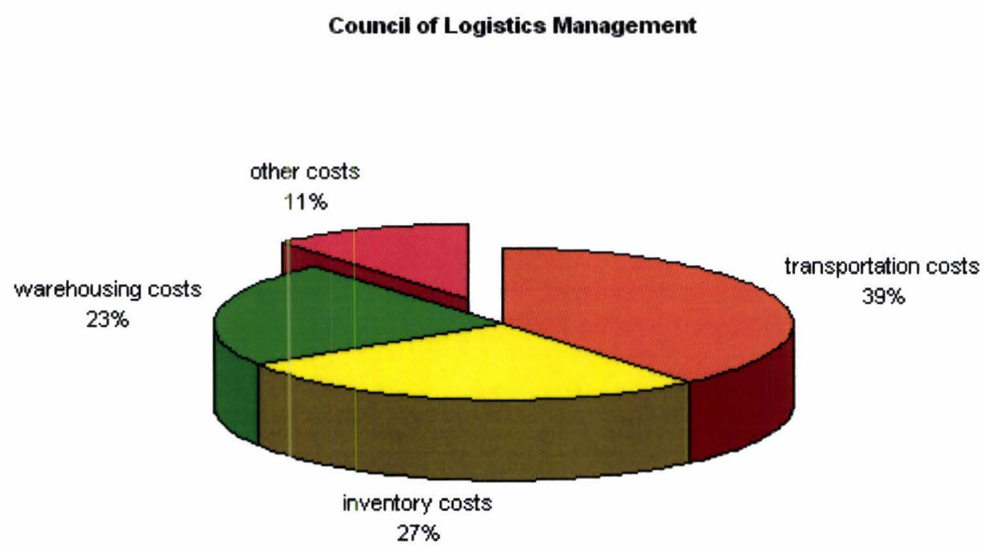

Figure 4.2: The Average Division of the Total Logistic Costs in the Supply Chain

To verify the results the warehouse, inventory, and transportation costs are matched. In our research these costs form 77% of the total costs. In the research of the CLM these costs are 89% of the total costs. These costs are higher, because the operations in the stores were excluded. Table 4.1 shows that the relative cost ratios are similar.

Platform	The Analysis (relative percentage)	CLM (relative percentage)
Transportation Costs	41.6%	43.8%
Inventory Costs	31.2%	30.3%
Warehousing Costs	27.3%	25.8%

Table 4.1: The Relative Cost Division

Broekmeulen et al (2004) also investigated the cost structure of retail chains (see Figure 4.3). The big difference between this cost structure, and the cost structure of Metro are the handling costs at the store. This cost share is considerably higher than at Metro. This difference can be explained by two factors. First, the required time to refill the shelves at Metro is lower than the time at a "normal" retailer, because Metro sells their products in larger packages. Moreover, some products are presented on pallets; so, (almost) empty pallets can be easily replaced by full pallets. Second, the remaining costs are higher for the situation of Metro than for the costs in the research of Broekmeulen et al (2004). This is due to the fact that the warehousing and transportation costs of the supplier are out of the scope of the research of Broekmeulen. Besides, the inventory costs at Metro are higher, because the Metro stores carry more inventory, and Metro uses a relatively high interest percentage. So, the difference between the cost structures can be explained.

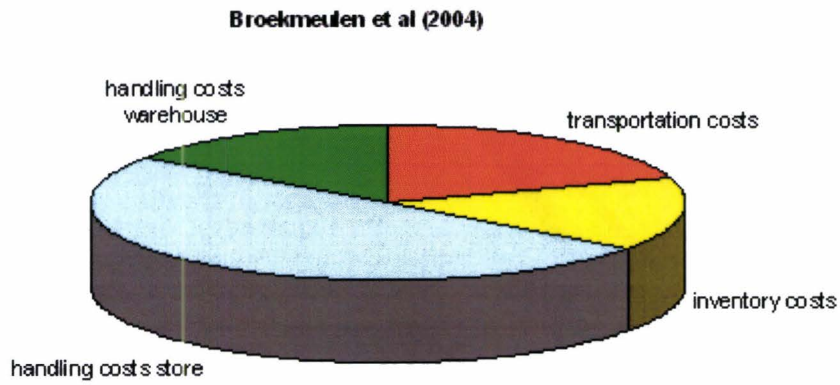

Figure 4.3: The Costs Structure of a Retail Chain

In summary, recommended is to further investigate the picking, transportation, inventory, facility, and filling costs. These costs make up more than 80% of the total costs. Therefore, the factors that will be the focus of this research are:

- *The transportation costs* both at the supplier and at the warehouse
- *The inventory costs* both at the warehouse and at the store
- *The shelf filling costs* at the store
- *The order picking costs* both at the supplier and at the warehouse
- *The fixed storage costs* at the platform

4.2 The Pilot Suppliers

This section describes the selection procedure for the pilot suppliers. Matching the models in the literature to all 300 relevant suppliers is not realistic. Therefore, a limited number of suppliers is selected and analysed, these are the so-called pilot suppliers. These suppliers are also used during the implementation and testing phase. Limiting the number of suppliers will not only accelerate the analysis but also the implementation phase.

The selection starts with a list of all the suppliers of non-perishable products, who delivered goods to Metro in 2005 (only until half November). This is a list of over 300 suppliers. Suppliers with different locations are split, and different suppliers at one location are combined. In this way the listed suppliers are all physically separate suppliers. However, suppliers located at one location are split up if different flowtypes are used for different articles.

The suppliers are divided into groups based on two criteria, total sales in selling units (SU), and sales per stock keeping unit (SKU). Section 3.3 already showed that these criteria influence the flowtype choice. The sales volume is measured in selling units, because the volume in case packs is not available. The total sales influence the transportation costs, because the more selling units the larger the freight and the lower the transportation costs per unit. The sales per stock keeping unit influence the order picking process. Stock keeping units with a large sales volume can be picked on full pallets, and will have considerably lower picking costs. Another factor that influenced the flowtype choice at Metro was the lead-time. This factor was not selected as a criterium, because most of the suppliers are located in the Benelux. So, the difference in the lead times will not be substantial. Moreover, the necessary data are hard to gather. Using the two criteria results in a three by three table as shown in Table 4.2. (The number of selling units is measured over the period 1-1-2005 to 14-11-2005.)

The Suppliers Classification

Sales per SKU (total SU/number of SKU)

Total Sales (total SU)		low	medium	high	Total
	low	s,s 71	23	11 s,l	105
	medium	24	m,m 46	28	98
	high	l,s 7	37	66 l,l	110
	Total	102	106	105	313

Table 4.2: The Suppliers Classification

The suppliers are split into nine groups, based on three equal classes of both criteria. However, some groups are very small and then the results of this group cannot be compared with a sufficient amount of comparable suppliers. Therefore, some groups are combined with quite comparable groups. Finally, five different groups of suppliers remain, which are coloured and named in Table 4.2. The names of the groups are related to the first letter of Small, Middle, and Large and starts with the total sales volume. From each group two suppliers are randomly selected, one that delivers through a central warehouse and one that delivers directly to the stores. From the "blue" group (l,l) four suppliers are selected, two that deliver through a central warehouse and two that deliver directly to the stores. More suppliers are examined from this group because of the importance of these suppliers to Metro. Besides these 12 suppliers, two suppliers are selected, that deliver through a break bulk cross-dock flowtype. Only two suppliers can be selected, because these are the only non-perishable good suppliers that deliver through a cross-dock platform. Unfortunately, no suppliers deliver pre allocated to the platforms. So, this flowtype cannot be analysed. (The selected pilot suppliers are listed in Appendix M.)

4.3 The Model

This section presents the theoretic model, which is used to derive general guidelines. A model is constructed for the five largest cost factors presented in Section 4.1. These five costs can be combined into three:

- *the transportation costs:* including the transportation from the supplier to the store or the warehouse, and the transportation from the warehouse to the store.
- *the handling costs:* including the order picking costs, both for the supplier and in the warehouse, and the costs of filling the shelves in the store.
- *the inventory costs:* including the interest and the storage space costs at the warehouse, and the interest costs at the store.

This section first states the most important assumptions. Second, the basic model and the input parameters are defined. Next, the most relevant costs factors are individually discussed. Finally, an attempt is made to integrate the different cost factors.

4.3.1 Assumptions

To be able to model the situation of Metro, some assumptions must be made. Most of the assumptions are discussed at the specific model, where the assumption is made. Two assumptions are discussed in this section, because these are important assumptions for several models.

Each store is assumed to have the same size and sales volume. In reality this is not true; there are larger stores that sell more products than other stores. This difference in volume influences the delivery frequency (See Appendix N). This means that the shipment and order quantity is similar for the different stores, and the average shipment and order quantity is a good approximation for the actual shipment and order quantity.

The promotions of Metro are left outside the scope of this research. This assumption is harder to validate. Appendix N shows that the delivery frequency increases, when the volume increases. This means that the order and shipment quantity stays quite steady. This also occurs during promotions. During a promotion a supplier will deliver more frequently than normally, which levels the order and shipment quantity. Therefore, the average order quantity is a good approximation for the actual order quantity.

4.3.2 The Input Parameters

Figure 4.4 presents the relevant situation; the word supplier is replaced by manufacturer, because it simplifies the notation. The different participants in the supply chain will be indicated by their first letter. (An overview of all used symbols is presented in Appendix O.)

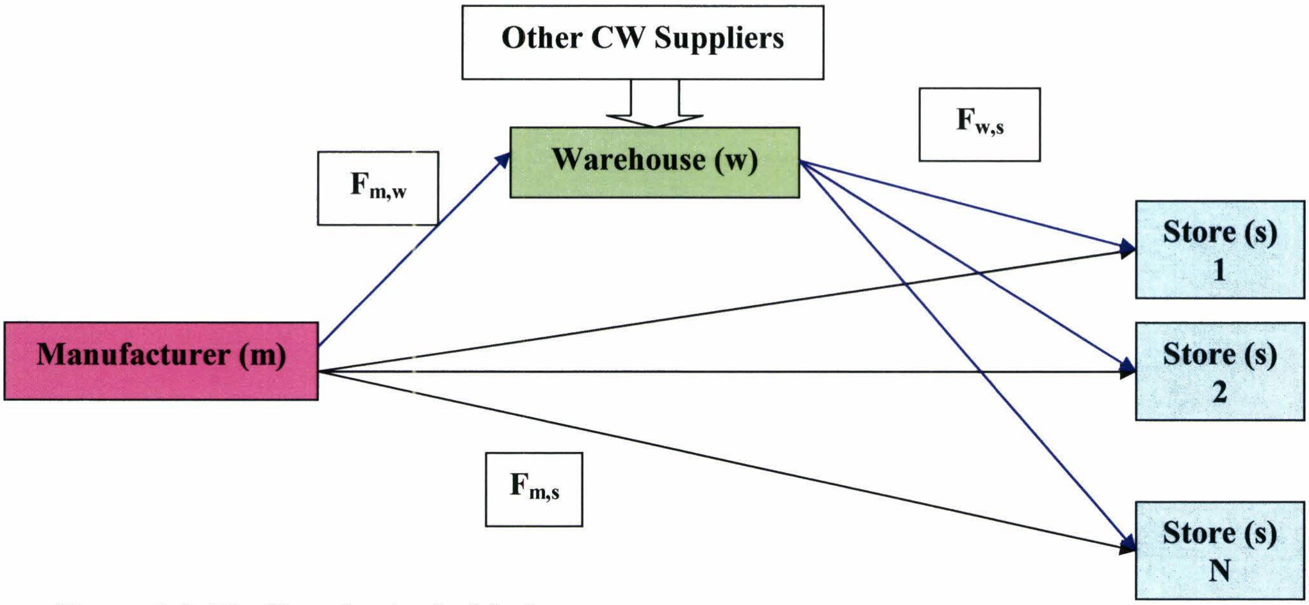

Figure 4.4: The Situation in the Market

An important control parameter that can be adjusted by Metro is the delivery frequency. Therefore, an important input variable of the model will be the delivery frequency, which is defined as follows:

$F_{i,j}$ = the delivery frequency from origin *i* to destination *j* (shipments/year)

with:

$i \in \{m, w, s\}$

$j \in \{m, w, s\}$

Based on some logical reasoning and the situation at Metro, where the maximum delivery frequency to the stores is five times a week, the following preconditions can be stated:

$$0 \leq F_{m,w} \leq N \cdot F_{m,s} \leq N \cdot F_{w,s} \leq 16 \cdot 260$$ *Equation 4.1*

with:

N = number of stores (16 for Metro)

To be able to make some general guidelines independent of the costs, the models will be dimensionless. This leads to cost ratios of the CW costs divided by the DSD costs. A cost ratio < 1 means that the DSD flowtype has the lowest cost, and a cost ratio > 1 means that the CW flowtype has the lowest cost

4.3.3 Transportation Costs Model

The transportation costs depend on the drop size (Lapierre et al, 2004; and Simchi-Levi et al, 2005). Van der Vlist and Broekmeulen (2006) developed a model that includes this fact. Moreover, the model includes the possibility that the empty space in a truck can be filled up with goods of other destinations. The model is formulated as follows:

$$FC_{i,j} = DC_{i,j} \cdot \left(\frac{Q_{i,j}}{W} \right)^{1-r}$$ *Equation 4.2*

with:

$FC_{i,j}$ = transportation costs for shipping a freight from origin i to destination j (euro/shipment)
$DC_{i,j}$ = total transportation costs of moving a full truckload from origin i to destination j (euro/shipment)
$Q_{i,j}$ = the shipment load from origin i to destination j (case packs/shipment)
W = the capacity of the truck (case packs/shipment)
r = the efficiency of the vehicle routing

The capacity of the truck is assumed to be independent of the supplier. This assumption is verified by the fact that the Metro platforms use "standard trucks" to ship the goods from the warehouse to the store.

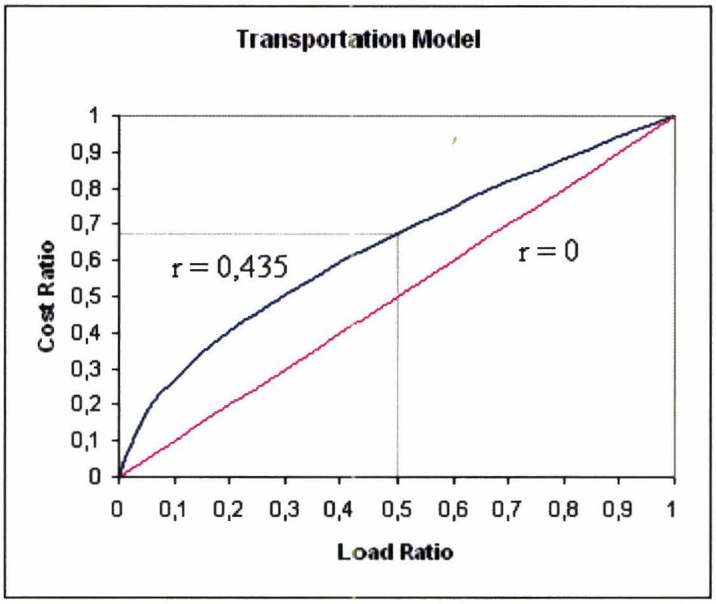

Figure 4.5: The Efficiency of The Vehicle Routing

The routing efficiency is displayed in Figure 4.5. The routing efficiency has a value between 0 and 1. For example, a value of the shape parameter 0.435 means that moving half of a full truck load costs two third of moving a full truckload.

The applicability of this model is tested for Metro by asking two large third party logistics service providers that operate for Metro. Both organisations approved the model, and suggested the following parameter values.

$DC_{i,j}$ = 280 euro/shipment (average within the Netherlands)
W = 33 (euro) pallets
r = 0.435

To model the transportation costs a dimensionless input variable is introduced, the load ratio:

$$\lambda_{i,j} = \frac{Q_{i,j}}{W} \qquad \textit{Equation 4.3}$$

with:

$$Q_{m,s} = \frac{V}{N \cdot F_{m,s}}$$

$$Q_{m,w} = \frac{V}{F_{m,w}}$$

$$Q_{w,s} = \frac{V}{N \cdot F_{w,s}}$$

and:

V = the total sales volume of a supplier (case packs/year)

This formula shows that the transportation costs are based on the average shipment load instead of the actual shipment loads. This assumption is verified by data of Metro. (See Appendix P)

A precondition of the model of Van der Vlist and Broekmeulen is that shipment size does not exceed the truck capacity:

$$0 \leq \lambda_{i,j} \leq 1$$

The validity of this precondition at Metro will be discussed for all three load ratio's:

$0 \leq \lambda_{m,s} \leq 1$ This precondition is checked by measuring the percentage of direct shipments of the supplier with the largest sales volume that exceeded the truck capacity. Only 1.15% of the shipments of the supplier with the highest volume exceeded the truck capacity (in 2005). So, the assumption can be made that the direct shipment size will not exceed the truck capacity.

$\lambda_{m,w} = 1$ The load ratio from the supplier to the warehouse is set at 1, because it is assumed that the supplier only delivers full truckloads to the warehouse. Testing this assumption for the relative small pilot suppliers shows that the load ratio is at least 0.5. When the load ratio approaches the value 1, the transportation costs do not increase much (see Figure 4.5). So, the difference in transportation costs between a value of nearly 1 and exactly 1 is not significant. Therefore, this assumption is justified.

$\lambda_{w,s} = 1$ The load ratio from the warehouse to the store is also set at 1, because the available consolidation volume is assumed to be large enough to fill the truck. This assumption is checked by dividing the total pallets that moved through the warehouse by the total number of shipments and the truck capacity, which results in a ratio of 1.13. So, this figure shows that there is enough consolidation volume to fill the trucks.

The formula for the transportation costs ratio is calculated by multiplying the number of shipments with the costs per shipment:

$$\frac{TRC_{CW}}{TRC_{DSD}} = \frac{F_{m,w} \cdot FC_{m,w} + N \cdot F_{w,s} \cdot FC_{w,s}}{N \cdot F_{m,s} \cdot FC_{m,s}} \qquad \textit{Equation 4.4}$$

with:

TRC_k = transportation costs for flowtype k (euro)

and:

$k \in \{CW, DSD, BBXD, PAXD\}$

However, the transportation costs of the indirect flowtype do not depend on the frequency but on the selling volume, because all shipments are assumed to be full. So, the number of shipments is V/W for both $F_{m,w}$ and $F_{w,s}$. This leads to the following formula:

$$\frac{TRC_{CW}}{TRC_{DSD}} = \frac{\frac{V}{W}\cdot FC_{m,w} + \frac{V}{W}\cdot FC_{w,s}}{N\cdot F_{m,s}\cdot FC_{m,s}}$$

$$= \frac{\frac{V}{W}\cdot DC_{m,w}\cdot \lambda_{m,w}^{1-r} + \frac{V}{W}\cdot DC_{w,s}\cdot \lambda_{w,s}^{1-r}}{N\cdot F_{m,s}\cdot DC_{m,s}\cdot \lambda_{m,s}^{1-r}} = \frac{\frac{V}{W}\cdot DC_{m,w} + \frac{V}{W}\cdot DC_{w,s}}{N\cdot F_{m,s}\cdot DC_{m,s}\cdot \lambda_{m,s}^{1-r}}$$

$$= \frac{V}{N\cdot F_{m,s}\cdot W}\cdot\frac{DC_{m,w}+DC_{w,s}}{DC_{m,s}}\cdot\left(\frac{V}{F_{m,s}\cdot W\cdot N}\right)^{r-1} = \frac{DC_{m,w}+DC_{w,s}}{DC_{m,s}}\cdot\left(\frac{V}{F_{m,s}\cdot W\cdot N}\right)^{r}$$

$$= \frac{DC_{m,w}+DC_{w,s}}{DC_{m,s}}\cdot \lambda_{m,s}^{r}$$

Equation 4.5

Some guidelines that can be derived from the previous formula are:

- If the volume per store increases, the direct store delivery becomes more beneficial. The sales (in case packs) for the Metro stores is relatively high compared to the sales of the supermarket chains. Therefore, the DSD flowtype becomes more beneficial for Metro.
- If the delivery frequency from the manufacturer to the store is allowed to be significantly lower than the delivery frequency from the central warehouse to the store, the direct store delivery turns out to be more beneficial. Metro allows suppliers to deliver less frequently than the central warehouse. Therefore, the direct store delivery becomes more beneficial.
- If the capacity of the transportation mode increases, the central warehouse flowtype becomes more beneficial. This is because more goods can be consolidated in a larger truck.
- If a supplier is located further away from the stores, the central warehouse becomes more beneficial. This is not so easy to see in the formula; therefore, this effect is now discussed.

The break-even point can be calculated for some different scenarios. The break-even point lies at the value 1. If a supplier is located in the Netherlands, the following assumption can be made:

$$DC_{m,w} = DC_{w,s} = DC_{m,s}$$

In this case the formula can be simplified:

$$\frac{TRC_{CW}}{TRC_{DSD}} = 1 \Rightarrow \frac{DC_{m,w}+DC_{w,s}}{DC_{m,s}}\cdot\lambda_{m,s}^{r} = 2\lambda_{m,s}^{r} = 1 \Rightarrow \lambda_{m,s}^{r} = \frac{1}{2} \Rightarrow \lambda_{m,s} = 0{,}203$$

This means that if the average shipment load of DSD would be higher than one fifth of a full truckload, the transportation costs of direct shipment are lower than the transportation costs of the CW flowtype.

If a supplier is located outside the Netherlands, for example in France, the following assumption could be made:

$$DC_{m,w} = DC_{m,s} = 3\cdot DC_{w,s}$$

In this case the formula can be simplified:

$$\frac{TRC_{CW}}{TRC_{DSD}}=1 \Rightarrow \frac{DC_{m,w}+DC_{w,s}}{DC_{m,s}}\cdot\lambda^{r}_{m,s}=\frac{3\cdot DC_{w,s}+DC_{w,s}}{3\cdot DC_{w,s}}\cdot\lambda^{r}_{m,s}=\frac{4}{3}\cdot\lambda^{r}_{m,s}=1$$

$$\Rightarrow \lambda^{r}_{m,s}=\frac{3}{4}\Rightarrow \lambda_{m,s}=0{,}516$$

This means that if the average shipment load of DSD would be higher than half a full truckload, the transportation costs of direct shipment are lower than the transportation costs of the CW flowtype.

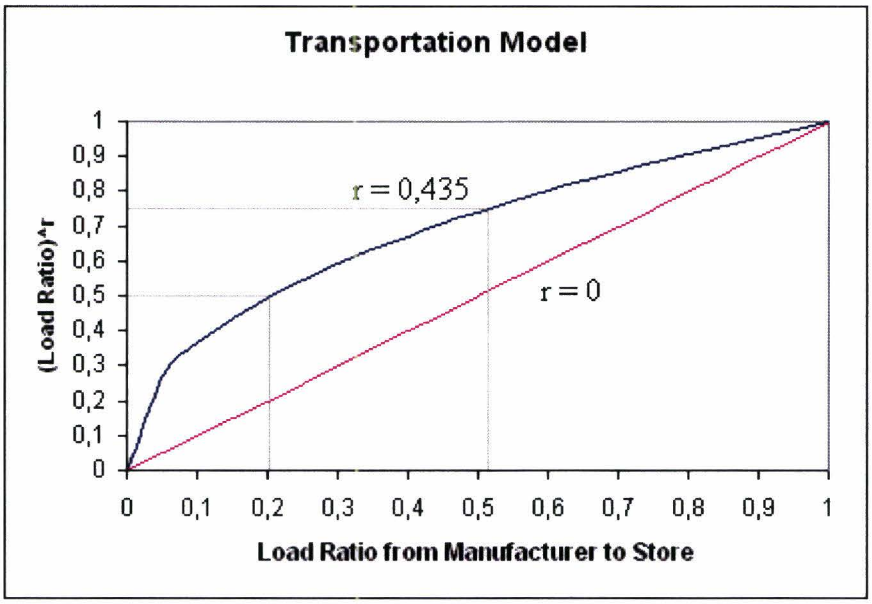

Figure 4.6: The Routing Efficiency of Different Scenarios

The effect of the location of the supplier is presented in Figure 4.6. This figure shows that the break-even load ratio increases when the supplier is located further away from the stores. This result aligns with the statement made in Section 3.4.3. This section namely states that it is more beneficial to consolidate freight by shipping goods through a warehouse, when the supplier is located far away from the stores. That is why the break-even load ratio for the direct store delivery increases when a supplier is further away.

4.3.4 Handling Cost Model

A second important cost factor is the handling cost. The most important handling costs are the order picking costs at the supplier and at the warehouse, and the costs of filling the shelves at the store. The order picking process is similar to the filling process but than just the other way around. This means that the costs of these processes can be approached by a similar model. This model is presented in this section.

The handling costs depend on the time needed for executing the process multiplied with the labour costs. The required time consists of the walk and search time, the grab and put away time, and a constant time for getting the pick list (Gray et al 1992). The total walk and search time depends on the number of stops (the line costs), and the total grab and put away time depends on the number of products (the unit costs). The constant time for getting the pick list can be excluded from the model, because the platform uses an electronic pick list that is send to the hand terminal. These statements are verified by data of a platform. (See Appendix Q).

The linear regression analysis based on these data show that the required picking time depends on the number of order lines and the number of case packs. However, one remark that should be made is that the number of order lines is correlated with the number of case packs. The line and unit costs ratio will be individually modelled.

The Line Costs

The line costs include the walk and search time for order picking, and filling the shelves. The number of stops is equal to the number of order lines that need to be "produced". Therefore, these costs are called the line costs. The formula for the line costs ratio is formulated as follows:

$$\frac{TLC_{CW}}{TLC_{DSD}} = \frac{\sum_{i=m,w,s} OLC_i \cdot OL_{i,j}}{\sum_{i=m,s} OLC_i \cdot OL_{i,j}}$$ *Equation 4.6*

with:

TLC_k = the total handling line costs for flowtype *k* (euro)
$OL_{i,j}$ = the number of order lines from location *i* to location *j* (order lines)
OLC_i = the order line handling costs at location *i* (euro/order line)

Now, the number of order lines needs to be determined. The number of order lines depends on the delivery frequency, the assortment width, and the number of stores. If the order policy would be a (R,S) system (Silver et al 1998), all the goods would be reordered every time a order can be placed. This policy would result in the following formula for the number of order lines:

$$OL_{m,w} = F_{m,w} \cdot A$$
$$OL_{w,s} = N \cdot F_{w,s} \cdot A$$
$$OL_{m,s} = N \cdot F_{m,s} \cdot A$$
Equation 4.7

with:

A = the assortment width (number of different SKU's)

This formula is validated with data of Metro. Metro uses a system that automatically generates orders. However, the employees can adjust the orders. The actual number of order lines of Metro is significantly lower than the calculated order lines. This means that not every article is reordered every time an order is placed. This difference can have two reasons:

- An article cannot be reordered every time because of its minimum order quantity. For most of the articles in the store a case pack is the minimum order quantity. A few fast moving products have larger minimum order quantities, like a pallet layer or a full pallet. For the products that move from the manufacturer to the warehouse, the minimum order quantity is a full pallet.
- The employees can consolidate orders to reduce or balance the workload in the stores. Van Donselaar et al (2006) further investigated this effect, and showed that the available filling capacity influences the order policy. The EOQ formula also shows that consolidating orders is not so bad for the costs (inventory plus order costs).

Both influences will lower the actual number of order lines. To measure the influence on the number of order lines a parameter is introduced, the order line ratio.

$OLR_{i,j}$ = the order lines ratio, defined as the actual number of order lines divided by the maximum number of order lines following an (R,S) system for shipping goods from location *i* to location *j*.

The influence of the minimum order quantity (MOQ) on the order line ratio is first investigated. An article will not be reordered every time, if the time it takes to sell the minimum order quantity is longer than the time between two deliveries. Therefore, the turnover rate of the minimum order quantity is further investigated. For most of the articles the minimum order quantity is equal to a case pack. Figure 4.7 shows the sales in case packs of the different SKU's. (The first 100 SKU's are separately shown in the left graph) The data show that the turnover rates differ a lot per SKU. This means that a small number of fast movers is reordered every time an order is placed and many slow movers are only incidentally reordered. So, one expects that the number of order lines is influenced by the average turnover of a SKU and the skewedness of the sales.

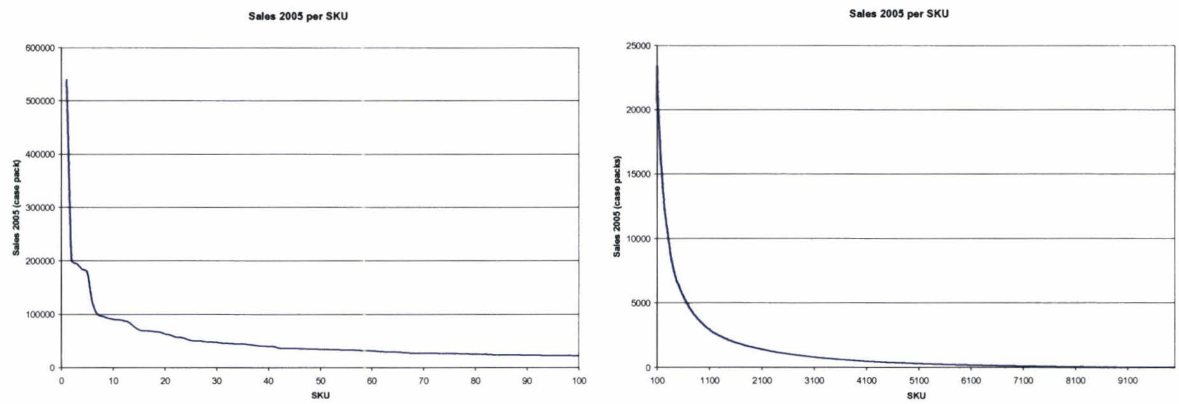

Figure 4.7: The Division of the Total Sales over the SKU's

An attempt is made to model this so called skewedness of the sales division over the articles. Silver et al (1998, pp 66-68) discussed the lognormal distribution. This probability distribution is tested for data of Metro. However, this probability distribution does not fit the data of Metro. Other distributions are also tested, and the most suitable model is the well-known Pareto division. Such a relation can be formulated on a similar way as the formula for the shipment costs:

$$CumS = V \cdot \left(\frac{a}{A}\right)^{s} \qquad \textit{Equation 4.8}$$

$$a \in \{1,\ldots,A\}$$

with:

$CumS$ = the cumulative sales for article 1 to a (case packs)
a = article number
s = the shape parameter (between 0 and 1)

This formula is fitted to data of Metro. Figure 4.8 shows the result of fitting the model to the sales of all non-perishable goods. The optimal value of *s* is set at 0.25, which means that about 25% of the SKU's is responsible for two third of the total sales. An important remark is the fact that if the value of s increases, the skewedness decreases. The figure shows that the model slightly deviates from the actual data. In the beginning the model has larger values than the actual data, and at the end the model has lower values than the actual data. The same analysis is executed for the pilot suppliers; the results are displayed in Appendix R. These figures show that this model is a good approximation for the division of the sales over the SKU's. The results also show that the optimal value of *s* differs per supplier.

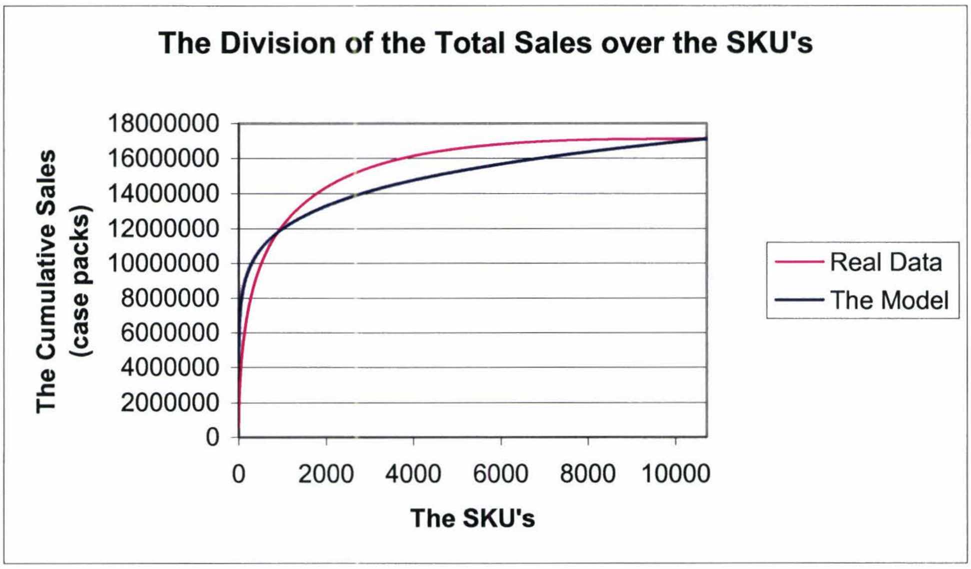

Figure 4.8: The Division of the Total Sales over the SKU's

A regression analysis measures the influence of the skewedness and the average turnover of a case pack on the order line ratio. The results are displayed in Appendix S. The results show that the skewedness (expressed by the value of s) has a significant influence on the order line ratio. The results also show that the influence of the average turnover rate is not significant. This is due to the fact that if the average turnover is high, the delivery frequency of a supplier is higher. So, this effect is enormously reduced.

The skewedness alone explains more than 80 per cent of the variance in the order line ratio. Therefore, the second effect, the adjustments of the employees, is not further investigated. So, the formula for the order line ratio is:

$$OLR_{i,j} = K_{i,j} \cdot s \qquad \textit{Equation 4.9}$$

with:
$K_{i,j}$ = a constant depending on the origin *i* and destination *j*

This formula is an empirical model based on data of Metro. The model shows that if the skewedness of the sales divided over the SKU's increases (the shape parameter decreases), the order line ratio decreases. This is a logical result because if a supplier has a few very fast movers and many slow movers (skewed sales division), a supplier will not reorder all slow movers when the fast movers are reordered. Therefore, the order line ratio decreases, when the skewedness increases.

Using the order lines ratio leads to the following formula for the line costs ratio:

$$\frac{TLC_{CW}}{TLC_{DSD}} = \frac{\sum_{i=m,w,s} OLC_i \cdot OL_{i,j} \cdot OLR_{i,j}}{\sum_{i=m,s} OLC_i \cdot OL_{i,j} \cdot OLR_{i,j}}$$

$$= \frac{OLC_m \cdot F_{m,w} \cdot A \cdot K_{m,w} \cdot s + (OLC_w + OLC_s) \cdot N \cdot F_{w,s} \cdot A \cdot K_{w,s} \cdot s}{(OLC_m + OLC_s) \cdot N \cdot F_{m,s} \cdot A \cdot K_{m,s} \cdot s} \qquad \textit{Equation 4.10}$$

$$= \frac{OLC_m}{OLC_m + OLC_s} \cdot \frac{K_{m,w}}{K_{m,s}} \cdot \frac{F_{m,w}}{F_{m,s} \cdot N} + \frac{OLC_w + OLC_s}{OLC_m + OLC_s} \cdot \frac{K_{w,s}}{K_{m,s}} \cdot \frac{F_{w,s}}{F_{m,s}}$$

Some general guidelines that can be derived from this formula are:

- The value of s and the assortment width does not influence the line handling costs ratio. However, it does influence the total line handling costs
- If the number of stores increases, the central warehouse flowtype becomes more beneficial.
- If the labour costs of the supplier are higher than the labour costs at the warehouse, the central warehouse flowtype is more beneficial.
- If the delivery frequency from the manufacturer to the store is allowed to be significantly lower than the delivery frequency from the central warehouse to the store, the direct store delivery turns out to be more beneficial.

<u>The Unit Costs</u>

The unit costs include the grab and put away time for order picking, and filling the shelves. The required time depends on the number of units, which is the number of case packs for order picking, and the number of selling units for shelf filling.
The formula for the unit costs ratio is formulated as follows:

$$\frac{TUC_{CW}}{TUC_{DSD}} = \frac{\sum_{i=m,w} UC_i \cdot V + \sum_{i=s} UC_i \cdot V_{SU}}{\sum_{i=m} UC_i \cdot V + \sum_{i=s} UC_i \cdot V_{SU}} \qquad \textit{Equation 4.11}$$

with:

TUC_k = the total handling unit costs for flowtype k (euro)
UC_i = the unit handling costs for moving case packs (euro/unit)
V_{SU} = the total sales volume of a supplier in selling units (selling units/year)

The volume will be independent of the flowtype. Moreover, the labour costs per hour in the stores are not influenced by the flowtype. So, the unit handling costs at the stores are independent of the flowtype and can be excluded from the model. The costs can only be influenced by the difference in labour costs, between the supplier and the warehouse. If the labour costs of the supplier are much higher than the costs of the warehouse, it might be beneficial to send the goods through a warehouse. Shipping goods over a central warehouse means that the supplier can reduce costs by picking full pallets instead of single case packs, which is a precondition for most suppliers to switch to central warehouse delivery. This leads to the following formula:

$$\frac{TUC_{CW}}{TUC_{DSD}} = \frac{\sum_{i=m,w} UC_i \cdot V}{\sum_{i=m} UC_i \cdot V} = \frac{(UC'_m + UC_w) \cdot V}{(UC_m) \cdot V} = \frac{UC'_m + UC_w}{UC_m}$$ *Equation 4.12*

with:
UC_i' = the unit handling costs for picking on full pallets (euro/unit)

A general guideline that can be derived from this formula is that the CW flowtype will only be beneficial if $UC'_m + UC_w \leq UC_m$. To give an indication, this condition is tested for Metro. The costs of full pallet pick are about five times lower as single case pack pick. This means that $UC_w \leq \frac{4}{5} UC_m$ to make the central warehouse more beneficial compared to direct store delivery.

4.3.5 Inventory Cost Model

The third and last important cost factor is the inventory cost. The inventory costs include the costs related to the inventory position at the stores and at the warehouse. It is assumed that supply and demand is not synchronised. This assumption can be made, because Metro only uses a vendor management inventory system, and POS data exchange with two out of the 314 non-perishable good suppliers. So, the inventory position at the supplier is not influenced by a change of the flowtype of one customer of the supplier. Therefore, the inventory position at the supplier is out of the scope of this project. The inventory costs related to the inventory position include the inventory carrying costs and the storage space costs at the warehouse, and the inventory carrying costs at the store. First, a formula for the inventory position is constructed. Next, a formula is derived for the inventory carrying costs ratio. Finally, a model is presented for the storage space costs at the warehouse.

The inventory position consists of an order quantity stock and a safety stock. (See Figure 4.9) The safety stock is influenced by a lot of factors, such as the delivery frequency, marketing factors, service level factors, and the local management policy. Because of this complicated situation, the safety stock is excluded from the model. However, when the difference between the delivery frequencies of the different flowtypes is large, the safety stock could differ significantly, and the model will use its validity!

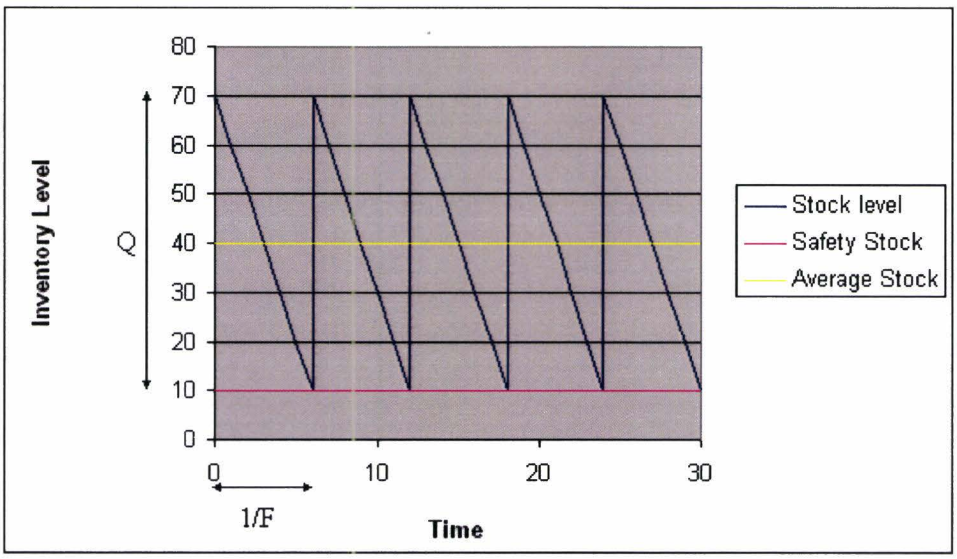

Figure 4.9: The Inventory Position

The inventory level that is modelled is the difference between the average stock and the safety stock. The formula to derive the average inventory position is formulated as follows:

$$I_j = \frac{1}{2} \cdot Q_{i,j} = \frac{1}{2} \cdot \frac{V}{N \cdot F_{i,j}}$$ *Equation 4.13*

with:

I_j = the average inventory position (case packs)

However, not every time an order is placed, every article is reordered. To take this effect into account the order line ratio (discussed in Section 4.3.4) is used to model the inventory position. This leads to the following formula:

$$I_j = \frac{1}{2} \cdot Q_{i,j} = \frac{1}{2} \cdot \frac{V}{N \cdot F_{i,j} \cdot K_{i,j} \cdot s}$$ *Equation 4.14*

This formula is checked for some suppliers. The results are shown in Appendix T. The results show that the inventory position without correction is considerably lower than the adjusted inventory position. Moreover, the adjusted inventory position is a better estimator of the actual inventory position. However, the adjusted inventory position of the suppliers with a low value for the shape parameter (Heineken and Geens) is too high. This is due to the fact that these suppliers have a much higher order quantity for the fast movers than for the slow movers. This effect can be adjusted by introducing a minimum value for s of 0.25, this value is based on the parameter value for the total assortment. Now, the calculated stocks still differ considerably from the actual data. One reason could be that the safety stock is excluded from the model. Another reason could be that the Metro stores hold commercial stock to fill the shelves. This makes it hard to model the inventory.

Based on the previously introduced formula for the inventory position, the inventory costs can be estimated. The inventory interest rate at the warehouse is assumed to be equal to the interest rate at the stores. Metro uses the same inventory carrying costs at the warehouse as in the store, so this assumption is justified. The inventory cost model based on the order quantity stock is formulated as follows:

$$\frac{TIC_{CW}}{TIC_{DSD}} = \frac{IC \cdot v \cdot I_w + N \cdot IC \cdot v \cdot I_s}{N \cdot IC \cdot v \cdot I_d} = \frac{\frac{1}{2} \cdot \frac{V}{F_{m,w} \cdot K_{m,w} \cdot s} + \frac{1}{2} \cdot \frac{V}{F_{w,s} \cdot K_{w,s} \cdot s}}{\frac{1}{2} \cdot \frac{V}{F_{m,s} \cdot K_{m,s} \cdot s}} = \frac{F_{m,s} \cdot K_{m,s}}{F_{m,w} \cdot K_{m,w}} + \frac{F_{m,s} \cdot K_{m,s}}{F_{w,s} \cdot K_{w,s}}$$ *Equation 4.15*

with:

TIC_k = the total inventory interest costs for flowtype k (euro)

v = the case pack value (euro/case pack)

IC = the inventory carrying costs (percentage)

Using the average $K_{i,j}$ values of Metro leads to the following formula:

$$\frac{TIC_{CW}}{TIC_{DSD}} = 1{,}73 \cdot \frac{F_{m,s}}{F_{m,w}} + 2{,}82 \cdot \frac{F_{m,s}}{F_{w,s}}$$

This formula shows that the central warehouse flowtype can only be beneficial if the direct store delivery frequency is a lot smaller (about half) than both other delivery frequencies. So, in most cases the inventory interest costs are larger for the CW flowtype.

Besides the inventory carrying costs, the storage space costs at the platform are an important cost factor. The storage space costs depend on the required pallet locations. The calculation of the required pallet locations at the warehouse is based on a model by Simchi-Levi et al (2005) on page 302. They state that the required pallet locations can be estimated by multiplying the required pallet locations with two. So, to determine the number of required pallet locations the average inventory position must be divided by the stacking and multiplied with the value two. However, a minimum is added to the number of pallet locations based on the number of stock keeping units. Each stock-keeping unit requires at least one pallet location. This can be formulated as follows:

$$TSC_{DSD} = PLC \cdot \max\left(2 \cdot \frac{I_j}{St}, A\right) = PLC \cdot \max\left(\frac{V}{F_{m,w} \cdot K_{m,w} \cdot s \cdot St}, A\right) \qquad \textit{Equation 4.16}$$

with:
TSC_k = the total storage space costs for flowtype k (euro)
PLC = the pallet location costs (euro/pallet location)
St = the stacking of a pallet (case packs/pallet)

This formula is roughly checked for the warehouse of Zuidema. First, the total volume is transformed to pallets by dividing the total volume of Zuidema in case packs by the average stacking of full pallets (assumed to be 60). Next, the volume in pallets is divided by the average turnover rate of the goods at Zuidema. The resulting figure is 35% higher than the actual required pallet locations. Thus, this model is an acceptable approximation.

This model leads to the following guidelines. The storage space costs will increase, when:
- the delivery frequency from the manufacturer to the warehouse decreases.
- the volume increases. This is consistent with the findings in Section 3.4, that it is not beneficial to move goods with a high volume through a central warehouse.
- the parameter value s decreases. So, if the sales are skewed, more pallet locations are required. This is explained by that the extreme fast movers require many pallet locations and each extreme slow mover also requires a pallet location. Thus, the total required pallet location are higher for a skewed sales division than if the sales would be equally divided over each SKU.

4.3.6 Total Cost

This section tries to integrate the different cost factors into one model. It is not possible to simply multiply or add the different cost ratios, because the cost ratios do not have the same weight. Therefore, the costs of the different flowtypes are first individually discussed. Next, one general guideline is derived from these formulas. Third, the most important guidelines of the previous section are compared and related to the situation of Metro. Finally, the cross docking flowtypes are briefly discussed.

Summing up the separate cost factors of each flowtype, leads to the following formulas for the total costs of the central warehouse flowtype:

$$
\begin{aligned}
TC_{CW} &= TRC_{CW} + TLC_{CW} + TUC_{CW} + TIC_{CW} + TSC_{CW} \\
&= \left\{ \left(DC_{m,w} + DC_{w,s} \right) \cdot \frac{V}{W} \right\} \\
&\quad + \left\{ OLC_m \cdot F_{m,w} \cdot A \cdot K_{m,w} \cdot s + \left(OLC_w + OLC_s \right) \cdot N \cdot F_{w,s} \cdot A \cdot K_{w,s} \cdot s \right\} \\
&\quad + \left\{ \left(UC'_m + UC_w \right) \cdot V + UC_s \cdot V_{SU} \right\} + \left\{ \frac{IC \cdot v \cdot V}{2 \cdot s} \cdot \left(\frac{1}{K_{m,w} \cdot F_{m,w}} + \frac{1}{K_{w,s} \cdot F_{w,s}} \right) \right\} \\
&\quad + PLC \cdot \max\left(\frac{V}{F_{m,w} \cdot K_{m,w} \cdot s \cdot St}, A \right)
\end{aligned}
$$

Equation 4.17

and the total direct store delivery costs:

$$
\begin{aligned}
TC_{DSD} &= TRC_{DSD} + TLC_{DSD} + TUC_{DSD} + TIC_{DSD} + TSC_{DSD} \\
&= \left\{ F_{m,s} \cdot DC_{m,s} \cdot N \cdot \left(\frac{V}{F_{m,s} \cdot W \cdot N} \right)^{1-r} \right\} + \left\{ \left(OLC_m + OLC_s \right) \cdot N \cdot F_{m,s} \cdot A \cdot K_{m,s} \cdot s \right\} \\
&\quad + \left\{ UC_m \cdot V + UC_s \cdot V_{SU} \right\} + \left\{ \frac{IC \cdot v \cdot V}{2 \cdot s} \cdot \frac{1}{K_{m,s} \cdot F_{m,s}} \right\}
\end{aligned}
$$

Equation 4.18

with:
TC_k = total supply chain costs for flowtype k (euro)

The previous models show that in most cases the handling costs are higher for the central warehouse than for direct store delivery. Moreover, the CW flowtype will probably have more inventory carrying costs, and definitely more storage space costs. So, the additional handling and inventory costs must be earned back by the savings in the transportation costs. So, if no savings can be made in the transportation costs a supplier should always deliver directly. For example, a supplier within the Netherlands (with r =0.435) should always deliver directly if $\lambda_d > 0.203$.

The previous presented sub models show that direct store delivery becomes more beneficial, when:
- *the volume increases:* This is due to the change in transportation and storage space costs.
- *the delivery frequency from the manufacturer to the store is allowed to be significantly lower than the delivery frequency from the central warehouse to the store:* This is due to transportation costs and the line handling costs.
- *the labour costs of the supplier are low compared to the labour costs at the platform used by Metro:* This is due to both type of handling costs, line and unit costs.
- *the number of stores decreases:* This effect is due to the line handling costs.

These guidelines show that direct store delivery is more beneficial to Metro than for a supermarket chain, because of the larger sales volume, the lower delivery frequency, and the smaller number of stores.

The formulas of both cross-dock flowtypes are not yet discussed. These flowtypes are not so thoroughly examined, because Metro barely uses these flowtypes. So, the available models in the literature cannot be verified with data of Metro. Based on the previous models and some assumptions, the total cost models of both cross-dock flowtypes are now presented.

The break bulk cross-dock flowtype differs from the central warehouse flowtype for a couple of issues. First, the frequency from the supplier to the warehouse is the same as the frequency from the warehouse to the store. This is due to the fact that no inventory is held at the platform. This will probably influence the load ratio from the supplier to the warehouse, because this delivery frequency will probably increase. Therefore, the assumption $\lambda_{m,w} = 1$ is no longer verified. The shipment from the warehouse to the store can be combined with other cross-dock or central warehouse suppliers. So, the load ratio from the warehouse to the store is not influenced. Second, as already stated no inventory is held at the warehouse. This means that the inventory costs at the warehouse including the storage space costs are reduced. Third, the unit handling costs at the supplier might be influenced by the flowtype change. However, the assumption is made that the orders at the supplier are round down to full pallets, so no change occurs in the unit handling costs. The previous discussion leads to the following formula:

$$\begin{aligned} TC_{BBXD} &= TRC_{BBXD} + TLC_{BBXD} + TUC_{BBXD} + TIC_{BBXD} + TSC_{BBXD} \\ &= \left\{ F_{m,w} \cdot DC_{m,w} \cdot N \cdot \left(\frac{V}{F_{m,w} \cdot W \cdot N} \right)^{1-r} + DC_{w,s} \cdot \frac{V}{W} \right\} \\ &\quad + \left\{ OLC_m \cdot F_{m,w} \cdot A \cdot K_{m,w} \cdot s + (OLC_w + OLC_s) \cdot N \cdot F_{w,s} \cdot A \cdot K_{w,s} \cdot s \right\} \\ &\quad + \left\{ (UC'_m + UC_w) \cdot V + UC_s \cdot V_{SU} \right\} + \left\{ \frac{IC \cdot v \cdot V}{2 \cdot s} \cdot \frac{1}{K_{w,s} \cdot F_{w,s}} \right\} \end{aligned} \qquad \textit{Equation 4.19}$$

The pre allocated cross-dock flowtype differs from the central warehouse flowtype for the same two reasons as the break bulk cross-dock. A third difference is the shift of the unit handling costs. Now, the supplier has to pick single case packs, and the warehouse can pick full pallets. This leads to the following formula:

$$\begin{aligned} TC_{PAXD} &= TRC_{PAXD} + TLC_{PAXD} + TUC_{PAXD} + TIC_{PAXD} + TSC_{PAXD} \\ &= \left\{ F_{m,w} \cdot DC_{m,w} \cdot N \cdot \left(\frac{V}{F_{m,w} \cdot W \cdot N} \right)^{1-r} + DC_{w,s} \cdot \frac{V}{W} \right\} \\ &\quad + \left\{ OLC_m \cdot F_{m,w} \cdot A \cdot K_{m,w} \cdot s + (OLC_w + OLC_s) \cdot N \cdot F_{w,s} \cdot A \cdot K_{w,s} \cdot s \right\} \\ &\quad + \left\{ (UC_m + UC'_w) \cdot V + UC_s \cdot V_{SU} \right\} + \left\{ \frac{IC \cdot v \cdot V}{2 \cdot s} \cdot \frac{1}{K_{w,s} \cdot F_{w,s}} \right\} \end{aligned} \qquad \textit{Equation 4.20}$$

Based on the formulas for cross docking some guidelines can be derived:

- Because the assumption of $\lambda_{m,w} = 1$ must be relaxed, the volume will influence the transportation costs. The cross-dock flowtypes will, therefore, be more beneficial for a supplier with a relative high volume.
- The cross-dock flowtypes could be used for products with high inventory costs, because the inventory costs at the warehouse are removed. However, the inventory costs at the stores might increase (Waller et al, 2005).
- Pre allocated cross docking is suitable for suppliers with lower labour costs than the labour costs at the warehouse, because most of the handling costs shift to the supplier.

4.4 Areas for Further Research

This section presents some limitations of the models, which are options for further research:

- *Promotions:* The models do not consider the promotions of Metro, which are about 26% of the dry goods sales. Promotions cause many sales in a short amount of time. This means that during a promotion the order quantity will increase. This will lower the transportation, handling, and inventory costs.
- *Safety Stock:* The inventory models exclude the safety stock. The difference in safety stock could influence the costs of the flowtype, when the delivery frequency differs substantial. Excluding the safety stock might be beneficial for the CW flowtype, because the safety stock at the platform is excluded. However, the safety stock in the stores is lower for the CW flowtype, because of the higher delivery frequency to the store. Therefore, further research is required to make better statements.

5. The Flowtype Selection Model

This chapter presents detailed information about the economic factors that influence the flowtype selection. This information is used to verify the results of the previous chapter. The cross-dock flowtypes are not discussed, because their data are not available. First, the flowtype selection model is presented. Second, the flowtype selection model is applied on the pilot suppliers and the results are presented. Third, the general guidelines of the analytical model are compared with the outcomes of the flowtype selection model. Finally, the flowtype selection model is applied on all dry good suppliers.

5.1 Design of the Flowtype Selection Model

This section presents a cost analysis that is based on a flowtype selection model that is put into a software programme, and can be used by Metro to select the economic best flowtype. The structure of this chapter is based on four levels (see Figure 5.1). First, the relevant processes are described and defined. Second, the procedures of Metro are described and compared with other models. Next, the parameter values for Metro are defined and compared with the standard tariffs. Finally, the method for gathering the necessary input data is described. The necessary inputs are the outputs of each process.

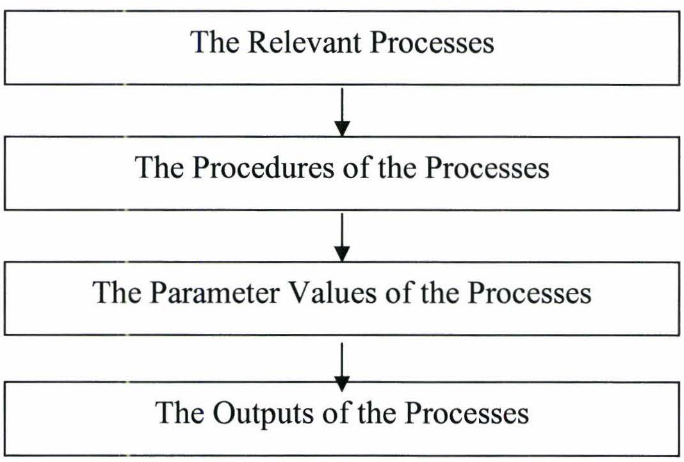

Figure 5.1: The Structure of Section 5.1

5.1.1 The Processes

The basic processes that are within the project scope are already defined in Section 3.1.1. The four basic processes are:

- The delivery process of the supplier
- The source process of the platform
- The delivery process of the platform
- The source process of the stores

These basic processes are each divided into sub processes (see Appendix H). In this section the relevant sub processes are selected and adjusted to the situation of Metro Cash and Carry NL. Next, the adjusted sub processes are further broken down into activities based on five information sources. First, the SCOR model gives a definition for each process. In this definition, some specific activities are mentioned. Second, the different procedures of the platform, Metro head office, and the Metro stores are all documented. These documentations are used to determine the activities. Third, observations are made to verify the documented information. Finally, two checklists are used to complete the list of activities. One checklist is a wizard developed by ECR Europe (1998) and the other is an article by van Damme et al (1994).

The Delivery Process of the Supplier

The relevant number of sub processes of the delivery process of the supplier is reduced to six processes. The first seven steps (D1.1 to D1.7) are combined into one sub process, because these steps use the same resources, namely the order receiving and planning department. The step of receiving the products at the warehouse (D1.8) is excluded, because the flowtype does not influence the costs of this step. The number of goods that move through the warehouse of the supplier does not change when the flowtype is changed. So, the number of products that are received in the warehouse of the supplier is also not influenced by the flowtype. The step of product installation (D1.12) is excluded, because the products are not installed. The resulting steps are displayed in Figure 5.2. The activities of the sub processes are described in Appendix U.

The Supplier Delivery Process

Figure 5.2: The Sub Processes of the Supplier Delivery Process

The Source Process of the Platform

The number of relevant sub processes of the source process of the platform is increased to six steps. The process of inventory management is included, because the inventory level triggers the sourcing process. The resulting steps are displayed in Figure 5.3. The costs of all the different steps are influenced by the flowtype choice, because the costs of the platform only occur when the goods move through a platform. The activities of the sub processes are described in Appendix U.

The Platform Source Process

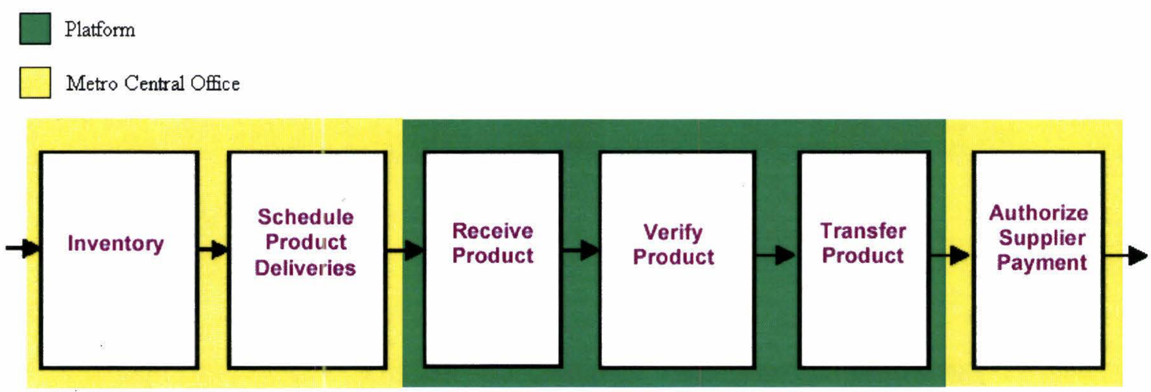

Figure 5.3: The Sub Processes of the Platform Source Process

The Delivery Process of the Platform

The number of relevant sub processes of the delivery process of the platform is reduced to five sub processes. The first seven steps (D1.1 to D1.7) are again, for the same reason, combined into one step. The step of product installation (D1.12) is again excluded, because the products are not installed. The step of invoice (D1.13) is also excluded, because the goods were already paid when they entered the platform. The step of receiving the products at the warehouse (D1.8) is transformed into refilling the pick places, because the step of receiving the goods is already included in the source process. Moreover, the step of refilling the pick location is not included in the SCOR model. The remaining steps are displayed in Figure 5.4. The costs of all the different steps are influenced by the flowtype choice, because the costs of the platform only occur when the goods move through a platform. The activities of the sub processes are described in Appendix U.

The Platform Delivery Process

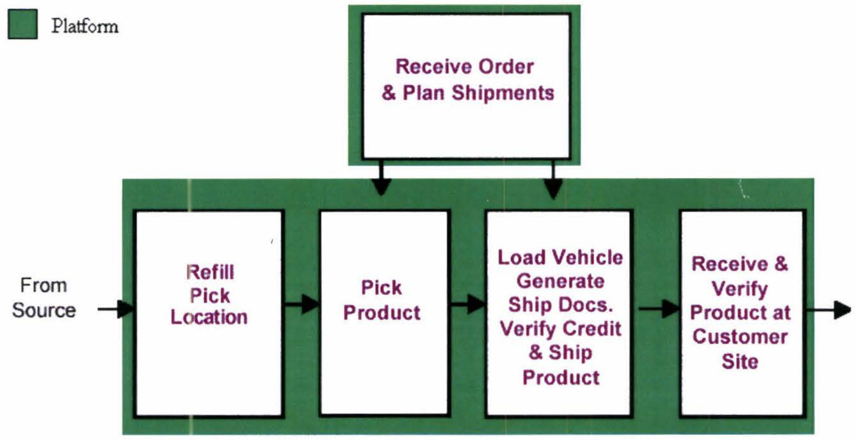

Figure 5.4: The Sub Processes of the Platform Delivery Process

The Source Process of the Stores

The number of relevant sub processes of the source process of the stores is also increased to six steps. The process of inventory management is again included, because the inventory level triggers the sourcing process. The resulting steps are displayed in Figure 5.5. The activities of the sub processes are described in Appendix U.

The Store Source Process

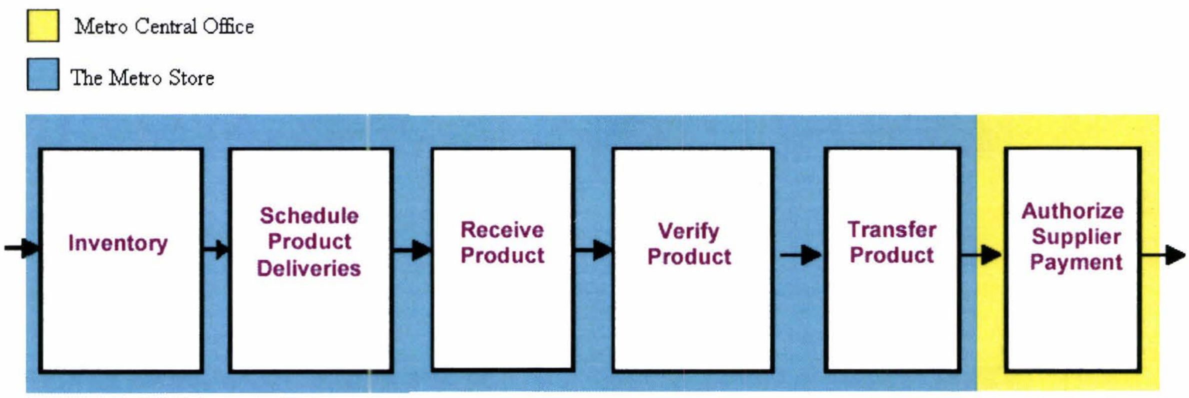

Figure 5.5: The Sub Processes of the Store Source Process

5.1.2 The Procedures of the Processes

This section gives the procedures of the sub processes defined in the previous section. A detailed description of the procedures of each activity is presented in Appendix V. The procedures of Metro and the platforms Zuidema and Bakker are described and compared to a standard, which is based on the DPP model (Doherty et al, 1993; ECR, 2003). Ketenmoduul (2000) published a list of standard tariffs for this DPP model. These tariffs are based on an estimated time needed for an activity multiplied with labour and equipment costs per hour. These tariffs are standards in the market. This means that the tariffs can give a good indication of the actual costs, but each individual company will deviate from this standard tariff.

The Delivery Process of the Supplier

The procedures of the sub processes of the delivery process of the supplier will differ per supplier. Besides, the information about the procedures at the supplier is not available. Therefore, only the standard procedures are discussed.

The Source Process of the Platform

The procedures of the relevant source processes at the platform are discussed for the standard tariffs of the DPP model, Metro, and for both platforms (Zuidema, and Bakker Logistiek). The head office of Metro executes the steps one, two, and six. The platform executes the steps three, four, and five. The steps at the platform are discussed as one step because the platform uses one tariff for receiving the goods.

The Delivery Process of the Platform

The procedures of the relevant delivery sub processes at the platform are discussed for the standard tariffs of the DPP model, and for both platforms (Zuidema, and Bakker Logistiek).

The Source Process of the Stores

The procedures of the relevant sub processes of the source process of the stores are presented for the standard tariffs of the DPP model and for the Metro stores.

5.1.3 The Parameter Values of the Processes

This section determines the parameter values for the different procedures and models described in the previous section. The different tariffs and productivity figures are compared, and the most suitable figures are selected for the model. First, the resource tariffs are discussed for the different participants in the supply chain. Next, the productivities figures for the different participants in the supply chain are reviewed. Third, the parameter values of the transportation and order picking models are presented.

The Resource Costs

The resource costs of different information sources are compared and one tariff is selected for the flowtype selection model. The information sources are the standard tariffs of Ketenmoduul, the costs of the platforms Zuidema and Bakker, and the costs of Metro both at the head office and in the store. The cost tariffs of Zuidema for the equipment are not available. These costs are included in the fixed costs. The fixed costs will be assigned to the goods by using activity based costing (Stapleton et al, 2004). An overview of the different resource costs is presented in Appendix W.

The labour costs presented by Ketenmoduul are lower than the costs of Zuidema, Bakker, and Metro. This is due to the fact that the figures of Ketenmoduul are of the year 2000. Moreover, the labour costs at the Metro stores are higher than the average labour costs. This is because the employees at the stores are older, and therefore more expensive, than the employees at the "average" store. Another difference between Ketenmoduul and Metro are the inventory coverage costs. Metro uses an interest fee of 7% and a depreciation fee of 7%. Taken together the total inventory coverage costs are 14% of the inventory value.

Most of the selected resource costs are based on the figures of Metro and Zuidema, because these are the most relevant costs for Metro. The two exceptions are the labour costs of the administration and the equipment costs. These two costs are based upon the standard tariffs of Ketenmoduul, because the lack of necessary data.

The previous chapter introduced some models, which are also used in the flowtype selection model. The transportation costs model of van der Vlist and Broekmeulen is also programmed in Excel, including a maximum value of five euro per case pack, because this is the cost of sending a single case pack. This model is used to determine the transportation costs from the supplier to either the store or the warehouse. So, the assumption of sending only full trucks from the supplier to the warehouse is relaxed. The transportation costs ratios showed that the location of the supplier could influence the flowtype choice. Therefore, the flowtype selection model introduces a ratio for the shipment costs of the supplier divided by the costs of a shipment within the Netherlands. This ratio is multiplied with the basic transportation tariffs from the supplier, including the minimum of five euro per case pack. The costs of sending a pallet from the warehouse to the store are set at the tariff of Zuidema.

The handling costs ratios showed that the labour costs of the supplier compared to those of the warehouse could influence the flowtype choice. Therefore, the flowtype selection model introduces another ratio for the labour costs of the supplier divided by the costs of the warehouse.

The Productivity Figures

The productivity figures of different information sources are compared and one productivity figure is selected for the flowtype selection model. The information sources are Ketenmoduul, the standards at the platforms Zuidema and Bakker, the actual productivity at Zuidema based on calculation of provided data, and the productivity at Metro measured by an external company. An overview of the different productivity figures is presented in Appendix X.

Most of the productivity figures are similar for the different information sources. The productivity figures at Bakker are somewhat higher than those of Ketenmoduul and Zuidema. However, the employees do not always reach the norms of Bakker. Another significant difference is the productivity of cleaning up the trash at the shop floor. The productivity figure of Metro is much higher than the figure of Ketenmoduul. This difference can be explained by the fact that Metro has larger package units with less trash. Besides, Metro placed their garbage containers on the shop floor.

Again, most of the selected productivities are based on the figures of Metro and Zuidema, with the exception for the activities at the supplier. The activities at the supplier are based on Ketenmoduul, because these figures give the best estimation for the productivity of the "average supplier". The exceptions to the above concern the following steps:

- *Receive order and plan shipment at the supplier:* The productivity of this step is synchronised with the figure of Ketenmoduul at the warehouse, because there are no valid reasons why these figures differ enormously (two compared to 12 shipments per hour)
- *Check goods:* This productivity figure is based on the norm of Bakker, because there are no other data sources available.
- *Prepare goods for shipment:* This productivity figure is based on the norm of Bakker, because the lack of other data sources.

Another model that was introduced in the previous chapter was the handling costs ratio, which was based on the number of units and order lines. However, the available data only give the unit costs. This means that the line costs are included in the unit costs. Therefore, the order picking and filling costs are only based on the number of units.

5.1.4 Gathering the Necessary Data

This section presents an input model to gather the necessary data for the flowtype selection model. First, the required data are listed. Next, a method is described to gather the actual historical data. Finally, a model is presented that can approximate the necessary input.

The Required Data

The productivity figures presented in Appendix X are based on the cost drivers of the activities. An overview of all cost drivers is presented in Appendix Y. These figures need to be determined per supplier, to calculate the total costs over a certain period of time for the different flowtypes. Based on this calculation the economically best flowtype can be selected.

The Actual Data

The process of gathering the actual data is explained in Appendix Z. This process is executed for the pilot suppliers (see Section 4.2). Based on their data the most important cost factors can be verified, and the most preferable flowtypes can be identified. This is discussed in the Section 5.2. Moreover, the actual data can be used to verify the actual data of the input model presented next.

The Input Model

This section presents a model to estimate the necessary data. This model is introduced for two reasons. First, gathering the necessary data with the method explained in Appendix Z is a very time consuming activity. Second, the flowtype selection model should be able to compare the different flowtypes; and, therefore, the data of the flowtype, that is not the current flowtype of a supplier, are not available and must be estimated. The approximation of the necessary input defined in Appendix Y will be individually discussed.

- *The orders:* this figure is calculated by multiplying the delivery frequency with the number of destinations. So, the assumption is made that one order generates one shipment. This assumption is partly verified by data of Metro. Sometimes, a shipment is generated by multiple orders, but the average number of orders per shipment does not exceed the value of 1.5. Another reason why this assumption is justified is the fact that the number of orders is only used to calculate the payment costs, and these costs are about 1% of the total costs.
- *The order lines:* Section 4.3.4 presented a model to estimate the number of order lines. The number of order lines is calculated by multiplying the number of orders with the number of stock keeping units and a correction factor. This correction factor uses a shape parameter multiplied with a constant. This constant is presented in Appendix S. The shape parameter differs per supplier; the average value is 0.25. The number of stock keeping units is based on the current number of stock keeping units, because this number stays quite steady. Most of the time that a new article is introduced, another article is removed from the assortment. (See Appendix AA)
- *The shipments:* the number of shipments is calculated by multiplying the delivery frequency with the number of destinations.
- *The case packs*: this number can be easily gathered from the Metro database or the supplier scorecard. This number is independent of the flowtype.

- *The full pallets out:* calculating this figure is complicated. First, the full pallet load must be calculated. If these data are not available the stacking (number of case packs per pallet) is assumed to be equal to 60 case packs per pallet. The stacking of 60 is based on the average pallet load. Next, the number of stock keeping units that can be delivered to the destination on full pallets must be estimated. This estimation is based on the average number of days it takes to sell the volume that is on a full pallet. If this time is short enough (for example less than one week) the products can be shipped on full pallets. Based on these two figures the number of full pallets out can be calculated. Matching the result of this calculation with actual data leads to good results (See Appendix AB).
- *The single case packs out:* this number can be determined by simply subtracting the case packs that are delivered on full pallets from the total case packs.
- *The mixed pallets out:* now, the stacking of the mixed pallets must be estimated. Based on some general findings the stacking of the mixed pallets is assumed to be 80% of the stacking of full pallets. This percentage is based on the general rule that mixed pallets contain 20% air. This assumption is also validated by the data. (See Appendix AB)
- *The total pallets out:* this figure is calculated by summing the full pallets and the mixed pallets.
- *The average shipment load:* this figure can be determined by dividing the number of total pallets by the number of shipments. This figure is used in the transportation cost model.
- *The total selling units:* this number can be easily gathered from the Metro database or the supplier scorecard. This number is independent of the flowtype.
- *The promotional selling units:* to determine this number, the percentage of promotional sales must be gathered. This percentage can be easily gathered from the Metro database or the supplier scorecard. This number is independent of the flowtype. Next, this percentage is multiplied with the number of total selling units to determine the number of promotional selling units.
- *The average stock value:* Section 4.3.5 already stated that only the order quantity stock is included. This section also introduced a formula to determine the average order quantity stock level. The total sales are divided by two times the delivery frequency and a correction factor. This correction factor uses a shape parameter multiplied with a constant. This constant is presented in Appendix S. The shape parameter differs per supplier; the average value is 0.25. This is also the minimum value, because otherwise the inventory position will be too high. The average inventory level is multiplied with the value of a case pack. The average case pack value can be easily calculated by dividing the sales (in buying value) by the total case packs. This information can be easily gathered from the Metro database or the supplier scorecard, and is independent of the flowtype. The outcome of the model could be compared to the real data of the current flowtype. This is an important recommendation because Appendix T showed that the results of the model deviate from the actual inventory position.
- *The pallet locations:* Section 4.3.5 also gives a formula to determine the required number of pallet locations based on a model by Simchi-Levi et al (2005) on page 302. To determine the number of required pallet locations the average inventory position must be divided by the stacking and multiplied with the value 2. However, a minimum of pallet locations is introduced based on the number of stock keeping units, because each stock-keeping unit requires at least one pallet location. Section 4.3.5 indicates that this formula can be used for the situation of Metro.

Now, all the required data for the flowtype selection model can be determined based on some figures that are easily to gather. The "new" input parameters are summarized in Appendix AC. It is important that all input values are based on the same time period.

Next, the cost can be calculated for each supplier for the flowtypes direct store delivery and central warehouse delivery. The costs are estimated by multiplying the data from the input model with the productivity and resource figures. In this way the costs can be calculated for each sub process. Appendix AD presents an overview of the output values of the cost analysis.

5.2 The Results of the Pilot Suppliers

This section presents the results of the analysis described in the previous section for the pilot suppliers. First, the most relevant cost factors are calculated for the pilot suppliers and matched with the results of Section 4.1. Second, an indication of the preferable flowtype for each group of suppliers is given. Third, the results of the cost ratio formulas are compared with the actual cost ratios.

5.2.1 The Most Relevant Costs

The most relevant costs presented in Section 4.1 are now verified, based on the estimated costs of the pilot suppliers. The data of the pilot suppliers are gathered based on the method presented in Appendix Z. These data are multiplied with the resource costs and productivity figures presented in Section 5.1, which results in the data shown in Appendix AD. Next, the average of all pilot suppliers is calculated and this results in the cost division of Figure 5.6.

Figure 5.6 confirms that the selected cost factors determine more than 80% of the total costs. The only difference is that the transportation costs are slightly higher than the percentage calculated before. This difference is due to the assumption made in Section 4.1, that the transportation costs of the supplier are equal to those of the platform. In most cases the transportation costs for the supplier are higher, because of the smaller shipping load.

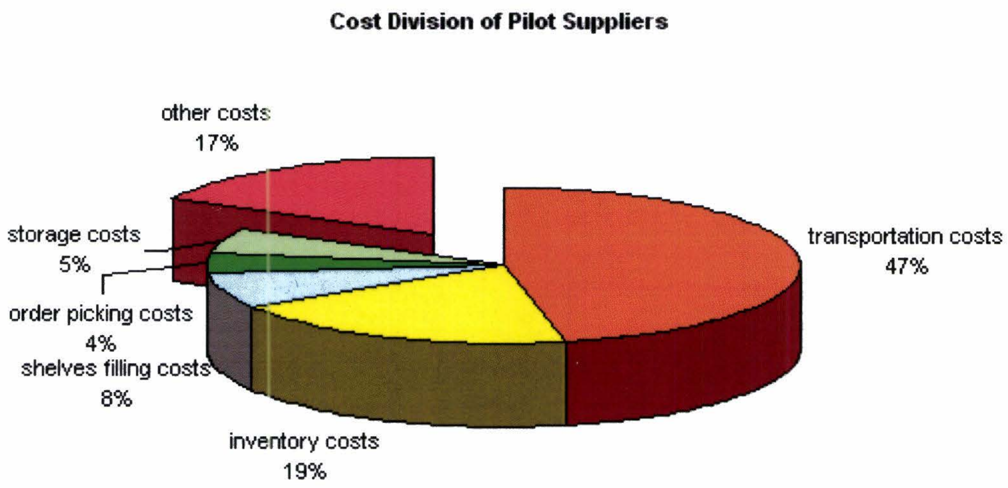

Figure 5.6: The Average Cost Division of the Pilot Suppliers

5.2.2 The Preferable Flowtype

This section presents an indication of the preferable flowtype for the pilot suppliers. This indication is based on the same data as the previous section. Figure 5.7 shows the average estimated costs per case pack for the pilot suppliers classified in the different groups. It also shows the division of the estimated costs over the different parties in the supply chain. The darker coloured, lower parts represent the costs of Metro C&C, and the lighter coloured, upper parts represent the costs of the supplier. The transportation from the supplier to either the platform or the store is assumed to be paid by the supplier.

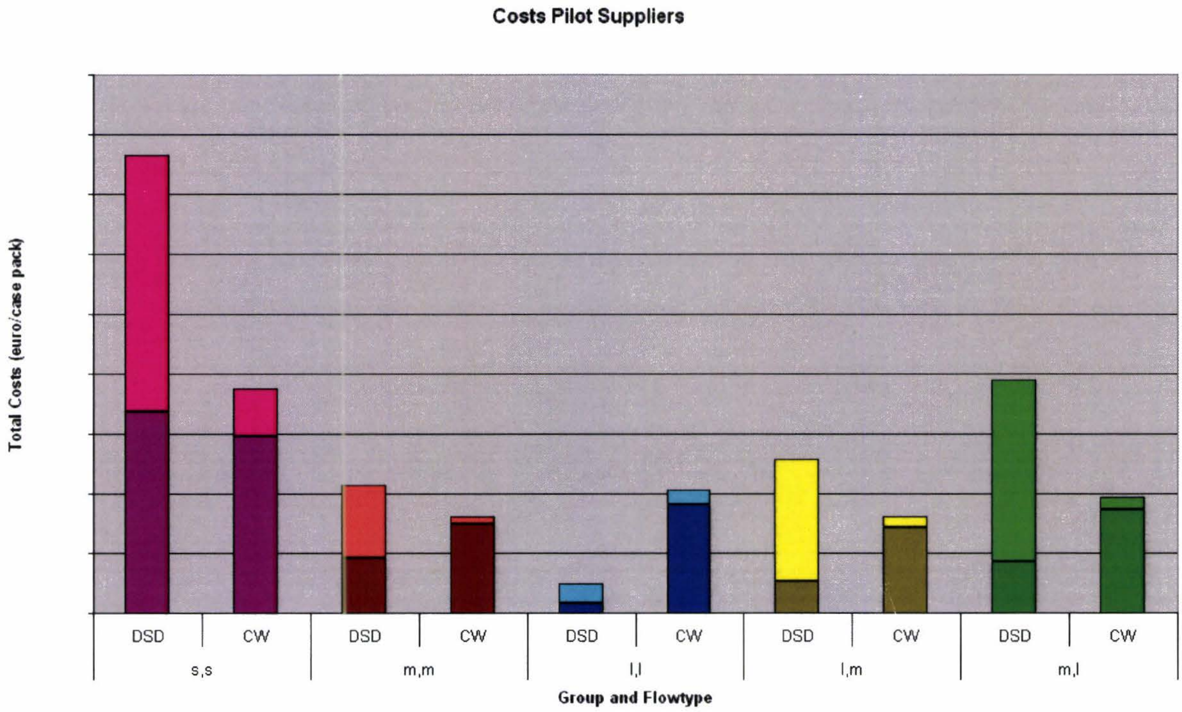

Figure 5.7: The Estimated Supply Chain Costs per Case Pack for the Pilot Suppliers

The figure shows that in most cases the most beneficial flowtype for the total supply chain is CW, but the most beneficial flowtype for Metro is DSD. The central warehouse flowtype will probably be beneficial for the suppliers with a small to middle total sales volume (the purple, orange and green group). For the suppliers with a relative large total sales volume (the yellow and orange group) the difference is not so obvious compared to the other groups, but the central warehouse seems to be the cheapest way to deliver the products. The figure shows that direct store delivery would probably be beneficial for suppliers with a large total sales volume and a large sales volume per article (the blue group). However, the figure also shows that the DSD flowtype is the most beneficial for Metro for most suppliers. This is because Metro has to pay for the additional costs of operating a warehouse. The only exception is the group of small suppliers, but these high costs for Metro where due to the high inventory value at the Metro stores.

Figure 5.8 clarifies why the costs for the supplier decrease and the costs for Metro increase, when the switch is made from DSD to CW. If a supplier delivers to the central warehouse, the transportation costs decrease. This effect is due to the consolidation of the freight, which increases the load ratio. For the smaller supplier this effect is more extreme, because their load ratio for direct delivery is very low. This conclusion is in line with the guideline of Section 4.3.3. Another benefit for the supplier for delivering to a central warehouse is that more goods can be picked on full pallets, which saves order-picking costs. So, switching from DSD to CW is beneficial for the supplier. However, the costs of Metro increase, because Metro has to pay for using the platform.

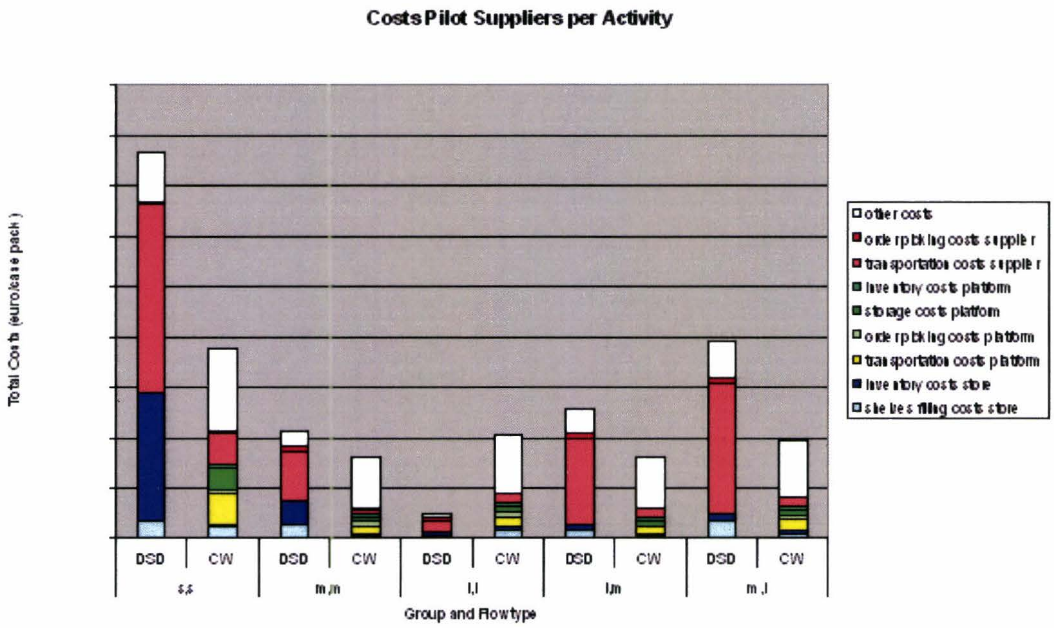

Figure 5.8: The Estimated Supply Chain Cost per Case Pack per Process for the Selected Suppliers

5.2.3 The Cost Ratios

The formulas of the cost ratios derived in Chapter 4 are compared to the cost ratios calculated by the flowtype selection model. Unfortunately, not all cost ratios can be compared. The handling costs consist of two cost ratios; so, these cannot be compared. Moreover, no formula for the total cost ratio could be derived. Therefore, only the transportation and inventory cost ratios are compared. The results are presented in Appendix AE.

The results show that the transportation costs ratio of the analytical model is lower than the cost ratio of the flowtype selection model. This difference can be explained by the fact that the assumption of full truckload from supplier to warehouse is relaxed in the flowtype selection model. Letting go this assumption will increase the transportation costs of the CW flowtype. Therefore, the cost ratio will also increase. There is no difference in the inventory costs ratio. So, this formula is good modeled in the flowtype selection model.

5.3 Comparing to the General Guidelines

This section compares the general guidelines derived in Section 4.3 with the outcomes of the flowtype selection model, using a linear regression model. The structure of this section follows the research methodology. First, the relevant input parameters of the flowtype selection model are selected. Second, the parameter values for each variable are determined, based on data of Metro. Third, the results of the flowtype selection model are calculated for all different scenarios. Fourth, the calculated results are compared with the general guidelines. Finally, the most important input parameters can be determined.

5.3.1 The Relevant Input Parameters

The parameter selection is based on the input variables of the analytical model. The input parameters can be divided into three groups:

1. Parameters that depend on the supplier and can be influenced by Metro:

- The delivery frequency form the supplier to the store
- The delivery frequency form the supplier to the warehouse
- The delivery frequency form the warehouse to the store

2. Parameters that depend on the supplier and cannot be influenced by Metro:
   - The sales volume measured in number of case packs
   - The assortment width measured in number of SKU's
   - The skewedness of the sales expressed in the shape parameter value
   - The value of the goods measured in euro per case pack
   - The number of selling units per case pack
   - The number of case packs per pallet
   - The location of the supplier, expressed in a ratio of the supplier shipment costs divided by the costs of a shipment within the Netherlands
   - The labour costs of the supplier, expressed in a ratio of the supplier labour costs divided by the labour costs of the warehouse.

3. Parameters that cannot be influenced by neither the supplier nor Metro:
   - The number of stores
   - The inventory interest costs
   - The transportation capacity of a truck
   - The routing efficiency of the transportation company

The parameters of group 3 are excluded from the research, because their values cannot be influenced. So, eleven parameters are selected for further research.

5.3.2 The Parameter Values

For each parameter three values will be determined based on data of Metro. Each parameter has a low, medium, and high value. The low value is equal to the first quartile, the medium to the median, and the high value to the third quartile. Most of these figures are based on data of all dry food suppliers of Metro. The results are presented in Table 5.2.

	Parameter	Unit	Parameter Value		
			Low	Medium	High
1	Frequency manufacturer to stores	shipments/year			
2	Frequency from manufacturer to warehouse	shipments/year			
3	Frequency warehouse to store	shipments/year			
4	Volume	case packs/year			
5	Assortment Width	number of SKU's			
6	Skewedness of the sales	shape value			
7	Value	euro/case pack			
8	Case Pack Size	SU/case pack			
9	Pallet Stacking	case pack/pallet			
10	Location	ratio			
11	Labour Costs	ratio			

Table 5.2: The Parameter Values

5.3.3 The Results of the Flowtype Selection Model

This section presents the result of the flowtype selection model. The different cost ratios defined in Chapter 4 are calculated for all $3^{11} = 177147$ scenarios. A regression analysis is performed on the gathered data. This is possible because the input parameters are not correlated. This is logical, because each input parameter has a low, medium, and high value independent of the other parameter values. The results of the linear regression analysis are shown in Appendix AF. Each cost ratio is individually discussed. The first table indicates which input parameters are significant. Next, the regression model based on the relevant parameters is presented. Finally, the second table gives the analysis of variance and the R-squared.

5.3.4 The Flowtype Selection Model vs. General Guidelines

The results of the flowtype selection model are compared to the general guidelines presented in Chapter 4. The different cost ratios are individually discussed.

The Transportation Costs Ratio

The significantly relevant parameters and their effect on the cost ratio are:

- $F_{ms} \Uparrow$ $\Rightarrow$ CW
- $F_{mw} \Uparrow$ $\Rightarrow$ DSD
- Volume $\Uparrow$ $\Rightarrow$ DSD
- Stacking $\Uparrow$ $\Rightarrow$ CW
- Distance $\Uparrow$ $\Rightarrow$ CW

These outcomes are consistent with the general guidelines of Section 4.3.3, the only difference is that F_{mw} also influences the transportation cost ratio in the flowtype selection model. This is because the assumption of full trucks from the supplier to the warehouse is relaxed.

The Handling Costs Ratio

The significantly relevant parameters and their effect on the cost ratio are:

- Case Pack Size $\Uparrow$ $\Rightarrow$ CW
- Stacking $\Uparrow$ $\Rightarrow$ CW
- Labour Costs Supplier $\Uparrow$ $\Rightarrow$ CW

These outcomes are consistent with the formulas for the unit handling costs derived in the previous chapter. The case pack size does have an influence on the costs ratio, because it ads the same costs to CW as to DSD, so it levels the cost ratio. Therefore, the relative difference decreases if the case pack size increases. This is beneficial for the CW flowtype because this flowtype has the highest handling costs in most cases. However, the effect on the line handling costs is not taken into account. This issue was already discussed at the end of Section 5.1.3.

The Inventory Costs Ratio

The significantly relevant parameters and their effect on the cost ratio are:

- $F_{ms} \Uparrow$ $\Rightarrow$ DSD
- $F_{mw} \Uparrow$ $\Rightarrow$ CW
- $F_{ws} \Uparrow$ $\Rightarrow$ CW

These outcomes are consistent with the general guidelines of Section 4.3.5.

The Total Costs Ratio

All the input parameters have a significant influence on the total cost ratio, the nature of their influence is individually discussed:

- F_{ms} ⇑ ⇒ CW
  This input parameter influences the transportation and inventory costs. The influence on the transportation costs is decisive, because if the frequency increases the central warehouse flowtype becomes more beneficial.
- F_{mw} ⇑ ⇒ CW
  This input parameter also influences the transportation and inventory costs. Now, the influence on the inventory costs is decisive. This is probably due to the fact that on the average the shipment load from the supplier to the warehouse is higher than from the supplier directly to the store. So, a change in frequency and, therefore, in shipment load has less influence on transportation costs. (See Figure 4.2.)
- F_{ws} ⇑ ⇒ CW
  This effect is due to the inventory costs.
- Volume ⇑ ⇒ DSD
  This effect is due to the transportation costs.
- Assortment Width ⇑ ⇒ DSD
  This is effect is due to the additional storage cost of a supplier with a high assortment.
- Shape parameter ⇑ ⇒ CW
  This parameter influences the inventory costs. A higher value for the shape parameter results in lower inventory costs (Equation 4.14). This is more beneficial for the CW flowtype, because this flowtype has a higher total inventory position.
- Value ⇑ ⇒ DSD
  In most cases the DSD flowtype has less inventory. So, a higher product value is more beneficial for direct store delivery.
- Case Pack Size ⇑ ⇒ DSD
  The case pack size does have an influence on the total costs ratio, because it ads the same costs to CW as to DSD, so it levels the cost ratio. Therefore, the relative difference decreases if the case pack size increases. This is beneficial for the DSD flowtype because this flowtype has the highest total costs in most cases.
- Stacking ⇑ ⇒ CW
  This effect is due to the transportation costs.
- Distance ⇑ ⇒ CW
  This effect is due to the transportation costs.
- Labour Costs Supplier ⇑ ⇒ CW
  This effect is due to the handling costs.

The general guideline derived from the literature and the analytical model is that the additional handling, and inventory costs of a platform should be earned back by the transportation volume to make the central warehouse flowtype beneficial. The flowtype selection model confirms this statement. The handling costs ratio is about 1, and the inventory costs ratio is considerably higher than 1 in most cases. So, these additional costs must be earned back by freight consolidation and lower transportation costs.

5.3.5 The Most Important Input Parameters

The previous section already indicated that all the parameters have a significant influence on the flowtype selection. However, some parameters have more influence than other. A forward selection is executed to determine the most relevant input parameters. The result of the forward selection is shown in Appendix AG. The forward selection shows the following relevance of the input parameters starting with the most relevant parameter.

1. Distance
2. Volume

3. Value
4. F_{mw}
5. F_{ms}
6. Stacking
7. Skewedness
8. F_{ws}
9. Assortment Width
10. Labour Costs Supplier
11. Case Pack Size

Comparing these results with the current situation described in Section 3.3 leads to the following conclusion:

- The location is the most important parameter. So, this clarifies why most of the international suppliers of Metro deliver through a central warehouse.
- The volume is the second most important parameter, which is in line with the conclusion presented in Section 3.3.6.
- The third most important parameter is the value of a case pack. So, unlike the current situation of Metro, the value should also influence the flowtype choice.
- The influence of the assortment width seems to be not so high. So, the reason why suppliers with a larger assortment prefer to deliver directly to the store probably is the higher sales volume, which is related to the larger assortment width.

5.4 All Non-Perishable Good Suppliers

This section presents an indication of the most preferable flowtype for all non-perishable good suppliers. Some parameters can be easily determined for all non-perishable good suppliers: the volume, value, assortment width and case pack size. The suppliers are assumed to be located in the Netherlands, except for the international wine and liquor suppliers. The other values are the same for every supplier, and based on the average value. These values are presented in the table below.

Parameter	Unit	Parameter Value
Frequency manufacturer to stores	shipments/year	52
Frequency from manufacturer to warehouse	shipments/year	26
Frequency warehouse to store	shipments/year	208
Stacking	case packs/pallet	60
Labour Costs	ratio	1

Table 5.3: The Parameter Values

Based on these data the most preferable flowtype for all non-perishable good suppliers are calculated. These results also show that location has the most influence on the flowtype choice. Most of the suppliers from outside the Benelux should deliver over a central warehouse. Some suppliers from outside the Benelux with a very large sales volume should deliver directly to the stores. So, the sales volume also influences the flowtype choice. The influence of the product value is limited. The influence of the three most important inputs is shown in Figure 5.9.

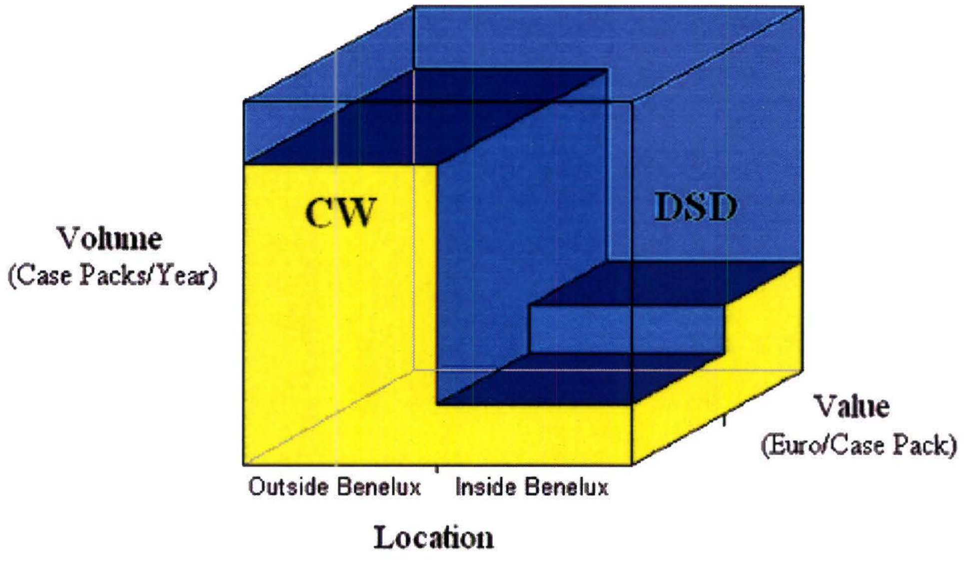

Figure 5.9 The Influence of the Three Most Important Input Parameters

The preferable flowtype of all dry good suppliers is compared to the current flowtypes. An overview is presented in Figure 5.10. The figure shows that most suppliers follow with their most preferable flowtype. Only four per cent of the suppliers should switch from central warehouse to direct store delivery. These are the suppliers that have a relative high sales volume. However, removing these large suppliers out of the warehouse will considerably lower the available consolidation volume. Therefore, it is better to:

-> First focus on the group of supplier that should switch from direct store delivery to central warehouse. This list of suppliers and their current and preferable flowtype is handed over to Metro.

-> Use the flowtype selection model to calculate the compensation that the supplier has to pay, to switch from direct store delivery to central warehouse delivery.

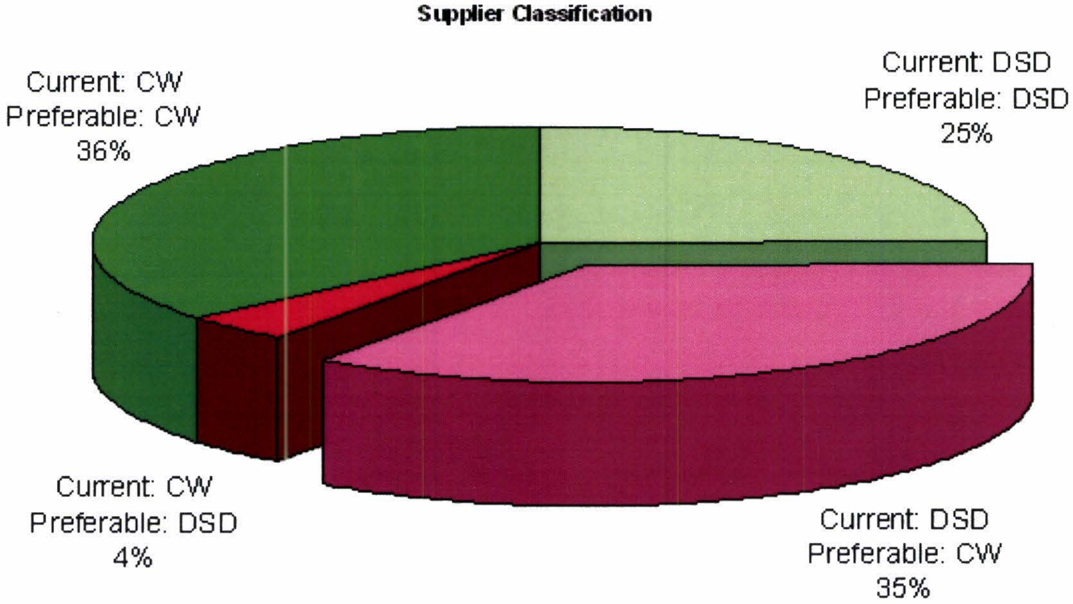

Figure 5.10: The Current and Most Preferable Flowtypes

Based on this analysis an estimation of the possible benefits can be made. This business case is presented in Appendix AH. The rough approximation shows that implementing this model could lead to **cost savings of over four million euro** in the total supply chain. These benefits must be divided over the different participants in the supply chain, the supplier and Metro.

62.7% of these savings can be made in the group that should change from direct store delivery to central warehouse delivery. These are mostly suppliers within the Benelux with a relative small sales volume. These cost savings are mostly due to the freight consolidation benefits for the supplier. So, Metro should negotiate with the supplier over the compensation.

The suppliers that should switch from CW to DSD are responsible for the remaining 37.3% of the benefits. These are mostly suppliers with a relative high sales volume, for which the freight consolidation benefit is lower than the additional costs of operating the platform. In this case, Metro benefits the most of the flowtype switch.

6. The Implementation

This chapter presents the last phase of the project, the implementation of the flowtype selection model. The flowtype selection model presented in this report should be embedded in the organisation. The selection model will be used by the supply chain department, and especially by the supply chain specialists. The model will be used for selecting and evaluating the flowtypes of a supplier. The manual for the flowtype selection model is presented in Appendix AI.

The model is designed for the non-perishable goods; so, the supply chain specialist for these goods will use the model the most. This person is familiar with the model, because he also gave guidance to this project. This person is also appointed for the maintenance of the model. The other supply chain specialists are also informed, since the model could also be used for other suppliers. The model is explained by making some example calculations, and discussing the manual.

7. Conclusion and Recommendations

This chapter presents the most important results and gives recommendations for the employees of Metro Cash and Carry.

7.1 General Guidelines

The analytical model provides general guidelines. One shortcoming of the analytical model is the not so accurate estimation of the inventory position. The most important general insights provided in this report are that direct store delivery becomes more beneficial, when:

- *the volume increases:* This is due to the change in transportation and storage space costs.
- *the delivery frequency from the manufacturer to the store is allowed to be significantly lower than the delivery frequency from the central warehouse to the store:* This is due to transportation costs and the line handling costs.
- *the labour costs of the supplier are low compared to the labour costs at the platform used by Metro:* This is due to both type of handling costs, line and unit costs.
- *the number of stores decreases:* This effect is due to the line handling costs.

These guidelines show that direct store delivery is more beneficial to Metro than for a supermarket chain, because of the relative larger sales volume, lower delivery frequency, and smaller number of stores.

The models also show that in most cases the handling costs are higher for the central warehouse than for direct store delivery. Moreover, the CW flowtype will probably have more inventory carrying costs, and definitely more storage space costs. So, the additional handling and inventory costs must be earned back by the savings in the transportation costs. So:

If no savings can be made in the transportation costs a supplier should always deliver directly.

7.2 Guidelines Specific for Metro Cash and Carry

The flowtype selection model aligns with these general guidelines. Moreover, this model provided some more insights that are specific for the situation of Metro Cash and Carry:

- The most important supply chain costs factors are:
  - *the transportation costs:* including the transportation from the supplier to the store or the warehouse, and the transportation from the warehouse to the store.
  - *the handling costs:* including the order picking costs, both for the supplier and in the warehouse, and the costs of filling the shelves in the store.
  - *the inventory costs:* including the interest and the storage space costs at the warehouse, and the interest costs at the store.
- In most cases the most beneficial flowtype for the total supply chain is CW, but the most beneficial flowtype for Metro is DSD. If a supplier delivers to the central warehouse, the transportation and order picking costs decrease due to the consolidation benefits. However, the costs of Metro increase, because Metro has to compensate for using the platform.
- All the input parameters have a significant influence on the total cost ratio. The nature of the three most important input parameters is:
  1. Distance ⇑ ⇒ CW
  2. Volume ⇑ ⇒ DSD

3. Value ⇑ ⇒ DSD

- An overview of the suppliers and their current and preferable flowtype is presented. The advice is to first focus on the group of supplier that should switch from direct store delivery to central warehouse. These are mostly suppliers with a small sales volume, which can benefit the most from the freight consolidation benefits.
- The flowtype selection model can be used to determine the compensation that need to be paid by suppliers that switch from direct store delivery to central warehouse delivery.
- A rough approximation shows that implementing this model could lead to cost savings of over **four million euro** in the total supply chain. These benefits must be divided over the different participants in the supply chain, the supplier and Metro.

7.3 Points of Interest

In addition some points are presented, which are noticed during the project, but were out of the project scope:

- The head office of Metro Cash and Carry uses the demand of the stores to the warehouse, to manage the inventory position of the central warehouse. However, they could better use the point of sale data, which is also available. This will reduce the bullwhip effect.
- Metro Cash and Carry uses two central warehouses for the non-perishable goods. This reduces the available freight for consolidation. It might be beneficial to combine both warehouses in one. Moreover, all the platforms might be combined into one composite platform, just like Albert Heijn. (See Appendix K)
- The location of the central warehouse at Moerdijk might not be the most beneficial location. Especially, the distance to Groningen and Leeuwarden is quite large. Another study could determine the optimal warehouse location.
- The picking process of the central warehouse at Zeewolde is not automated. This could lead to lower productivity figures and more faults in the picking process.
- The labour costs at the stores are relative high compared to other retail chains. This is because the employees are relatively old. Hiring younger employees can reduce the costs in the stores.

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