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MASTER

Identifying the best vehicle utilization improvement plan for Procter & Gamble Benelux and the Benelux customers

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Identifying the best vehicle utilization improvement plan for Procter & Gamble Benelux and the Benelux customers

by

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in Operations Management and Logistics**

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I Abstract

Sustainability has become essential and transportation costs increased in the last couple of years. These two topics were the focus of this master thesis; the objective was "*identify the best vehicle fill improvement plan for Procter & Gamble Benelux and for the customers located in the Benelux*". Several vehicle fill improvement plans have been identified based on academic research and practices from industry. The applicability of each plan was discussed and the feasible plans were assessed in terms of sustainability, customer costs and supplier costs. Models for the different relevant (cost) components were developed and to assess the reliability of the conclusions, a sensitivity analysis was performed. Structurally changing the physical distribution by means of one of these improvement plans can result in a structural CO_2-emissions reduction and the transport movements can be reduced by 20%.

II Management summary

Improving sustainability and reduction of transportation becomes more important every day. The efficient use of vehicles on the road is one of the key challenges in reducing CO_2 emissions. Trucks on the road are on average only filled for 53% and the empty trucks are even not taken into account yet (McKinnon, 2010a). Substantial CO_2-savings can be realized when trucks would be better utilized.

Procter & Gamble, an $ 84 billion company in the fast moving consumer goods industry, is working on the reduction of transportation since 2008. Several projects have been initiated and improvement plans have been implemented. However, structural changes were absent until now and the question arose in the Benelux organization of Procter & Gamble what the best plan would be to reduce transport. The overall objective of this project is therefore:

"Identify the best vehicle fill improvement plan for Procter & Gamble Benelux and for the customers located in the Benelux, with a strong focus on double stacking"

Based on academic literature, research already done by Procter & Gamble, practices from (non) competitors and industry, feasible vehicle fill improvement plans for the Benelux were identified. For each of the plans, the costs and benefits both for P&G and the customers in the Benelux were determined and compared to the current situation.

Next to the identification of the best vehicle fill improvement plan, an implementation strategy containing the key concept selling arguments for double stacking was developed. This was done irrespective of the earlier results.

In the remainder of this management summary, the main results and conclusions are summarized.

Methodology

Based on the literature study and research proposal performed as a preparation on this master thesis (Slob, 2013a, 2013b), two scenarios were identified as feasible vehicle fill improvement plans: 1) double stacking and 2) on-top loading. To be able to make a comparison with the current situation, a scenario was developed for the current situation as well. The key difference between the three scenarios is how products are put on pallets, loaded in trucks and stored in the DCs. The layout in the truck is graphically shown in Figure 1.

Current situation   Double stacking   On-top loading

Figure 1: The three different scenarios analyzed in this project

Current situation (CS)

In the current situation, it is agreed by suppliers and retailers that pallets have a maximum height of 180-185 cm (current industry standard). The height of a truck which is available for products is approximately 240 cm. As can be seen in Figure 1, a lot of air is left to fill with products.

Double stacking (DS)

Double stacking is a concept where the pallet height is reduced in such a way that two pallets can always be put on top of each other. Ideally, the height of a pallet would be 1,20m, set as a standard by the industry. With double stacking, also load consolidation is investigated. The assumption is that all customers will be supplied from one full service distribution center (FSDC) which consolidates all demand.

On-top loading (OTL)

With on-top loading, the customer order is put as efficiently as possible in a truck by putting pallets on top or below each other. Software is used to maximize the truck utilization then. In this project a specific case of on-top loading is investigated. It can be seen in Figure 1 that at every full pallet, layers are put on top.

Scope of the analysis

It should be taken into account that five big customers were selected for this analysis and a limited part of the supply chain is taken into account (shown in Figure 2).
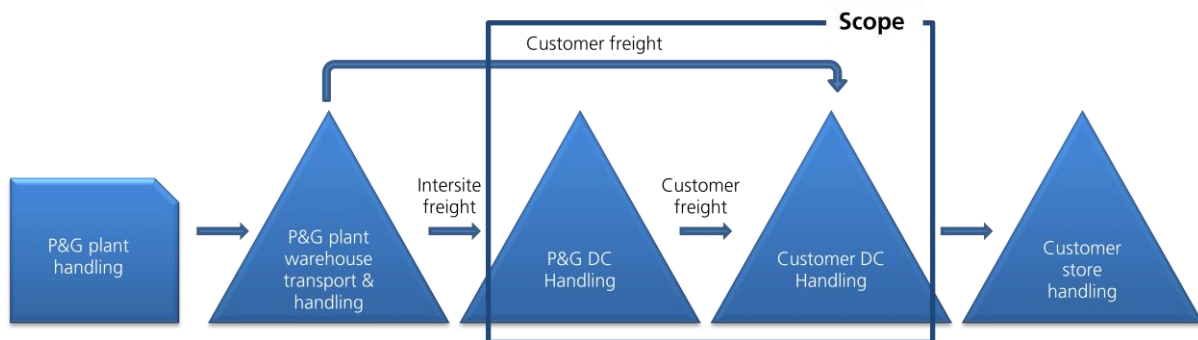

Figure 2: Total supply chain and selection of scope

Results

Every scenario is assessed on the reduction of transport, the customers' costs, P&G's costs, the volume utilization of a truck, and the delivery frequency of products at the customers.

With respect to double stacking, the volume utilization of the trucks would increase with approximately 20% in case of double stacking; that is also the possible reduction in the amount of shipments. Furthermore, since the products are all consolidated and supplied from the FSDC, the delivery frequency ex FSDC increases in general. This implies that the customer service will improve, because P&G will supply the customer more frequently from the FSDC.

The financial results show a possible cost decrease of ▉ per year for the customers and P&G together. An overview of the financial results is shown in Table 1. When looking at the results in more detail, it can be seen that the customers' costs increase while P&G's costs sharply decrease. In the sensitivity analysis, it became clear that a customer cost increase can easily switch to a cost decrease. This means that the results are very sensitive to the parameter values, especially the percentage of pallets shipped as twins to the customer. By means of effort of both parties, a cost saving might be realized for some of the customers as well.

Table 1: Financial results in costs per year for double stacking (DS) and the current situation (CS)

x € 1000	DS customers and P&G	CS customers and P&G	DS customers	CS customers	DS P&G	CS P&G
Total supply chain costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Administrative costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cycle stock costs (customer)	[redacted]	[redacted]	[redacted]	[redacted]		
Handling costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Transportation costs	[redacted]	[redacted]			[redacted]	[redacted]

The financial results of on-top loading led to virtually no change in costs. The small cost saving gained by the customers is approximately the same as the small cost increase for P&G. On the long-term this scenario will not result in any structural savings. The volume utilization of the trucks would only increase with [redacted]; this is due to the small amount of products not ordered on full pallets but on layers. Full pallets of one product could be restacked and put on top of other full pallets; however, the increase in handling costs would never outweigh the decrease in transportation costs. Furthermore, with on-top loading the delivery frequency would slightly go down because there are on average more products in a truck, which will slightly downturn customer service.

During the project, it was requested by Procter & Gamble to broaden the scope of the project and take also intersite freight and all Benelux customers into account for double stacking, in order to get an overview of the complete picture for Procter & Gamble. Rough estimates have been made and it appears that P&G Benelux will save about [redacted] on its total costs when implementing double stacking. The relative impact of the savings for the project in scope is much bigger than for the savings for total P&G Benelux.

It should be noted that possible investments required to enable scenarios are not taken into account in the yearly costs. Furthermore, double stacking will result in a shift of money because trade terms will change. P&G will most likely change their pricing scheme as a function of the volume shipped. Net, this would not change the final outcome, but P&G will need to take into account that there will be a shift of money.

Conclusions

It can be concluded that double stacking is the best vehicle fill improvement plan for P&G Benelux and the customers in the Benelux. A structural cost saving of [redacted] can be realized and transportation and CO_2-emissions can be reduced. The saving in the number of transport movements can be 20%. However, it should be carefully determined for each customer how the specific situation will change. For some of the customers, a cost decrease can be achievable while for other customers a cost increase seems unavoidable. To be able to implement double stacking, all customers will need to be convinced of the advantages and P&G should do that carefully.

III Preface

With this master thesis, I have completed the Master Operations Management and Logistics at the Eindhoven University of Technology, my internship at Procter & Gamble, and I say goodbye to my student life. I would like to use this part of my thesis to pay attention to the people who surrounded me and who were of great support to me.

First of all, I would like to thank Dorothee Honhon for her great support during the last two years. She has helped me already tremendously during the application process for studying at Berkeley, University of California, and the preparation for graduation. During the last seven months, she has challenged me to improve myself all the time and was always there when I needed her. Furthermore, I really appreciated the social chat with which we started most of the time we talked to each other. I believe you are a great and very knowledgeable woman and I wish you all the best with your new job in the USA. I would also like to thank Tom van Woensel for being my second supervisor and his guidance in the project.

Next, I would like to say thanks to Joep Aerts and Bram Keteleer, my supervisors at Procter & Gamble. Joep, as my first supervisor, you really challenged me during the project by asking critical questions and providing me with constructive feedback. Although your agenda was full with appointments, there was always a moment to constructively recap, review and discuss the next steps. Bram, as a second supervisor you were there at the critical moments, and always patiently answered my questions and supported me whenever necessary.

François Olsthoorn, as overall sponsor I would like to thank you for the many great opportunities you gave me in this project. Soon, it became clear to me that for Procter & Gamble this would be a big project with possibly a considerable impact. Although you were very busy, you have invested time in guiding me and you challenged me by giving me constructive feedback and opportunities which made me grow. I have learned so much in the last seven months and I am really looking forward to start with my first job at Procter & Gamble.

Next I would like to thank all my close friends who offered me a listening ear and with whom I could relax during the evenings and weekends, to reload energy for another new day or week ahead.

And of course, last but not least, I would not have been able to successfully finish my studies without the unconditional and tremendous support and love of my family and boyfriend. I truly believe that I am very fortunate with having people like you by my side, thank you very much!

Annella Slob
August 2013

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1. Introduction

This project is executed at the Supply Network Operations (SNO) department of Procter & Gamble (P&G) Benelux. It is investigated how goods can be transported more efficiently to the customer, in order to improve sustainability and realise a costs reduction for P&G and for the customer. Two cost models have been developed (a customer cost model and a P&G cost model) and the net results for two feasible improvement plans compared to the current situation are calculated. In the remainder of this chapter, a short introduction of the company and the topic are given. Furthermore, the report structure is described.

1.1 Company description

Procter & Gamble is founded in 1837 by William Procter and James Gamble, respectively candle maker and soap maker. P&G is in the so called fast moving consumer goods (FMCG) industry. In 2012, the company's sales were nearly $84 billion and the company's net earnings were more than $10 billion. With approximately 126,000 employees, P&G has built a brand portfolio including 25 billion-dollar brands, each of which generates $1 billion to more than $10 billion of sales per year. Some of the big brands of P&G are Pampers, Gillette, Tide, Ariel, Downy, Pantene, Head & Shoulders, Olay, Oral-B, Crest, Dawn, Fairy, and Always. The products of P&G are sold in more than 180 countries all over the world. (McDonald, 2012)

The company has five Market Development Organizations (MDOs), which indicate geographical distinction. The MDO relevant in this project is Western Europe (WE); the other MDOs are North America, Central & Eastern Europe/Middle East/Africa (CEEMEA), Latin America, and Asia (Japan, Greater China and ASEAN/Australia/India/Korea (AAIK)). Within WE, the focus is on customers located in Belgium, The Netherlands, and Luxembourg (BNL). (McDonald, 2012)

The company is also divided in two global business units (GBUs): Beauty & Grooming and Household Care. All brands and products produced belong to one of these two GBUs. (McDonald, 2012)

1.2 The improvement of vehicle utilization

In this project, the improvement of vehicle utilization is the central theme. The urgency for this theme is due to two reasons: the increase of oil prices and the rising urgency to improve sustainability. At P&G, already since 2007/2008 the Physical Distribution (PD) department is thinking about and working on the improvement of vehicle utilization. As shown in Figure 3, the oil prices sharply increased by that time. In the same period, P&G acquired Gillette and wanted to integrate the two supply chains to reduce transportation costs. Globally, the Vehicle Fill Program was launched in order to realize smooth supply chain integration. Now, as many initiatives have been investigated and several plans are implemented, a more specific approach is requested for the Benelux organization.
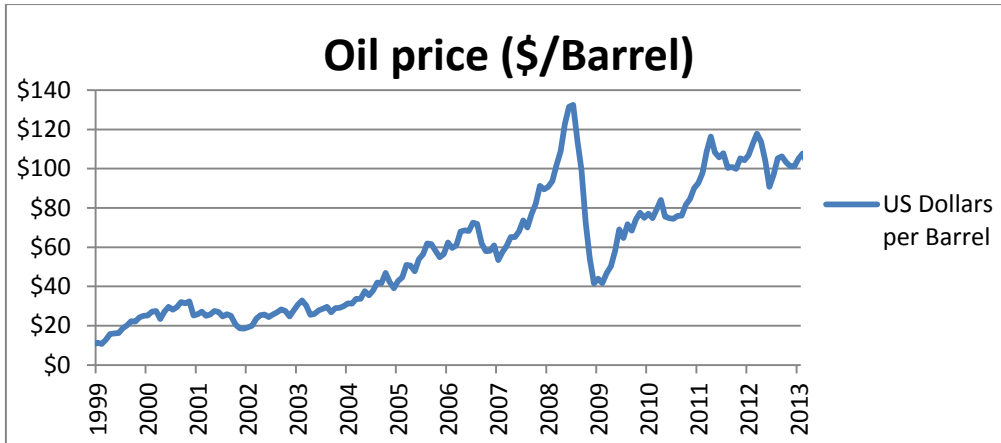
Figure 3: Oil price in US dollars per barrel 1998-2013

1.2.1 Vehicle utilization measures

P&G measures vehicle utilization in three ways: by measuring volume utilization, weight utilization and floor surface utilization. Volume and weight per shipment are measured both gross and net. In Figure 4, the different parts of a shipment are highlighted to indicate which is and is not taken into account. The cases with products (green part) represent the net volume or net weight, the cases (green part) and pallets and packaging material (blue parts) together represent the gross volume or gross weight. The gross volume and the air which is not used (red parts) define the total volume available. The maximum volume and weight per truck is defined per truck type.

P&G measures the net volume utilization of a truck by means of the Vehicle Fill Rate (VFR). The formula for this measure is $\forall i \; VFR = \frac{net \; volume \; of \; products \; in \; shipment \; i}{maximum \; volume \; of \; the \; truck \; of \; shipment \; i}$. The VFR is for P&G the key performance indicator with respect to volume utilization. The net volume is displayed by the green parts in Figure 4. It is assumed that in a 33/34 pallet truck, 2,40m of the truck height can be used for the gross volume; there should be some space left to move pallets in and out, up and down. In this report, I will often refer to the VFR as it is one of the key measures for P&G.
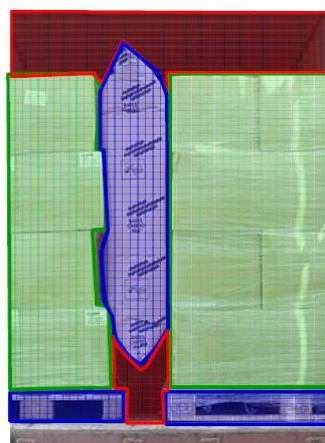
Figure 4: Visualization of net and gross weight and volume

The number of floor positions available depends on the truck type as well. There are two different truck types used in the Benelux: the 33/34 pallet truck and the 38 pallet truck. The characteristics per truck type are shown in Table 2 and are discussed in paragraph 1.2.3. P&G does not own a

vehicle fleet, but hires third parties to ship their products to the customers. A contract is drawn with each hauler and it is agreed for which amount of goods which costs are charged (e.g., cost per pallet and cost per full truck).

1.2.2 Pallet standards

Currently, every country within Europe has different standards with respect to pallet height. The current standard for pallet height is set to be 1,85m for Belgium and 1,80m for The Netherlands. When considering different pallet heights throughout Europe, it can be seen in Figure 5 that pallet height varies between approximately 1,65m (UK) and 2,00m (Spain and Portugal).

Figure 5: Current pallet height standard per country in Western Europe (WE) (Yiannakou, 2013)

1.2.3 Truck characteristics Benelux

In Table 2, the internal truck height per truck type is listed. It can be seen that with the current pallet height standards in the Benelux and internal truck heights, a truck is never fully utilized in terms of volume. The current standards for pallet height should enable a person to pick products from the pallet. From a customer perspective, by stacking products on a pallet as high as possible, the handling of restaging pallets within a warehouse can be minimized. Next to the internal height per truck type, also the number of floor positions, volume, weight limits and possible origin points per truck type are given. The weight limit of a 33/34-pallet truck is higher than the weight limit for a 38-pallet truck, because the weight of the 33/34-pallet truck itself is less and thus more weight is left to use for goods. The origin points per truck type show the P&G locations from which the goods are shipped to the Benelux customers.

Table 2: Truck characteristics per truck type

Truck type	Number of floor positions	Volume used by P&G to calculate VFR	Internal height	Weight limit	Origin points
33/34-pallet truck	33/34	80m³	2,6m	25.000 kg	Rumst, Euskirchen, Amiens
38-pallet truck	38	92m³	3,0m	22.500 kg	Rumst, Euskirchen

In the next paragraph, the structure of the report is discussed.

1.3 Report Structure

In this thesis, the regulative cycle of van Strien (1997) is followed, which is shown in Figure 6.
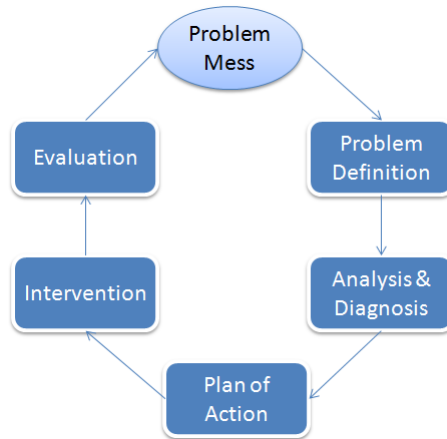
Figure 6: The regulative cycle (van Strien, 1997)

In this first chapter, a short introduction to P&G and the theme is given. In chapter 2, the Research Design is discussed (Problem Definition). The research objective, questions and scope are described in this chapter. In chapter 3, the current situation is analyzed, key characteristics of P&G and the customers are given and the Benelux market is shortly described. Furthermore, a short summary is given of the literature study which is performed as a preparation on this graduation and internship project. The data analyzed in chapter 3 are used as input for chapter 4, in which the research method is defined. The results of the research method and sensitivity analysis are discussed next in chapter 4 as well. Chapter 4 is structured per scenario, to get a clear overview. In chapter 5, an implementation plan is defined for one of the scenarios: double stacking. Chapter 3, 4 and 5 together represent the Analysis & Diagnosis phase. Last, in chapter 6, the final conclusions and recommendations are stated. The Intervention (actual implementation) and Evaluation are out of scope for this project.

2. Research Design

In this chapter, the research objective, questions and scope are described. These were earlier defined in the research proposal, which was written as preparation on this project. (Slob, 2013a)

2.1 Research objective

As discussed in paragraph 1.2, already in 2007/2008 the PD department has started thinking about how to reduce transportation costs. Now, several initiatives have been implemented and there are still a lot of projects where P&G is working on. For the Western European organization of P&G, it is clear which initiatives are the most promising; however, the end-to-end picture for the Benelux is not clear yet. As the Benelux is a specific, relatively small market with short supplier-customer distances and highly promotional demand, the question arose what would be the most promising initiave for the Benelux when P&G would like to improve vehicle utilization. Both P&G and the customer should be taken into account here, as P&G wants to create a win-win situation. Furthermore, not only the saving in transportation costs, but also the impact on other significant cost components should be taken into account.

The research already done for the Western Europe organization of P&G will be used as input for possible initiatives in the Benelux. However, it is also questioned whether there are any other initiatives known from academic research and (non)competitors which P&G has not taken into account.

Based on the situation described above, the problem statement becomes the following: "It is unknown what VFR improvement plan is the best to make sure that in the BNL MDO target levels will be achieved, in agreement with the customers"

2.2 Research questions

In order to solve the problem as defined in the previous paragraph, the overall objective of this thesis can be formulated as follows:

"Identify the best vehicle fill improvement plan for P&G Benelux and for the customers located in the Benelux, with a strong focus on double stacking"

The concept of double stacking will be discussed in more detail in the paragraph 'Introduction of different scenarios'. The main objective can be split up in different sub questions, which are listed below:

1. Based on academic literature, P&G research, practices from (non) competitors, and industry standards, what are <u>feasible</u> VFR improvement plans for P&G's MDO BNL?
2. What are the costs and <u>benefits</u> for the customers located in MDO BNL for each of the possible VFR improvement plans?
3. Based on the answers on sub questions 1 and 2, what is/are <u>the best</u> VFR improvement plan(s) for P&G's MDO BNL?
4. Irrespective of the results from sub question 3, what is a <u>feasible</u> double stacking <u>implementation strategy</u> for the customers located in the Benelux?

The final deliverable is this report in which the performed analysis is described, and answers on the questions as stated above are given. There is no tool to be produced; it will purely be an analysis, processing of the results, based on that an implementation strategy for double stacking in the Benelux is developed, and further recommendations are given.

In the sub questions, different concepts are used which might be unclear or can be interpreted in different ways. These words are underlined and will be described below.

The best: the best in this thesis is twofold: it has to be beneficial for both P&G and the customers located in MDO BNL. The challenge is to find VFR improvement plans which fulfill both requirements.

Feasible: not all improvements plans or implementation strategies will be feasible. Restrictions can be identified based on the schedule, investments, category specifications, and customer and trade lane level for example.

Benefits: benefits will mainly be identified on a cost savings level, but also sustainability can be a benefit. For P&G, another benefit which is playing a central role is the relative VFR improvement.

Implementation strategy: an implementation strategy will be developed specifically for double stacking in the Benelux. By means of the results of this project it will be stated how to convince the customer to implement double stacking. It should become a win-win situation, both for P&G and the customer.

2.3 Research scope

As the problem is defined, the scope of the project can be determined. The scope is summarized below; a graphical representation of the scope is shown in Figure 7.
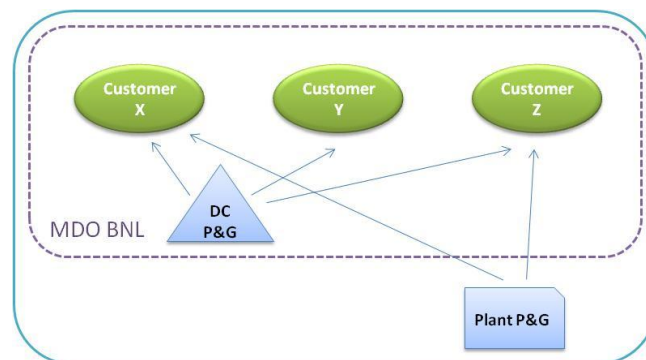
Figure 7: Geographical scope project

- The relevant MDO in this case is BNL; anything wider is out of scope. Answering questions will be specifically done for customers located in BNL; however, it should be noted that most of P&G's plants are located outside BNL and transportation from these plants to the customers will be taken into account. The main Distribution Center (DC) for BNL is located in Rumst, Belgium. There are two plants which supply customers: one in Amiens, France, and one in Euskirchen, Germany. To get an overview of the volume shipped from the DC and from the plants, data from January-March 2013 is analyzed. ▮▮ of the volume is shipped from Rumst (DC), ▮▮ of the volume is shipped from Amiens, and ▮▮ of the volume is shipped from Euskirchen. Another relatively small DC is located in Altfeld, Germany, but this DC is out of scope for the project.

- The focus is on outbound transportation, inbound transportation (between P&G sites) is out of scope. Outbound transportation can take place ex-plant or ex-DC.
- All customers in BNL will be taken into account. However, there will be a focus on the big customers. The customers selected for this project are Customer A, Customer B, Customer C, Customer D, and Customer E. More details about these customers are discussed in the next chapter.
- All product categories supplied in the BNL are taken into account.
- Although more options are discussed, the focus of this project with regards to possible VFR improvement plans will be on double stacking and closely related topics, like on-top loading for example.

2.4 Summary Research Design

In this project, the best vehicle fill improvement plan for P&G's MDO Benelux will be identified. The plan should create a win-win situation, both for P&G and the customer. Information from academic research, practices from (non) competitors and industry will be used to identify feasible plans and next, the costs and benefits per plan are determined.

3. Analysis current situation

The current situation is described based on the performed data analysis. Procter & Gamble has several databases available which enable downloading reports. The main databases used for this data analysis are T-View (Transportation View) and OSB (Order, Shipping, Billing). In the next paragraphs, general and more detailed information with respect to transportation and vehicle utilization is given. Last, the information is shortly summarized.

For the data analysis, data of the first three months (January, February and March: JFM) of 2013 is used. The product category Snacks is excluded, since Pringles is sold to Kellogg's and since March 2013 no products in the category Snacks are sold by P&G anymore. For the future, Pringles will not be relevant anymore. The customers taken into account are Customer A, Customer B, Customer C, Customer D and Customer E. These five customers are the top 5 customers and cover more than 53% of the net volume shipped to Benelux customers. The customers are selected in consultation with P&G. In Table 3, per customer (location) the percentage of the total net volume in the Benelux is given.

Table 3: Percentage net volume per customer (location) vs. total net volume customer BNL

In the next paragraph, the major customers are discussed in more detail. Next, P&G's Benelux MDO, the supplying locations and the current vehicle utilization are discussed. Then, it is discussed how P&G and the customers are serving the Benelux market. Last, a summary is given of the literature study which is performed as a preparation on this master thesis. (Slob, 2013b)

3.1 Major customers in the Benelux

As discussed before, the key customers selected for this project are Customer A, Customer B, Customer C, Customer D, and Customer E. Each customer has its own characteristics; the customers together represent the biggest customers in the Benelux. The ratio of ex-plant shipments versus ex-DC shipments is different from the total Benelux (described in paragraph 2.3) because more products are shipped ex-plant. For the five key customers in scope of this project, ▬ of the

products are shipped ex-DC, ██ of the products are shipped ex-Euskirchen, and ██ of the products are shipped ex-Amiens.

The customers are shortly described next and compared based on several characteristics. ██
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Table 4: Overview of characteristics per customer

3.2 P&G Benelux

The part of P&G's organization taken into account in this project consists of three different shipping points from which the customers are supplied. These are the plants in Amiens (France) and Euskirchen (Germany) and the DC in Rumst (Belgium). Each combination of a shipping point and customer location as destination indicates a trade lane. The relevant trade lanes are listed in Appendix I (confidential).

The plant in Euskirchen produces mainly Pampers and is known for its relatively high volume and low weight. The plant in Amiens produces fabric care and home care products; these products have a relatively low volume and high weight.

As discussed in the introduction, products can be shipped in two different types of trucks; their characteristics are shown in Table 2. All trucks are owned by third parties; P&G does not have a truck fleet but hires transportation companies to ship the goods to the customers.

Shipments are sometimes combined for one customer but for multiple customer locations, these are called multi-drop shipments. The shipments are combined to enable creating a full truckload (FTL) instead of a smaller shipment, which results in lower transport costs for P&G and a rebate for the customer. Furthermore, when the customer receives as many FTLs as possible, administrative costs can be reduced, less docking stations will be occupied, etcetera. A full truckload is defined by P&G as a shipment with 32 or more full pallets.

For some customer locations, the demand is too low to create every day a full truckload, but by combining two orders into a multi-drop shipment, a FTL can still be realized. A multi-drop shipment combines orders in the same truck and has two or more delivery addresses. The multi-drop lanes relevant in this project are:

- Rumst > Customer A Location C > Customer A Location E
- Rumst > Customer A Location B > Customer A Location D
- Rumst > Customer C Location B > Customer C Location A
- Rumst > Customer B Location A > Customer B Location B
- Rumst > Customer B Location A > Customer B Location C
- Amiens > Customer B Location C > Customer B Location B
- Euskirchen > Customer B Location C > Customer B Location B

As stated in the introduction, P&G measures vehicle utilization by means of the vehicle fill rate (VFR). Data from T-view is used to calculate the VFR. In T-view, the net volume of each unique shipment can be found and connected to the origin and destination point, or multiple destination points. Several filters are applied by P&G to the data in order to find the average VFR:

- All shipments with < 33 pallets are removed from the data; only FTLs are included. This is since the costs of a less than truckload (LTL) shipment are often based on the number of pallets, so no full truck is paid.
- Shipments of two haulers (████████████████████████████████) are excluded as they only ship LTL.
- Cross dock shipments are removed from the data, as the shipment's costs are based on a tariff per pallet, not per full truck.
- All trucks (also the 38-pallet truck) are assumed to have a maximum volume of 80m³. This is because the costs for a 38-pallet truck were approximately the same as the costs of a 33/34 pallet truck. From a costs perspective, this approach could stimulate the use of 38-pallet trucks and reduce costs.

The result in terms of the amount of data left and the VFR based on JFM 2013 are shown in Table 5. It can be seen that for the customers in scope, the VFR for JFM 2013 according to P&G is 56,3%. This indicates that on average only 56,3% of the volume available in a truck is occupied by products. The maximum VFR is not 100% but approximately 80% because of weight limitations, inefficient product height and volume used for the wooden pallets and packaging material.

What to change:	Amount of data left	VFR
-	2379 rows	49,6%
Remove all shipments <33 pallets	1747 rows (73%)	56,2%
Exclude ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮	1730 rows (73%)	56,2%
Remove cross dock shipments	1718 rows (72%)	56,3%

During the data analysis I have realized P&G did not truly calculate the VFR from a costs perspective. There are more restrictions on the costs of a FTL. The 38-pallet truck is per pallet spot slightly cheaper than the 33/34-pallet truck; however the FTL costs are in general higher. Furthermore, there are some errors in the data, e.g., shipments where the truck type is not known. Therefore I have applied new filters, which are listed below and in Table 6. The results in terms of VFR are shown as well:

1) Some shipments are recorded double; these double lines are removed
2) Shipments for which the vehicle type is unknown are removed (maximum volume is unknown).
3) Shipments with a maximum volume of 240m³ are removed; this is a masterdata error as there are no trucks with 240m³ available.
4) Crossdock shipments are removed as the costs are based on the rate per pallet.
5) All shipments for which the LTL tariff is paid are removed (▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮)
6) As stated before, multi-drop shipments are created to optimize truck utilization. In the data file, multi-drop shipments are separated in two lines (one for each customer location). In order to find the VFR for one shipment, these lines should be combined.
7) Last, there are multi-drop shipments with customers which are out of scope. These shipments are removed. For example: a multi-drop shipment with destinations Customer E and ▮▮▮▮.

Table 6: New filters applied to find VFR based on costs

What to change:	Amount of data left	VFR (based on 80m³ (33/34-pallet) and 92m³ (38-pallet))	VFR 33/34 pallet truck (80m³)	VFR 38 pallet truck (92m³)	VFR (all 80m³)
-	2379 rows	47,0%	46,4%	48,3 %	49,6%
1	2138 rows (90%)	48,6%	47,8%	50,0%	51,3%
2	2128 rows (89%)	48,6%	47,7%	50,0%	51,3%
3	2122 rows (89%)	48,6%	47,8%	50,0%	51,3%
4	2101 rows (88%)	48,7%	48,0%	50,0%	51,5%
5	2026 rows (85%)	50,0%	49,8%	50,2%	52,8%
6	1873 rows (79%)	54,0%	53,9%	54,2%	54,5%
7	1847 rows (78%)	54,2%	54,1%	54,4%	54,6%

After applying all different filters, the VFR becomes 54,2%. This indicates that on average a little bit more than half of the truck is used for shipping products and significant improvements can be made.

When differentiating the two truck types, it can be seen that the 38 pallet truck is performing slightly better but no significant differences are found.

3.3 P&G and the customers in the Benelux market

P&G and the customers in the Benelux face a challenging market, mainly driven by the Benelux consumers. Benelux consumers often buy products when these products are in promotion and then again during a new promotion. Demand is highly volatile therefore. Customers try to attract consumers with high discounts and nice promotions and thereby stimulate demand.

A last topic to discuss therefore is the delivery frequency. Both for P&G and the customers it is important to realize a steady and reliable delivery frequency. Both parties will lose money in case of late deliveries, since the customer can go out of stock then. Furthermore, frequent deliveries are crucial in managing the inventory levels. As P&G is managing inventory levels at VMI customers, this is critical for both P&G and the customers. In extreme cases, one or two promotions can make or break a year, both for P&G and the customers.

The current delivery frequencies are analyzed and the results per customer location are shown in Table 7. The rows which are highlighted indicate multi-drop shipments; the colors indicate the combinations. The formula which is used to calculate the frequency is:

$$\forall j \; Average \; delivery \; frequency = \frac{total \; number \; of \; shipments \; to \; customer \; location \; j}{63},$$ where 63 is the

total number of shipping days in JFM 2013.

Table 7: Average delivery frequency per shipping day per trade lane

It is noticeable that 9 out of 13 customer locations have a delivery frequency of approximately once per day for shipments ex-DC (Rumst). From a service point of view, it is important to keep the delivery frequency at that level or higher. The delivery frequency can have a big impact on inventory and out-of-stock performance for example. Ex-plant shipments are not very frequent, except for the tradelanes Euskirchen-Customer E Location B and Euskirchen-Customer C Location B. Ex-plant shipments are often promotionally driven, as the Benelux demand is highly promotional. It can be

argued that the delivery frequency would decrease in case vehicle utilization would increase. It is important to keep in mind the interrelatedness of vehicle utilization and the delivery frequency when assessing possible vehicle fill improvement plans.

In the next section, the main findings from the literature study will be described.

3.4 Literature review and developments in industry

In the literature study (Slob, 2013b) performed as a preparation on this graduation project, I investigated what research is done to improve vehicle utilization. Both from practice and from the academic world, there are several recommendations made on how to improve vehicle utilization.

3.4.1 Recommendations

The key recommendations from both the academic world and from practice (IGD, 2012; ECR Europe, 2012) to improve vehicle utilization are listed next:

- Increase load consolidation, and for example mix heavy and light products (Banik & Rinehart, 2011; McKinnon, 2003)
- Packaging material should be removed as much as possible, but at the same time products should be strong enough to be stackable (Jordan, 2011)
- Increase the use of more layers in a truck, e.g., double deck or double stack (McKinnon, 2003)
- For a logistics service provider or company owning a vehicle fleet: start back loading (McKinnon, 2010b)
- Establish standards industry wide, on pallet size and height for example (A.T. Kearney & ECR Europe, 1997)
- Use available software to optimize vehicle utilization (Baumgartner, Leonardi, & Krusch, 2008; Morabito, Morales, & Widmer, 2000)

Vendor Managed Inventory (VMI) may also improve vehicle utilization, as the supplier has the freedom to create the orders and organize them in truckloads. (Disney, Potter, & Gardner, 2003) However, this is only relevant for those customers who have a considerable demand and need to be supplied with multiple trucks per day. Otherwise there will not be a benefit.

3.4.2 Measuring vehicle utilization

To be able to compare vehicle utilization, a clear measure should be identified. P&G uses the Vehicle Fill Rate (VFR) for this purpose. In literature, several measures have been identified to calculate vehicle utilization; these are mentioned in the literature study. (Slob, 2013b) It is proposed to measure vehicle utilization by combining (1) the volume utilization, and (2) the weight utilization. Volume and weight are the key constraints when using a truck. A distinction can be made between gross and net volume or weight, where net excludes all materials which are not part of the physical product (pallets, packaging material, et cetera). P&G has a strong focus on volume based metrics at the moment; weight utilization is on the background and the VFR is the key measure to compare vehicle utilization internally. Weight utilization is rarely a constraint now, but as volume utilization has to be improved, also weight utilization is expected to be improved and may become a load constraint.

3.5 Summary analysis current situation

In this chapter, the current situation is analyzed. Both the customers in scope and P&G's Benelux organization are discussed and current performance in terms of truck utilization is analyzed. It has to be taken into account that customer response on vehicle utilization improvements varies, and P&G has a big opportunity to reduce transportation and improve sustainability and the VFR. However, when improving truck utilization, the delivery frequency could decrease, which should be avoided from a service point of view. Last, in the literature study performed, six key recommendations were done to improve truck utilization. These will serve as input for the next chapter, where the feasible scenarios are identified, modeled and validated.

4. Research method, results and validation

After the literature study was performed, it was determined which of the recommendations could be applied at the Benelux organization of P&G. Below, it is shortly discussed why recommendations can or cannot be applied or are (not) relevant for P&G Benelux.

- *Increase load consolidation, and for example mix heavy and light products.* This is releveant for P&G Benelux. Currently, customers are supplied from three different locations. Consolidation could be increased by shipping only ex-DC and eliminate ex-plant shipments for example. It should be taken into account that physical changes will be required to enable consolidation, but in agreement with P&G it is decided this is a relevant and feasible recommendation for the scope of the project.

- *Packaging material should be removed as much as possible, but at the same time products should be strong enough to be stackable.* This is not relevant for P&G Benelux, as P&G Benelux does not own the production facilities. However, this is relevant for P&G Western Europe, because improvements in the production facilities will also affect P&G's Benelux vehicle utilization. P&G Western Europe is already working on the reduction of packaging materials and is trying to find a balance between product strength and minimizing waste (of space) due to excess packaging materials.

- *Increase the use of more layers in a truck, e.g., double deck or double stack.* This is relevant for P&G Benelux. For this project, two scenarios are developed which both take into account the increase of layers in a truck. The scenarios will be explained in the next paragraph: Introduction of different scenarios. There are more scenarios which could be discussed, for example using a double deck trailer. However, after a feasibility assessment and in agreement with P&G it was decided which scenarios were selected for further investigation.

- *For a logistics service provider or company owning a vehicle fleet: start back loading.* P&G Benelux does not own a vehicle fleet but all products are shipped to the customers by third parties. However, it is recommended to investigate opportunities to cooperate with other companies on a Western European level. Furthermore, it can be discussed with the third parties whether they see possible opportunities. By making smart decisions, shipments and routes of P&G and other companies may be combined and together, cost savings and improvements in sustainability may be realized.

- *Establish standards industry wide, on pallet size and height for example.* This is relevant for P&G Benelux, but also depends on many other parties: (non) competitors, customers and other retailers. P&G's Benelux influence is not enough to drive the change; however, it is recommended to discuss this topic with all involved parties and try to find a feasible standard. This could result in a significant efficiency improvement.

- *Use available software to optimize vehicle utilization.* P&G Benelux already uses software packages which enable optimization of vehicle utilization. It is recommended to regularly review these packages and investigate whether there are new packages available, but no more action is needed now as P&G does not want to prioritize this recommendation in the project.

To summarize, the two key recommendations which are feasible for investigation for P&G Benelux are:

1) *Increase load consolidation, and for example mix heavy and light products*
2) *Increase the use of more layers in a truck, e.g., double deck or double stack*

These recommendations will be central in the assessment of the different scenarios, which will be discussed next.

4.1 Introduction of different scenarios

Based on the two recommendations stated in the previous paragraph, different scenarios were identified to investigate. First, the current situation needs to be assessed in more detail to get a clear overview of the costs and benefits. The costs and benefits of the current situation, both for P&G and the customers, will be compared to the two different scenarios. Furthermore, several Key Performance Indicators will be assessed. These are listed in Appendix II – Key Performance Indicators (KPIs).

The feasible scenarios which have been identified based on the recommendations are:

1) **Double stacking.** Double stacking is a concept where the pallet height is reduced in such a way that two pallets can always be put on top of each other. Ideally, the height of a pallet would be 1,20m (B1-pallet), because the effective height of an average truck is 2,40m (real height: app. 2,65m). In Figure 8, graphically the difference is shown between the current situation and double stacking. With double stacking, also load consolidation is investigated. In agreement with P&G it was decided to assume load consolidation would only be applied in case of double stacking; for other scenarios load consolidation was not feasible in terms of costs. The assumption is therefore that all customers will be supplied from one full service distribution center: P&G's current DC in Rumst.

Figure 8: Current situation vs. double stacking

2) **On-top loading.** With on-top loading, the customer order is put as efficient as possible in a truck by putting pallets on top or below each other. Software can be used to maximize the truck utilization. An example of a truck filled with pallets by means of software is shown in Figure 9. For this project, a specific case of on-top loading will be investigated. The on-top loading scenario assessed in this project is shown in Figure 10. It can be seen that layers are put on top of every full pallet. Note that, in practice there may not be enough layers to cover all pallets. On-top loading could however reduce the amount of trucks and the impact on handling is relatively small.
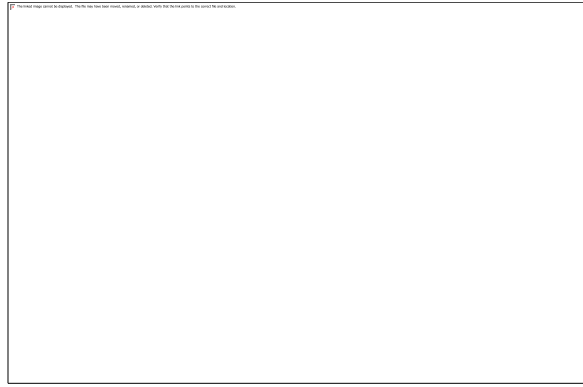
Figure 9: Example of a truck where on-top loading was applied

Current situation   On-top loading

Figure 10: Current situation vs. on-top loading

In the next section, the current situation is assessed in terms of KPIs. Next, double stacking and on-top loading are assessed as well; the scenarios are compared to the current situation. For each scenario, cost models for P&G and the customers are developed and the results are compared to the current situation. Furthermore, a sensitivity analysis is performed. Last, the research is summarized and conclusions are drawn.

4.2 Cost components

For each scenario, several cost components are assessed. In Figure 11, an overview of the supply chain is given. It is shown which parts of the supply chain are assessed in terms of costs. The supply chain cost components are: customer freight, P&G DC handling and Customer DC handling.
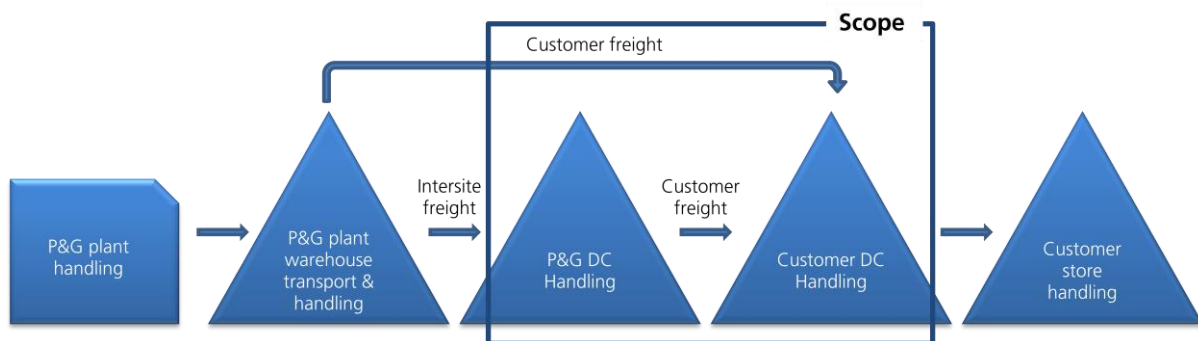

Figure 11: Total supply chain and selection of scope

For both P&G and the customers, a list of the main cost components is made. This list is shown in Table 8. The supply chain cost components are included here as well. It may be noticed that P&G's cycle stock costs are not taken into account. This is because the relative importance of cycle stock costs is low for P&G and inclusion would highly increase the complexity of this study. Furthermore, it should be noted that 'Changing trade terms' is actually not a cost component, but indicates a shift of money. Trade terms state which premium or discount a customer gets under which circumstances.

When the premium or discount is eliminated or changed, the rebate/premium paid to/by the customer changes as well.

<p align="center">**Table 8: Cost components P&G cost model and customer cost model**</p>

Customer cost components	P&G cost components
Warehouse Handling costs	Transportation costs
Cycle stock costs	Warehouse Handling costs
Administrative costs	Administrative costs
Changing trade terms	Changing trade terms
Investments	Investments

The data used to model the costs and to calculate the results for all models is data from JFM 2013. It is assumed that the results of this period can be linearly extrapolated to calculate the costs per year. Only for the cycle stock costs this extrapolation is not necessary, as the costs are calculated per year. Tali (2011) already investigated for P&G the impact of increasing the VFR and reducing minimum order quantity levels on the inventory levels of the customers. Her study will be used as input for the cycle stock costs models. The changing trade terms and investments are not included in the yearly costs results, but will be discussed.

In the next sections the cost models will be discussed in more detail per scenario.

4.3 Current situation (CS)

For the current situation, it is determined what the costs are per cost component as shown in Table 8. In this paragraph, first the mathematical models for the current situation will be presented. Then, the key assumptions are stated, results are discussed and last a conclusion will be drawn.

4.3.1 Mathematical model

Two cost models were developed: a customer cost model and a P&G cost model. These will be described next.

4.3.1.1 P&G cost model CS

The P&G cost model consists of 1) transportation costs, 2) warehouse handling costs, 3) administrative costs, 4) costs of changing trade terms, and 5) investments. The costs of changing trade terms and investments are left out of scope, because in the current situation their value will be zero. Below, the formulas are given; the detailed formulas can be found in Appendix III – P&G cost model current situation. The formulas are used to calculate the total costs for P&G Benelux for the customers in scope.

$$Transportation\ costs = transport\ costs/tradelane \times \#\ shipments\ per\ tradelane \qquad [1]$$

$$Handling\ costs = \#\ pallets \times (unloading\ costs/pallet + loading\ costs/pallet) \qquad [2]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [3]$$

4.3.1.2 Customer cost model CS

The customer cost model consists of 1) warehouse handling costs, 2) cycle stock costs, 3) administrative costs, 4) costs of changing trade terms, and 5) investments. The costs of changing trade terms and investments are irrelevant for this model, because in the current situation their value will be zero. Below, the formulas are given; the detailed formulas can be found in Appendix IV

– Customer cost model current situation. The formulas are used to calculate the costs per customer location.

$$Handling\ costs = \#\ pallets \times (unloading\ costs/pallet + repositioning\ costs/pallet) \qquad [4]$$

$$Cycle\ stock\ costs = \sum_{i=1}^{n} \frac{1}{2} \times average\ gross\ invoice\ value\ SKU\ i \times holding\ costs\ \% \qquad [5]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [6]$$

4.3.2 Assumptions CS

A detailed overview of all assumptions can be found in Appendix V –Assumptions current situation. Next, the main assumptions are explained.

In general:

- Demand does not change
- All costs can be linearly extrapolated to calculate the costs per year

4.3.2.1 P&G cost model assumptions

When a truck with products arrives at the P&G DC, the pallets move two times: from the truck to the rack and from the rack to the truck to ship products to the customer. This is also shown in Figure 12.

In from plant   **P&G DC rack**   **Out to customer**

Figure 12: Handling at P&G's DC in Rumst, Belgium

The cost charges for these two movements are equal. The handling at P&G's DC is done by a third party logistics provider (3PL) and the charges for the movements are equal. The costs of picking products which are ordered on a partial pallet are left out of scope, because no significant changes are expected for the different scenarios. Picking costs refer to the costs of manually picking individual items from a rack. It is assumed that a full pallet consists of 8 layers on average and pallets can be composed of different products. This is only relevant for the last movement in P&G's DC; arriving shipments from the plant always consist of full pallets.

4.3.2.2 Customer cost model assumptions

It is assumed that when a pallet arrives at the customer, two pallet movements will be required before the customer is able to start picking products for the stores: unloading the pallet and putting it in the rack, and repositioning the pallet from the rack to the store picking area. This is also shown in Figure 13.

Figure 13: Handling at a customer location

In the baseline model, the costs for these movements are based on P&G's handling costs and the global guideline for handling costs at Customer B. The first movement is assumed to be 4 times as expensive as the second movement, as the distance to cover is estimated as well to be 4 times as large. Based on the experiences from P&G's DC in Rumst, this assumption is made.

The costs of picking products which are delivered on a partial pallet are left out of scope, as no significant changes are expected for the different scenarios. It is assumed that a full pallet consists of 8 layers on average and pallets can be composed of different products.

The costs per order are equal to P&G's WE costs per order.

The cycle stock holding costs are assumed to be ▮ of the gross invoice value; this is P&G's guideline.

All relevant parameter values used in the baseline model are listed below.

- Administrative costs per order ▮
- Unloading costs per pallet customer ▮
- Repositioning costs per pallet customer ▮
- Unloading costs per pallet P&G = loading costs per pallet P&G ▮
- Holding costs percentage ▮

4.3.3 Results current situation

The results in terms of costs per year for the current situation are shown in Table 9 and Figure 14. It should be taken into account that P&G's costs are the costs related to the customers in scope; the total costs for the Benelux would be approximately twice as high. Furthermore, P&G's handling costs only include handling costs at P&G's DC in Rumst; handling for ex-plant shipments is not taken into account as is shown in Figure 11. Furthermore, intersite freight is not taken into account either. However, a rough estimate will be given in order to get an overview of the complete picture. The intersite freight (ISF) costs for shipments from the plants to P&G DC Rumst are approximately ▮▮ ▮▮ for the total Benelux; for the customers in scope (based on the share of volume) this is approximately ▮▮▮▮. With respect to picking costs, the customers in scope cover 30% of all picking costs which results in approximately ▮▮▮▮ or ▮▮▮▮ for the total Benelux. A detailed overview of the costs per customer can be found in Appendix XII – Cost overview per scenario Customer A to Appendix XVI – Cost overview per scenario Customer E. There is not a lot of variation across the different customers; a general pattern in changes per cost component can be

seen across the customers. In the Appendices, the costs for the other scenarios are shown as well and the differences between the scenarios are discussed.

Table 9: Results in costs per year for the current situation

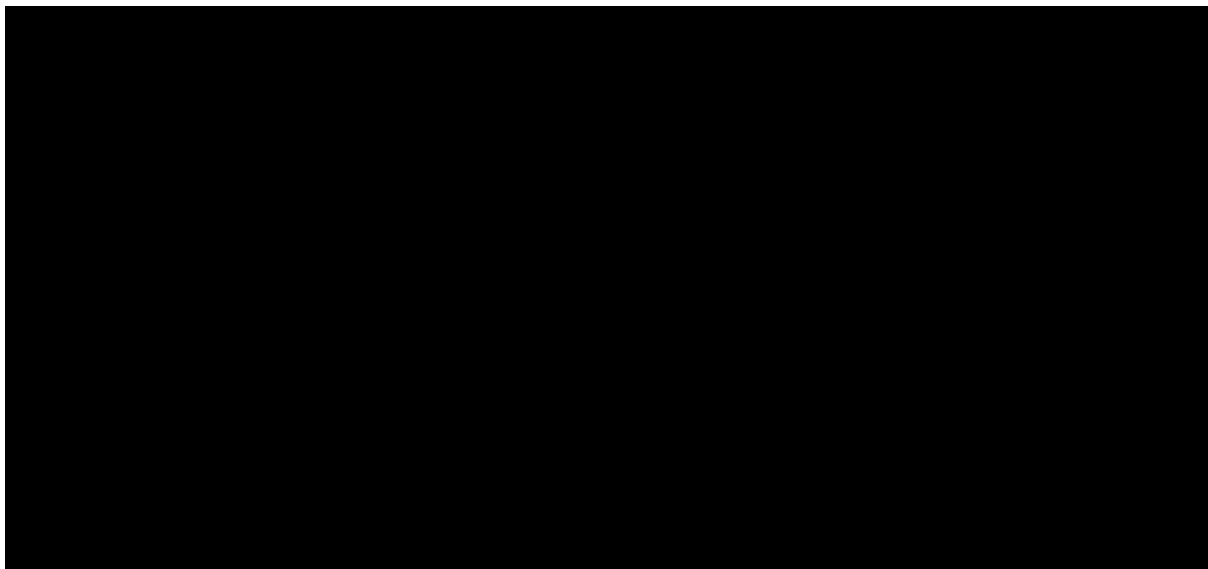| x € 1000	Current situation customers and P&G	Current situation customers	Current situation P&G
Total supply chain costs	██████	████	████
Administrative costs	███	███	███
Cycle stock costs (customer)	███	███	
Handling costs	████	███	███
Transportation costs	███		████

Figure 14: Total supply chain costs per year current situation

It can be seen in Table 9 and Figure 14 that for the customers, handling costs are currently the biggest cost component. For P&G, the main cost component is transportation costs. Transportation costs are also the most important cost component for the total supply chain in scope. In order to validate the model, the costs are compared to the actual costs available from the different databases. The actual costs for transportation and handling for P&G can be used to validate the modeled costs and it appears that for these cost components, the model inaccuracy is approximately 1%.

4.3.4 Discussion and conclusions

In this section, the costs for the current situation are analyzed. The most important cost components for the current situation are the transportation costs for P&G and the handling cost for the customers. In the next paragraphs, the results of the two scenarios will be compared to the current situation. After the costs analysis is completed, a conclusion is drawn and it is discussed which scenario is the best as a vehicle fill improvement plan, both for P&G and the customers.

4.4 Double stacking (DS)

For double stacking, it is determined what the costs are per cost component as shown in Table 8. In this paragraph, first the mathematical model will be presented. Then, the key assumptions are stated, results are discussed and a sensitivity analysis is performed. Last, a conclusion is drawn.

Concept explanation

B2 pallet: this is the regular pallet type used by P&G in the current situation and defined by sizes of the pallet: 0,8m*1,2m*1,8m. Normal pallets refer to B2 pallets. These pallets can have a varying height due to product restrictions and/or weight limitations; however, the current industry standard is that the pallets have a maximum height of 1,80m-1,85m.

 # B1-pallets: with the current product height, it is determined for each product how many products can be put on a B1-pallet (height: 1,20m). The key condition for a pallet to be a B1 pallet is that it should be able to carry its own weight. The maximum sizes for a B1 pallet are 0,8m*1,2m*1,2m. Based on the ordering history of JFM 2013, it is calculated what the ordering quantity in number of B1-pallets would have been. It is also possible to calculate the results in terms of costs when the assortment is not completely converted to B1-pallets for example.

% twins: represents the percentage of pallets where two pallets of the same product are put on top of each other. Only twins are always moved and stored double stacked (two by two) in a warehouse. The percentage should be known in order to be able to identify the number of movements to make in the warehouse. It is assumed that twins are always moved and stored double stacked; it does not happen that pallets are moved double stacked and stored single stacked or vice versa.

Situational difference P&G: A distinction is made % twins in the 1st move and the 2nd move in P&G's DC. The number of pallets which can be shipped as twins from the plant to the DC is expected to be higher or different from the number of pallets which can be shipped as twins from the DC to the customer.

% hybrids: represents the percentage of pallets where two pallets of different products are put on top of each other. It is assumed that hybrids are always moved and stored pallet by pallet; two pallets with different products are never moved or stored at together. The % twins + % hybrids = 100%.

4.4.1   Mathematical model

Again, two cost models were developed, one for P&G's costs related to the customers in scope and one for the customer costs. These models will be discussed next, after the concept explanation.

4.4.1.1 P&G cost model DS

The P&G cost model consists of the same cost components as discussed in paragraph P&G cost model CS. In contrast with the model for the current situation, the changing trade terms and investments are taken into account this time. The results are not converted into yearly costs, but will be discussed separately. Below, the formulas are given; the detailed formulas can be found in Appendix VI – P&G cost model double stacking. The formulas are used to calculate the costs per customer location. Next, the costs of all customer locations are summed up to find the total costs for the customers in scope.

$$Transportation\ costs = \frac{\#\ B1\ pallets}{\#\ B1\ pallets/truck} \times transport\ costs/tradelane\ ex\ Rumst +$$

$$\frac{\#\ normal\ pallets}{\#\ normal\ pallets/truck} \times transport\ costs/tradelane \qquad [7]$$

$$Handling\ costs = \left(\#\ B1\ pallets \times \left(\left(1 - \frac{\%twins\ 1st\ move}{2}\right) + \left(1 - \frac{\%twins\ 2nd\ move}{2}\right)\right) + 2 \times\right.$$

$$\left.\#\ normal\ pallets\ ex\ DC\right) \times (un)loading\ costs\ per\ movement \qquad [8]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [9]$$

$$Changing\ trade\ terms = gross\ invoice\ value\ ex-plant\ shipments \times change\ in\ rebate \quad [10]$$

$$Investment\ costs = total\ of\ investment\ costs \qquad [11]$$

4.4.1.2 Customer cost model DS

The customer cost model consists of the same cost components as discussed in paragraph Customer cost model CS. In contrast with the model for the current situation, the changing trade terms and investments are taken into account as well in this scenario. The results for the two cost components are not converted into yearly costs, but will be discussed separately. Below, the formulas are given; the detailed formulas can be found in Appendix VII – Customer cost model double stacking. The formulas are used to calculate the costs per customer location.

$$Handling\ costs = \left(\left(\frac{\%\ twins}{2} + (1 - \%\ twins)\right) \times \#\ B1\ pallets + \#\ normal\ pallets\right) \times$$

$$unloading\ costs/pallet + (\#\ B1\ pallets + \#\ normal\ pallets) \times repositioning\ costs/pallet$$
$$[12]$$

$$Cycle\ stock\ costs = \sum_{i=1}^{n} \frac{1}{2} \times average\ gross\ invoice\ value\ SKU\ i \times holding\ costs\ \% \qquad [13]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [14]$$

$$Changing\ trade\ terms = gross\ invoice\ value\ explant\ shipments \times change\ in\ rebate \qquad [15]$$

$$Investment\ costs = total\ of\ investment\ costs \qquad [16]$$

4.4.2 Assumptions

A detailed overview of all assumptions can be found in Appendix VIII –Assumptions double stacking. Next, the main assumptions are explained.

In general:
- Demand does not change
- All costs can be linearly extrapolated to calculate the costs per year

4.4.2.1 P&G cost model assumptions

Transportation costs will change. It is assumed that all double stacked pallets are shipped from the DC (Rumst). When the full assortment is supplied on B1-pallets, ex-plant shipments to the customer are eliminated. This results in two savings: the distances for shipments to the customer become shorter and the total number of shipments can be reduced.

When a truck with products arrives at the DC, two movements will be made with the pallets: moving the pallet from the truck in the rack and moving the pallet from the rack to the truck to ship the pallet to the customer. This is also shown in Figure 15. The pallets can either be moved as hybrids

(red pallets) or as twins (green pallets). In the baseline model, it is assumed that 80% of the pallets can be moved as twins at the first move. There are some restrictions which limit the percentage of twins, for example weight per pallet (which is limited to 1.000 kg for one pair of twins). For the second move, it is assumed that 60% the pallets can be moved as twins. When considering the ordering data, it can be seen that for >80% of the volume the ordering quantity is 2 B1-pallets or more. However, there will be a weight restriction, customers may change their ordering pattern and to be careful, the percentage twins is assumed to be 60% in the baseline model.

Figure 15: Double stack handling at P&G's DC

The costs for the two movements are again equal, as explained in P&G cost model CS. The costs of picking products which are ordered on a partial pallet are left out of scope, as no significant changes are expected for the different scenarios. It is assumed that a full B1-pallet can consist of 4 layers of different products on average. This is only relevant for the last movement in P&G's DC, because arriving shipments always consist of full pallets.

4.4.2.2 Customer cost model assumptions

It is assumed that when a pallet arrives at the customer, two pallet movements will be required before starting picking products for the stores: unloading the pallet and putting it in the rack, and repositioning the pallet from the rack to the store picking area. This is also shown in Figure 16. The pallets can be moved as hybrids (red pallets) or as twins (green pallets). The second movement needs to be executed with one B1-pallet per movement, as the people picking products from the store picking area are not able to pick products from 2,40m (which is simply too high).

Figure 16: Double stack handling at a customer location

The costs for these movements are based on P&G's handling costs and the global guideline for handling costs at Customer B. The first movement is assumed to be ▮ times as expensive as the second movement, because the distance to cover is estimated as well to be ▮ times as large.

The costs of picking products which are delivered on a partial pallet are left out of scope, as no significant changes are expected for the different scenarios. It is assumed that a full B1-pallet consists of 4 layers on average and pallets can be composed of different products.

The costs per order are equal to P&G's WE costs per order.

The cycle stock holding costs are assumed to be ▮ of the gross invoice value; this is P&G's guideline.

4.4.3 Results

The results in terms of costs per year for double stacking versus the current situation are shown in Table 10 and Figure 17. It can be seen that for the total supply chain in scope, the handling costs increase and become the biggest and most important cost component and transportation costs decrease compared to the current situation. The increase in handling costs is mainly due to the increase in the amount of pallets, which is approximately 60%. There is an increase in costs for the customer and a significant decrease in costs for P&G (the changing trade terms are not taken into account). The decrease in costs is mainly due to the reduction in transportation costs. Overall, the results are positive and a cost saving of approximately ▮ can be realized for the whole supply chain. In order to determine whether and how to distribute the savings, cooperative game theory and the Shapley value could be applied. Although this may not be attractive to P&G, the customers may be convinced by means of a fair distribution of the savings. (Shapley, 1988) It is recommended to further research this option.

Table 10: Results in costs per year for double stacking vs. current situation

x € 1000	DS customers and P&G	CS customers and P&G	DS customers	CS customers	DS P&G	CS P&G
Total supply chain costs	▮ ▮	▮	▮ ▮	▮	▮ ▮ ▮	▮
Administrative costs	▮	▮	▮	▮	▮	▮
Cycle stock costs	▮	▮	▮	▮		
Handling costs	▮	▮	▮	▮	▮ ▮	▮
Transportation costs	▮	▮			▮ ▮	▮
Changing trade terms			▮		▮	

It should again be taken into account that P&G's costs are the costs related to the customers in scope; the costs for the total Benelux would be approximately twice as high. Furthermore, P&G's handling costs only include handling costs at P&G's DC in Rumst; handling for ex-plant shipments is not taken into account as is shown in Figure 11. Intersite freight is neither taken into account. A rough estimate will be given in order to get an overview of the complete picture for the Benelux.

The intersite freight (ISF) costs for shipments from the plant to the P&G DC Rumst are approximately ▮▮▮▮▮▮▮ for the total Benelux. The savings due to double stacking in terms of ISF are estimated to be approximately ▮▮▮▮▮▮ for the total Benelux, this is an estimate made by P&G. However, the intersite freight volume will also increase because shipments from the plant to the customer are eliminated and will go via the DC in Rumst. This will result in an increase of ISF costs of approximately ▮▮▮▮▮▮ for the total Benelux. Taking into account the estimated savings due to double stacking, the increase in costs would be ▮▮▮▮▮▮, while the saving in costs is also ▮▮▮▮▮▮. Net, this indicates there is no cost increase or saving with respect to ISF costs. When taking into account the change in customer freight as well, the final result is that the net transport savings for the Benelux will be approximately ▮▮▮▮▮▮▮. A graphical overview is shown in Figure 18.
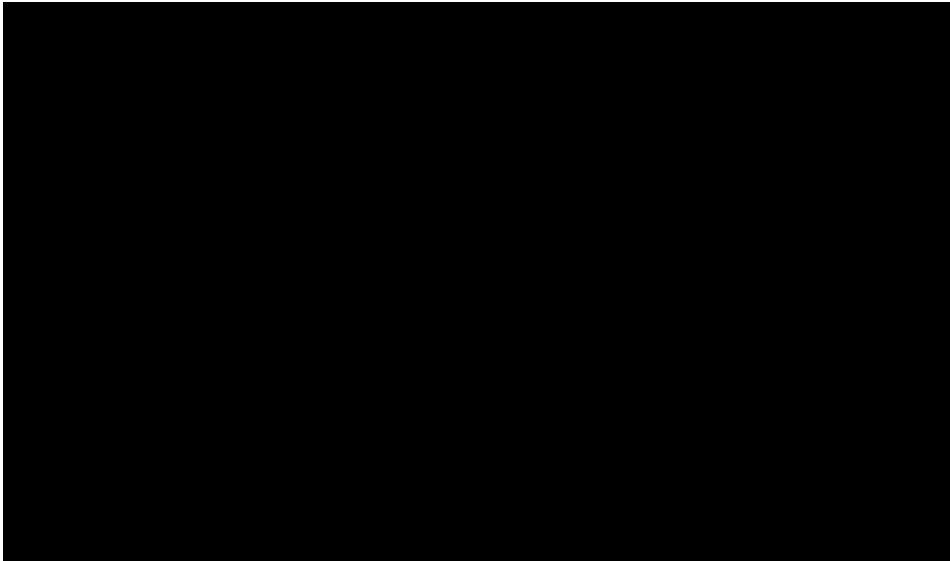
Figure 18: Overview transportation costs current situation vs. double stacking for the total Benelux

With respect to picking costs, the customers in scope cover approximately ▮▮ of all picking costs in Rumst, which results in approximately ▮▮▮▮▮▮. Picking costs may be reduced because there are fewer products required for a full pallet. The amount of partial pallets ordered (which cause the picking costs) will decrease with approximately 20%; this would result in a cost savings of approximately ▮▮▮▮▮▮. It is recommended to further investigate the possibsavings as it is not clear whether these savings can be extrapolated for all customers in the Benelux. The customers in scope have relatively high ordering quantities and therefore it can be argued that the possible saving is potentially bigger than for the total Benelux. Smaller customers order on average less and are less efficient. A careful estimate would be that the total savings in picking costs could be ▮▮▮▮▮▮▮▮ ▮▮▮▮▮▮.

The handling costs of moving pallets in Rumst for the total Benelux ▮▮▮▮▮▮) will increase with approximately ▮▮▮▮▮▮. The volume of products and the number of pallets in Rumst will increase because the ex-plant shipments to the customers are assumed to be eliminated. When in the current situation all pallets supplied to the customers would be shipped via Rumst, the amount of pallets handled in Rumst would increase with 50%. Furthermore, the amount of pallets will increase because of the switch from B2-pallets to B1-pallets; this will result in another 60% increase. In total, the amount of pallets handled in Rumst will more than double and moving pallets as twins will not offset the increase in costs. The increase in handling costs in Rumst will therefore be approximately ▮▮▮▮▮▮ per year.

Next, the shift of money due to changing trade terms is not taken into account. At the moment, the customers get a higher rebate for shipments ex-plant than shipments ex-DC. The change in rebate results in a shift of ▮▮▮▮▮▮ per year for the customers in scope; for the total Benelux the shift would be ▮▮▮▮▮▮. P&G will need to compensate the customers to prevent this 'loss'. For the biggest customer, the impact is ▮▮▮▮▮▮ per year.

Last, the investment costs are not taken into account in the results. I discussed with the P&G DC what investments are required to be able to efficiently handle double stacking. There were two big investments mentioned: the rack height in the DC needs to be changed in order to efficiently store

the B1-pallets (app. ██████████) and the automated system for loading pallets (called 'Black Box') needs to be adapted to be able to process higher pallets (app. ██████████). Net, the total investment costs result in ██████████ for P&G. For the customers, it is clear the rack heights need to be changed as well. For the customers in scope, there are 13 DCs which will need to be adapted. However, it is not clear which share of the total warehouse is occupied by P&G's products. If the whole industry would move to double stacking, the perspective for the customer would become different. It is hard to give a number for the investments at the customer side; however it should be approached as a long-term investment which could reduce complexity and standardize many processes when the whole industry would adopt double stacking.

VFR
The result of double stacking versus the current situation in terms of VFR is that the VFR will increase to 70% compared 57% in the current situation (this is the VFR modeled, assuming 32 normal pallets or 64 B1-pallets per truck). This is a significant increase; double stacking can realize structural transportation cost savings on the long-term.

Delivery frequency
In general, the delivery frequencies ex-DC will increase compared to the current situation. Because ex-plant shipments are eliminated, the total volume of products will be shipped from the DC to the customers. Even though more products are put in a truck, the delivery frequency will increase, which is positive for the customer as service will increase. Out of stocks may be reduced and customers will be able to order smaller amounts of a product more frequently which reduces cycle stock costs.

A detailed overview of the costs per customer can be found in Appendix XII – Cost overview per scenario Customer A to Appendix XVI – Cost overview per scenario Customer E.

Test case
On April 22nd, the VFR Challenge Day was organized for P&G Benelux. The goal was to maximize the vehicle utilization for one day and to test the concept of double stacking. Normal full pallets were manually restacked to B1-pallets to be able to apply double stacking. A 38-pallet truck was used for this test case. The result was that 76 B1-pallets and 6 layers of products were put in one shipment. The result in terms of VFR was 78% (based on 80m³) or 68% (based on 92m³). Below, pictures of the shipment are shown.

4.4.4 Sensitivity analysis
To assess the results and the reliability of the conclusions, a sensitivity analysis is performed. The parameters which will be tested in the sensitivity analysis are:

- Cycle stock holding costs percentage
- Percentage of pallets shipped as twins intersite
- Percentage of pallets shipped as twins to the customer

- Number of floor positions used per truck
- Unloading and repositioning costs per pallet at customer's DC

Next, per parameter/variable the varying values and results are discussed.

4.4.4.1 Cycle stock holding costs percentage

It is assumed, based on P&G's guideline, that the cycle stock holding costs percentage is equal to ▮ of the gross invoice value for all customers. There are four values chosen to vary with: ▮▮▮▮ ▮▮▮. The results for the different values are shown in Table 11: the customer costs are given for the current situation and double stacking. It can be seen that with a lower percentage, the difference in total costs is relatively big. This is due to the relative impact of the cycle stock holding costs; the positive impact due to cycle stock costs reduction is smaller with a smaller percentage. The bigger the cycle stock holding costs percentage, the more positive double stacking becomes. The saving in cycle stock holding costs (together with administrative costs) will outweigh the cost increase at a cycle stock holding costs percentage of ▮▮. However, it is unlikely that this percentage or higher is used by a customer; therefore the initial conclusion remains unchanged.

Table 11: Results sensitivity analysis cycle stock holding costs percentage

▮▮▮▮		▮▮▮▮▮	▮▮▮▮▮	▮▮▮▮▮
▮▮▮▮▮▮▮▮▮				
▮		▮▮▮	▮▮▮	▮▮▮▮
▮		▮▮▮	▮▮▮	▮▮▮▮
▮		▮▮▮	▮▮▮	▮▮▮▮
▮		▮▮▮	▮▮▮	▮▮▮▮
▮▮		▮▮▮	▮▮▮	▮▮

4.4.4.2 Percentage of pallets shipped as twins intersite

It is assumed that the percentage of pallets which can be shipped as twins between the plants and P&G's DC is 80%. From the plant to the DC, products are always shipped in full pallets and it should easily be possible (because of the high volumes) to ship pallets as twins. There are however limitations due to the maximum weight per pallet. The values used for sensitivity analysis are 50% (worst case), 60%, 70%, 80%, 90%, and 100% (best case). The results are shown in Table 12. From that table, it can be seen that the higher the percentage, the better the result for the double stacking scenario. Even with the worst case scenario (50% of the pallets shipped as twins intersite), the outcome for the double stacking scenario is still positive for the total supply chain. The conclusions remain the same; however, the higher the percentage of pallets shipped as twins intersite, the better.

Table 12: Results sensitivity analysis percentage pallets shipped as twins intersite P&G

▮▮▮		▮▮▮▮	▮▮▮▮▮	▮▮▮▮▮
▮▮▮▮▮▮▮▮▮				
▮		▮▮	▮▮▮	▮▮▮
▮		▮▮▮	▮▮▮	▮▮▮
▮		▮▮	▮▮▮	▮▮▮
▮		▮▮▮	▮▮▮	▮▮▮

4.4.4.3 Percentage of pallets shipped as twins to the customer

It is assumed that the percentage of pallets which can be shipped as twins to the customer is 60%. When assuming that the customer will stay ordering the same quantities, this is a fair assumption. However, if the customer would decide to change its ordering pattern and order more different products in a truck and more often ex-DC, this assumption may not be valid anymore. The percentage of pallets shipped as twins to the customer has an impact both on P&G's handling costs and the customers' handling costs, because P&G needs to load the truck and the customer will unload it. The values which will be used for sensitivity analysis are 0%, 20%, 40%, 60%, and 80%. It is not likely that the percentage will ever become 100% as the demand for certain products is too low and there are weight limits to take into account. The results are shown in Table 13. For the customers, this percentage is critical as the result can be either a cost saving or a cost increase. For the customers it is crucial to ship as much pallets as twins as possible. The turning point (where double stacking results in a cost saving for the customers) is 72%. The key challenge for the customers will be to reach that percentage. When the customers reach a higher percentage, the customers will start to save money as well (just like P&G). For P&G, the situation is different. P&G will start saving money almost immediately; the turning point is 2%. When looking at the total supply chain, it can be seen that the turning point is at 35% approximately.

With the current assumption of 60%, the customers' costs would slightly increase, but P&G realizes a significant saving. However, if the customer will be able to increase the percentage of pallets shipped as twins to 72%, the customer will start to save money as well. This parameter is critical for the final conclusions, because it makes the difference between a cost increase and decrease for both the customers and the total supply chain.

Table 13: Results sensitivity analysis percentage of pallets shipped as twins to the customer

4.4.4.4 Number of floor positions used per truck

Currently, all systems and trade terms of P&G are set to ■ floor positions per truck. However, it is possible to put more pallets in the same truck: ■ pallets (or ■ B1-pallets) is not a problem at all

and even ▮ pallets (or ▮ B1-pallets) per truck is possible when loading accurately. The result would be that P&G could reduce its transportation costs, and both P&G and the customers could reduce administrative costs. The values used for sensitivity analysis are ▮▮▮▮▮▮ floor positions/pallets. The results are shown in Table 14. It can be seen that indeed both P&G and the customers can reduce the costs; the maximum saving which can be gained in the total supply chain compared to the current situation is approximately ▮▮▮▮▮ per year. However, the initial conclusions remain unchanged. Customers' costs will still slightly increase and P&G's costs decrease significantly. For the total supply chain, costs decrease.

Table 14: Results sensitivity analysis number of floor positions per truck

4.4.4.5 Unloading and repositioning costs per pallet at customer's DC

Based on the costs of loading and unloading pallets in Rumst and the global guideline of Customer B, it is assumed that the unloading costs of a pallet are ▮▮ at the customer and the repositioning costs of a pallet are ▮▮ at the customer. However, these costs may differ per customer and there may also be different warehouse configurations per location. The values used for sensitivity analysis for the unloading costs per pallet are ▮▮▮▮▮▮▮▮▮. The values used for sensitivity analysis for the repositioning cost per pallet are ▮▮▮▮▮▮▮▮▮▮. The results for the difference in costs between the current situation and double stacking for the customers are shown in Table 15. In the first column, the values for the unloading costs per pallet are shown. In the first row, the values for the repositioning costs per pallet are shown. It can be seen that the lower the unloading costs per pallet, the bigger the costs difference between the current situation and double stacking. The same is true for the repositioning costs per pallet: the lower the costs, the more positive the double stacking scenario. These costs parameters have a significant impact on the final outcome; either a cost saving or a cost increase can be realized for the customer. It is likely that the costs vary per customer, however this is sensitive customer information, which is not available (yet) and therefore together with the customer it should be determined how to make the concept of double stacking a winning strategy.

Table 15: Results sensitivity analysis unloading and repositioning costs per pallet at customer's DC

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4.4.5 Discussion and conclusions

In this paragraph, the double stacking scenario is analyzed in detail and a sensitivity analysis is performed to get an overview of the costs and benefits of the double stacking scenario. It can be concluded that the double stacking scenario could realize a considerable cost saving of ████████ or ██ per year compared to the current situation for the supply chain in scope of this project. When considering the sensitivity analysis performed, the results would vary between a cost increase of █ ██ and a cost decrease of ███.

For the customers in scope, the double stacking scenario would result in a small cost increase, excluded the changing trade terms and investments. For P&G, double stacking would result in a cost saving. In the sensitivity analysis it became clear that there are some important parameters which might turn the cost increase into a cost saving for the customers. The percentage of pallets shipped as twins to the customer is the most important parameter. If, based on the assumptions stated, the customers would on average be able to ship 72% or more of the pallets as twins, the customers will start to save money as well. Per customer the turning point may differ, however it should be possible to realize a win-win situation with double stacking. This will be discussed in more detail in chapter 5, Implementation strategy double stacking Benelux (confidential).

For P&G, the savings can become even higher when taking into account the possible reduction in picking costs.

When considering the total Benelux including all customers and intersite freight, it can be seen that the total costs (transportation costs, handling costs, picking costs and administrative costs) are approximately ████████. The net transportation savings will be approximately ████████. The reduction in picking costs may realize a saving as well of ████████████. However, it should also be taken into account that P&G's handling costs of moving pallets will increase with ████ ████████ as well. Net, there is still a saving of app. ████████████ (taking into account the reduction of administrative costs as well), but with total costs of app. ████████, this a relatively small cost saving. It is recommended to further investigate the double stacking scenario without consolidating all loads in Rumst. This could result in a reduction of handling costs in Rumst instead of an increase and also further decrease the transportation cost. This however would also harm the customer service as the delivery frequency ex-DC will decrease significantly, while the delivery frequency increases in case of consolidation at Rumst DC.

In the next section, the on-top loading scenario as defined in Introduction of different scenarios is assessed.

4.5 On-top loading (OTL)

For on-top loading, it is determined what the costs per cost component are as shown in Table 8. In this paragraph, first the mathematical model for on-top loading will be presented. Then, the key assumptions are stated, results are discussed and a sensitivity analysis is performed. Last, a conclusion will be drawn.

4.5.1 Mathematical model

Again, two cost models were developed: a customer cost model and a P&G cost model. These will be described next.

4.5.1.1 P&G cost model OTL

The P&G cost model consists of 1) transportation costs, 2) warehouse handling costs, 3) administrative costs, 4) costs of changing trade terms, and 5) investments. The costs of changing trade terms are irrelevant, because their value will be zero. However, to implement this scenario, P&G needs to invest in the DC in Rumst. Below, the formulas are given; the detailed formulas can be found in Appendix IX – P&G cost model on-top loading. The formulas are used to calculate the costs for P&G Benelux in scope.

$$Transportation\ costs = transport\ costs/tradelane \times \#\ shipments\ per\ tradelane \qquad [17]$$

$$Handling\ costs = \#\ pallets \times (unloading\ costs/pallet + loading\ costs/pallet) + \\ additional\ costs/shipment \times number\ of\ shipments \qquad [18]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [19]$$

$$Investment\ costs = total\ of\ investment\ costs \qquad [20]$$

4.5.1.2 Customer cost model OTL

The customer cost model consists of 1) warehouse handling costs, 2) cycle stock costs, 3) administrative costs, 4) costs of changing trade terms, and 5) investments. The costs of changing trade terms and investments are left out of scope, because their value will be zero. Below, the formulas are given; the detailed formulas can be found in Appendix X – Customer cost model on-top loading. The formulas are used to calculate the costs per customer location. It can be seen that the formulas are actually the same as in the current situation; however the number of pallets and orders will differ.

$$Handling\ costs = \#\ pallets \times (unloading\ costs/pallet + repositioning\ costs/pallet) \qquad [21]$$

$$Cycle\ stock\ costs = \sum_{i=1}^{n} \frac{1}{2} \times average\ gross\ invoice\ value\ SKU\ i \times holding\ costs\ \% \qquad [22]$$

$$Administrative\ costs = costs\ per\ order \times number\ of\ orders \qquad [23]$$

4.5.2 Assumptions

A detailed overview of all assumptions can be found in Appendix XI –Assumptions on-top loading. Next, the main assumptions are explained.

In general:
- Demand does not change and the volume which is picked (partial pallets) also does not change
- All costs can be linearly extrapolated to calculate the costs per year

4.5.2.1 P&G cost model assumptions

To be able to compare this scenario with the current situation, it is assumed that all products ordered on layers can be put on top of a full pallet. Per full pallet, two layers can be put on top. Yet, there are not enough layers available to cover all full pallets. It is calculated that only 25% of the pallets can have layers put on top of them.

Because of this change in handling, there are additional handling costs for P&G due to the additional wrapping and putting the layers on two by two instead of composing a new pallet. In April 2013, the concept of on-top loading has been tested and the additional costs per shipment were ███.

4.5.2.2 Customer cost model assumptions

To be able to compare this scenario with the current situation, it is assumed that all products ordered on layers can be put on top of a full pallet. Per full pallet, two layers can be put on top. In that case, still for only 25% of the full pallets, an extra product is put on top. Otherwise, full pallets need to be restacked to lower pallets, which is very inefficient in terms of handling. It is assumed that there is no additional cost for the customer compared to the current situation, as the customer would receive the product per layer(s) already anyway. It could even be argued that the customer's costs would decrease since the pallets with layers on top are per product and the customer does not need to separate the different products anymore.

The costs of picking products which are delivered on a partial pallet are left out of scope, as no significant changes are expected for the different scenarios.

The costs per order are equal to P&G's WE costs per order.

The cycle stock holding costs are assumed to be ██ of the gross invoice value; this is P&G's guideline.

4.5.3 Results

The results in terms of costs per year for on-top loading compared to the current situation are shown in Table 16 and Figure 19. It can be seen there are hardly any changes. It should be taken into account that P&G's costs are the costs related to the customers in scope; the total costs for the Benelux would be approximately twice as high. Furthermore, P&G's handling costs only include handling costs at P&G's DC in Rumst; handling for ex-plant shipments is not taken into account as shown in Figure 11. Intersite freight is neither taken into account. However, both handling at the plant as intersite freight would not change in case of on-top loading as only full pallets are shipped ex-plant. A detailed overview of the costs per customer and a comparison with the current situation can be found in Appendix XII – Cost overview per scenario Customer A to Appendix XVI – Cost overview per scenario Customer E.

It can be seen in Table 16 and Figure 19 that for the total supply chain in scope, the handling costs increase slightly and transportation costs decrease slightly. Furthermore, transportation cost is still the biggest cost component. There is a small decrease in costs for the customer and a small increase in costs for P&G; however, the net change is about zero. More money could have been saved if the volume of products ordered on layers would have been bigger, but that is not the case in this situation.

The investments are not taken into account in the yearly costs. However, P&G should invest in the DC if they want to realize the on-top loading scenario. The automated loading system (called 'Black Box') should be adapted to be able to process higher pallets (full pallet plus layers on top). The costs for this change are estimated to be ███████.

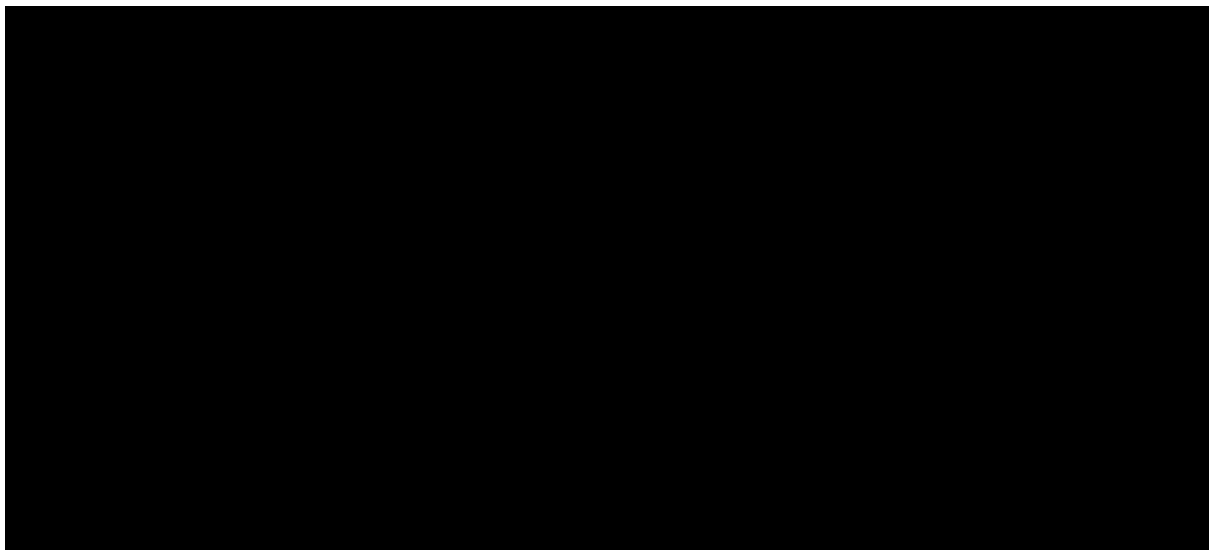| ███████	██ ███	██ ██	██ ██	███ ███
██████████ ███	████ ████	████ ████	████ ████	████ ███
███████ █	██ ███	██ ███	██ ███	██ ███
███████████	██ ███	██ ███		
████████ █	████ ████	████ ████	███ ███	
████████	███ ████		████ ████	

Figure 19: Total supply chain costs per year on-top loading vs. current situation

VFR

The result of on-top loading versus the current situation in terms of VFR is that the VFR will become 60% compared to 57% in the current situation (this is the VFR modeled, assuming ██ normal pallets or ██ B1-pallets per truck). This is a slight increase but as already stated, on the long-term no structural savings will be realized with the on-top loading scenario.

Delivery frequency

The delivery frequencies ex-DC will slightly decrease compared to the current situation, but there will be no significant changes. This is because on average more products are put in a truck.

Test case

As also discussed for double stacking, on April 22nd the VFR Challenge Day was organized for the Benelux. The goal was to maximize the vehicle utilization for one day and to test the concept of on-top loading as defined in the Introduction of different scenarios. The shipment contained 34 full pallets; 33 full pallets had layers of products on top. The result in terms of VFR was 73%. Below, pictures of the shipment are shown. The reason that the VFR was relatively high is that the amount of pallets with layers was relatively high as well. In practice, this cannot be realized unfortunately.

4.5.4 Sensitivity analysis

To assess the results and the reliability of the conclusions, a sensitivity analysis is performed. Next, for the additional handling costs per shipment at P&G the varying values and results are discussed.

4.5.4.1 Additional handling costs per shipment P&G

It is assumed that, based on a test case performed, the additional costs for loading a shipment where on-top loading is applied, is ▮▮▮. In order to analyze the impact of these costs, different values have been chosen to use for a sensitivity analysis: ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮. The results for the sensitivity analysis are shown in Table 17. It can be seen from the table that the lower the additional handling costs, the more positive the result for on-top loading. The turning point to realize a cost saving for P&G can be found at ▮▮▮; with ▮▮▮ additional costs per shipment, a cost saving of ▮▮▮▮ per year could be realized.

Table 17: Results sensitivity analysis additional handling costs per shipment P&G

▮▮▮	▮▮▮▮▮	▮▮▮▮	▮▮▮▮
▮▮▮▮▮▮▮▮			
▮▮	▮▮	▮▮	▮▮
▮▮	▮▮	▮▮	▮▮
▮▮	▮▮	▮▮	▮▮
▮▮	▮▮	▮▮	▮▮
▮▮	▮▮	▮▮	▮▮

4.5.5 Discussion and conclusions

In this paragraph, the on-top loading scenario is modeled and analyzed. It can be concluded that this scenario will not result in any significant changes in costs compared to the current situation. The key reason is that the relative volume of products ordered in layers instead of pallets is so small that only 25% of the full pallets will get two layers on-top. Therefore, the VFR will also only increase with 3% to 60%. The customers will save some money, but P&G will need to pay approximately the same amount for additional handling. This scenario does not realize the structural improvement of vehicle utilization P&G is looking for.

4.6 Summary and conclusions research method, results and validation

In this chapter, three different scenarios are discussed: 1) the current situation, 2) double stacking and 3) on-top loading.

When comparing the three situations, it can be concluded that double stacking is the best vehicle fill improvement plan for P&G Benelux and the customers in scope in the Benelux. The cost savings are ▮▮▮▮▮▮ or ▮▮ per year for the total supply chain in scope. Under the assumptions made, the customers' costs would increase and P&G costs would decrease. However, a net result of zero could be realized when the customers are able to increase the number of pallets ordered as twins to on

average 72%. However, when the handling costs parameters for the customer would change, the conclusions for the customers would change as well. Unfortunately, the customer did not want to provide more detailed information.

On-top loading could have been a promising scenario as well if the volume of products ordered on partial pallets would have been bigger. The ratio full pallets versus the amount of layers ordered is skewed, which causes an inefficient distribution of layers among full pallets. As stated before, only 25% of the full pallets will have another product on top, as there is no more demand for products in layers or partial pallets.

As discussed in the paragraph Research scope, several parts of the supply chain and customers were out of scope for this project. However, during the project, the question arose what would happen in case of double stacking in the total Benelux, taking into account intersite freight and the possible picking costs reduction. It appears that a saving of approximately ▮▮▮ per year can be realized for P&G, which is not a very high number. This is mainly due to the increase in handling and intersite freight because of consolidation. All ex-plant shipments which currently go directly to the customer go via the DC in case of double stacking. This results in an increase of both intersite freight and handling costs at the DC. The intersite freight savings are net zero (the saving due to double stacking is cleared by the increase in intersite freight) and handling costs increase with approximately ▮▮▮▮ ▮▮▮▮. The last note to make is that both P&G and the customers will need to make investments in their DCs to be able to efficiently process double stacked or single stacked B1-pallets. For P&G, these costs will be approximately ▮▮▮▮▮▮, for the customers it is hard to make a good estimate. Furthermore, the change in trade terms will cause a shift of ▮▮▮▮▮▮ per year from the customers to P&G, because the ex-plant rebate is eliminated.

4.6.1 Recommendations
Based on the research done new questions arose and several recommendations for further research on the double stacking scenario can be done.

Picking costs
It is recommended to further investigate the picking costs in the Benelux. For the customers in scope, the estimated saving is about ▮▮▮▮▮▮, but these customers cover only 35% ▮▮▮▮ ▮▮▮▮) of the total picking costs ▮▮▮▮▮▮). When P&G's picking costs are representative for the customers' picking costs as well, some of the customers may save money when switching to double stack, based on the stated assumptions. This should however be carefully researched in more detail before stating any conclusions. Furthermore, it is expected that the smaller customers order a higher share of their volume in partial pallets and therefore the saving may be higher for smaller customers. The volume of pallets picked is only 5% of the total volume; however, the costs related to picking are equally high to the costs related to handling. To draw any valid conclusions, further research is needed.

Intersite freight
In the analysis, a rough estimate for the intersite freight savings in case of double stacking is given. Furthermore, it is investigated how the intersite freight Euskirchen – Rumst DC and Amiens – Rumst DC change. Although it is expected the estimates are reliable, it is recommended to perform a more

detailed analysis: determine how the amount of pallets would change and what the VFR would become to find the real intersite freight savings.

Changing trade terms

The changing trade terms will result in a shift of ▮▮▮▮▮▮ per year. The customer will not accept a decrease in rebates, therefore it should be investigated how the customer can be compensated. In Appendix XII – Cost overview per scenario Customer A to Appendix XVI – Cost overview per scenario Customer E, per customer it is shown what the shift in money is.

Exclusion of consolidation

It is recommended to investigate the double stacking scenario without consolidation as well. As was discussed above, because of consolidation both intersite freight and handling costs increase. This may harm the customer service as well, as the delivery frequency ex-DC will significantly decrease; however, it can also result in a considerable cost saving for P&G. A note to make is that weight limits can become a restriction as well, especially for products shipped ex Amiens.

5. Implementation strategy double stacking Benelux (confidential)

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6. Conclusions and recommendations

In this graduation and internship project, P&G asked to investigate what the best vehicle fill improvement plan would be for both P&G Benelux and the customers in the Benelux. The question arose because of the urgency to improve sustainability and reduce transportation costs. The goal was to get an end-to-end overview of all feasible vehicle fill improvement plans and to determine what the best plan for the Benelux would be. It should be taken into account that the scope of the project is not the complete Benelux and not the complete supply chain. The customers in scope represent 52% of the Benelux volume and 48% of the Benelux gross invoice value. The cost results for P&G are related to these customers. The supply chain in scope is shown in Figure 11.

In this chapter, an overview of the results will be given and conclusions will be drawn. Furthermore, recommendations for further research will be made.

6.1 Conclusions

Based on academic literature, P&G research, practices from (non) competitors, and industry standards, two feasible vehicle fill improvement plans were identified for P&G Benelux and the customers in the Benelux: 1) double stacking, and 2) on-top loading. The physical differences compared to the current situation are shown in Figure 20.

Figure 20: Physical layouts current situation versus double stacking and on-top loading

Cost models were developed for each of the three scenarios, both for P&G and for the customers. When considering the total supply chain in scope of this project, double stacking is the best vehicle fill improvement plan. The total supply chain costs per year can be reduced with ▮ compared to the current situation. Furthermore, the VFR will become 70% and the delivery frequency of shipments supplied from the P&G DC will increase. By significantly reducing transportation costs, sustainability can be improved as well.

The costs for P&G Benelux decrease with ▮, while the costs for the customers increase with ▮. However, there are some improvements possible when considering the situation per customer. For three out of five customers, it is even possible to realize a cost decrease when putting in the right efforts. The key to realize savings can be found in maximizing the percentage twins. For two out of the five customers, a cost increase is inevitable. P&G should take this into account when considering implementing double stacking in the Benelux. The customers will need to be compensated for the losses.

For on-top loading, the total supply chain costs per year will increase with ▮. P&G's costs will increase with ▮ while the costs for the customers in scope will decrease with ▮. The VFR will become 60% and the delivery frequency of shipments supplied from the P&G DC will slightly decrease for the customers. Sustainability will improve with the reduction of transportation; however, the improvement is smaller than the improvement when applying double stacking.

An overview of the change in costs for the customers, P&G and both the customers and P&G is also shown in Table 21.

Table 21: Overview of results for the current situation, double stacking, and on-top loading

During the project, P&G asked to model the costs and savings for the total supply chain of P&G and not only the supply chain in scope. The total transportation costs (both intersite and customer freight) will decrease with ████████ per year, which is 11% of the total transportation costs. Handling costs at P&G's DC in Rumst will increase with ████████, which is 45% of the total handling costs. This increase in costs is due to the increase in volume processed by the DC (50%) and the increase of the number of pallets (60%). Shipping and storing pallets as twins does not clear this increase in costs. Furthermore, picking costs may be reduced with ████████ to ████████. This is due to the reduction of pallet height: fewer layers are required to compose a full pallet, which will reduce the amount of partial pallets ordered. Net, it is expected that there will be a small cost decrease of ██ for the total P&G Benelux. However, it is highly recommended to perform a more detailed analysis on these numbers, especially on the intersite freight changes and the changes in picking costs.

It should be noted that costs of potential investments and the shift of money because of changing trade terms are not taken into account in the results discussed.

To summarize, it can be concluded that double stacking is the best vehicle fill improvement plan. P&G and the customers in scope will save ██ on total costs. It should be taken into account that there is a challenge at the customer side; handling costs will increase but both P&G and the customers should attempt to reduce them to a minimum. Then, it may be possible to also realize a cost saving for the customers.

6.2 Further research and recommendations

Next to the conclusions for this project, insights were gained which result in the recommendations for further research. These recommendations are stated next.

Picking costs

It is recommended to perform a more detailed analysis on the picking costs in the Benelux. Although the percentage of pallets picked is only 5% of the total volume, the costs related to picking are equally high compared to the handling costs. The customers in scope are only responsible for ████ of the picking costs; they have a relatively high demand which results in relatively low picking costs per volume unit per customer. It should be investigated whether the smaller customers could realize

the same saving in picking costs for double stacking as the customers in scope of this project. If that is the case, P&G Benelux could save approximately ▮▮▮▮▮▮▮▮ per year.

Intersite freight
In order to get a complete picture for the Benelux, a rough estimate is given for the intersite freight savings for double stacking. Although it is expected the numbers are fairly reliable, it is recommended to perform a more detailed analysis. Based on the product configuration, it should be determined to what extent truck utilization can be improved when applying double stacking. A more reliable overview of potential savings can be given then.

Changing trade terms
The changing trade terms will result in a shift of ▮▮▮▮▮▮▮▮ per year for the total Benelux in case double stacking is implemented. In the analysis performed and the results discussed, this shift in money is not taken into account. However, P&G should decide what to do with this shift of money. The net result will not change, but P&G will face a 'benefit' of ▮▮▮▮▮▮▮▮ per year and the customers will face a 'hurt' of ▮▮▮▮▮▮▮▮ per year.

Exclusion of consolidation
For this project, it is assumed that P&G's DC in Rumst will be converted into a full service consolidation center and that all products ordered by the customers will be supplied from that consolidation center. This has however a negative impact on intersite freight and handling costs: the volume of intersite freight will increase and handling in the consolidation center will increase. It is expected that these negative effects can be avoided by omitting the consolidation center and keeping physical distribution as it is in the current situation. However, the disadvantage is that the customer service will drop and the delivery frequency of products supplied from the DC will decrease significantly which may also cause an increase in customer cycle stock costs. Furthermore, weight limits can become a restriction, especially for products shipped ex-Amiens as these products are relatively heavy. It is thus recommended to investigate double stacking without one full service consolidation center as well.

Improvement of height utilization per pallet
It appeared that due to product height inefficiency, the vehicle utilization improvement in case of double stacking is not as big as was expected by P&G. The number of layers which can be put on a pallet is rounded down to avoid exceeding the 1,20m limit. Compared to the current situation (which is suboptimal) the used volume can be increased with approximately 20%, but then still only 80% of the maximum volume is used for gross products (including pallets). Additional transportation savings can be realized when the pallet height utilization can be improved.

Academic research
It was noticed during the literature study that academic research on the topics discussed in this project and research to the interrelatedness is very limited. Vehicle utilization is a relatively new topic in the academic world. Very extensive research has been and is being done on the optimization of vehicle routings; however, optimizing vehicle utilization has had limited attention until now. Furthermore, often the costs components of supply chain costs are treated separately and optimized without taking into account the total supply chain. However, it is important to take into account

effects on other cost components as well. As was shown for example for the double stacking scenario, minimizing the cycle stock costs caused an increase in handling costs and vice versa.

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Abbreviations

Abbreviation	Definition
3PL	Third party logistics provider
AAIK	ASEAN/Australia/India/Korea
ASEAN	Association of South East Asian Nations
BNL	Belgium, The Netherlands & Luxemburg
CEEMEA	Central & Eastern Europe/Middle East/Africa
CS	Current situation
DACH	Germany, Austria, Suisse
DC	Distribution Center
DS	Double stacking
FMCG	Fast moving consumer goods
FSDC	Full service distribution center
FTL	Full truckload
GBU	Global Business Unit
Iberia	Spain and Portugal
ISF	Intersite Freight
JFM	January, February, and March
KPI	Key Performance Indicator
LDC	National Distribution Center (L: "Landelijk")
LTL	Less than truckload
MDO	Market Development Organization
Nordic	Norway, Sweden, Finland, Denmark
OSB	Order, Shipping, Billing
OTL	On-top loading
P&G	Procter & Gamble
PD	Physical Distribution
SKU	Stock Keeping Unit
SNO	Supply Network Operations
T-View	Transportation View
UK	United Kingdom and Ireland
VFR	Vehicle Fill Rate
VMI	Vendor Managed Inventory
WE	Western Europe

Appendix I (confidential)

Appendix II – Key Performance Indicators (KPIs)

The Key Performance Indicators are listed below. Customer costs are assessed by making assumptions based on the costs made by P&G where appropriate. The indicators which require assumptions (partially) are marked with an *.

- Net costs or cost savings for the customer, which consists of:
    o Inventory costs*
    o Warehouse Handling costs*
    o Administrative costs (orders, invoices, etcetera)*
    o One-off investments to be made (e.g., warehouse changes)*
- Net costs or cost savings for P&G, which consists of:
    o Warehouse Handling costs
    o Transportation costs
    o Administrative costs (orders, invoices, etcetera)
    o One-off investments to be made (e.g., warehouse changes)
- Expected VFR improvement
- Sustainability (probably soft assessment)*
- Delivery frequency per trade lane

The KPIs will serve as a guideline in determining the best vehicle fill improvement plan for the Benelux MDO.

Appendix III – P&G cost model current situation

Parameters

$\alpha = administrative\ costs\ per\ order$

$\varepsilon = (un)loading\ costs\ per\ pallet$

$\rho_{qr} = average\ transportation\ costs\ for\ one\ shipment\ from\ shipping\ point\ q$

$to\ customer\ location\ r$

Δ_{qr}
$= number\ of\ pallets\ per\ time\ unit\ shipped\ from\ shipping\ point\ q\ to\ customer\ location\ r$

$q = 1(Rumst), 2(Amiens), 3(Euskirchen)$

$r = 1, ..., 13$

Decision variables

$T = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$X_{qr} = number\ of\ shipments\ per\ time\ unit\ from\ shipping\ point\ q\ to\ customer\ location\ r$

Formulas

$$P\&G\ transportation\ costs\ (\mathbf{1}) = \sum_{q=1}^{3}\sum_{r=1}^{13} \rho_{qr} \times X_{qr}$$

$$P\&G\ handling\ costs\ (2) = \sum_{r=1}^{13} \varepsilon \times 2 \times \Delta_{1r}$$

$$P\&G\ administrative\ costs\ (3) = \alpha \sum_{q=1}^{3}\sum_{r=1}^{13} X_{qr}$$

$$X_{qr} = \frac{\Delta_{qr}}{T}$$

$$\Delta_{qr} = amount\ of\ full\ pallets + \frac{amount\ of\ layers\ ordered}{8}$$

Appendix IV – Customer cost model current situation

Parameters

$\alpha = administrative\ costs\ per\ order$

$h = cycle\ stock\ holding\ costs\ percentage\ of\ gross\ invoice\ value$

$\varepsilon_1 = unloading\ costs\ per\ pallet$

$\varepsilon_2 = repositioning\ costs\ per\ pallet$

$AGIV_i = Average\ gross\ invoice\ value\ of\ SKU\ i\ per\ order$

$i = 1, 2, \dots, n$

$\Delta_c = number\ of\ pallets\ per\ time\ unit$

Decision variables

$T = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$X = number\ of\ orders\ per\ time\ unit$

Formulas

Customer handling costs $(\mathbf{4}) = \Delta_c \times (\varepsilon_1 + \varepsilon_2)$, where

Customer cycle stock costs $(\mathbf{5})$ (Silver, Pyke, & Peterson, 1998) $= \sum_{i=1}^{n} 1/2 \times AGIV_i \times h$

Customer administrative costs $(\mathbf{6}) = \alpha X$

$X = \dfrac{\Delta_c}{T}$

$\Delta_c = total\ amount\ of\ full\ pallets + \dfrac{total\ amount\ of\ layers\ ordered}{8}$

Appendix V –Assumptions current situation

- Demand does not change
- All costs can be linearly extrapolated to calculate the costs per year

Administrative costs
- The costs per order are equal to P&G's Western Europe costs per order: ███████████
- One order = one shipment
- When products are ordered per layer, a new B2 pallet can be composed of 8 layers

Cycle stock holding costs
- The customer order quantity is equal to the customer store demand
- The customer's safety stock will remain the same; cycle stock holding costs are only determined based on the actual customer demand and the associated cycle stock.
- Cycle stock holding costs are ██ of the gross invoice value. This is P&G's guideline.
- Stock decreases linearly; on average half of the ordered quantity is cycle stock
- The calculations for the cycle stock holding costs are based on the EOQ model.

Handling costs
- The customer makes 2 pallet movements in the DC:
  1) unloading the pallet of the truck & storing the pallet in the rack
  2) moving the pallet from the rack to the store picking area
- P&G makes 2 pallet movements in the DC:
  1) unloading the pallet of the truck & storing the pallet in the rack
  2) retrieving the pallet from the rack and loading it into the truck (moving the pallet to the store picking area when necessary is included here as well)
- ε_1 is assumed to be ████
- ε_2 is assumed to be ████
  ε_1 and ε_2 cover the pallet movements in the customer DC. The global guideline of Customer ██ is ██████ for these two movements together. In the sensitivity analysis, these values will be varied with to analyze the possible effects of cheaper/more expensive movements.
- ε is assumed to be █████ (= the costs for one pallet movement in Rumst)

Transportation costs
- It is assumed all loads are full truck loads, which contain ██ pallets. P&G's system is arranged in such a way that ██ pallets is the minimum for a FTL.

Appendix VI – P&G cost model double stacking

Parameters

$\alpha = administrative\ costs\ per\ order$

$\varepsilon = (un)loading\ costs\ per\ pallet$

$\rho_{qr} = average\ transportation\ costs\ for\ one\ shipment\ from\ shipping\ point\ q$
$to\ customer\ location\ r$

$\iota_p = \dfrac{discount}{premium} per\ category\ p$

$\kappa = investment\ costs$

$p = 1$ ▮▮▮▮ $2\ ($▮▮▮▮$)$

$\Delta_{cqr} = number\ of\ pallets\ per\ time\ unit\ from\ shipping\ point\ q\ to\ customer\ location\ r$

$\Delta_{DSr} = number\ of\ pallets\ per\ time\ unit\ in\ B1\ equivalents\ to\ customer\ location\ r$

$q = 1(Rumst), 2(Amiens), 3(Euskirchen)$

$r = 1, \dots, 13$

Decision variables

$\beta = \%\ of\ assortment\ on\ B1\ pallets$

$\delta_1 = \%\ twins\ first\ move\ P\&G\ DC$

$\delta_2 = \%\ twins\ second\ move\ P\&G\ DC$

$T = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$X_{qr} = number\ of\ shipments\ per\ time\ unit\ from\ shipping\ point\ q\ to\ customer\ location\ r$

Formulas

$$\textbf{\textit{P\&G transportation costs }}(\textbf{7}) = \sum_{q=1}^{3}\sum_{r=1}^{13}\frac{\beta \times \Delta_{DSr}}{2T}\times \rho_{1r} + \frac{(1-\beta)\times \Delta_{cqr}}{T}\times \rho_{qr}$$

$$\textbf{\textit{P\&G handling costs}}(8) = \sum_{r=1}^{13}\varepsilon \times \Delta_{1r}$$

$$\Delta_{1r} = 2 \times \Delta_{c1r}\times (1-\beta) + \Delta_{DS}\times \beta \times \left(\left(1-\frac{\delta_1}{2}\right)+\left(1-\frac{\delta_1}{2}\right)\right)$$

$$\textbf{\textit{P\&G administrative costs }}(9) = \alpha X$$

$$X = \frac{(\Delta_{\text{DS}} \times \beta) \times \left(1 - \frac{\delta}{2}\right) + \Delta_{\text{c}} \times (1 - \beta)}{T}$$

$$\Delta_{\text{c}} = total\ amount\ of\ full\ pallets + \frac{total\ amount\ of\ layers\ ordered}{8}$$

$$\Delta_{\text{DS}} = total\ amount\ of\ full\ pallets\ in\ B1\ equivalents + \frac{total\ amount\ of\ layers\ ordered}{4}$$

$P\&G$ costs of changing trade terms $(\mathbf{10}) = \Theta_2(\iota_2 - \iota_1)$

$P\&G$ investment costs $(11) = \kappa$

$$X = \frac{(\Delta_{\text{DS}} \times \beta) \times \left(1 - \frac{\delta}{2}\right) + \Delta_{\text{c}} \times (1 - \beta)}{T}$$

$$\Delta_{\text{c}} = total\ amount\ of\ full\ pallets + \frac{total\ amount\ of\ layers\ ordered}{8}$$

$$\Delta_{\text{DS}} = total\ amount\ of\ full\ pallets\ in\ B1\ equivalents + \frac{total\ amount\ of\ layers\ ordered}{4}$$

Appendix VII – Customer cost model double stacking

Parameters

$\alpha = administrative\ costs\ per\ order$

$h = cycle\ stock\ holding\ costs\ percentage\ of\ gross\ invoice\ value$

$\Delta_c = number\ of\ normal\ pallets\ per\ time\ unit$

$\Delta_{DS} = number\ of\ pallets\ per\ time\ unit\ in\ B1\ equivalents$

$\varepsilon_1 = unloading\ costs\ per\ pallet$

$\varepsilon_2 = repositioning\ costs\ per\ pallet$

$\Theta_p = total\ gross\ invoice\ value\ of\ products\ per\ discount/premium\ category\ p$

$\iota_p = discount/premium\ per\ category\ p$

$\kappa = investment\ costs$

$i = 1, 2, \dots, n$

$p = 1\ \rule{2cm}{0.3cm}\ 2\ \rule{2cm}{0.3cm}$

Decision variables

$\beta = \%\ of\ assortment\ on\ B1\ pallets$

$\delta = \%\ twins\ first\ move\ customer$

$T = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$AGIV_i = Average\ gross\ invoice\ value\ of\ SKU\ i\ per\ order$

$X = number\ of\ orders\ per\ time\ unit$

Formulas

Customer handling costs $(12) = \left((\Delta_{DS} \times \beta) \times \left(1 - \frac{\delta}{2}\right) + \Delta_c \times (1 - \beta) \right) \times \varepsilon_1 + \left((\Delta_{DS} \times \beta) + \Delta_c \times (1 - \beta) \right) \times \varepsilon_2$

Customer cycle stock costs (13) (Silver, Pyke, & Peterson, 1998)$= \sum_{i=1}^{n} 1/2 \times AGIV_i \times h$

$AGIV_i =$

$\dfrac{AGIV_i}{average\ ordering\ quantity\ SKU\ i\ in\ B1\ equivalents}$ $if\ 1\ B1 \leq average\ ordering\ quantity\ SKU\ i \leq 2\ B2$

$AGIV_i\ otherwise$

Customer administrative costs $(14) = \alpha X$, where

$X = \dfrac{(\Delta_{DS} \times \beta) \times \left(1 - \frac{\delta}{2}\right) + \Delta_c \times (1 - \beta)}{T}$

$\Delta_c = total\ amount\ of\ full\ pallets + \dfrac{total\ amount\ of\ layers\ ordered}{8}$

$\Delta_{DS} = total\ amount\ of\ full\ pallets\ in\ B1\ equivalents + \dfrac{total\ amount\ of\ layers\ ordered}{4}$

Customer costs of changing trade terms $(15) = \Theta_2(\iota_1 - \iota_2)$

Customer investment costs $(16) = \kappa$

Appendix VIII –Assumptions double stacking

- Demand does not change
- All costs can be linearly extrapolated to calculate the costs per year

Administrative costs
- The costs per order are equal to P&G's Western Europe costs per order: ███████████
- One order = one shipment
- When products are ordered per layer, a new B1-pallet can be composed of 4 layers

Cycle stock holding costs (customer)
- The customer order quantity is equal to the customer store demand
- The customer's safety stock will remain the same; cycle stock holding costs are only determined based on the actual customer demand and the associated cycle stock.
- Cycle stock holding costs are ██ of the gross invoice value. This is P&G's guideline.
- Stock decreases linearly; on average half of the ordered quantity is cycle stock
- Cycle stock will only change when the average amount of products ordered per time ordered is between 1 B1 and 2 B2, C2, J2 or P2 pallet(s), because:
    - When the pallet type is already B1 or P1, the amount of products ordered will not change
    - When ordering on average more than 2 B2, C2, J2 or P2 pallets per product per time and there are more trucks arriving than the number of times the product is delivered, there is no cycle stock benefit to order less (also due to promotions)
- When ordering on average less than 1 B1-pallet per time, the ordering amount (in terms of items) will not increase in any situation. The cycle stock costs will outweigh the economies of scale of ordering more at once.
- When the delivery frequency becomes higher than once per day, the cycle stock does not change.
- The calculations for the cycle stock holding costs are based on the EOQ model.

Handling costs
- The customer makes 2 pallet movements in the DC:

    1) unloading the pallet of the truck & storing the pallet in the rack

    2) moving the pallet from the rack to the store picking area
- P&G makes 2 pallet movements in the DC:

    1) unloading the pallet of the truck & storing the pallet in the rack

    2) retrieving the pallet from the rack and loading it into the truck (moving the pallet to the store picking area when necessary is included here as well)
- ε_1 is assumed to be ████
- ε_2 is assumed to be █████

    ε_1 and ε_2 cover the pallet movements in the customer DC. The global guideline of Customer █ is ██████ for these two movements together. In the sensitivity analysis, these values will be varied with to analyze the possible effects of cheaper/more expensive movements.
- ε is assumed to be ████ (= the costs for one pallet movement in Rumst)
- $\delta=\delta_2$ is assumed to be 60%. > 80% of the volume has an ordering quantity ≥ 2 B1-pallets. Besides, the amount of double stacked movements is limited by the weight per pallet as well; heavy products cannot be double stacked. It is assumed that 20% of the products is too heavy to double stack, which makes a rough estimate of 60%.

- δ_1 is assumed to be 80%. It could be argued that all pallets shipped between the plants and P&G's DC could be double stacked; however, there are weight restrictions which will limit the percentage. It is assumed that 20% of the pallets is too heavy to double stack.

Trade terms
- Only the change in trade terms costs is assessed, not the total GIV, because of simplification. As reference, the total gross invoice value will be given to determine the relative impact.
- As a given: the discount/premium per specific situation is shown in Table 22 and Table 23 below.

Table 22: Current trade terms; NL=The Netherlands and BELU=Belgium and Luxembourg

- The trade terms in case of double stacking will become the following:

Table 23: New trade terms for double stacking; NL=The Netherlands and BELU=Belgium and Luxembourg

- Ex-plant deliveries will be eliminated. All products are sent from one full service distribution center then (Rumst DC in this case). Subsequently, the ex-plant discount will be eliminated.
- The possible change in the number of pallets shipped and the number of shipments will not affect the final outcome of the trade terms.

Transportation costs
- It is assumed all loads are full truck loads, which contain ▮ pallets. P&G's system is arranged in such a way that ▮ pallets is the minimum for a FTL.

Investment costs
- All investments are covered by κ

Appendix IX – P&G cost model on-top loading

Parameters

$\alpha = administrative\ costs\ per\ order$

$\delta = additional\ costs\ per\ shipment\ for\ on-top\ loading$

$\varepsilon = (un)loading\ costs\ per\ pallet$

$\kappa = investment\ costs$

$\rho_{qr} = average\ transportation\ costs\ for\ one\ shipment\ from\ shipping\ point\ q$

$to\ customer\ location\ r$

Δ_{qr}
$= number\ of\ full\ pallets\ per\ time\ unit\ supplied\ from\ shipping\ point\ q\ to\ customer\ location\ r$

$q = 1(Rumst), 2(Amiens), 3(Euskirchen)$

$r = 1, \dots, 13$

Decision variables

$T = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$X_{qr} = number\ of\ shipments\ per\ time\ unit\ from\ shipping\ point\ q\ to\ customer\ location\ r$

Formulas

$$P\&G\ transportation\ costs\ (\mathbf{17}) = \sum_{q=1}^{3}\sum_{r=1}^{13} \rho_{qr} \times X_{qr}$$

$$P\&G\ handling\ costs\ (\mathbf{18}) = \sum_{r=1}^{13} \varepsilon \times 2 \times \Delta_{1r} + X_{qr} \times \delta$$

$$P\&G\ administrative\ costs\ (19) = \alpha \sum_{q=1}^{3}\sum_{r=1}^{13} X_{qr}$$

$$X_{qr} = \frac{\Delta_{qr}}{T}$$

$$P\&G\ investment\ costs\ (20) = \kappa$$

Appendix X – Customer cost model on-top loading

Parameters

$\alpha = administrative\ costs\ per\ order$

$h = cycle\ stock\ holding\ costs\ percentage\ of\ gross\ invoice\ value$

$\varepsilon_1 = unloading\ costs\ per\ pallet$

$\varepsilon_2 = repositioning\ costs\ per\ pallet$

$AGIV_i = Average\ gross\ invoice\ value\ of\ SKU\ i\ per\ order$

$i = 1, 2, \dots, n$

$\Delta_c = number\ of\ full\ pallets\ per\ time\ unit$

Decision variables

$\text{T} = average\ number\ of\ floor\ positions\ used\ in\ a\ truck$

Dependent variables

$\text{X} = number\ of\ orders\ per\ time\ unit$

Formulas

Customer handling costs $(\mathbf{21}) = \Delta_c \times (\varepsilon_1 + \varepsilon_2)$

Customer cycle stock costs $(\mathbf{22})$ (Silver, Pyke, & Peterson, 1998)$= \sum_{i=1}^{n} \frac{1}{2} \times AGIV_i \times h$

Customer administrative costs $(\mathbf{23}) = \alpha \text{X}$

$\text{X} = \frac{\Delta_c}{T}$

Appendix XI –Assumptions on-top loading

- Demand does not change
- All costs can be linearly extrapolated to calculate the costs per year

Administrative costs
- The costs per order are equal to P&G's Western Europe costs per order: ▮▮▮▮▮▮▮
- One order = one shipment
- When products are ordered per layer, all layers are put on top of full B2 pallets. The amount of full B2 pallets with layers on-top would only be app. 25%, because the customers are ordering much more full B2 pallets than layers. Per full pallet, it is assumed that two layers of another product can be put on-top.

Cycle stock holding costs
- The customer order quantity is equal to the customer store demand
- The customer's safety stock will remain the same; cycle stock holding costs are only determined based on the actual customer demand and the associated cycle stock.
- Cycle stock holding costs are ▮ of the gross invoice value. This is P&G's guideline.
- Stock decreases linearly; on average half of the ordered quantity is cycle stock
- The calculations for the cycle stock holding costs are based on the EOQ model.

Handling costs
- The customer makes 2 pallet movements in the DC:
  1) unloading the pallet of the truck & storing the pallet in the rack
  2) moving the pallet from the rack to the store picking area
- P&G makes 2 pallet movements in the DC:
  1) unloading the pallet of the truck & storing the pallet in the rack
  2) retrieving the pallet from the rack and loading it into the truck (moving the pallet to the store picking area when necessary is included here as well)
- ε_1 is assumed to be ▮▮
- ε_2 is assumed to be ▮▮
  ε_1 and ε_2 cover the pallet movements in the customer DC. The global guideline of Customer ▮ is ▮▮▮▮ for these two movements together. In the sensitivity analysis, these values will be varied with to analyze the possible effects of cheaper/more expensive movements.
- ε is assumed to be ▮▮▮ (= the costs for one pallet movement in Rumst)
- δ ▮▮▮▮ per shipment. This is based on a test case executed to test this scenario.

Transportation costs
- It is assumed all loads are full truck loads, which contain ▮ pallets. P&G's system is arranged in such a way that ▮ pallets is the minimum for a FTL.

Investment costs
- All investments are covered by κ

Appendix XII – Cost overview per scenario Customer A (confidential)

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Appendix XIII – Cost overview per scenario Customer B (confidential)

Appendix XIV – Cost overview per scenario Customer C (confidential)

Appendix XV – Cost overview per scenario Customer D (confidential)

Appendix XVI – Cost overview per scenario Customer E (confidential)