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Master Thesis MSc. Business Administration

Topic: Via a cost estimation model for volatility towards a more efficient supply chain: a case study at Case company.

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Management Summary

Nowadays many organisations have to operate in an uncertain and fast changing environment, which is highly turbulent and volatile. This brings constraints and limitations and therefore requires a high amount of flexibility within organisations. This research has a focus on demand side uncertainty, the frequent and unpredictable changes in demand. The research has been carried out at a case company, a producer of fast moving consumer goods (FMCG) in the personal care industry. The problem statement analysed was *"How should FMCG organisations deal with volatility of customers' demand and its related costs within their supply chain?"*. The goal of this research was to provide a better understanding of the impact of volatility on costs and to provide the case company with hands-on recommendations to become less dependent on the volatility of their customers' demand.

To carry out this research the design science methodology has been used. This methodology focusses on whether a particular design is suitable in a given setting. The design science methodology is recognised for its ability to bridge the relevance gap between theory and practice. During the relevance cycle the case has been analysed extensively, to identify the relevance of the problem statement. During the rigor cycle a literature research has been carried out in order to identify the origins, consequences and costs of volatility and their applicability on the FMCG business. This general knowledge has been applied on the specific case, resulting in a volatility cost model which did not exist in academic literature yet. The model shows that both process related costs as well as overhead costs are subject to volatility. During the design cycle a redesign for the process analysed within the case company has been developed. By moving the decoupling point upstream in the process and by eliminating additional process steps as much as possible the organisation will obtain a more flexible and less expensive supply chain. If customisation on products is only done after the customer demand, the order, is fully known the organisation will become less vulnerable to volatility in their customers' demand, because the demand of the customer will penetrate less far into the process.

This research can be used as a starting point for scholars that want to develop a general cost model for volatility. To be able to improve and generalise the model proposed in this research follow-up studies in different organisations and in different industries have to be done.

Content

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List of abbreviations

ADR	'Accord européen relatif au transport international de marchandises Dangereuses par Route' – classification for flammable products
DCS	Delivery to customer and storage
FMCG	Fast moving consumer goods
LAS	Logistics added service – repacking is done after picking the goods
MRP	Material requirements planning
OOS	Out of stock
PS	Problem statement
RQ	Research question
SC	Subcontractor
SKU	Stock keeping unit
VAS	Value added service – repacking is done before picking the goods
VMI	Vendor managed inventory

1 Introduction: volatility in demand leads to high costs and either excess stock or out of stock situations – The relevance cycle

1.1 Introduction to volatility and its implications

Today, many companies face an uncertain environment which is highly turbulent and volatile[1]. In general, four sources of uncertainty can be identified; supply side uncertainty, process side uncertainty, control side uncertainty and demand side uncertainty[2]. This research will focus on demand side uncertainty, the frequent and unpredictable changes in demand. However, different types of volatility will be addressed during the literature review. Volatility is a phenomenon that describes frequent, rapid and unpredictable changes[3]. The research will be carried out at a case company, a producer of fast moving consumer goods (FMCG) in the personal care industry. The impact of volatility in demand for their business will be researched. Demand volatility is defined as inconsistent, highly variable demand for a company's goods and/or services[4].

Volatility has an influence across organisations, both on the process and the control side of an organisation. Volatility can have an impact on prices, demand, security of supply, planning, sourcing, and so on. This means that the whole supply chain will be influenced by volatility on a daily basis. Unsecure upstream and downstream prices directly affect the profit margins of organisations[5]. Unsecure demand and supply directly affect stock levels, production planning schedules and sourcing decisions. In a broader perspective volatility can even influence make or buy decisions, investment decisions, the amount of labour needed and the use of subcontractors. Volatility obviously results in additional costs for an organisation. A mismatch in demand and supply results in either excess stock or out of stock situations[6]. Furthermore, volatility can result in adjusted or extra process steps and necessary investments in people and processes.

1.2 Description of Case company Amsterdam: a subsidiary of an international producer of innovative skin care products

This research will be carried out within Case company Amsterdam, an independent subsidiary of Case company head quarter. The company produces innovative skin care

[1] See Tachizawa/Thomsen (2007), p.1115
[2] See Yang/Burns (2003), p.2082
[3] See Oxord Dictionary, via http://www.oxforddictionaries.com/definition/english/volatile
[4] See Saldanha et al. (2013), p.314
[5] See Wong et al. (2006), p.712
[6] See Hendricks/Singhal (2009), p.509

products and is responsible for the supply of A-listed brands like Brand A, Brand B and Brand C. Case company head quarter was founded in 1882, Case company was established in 1932. Globally, the company focuses on fast growing markets in Asia and South-America, to stay competitive in the fast moving market. The company consists of more than 150 affiliates and has more than 16.500 employees. Around 80 people in different disciplines are working at the office of Case company in Amsterdam, to supply the Dutch market. Case company does not have a production facility in the Netherlands, the products for the Dutch market are mainly produced in Germany and Poland.

1.3 Case description: the volatile demand curve and the repack process for Customer A lead to inflexibility, high transport costs and storage of two variants per article

This research wascarried out at the supply chain department of Case company, which especially has to deal with the sometimes highly volatile demand of Case company's customers. The research will focus on so called value added services (VAS) articles that fall under ADR legislation and are delivered to Customer A (Retailer B and Retailer A).
Articles fall under ADR legislation when they are flammable. ADR is an abbreviation for *'Accord européen relatif au transport international de marchandises Dangereuses par Route'*, which states that all flammable products must be classified, in order to decide how they should be treated, transported and stored[7]. The decision to focus on these ADR products was made because they are costly to transport and store, as precautions for fire prevention have to be taken. Furthermore, some very good selling articles, like Brand A deodorants and hair sprays, are amongst this group of products which makes this a relevant research for Case company.
An article becomes a VAS article when it is cultivated and therefore differs from a standard product. For Customer A, Case company has to repack all their standard products. Standard products, shower gels, deodorants, shampoos etc., are packed with twelve in a carton and shrinked (packed together in plastic) per six products. Customer A however, wants to receive these products in cartons that contain only six pieces of an article. These requirements from Customer A have to do with the storage of flammable products in their warehouses and shops and the number of items that can stay on the shelf.

[7] See Rijksinstituut voor Volksgezondheid en Milieu, Risico's van stoffen – ADR (n.d.). Downloaded July 8th, from http://www.rivm.nl/rvs/Gevaarsindeling/ADR

After production the products for the Dutch market are shipped and stored at a warehouse in ‘s Heerenberg, which is not owned by Case company. Case company has to repack all their standard products for Customer A due to above mentioned requirements made by the customer. In the current situation all products that are to be delivered to Retailer B or Retailer A need to be transferred from the warehouse in ‘s Heerenberg (Gelderland) to the subcontractor in Stadskanaal (Groningen), and vice versa. Furthermore, this means that the warehouse in ‘s Heerenberg has two types of storage for every article, the standard variant and the repacked Customer A variant. This repack process results in high transport costs (around €75.000,- a year only for Customer A articles) and inflexibility due to storage of two variants of the same article. Case company establishes a rolling promotion planning with all their customers to get visibility on peaks in demand, since these peaks in demand are almost always caused by promotions as figures 7 and 8 will show. However this still does not give Case company full visibility on demand, since Customer A can change the place where products will be placed in stores during promotions within days. It makes a difference if products appear on their regular spot on the shelf, or that they are displayed at the front end of the shelf. Since volatility is a phenomenon that describes frequent, rapid and unpredictable changes the demand of Customer A will be considered volatile[8]. As figures 7 and 8 show promotions placed at the front end of the shelf can result in twice as high sales and therefore demand as promotions placed at the regular spot on the shelf.

Because of the high volumes (repack quantity around 4.1 million pieces a year), the volatility of Customer A’s demand and the fact that Customer A is the second biggest customer of Case company (see figure 1), it is worthwhile to investigate whether a change in the process of repacking ADR products for Customer A could lead to more flexibility in the supply chain and a cost saving for Case company.

[8] [8] See Oxord Dictionary, via http://www.oxforddictionaries.com/definition/english/volatile

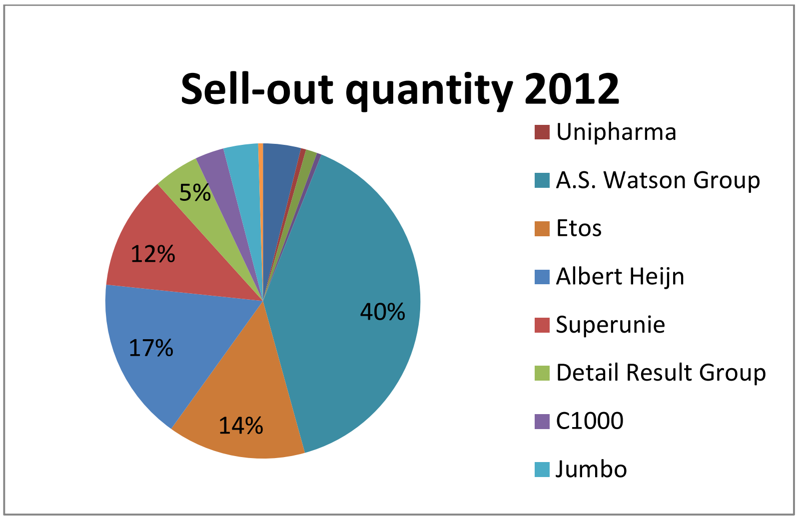

Figure 1: Sell out quantity (all ADR products) in 2012

1.4 Problem statement: "How should FMCG organisations deal with volatility of customers' demand and its related costs within their supply chain?"

Based on the available information regarding demand volatility, and the case description provided, the problem statement for this research is:

"How should FMCG organisations deal with volatility of customers' demand and its related costs within their supply chain?"

The problem statement should be answered through several research questions, which are outlined below.

This research will focus on volatility in demand. The goal is to provide organisations with an opportunity to deal in a more efficient way with demand volatility. To examine how a company can deal best with this volatility, it is important to identify the origins of volatility. Therefore, the first research question will be:

"What are the origins of volatility?"

After the origins of volatility have been identified it is important to get a clear view on their consequences for the business. By examining the consequences the impact of volatility on supply chain management will become clear. This results in the second research question:

"What are the consequences of volatility for the business?"

A company needs to make profit in order to survive in the market. Since competition in the FMCG sector is heavy nowadays, it is important to produce, sell and deliver the products as (cost) efficient as possible. To make the (repack) process more cost efficient, it is important to identify the costs of volatility within the process. The third research question will be:

"Which costs in the supply chain can be related to volatility?"

This research will be carried out within a case company, Case company. To provide them with a solution feasible for their case as described in section 1.3, it is necessary to identify which of the origins of volatility are applicable on their case. The fourth research question is:

"Which of the origins of volatility are applicable on the FMCG business?"

To design a new (repack) process which will make Case company less dependent on the volatility of Customer A's demand, the current process need to be described in detail. The influence of volatility on this process needs to be highlighted, in order to provide a feasible solution. Therefore, the fifth research question will be:

"How is the current repack process for Customer A influenced by volatility?"

As could be derived from the problem statement, it is important to redesign the process so that it becomes more efficient and less costly. In particular it is important that the new process should make Beierdorf NV less influenced by volatility. In order to know how this redesign should be done, it is important to analyse existing literature on supply chain process (re)design. Therefore, the last research question is:

"What are successful (re)designs for upstream supply chain processes within FMCG, to be as little as possible influenced by volatility?"

A structured overview of the problem statement (PS) and research questions (RQ) is provided in table 1.

PS.	How should FMCG organisations deal with volatility and its related costs within their supply chain?
RQ.1	What are the origins of volatility?
RQ.2	What are the consequences of volatility for the business?
RQ.3	Which costs in the supply chain can be related to volatility?
RQ.4	Which of the origins of volatility are applicable on the FMCG business?
RQ.5	How is the current repack process for Customer A influenced by volatility?
RQ.6	What are successful (re)designs for upstream supply chain processes within FMCG, to be as little as possible influenced by volatility?

Table 1: Structured overview of problem statement and research questions

1.5 Thesis structure: a cost estimation model as a basis to be less dependent on volatility

So far, an introduction to volatility has been provided. Furthermore, the case has been outlined and the problem statement and research questions have been presented. In the remainder of this thesis, answers to the research questions will be provided by an in-depth analysis of volatility and its related costs.

In the next section the chosen research methodology, design science research, will be outlined and discussed. The section thereafter will be a literature research about the origins of volatility, their consequences and related costs. This section will result in a cost estimation model for volatility. The fourth section will elaborate on supply chain designs that enable an organisation to handle volatility as efficient as possible. The thesis will end with conclusions and managerial implications. Furthermore, the relevance and limitations of this research will be presented.

2 Research methodology

2.1 Goal of this research: to provide a better understanding of the impact of volatility on costs and to provide Case company with recommendations to become less dependent on the volatility of their customers' demand

The goal of this research is twofold. First, this research will contribute to existing academic literature by providing a better understanding of the influence of volatility on business, especially on costs. This part of the research will result in a cost estimation model for volatility. In addition, this research will provide a specific company, Case company, with hands-on recommendations to become less dependent on the volatility of their customers' demand.

Research can be carried out within three categories of scientific disciplines. The first one is the formal sciences, whose mission is to build systems of propositions that test their internal logical consistency. The second one is the explanatory science, which describes, explains and possibly predicts observable phenomena within a certain field. The third category is design science, whose mission is to develop knowledge for instrumental use. This means using the research results to act in a specific and direct way, for designing solutions in a specific field of research. Design science research supports the design of interventions, to solve improvement problems[9].

2.2 Design science research: interaction between the environment, the knowledge base and a new design

This research will adopt a design research methodology for various reasons. First of all, design science is successfully used beforehand to research engineering issues. Improvement problems, designing a new process or structure according to specifications as performance and cost, are typical engineering problems that can be solved with design research[10]. The redesign of the repack process for Case company is an example of an improvement problem. The key question in design research is whether a particular design is suitable in a given setting, whether it will work or not[11]. Second, the design science research approach states that general knowledge must be translated to a specific case or issue[12]. General knowledge will be obtained by examining the origins, consequences and costs of volatility. The specific case where the knowledge will be applied to is designing a more (cost) efficient repack process that ensures the case company is as little as possible influenced by demand volatility of its customers. Last but not least, the design research methodology tries to bridge the relevance gap between theory and practice, the weakness organization and management theory is often criticised for[13]. This research will contribute to bridge the relevance gap by designing a solution for an improvement problem brought up by the business, based on findings in academic literature.

[9] See van Aken (2004), p.223/224
[10] See van Aken (2005), p.24
[11] See Romme (2003), p.564
[12] See Romme (2003), p.563; van Aken (2004), p.227
[13] See Romme (2003), p.559

Design science is not concerned with the action itself, but with the knowledge that will be used in designing solutions. This will be followed by design-based actions to solve a specific case[14]. By adopting a design research methodology, which is often done in case studies, the focus will lay on establishing the right specifications. Understanding the needs of the client is a key concern[15].

The outcome of design research is a set of design propositions, providing recommendations for the best possible solution[16]. These propositions are often prescriptions with a heuristic nature, "if you want to achieve Y in situation Z, then something like action X will help"[17]. These propositions will be developed using three cycles, the relevance cycle, the rigor cycle and the design cycle[18]. The use of these three cycles leads to the research model below.

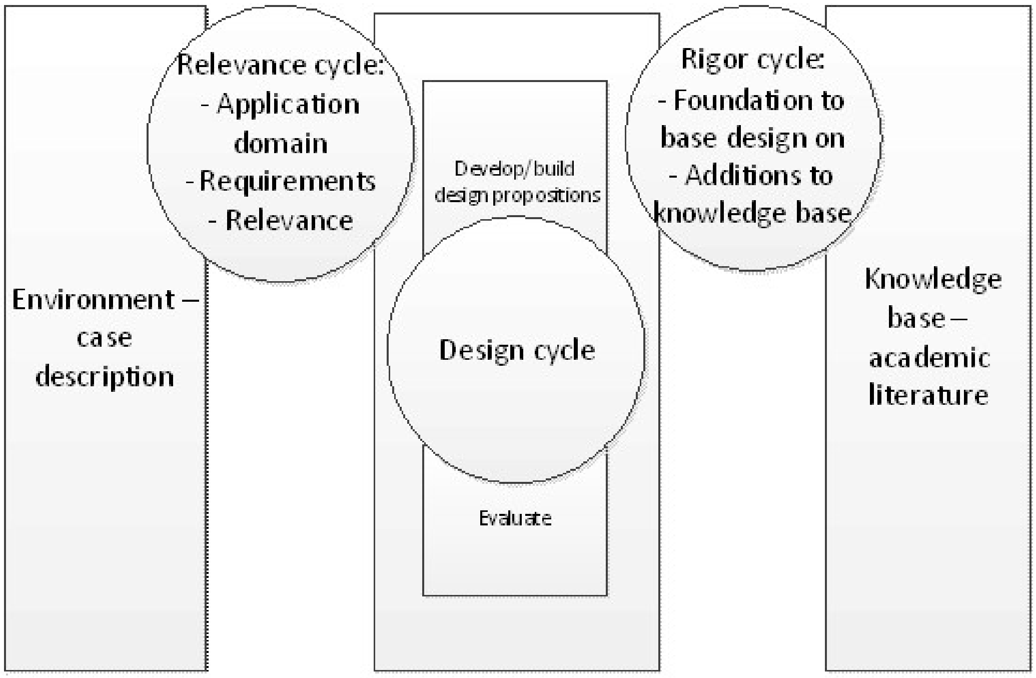

Figure 2: Research model, based on Hevner et al., 2004; Hevner, 2007

2.3 The relevance cycle: identifying the relevance of the problem

During the relevance cycle, the goal is to identify the problem in an actual application environment[19]. Case company perceives the current repack process as too costly and

[14] See van Aken (2004), p.226
[15] See van Aken (2007), p.69/70
[16] See Romme (2003), p.569; See van Aken (2004), p.228
[17] See van Aken (2004), p.227
[18] See Hevner et al. (2004); Hevner (2007)
[19] See Hevner (2007), p.89

inflexible. Because of this inflexibility, Case company cannot always handle the volatility in demand of their customers, resulting in either excess stock or out of stock situations. This means that they have either high storage costs, or they are not able to deliver the demanded products to the customer which results in lost sales. The relevance cycle addresses the opportunity or problem to be solved and defines the acceptance criteria for the evaluation and acceptance of the research results (the solution)[20]. To discover what the problem exactly is, an investigation of the current repack process will be made. Demanded and sold volumes, lead times and costs of repacking, transport and warehousing will be detected. Furthermore, the current decoupling point and order scheme have to be analysed in order to identify if certain patterns exist. This will be done by analysing quantitative data available from SAP, the Nielsen database (customer order information), (financial) administration of transport and warehousing and contracts signed with third parties (warehouse, repack partner, transportation company). The outcome of the relevance cycle should be a clear problem definition, grounded with data. As a result, a detailed description of the current process must be given, including all process steps, lead times and costs. Last but not least, requirements for the ideal problem solution should be presented. Chapter 1 and section 5.1 will be the outcome of the relevance cycle.

2.4 The rigor cycle: a literature review to find applicable knowledge

Within the rigor cycle, the existing knowledge base regarding the exact problem found during the relevance cycle will be analysed. State-of-the-art knowledge about the application domain of the research and the existing artefacts and processes found in the domain of application need to be identified[21]. For this research a literature study will be carried out to get the required understanding of the current knowledge base. The origins of volatility and their influence on business, especially on the supply chain, will be analysed. Furthermore, a state of the art overview of literature about the influence of volatility on costs is needed in order to establish a cost estimation model for volatility. A thorough understanding of supply chain process (re)design is needed in order to provide Case company with suitable recommendations for their process redesign. Insisting the idea that all design research should be grounded on descriptive theories is unrealistic. The goal of

[20] See Hevner (2007), p.89
[21] See Hevner (2007), p.89

the rigor cycle is to find core theories on which to base the activities of design research[22]. Chapter 3 and 4 will be the outcome of the rigor cycle.

2.5 The design cycle: towards a cost calculation model and a new process design

During the design cycle, the real work of design research is done. The requirements for this cycle are input from the relevance and the rigor cycle. The relevance cycle should make clear what the actual problem is. The rigor cycle will result in a thorough understanding of the origins, consequences and costs of volatility, resulting in a general cost estimation model for volatility. Within the design cycle, design alternatives are generated. Furthermore, these alternatives will be evaluated against requirements from the relevance cycle, until a satisfactory improvement design is achieved[23]. The outcome of this cycle in the research will be design propositions that will result in recommendations to improve Case company's repack process. Section 5.2 and chapter 6 will be the outcome of the design cycle.

2.6 Collection of data

At this time, a cost estimation model for volatility does not exist within academic literature. To create such a model, the influence of volatility on costs needs to be identified. In order to identify this influence, the costs of diverse Case company products will be calculated. Thereafter, normal sales and sales during times of promotions will be analysed for deodorants. By examining the differences in volumes and costs between stable and volatile sales, the so called volatility costs can be identified. These costs have to be expressed in a percentage, in order to create a general cost estimation model for volatility. The costs will be obtained via the financial department of Case company. For costs that can or will not be provided an estimation needs to be made. As can be concluded from the previous information, this research will be a quantitative research.

[22] See Hevner (2007), p.90
[23] See Hevner (2007), p.90

3 The origins of volatility and their implications for business – The rigor cycle

3.1 Relevance: business should learn to gain from disorder, by clearly identifying the influence of volatility on the business, especially on costs

Almost every company, especially within the FMCG industry, is impacted by volatility on a daily basis. Volatility can have an impact on the processes side and the control side of an organisation, and on the supply and demand a company faces[24]. Continuously changing demand influences the production planning, stock levels, costs and profit margins[25].

The volatility phenomenon is investigated since the late 1800's. The first studies focused on the volatility of different chemicals. From 1980 onwards the influence of volatility on doing business is extensively researched, as the below figures show. Especially in Finance related studies volatility became a popular research topic[26]. Section 3.2 will elaborate more on the development of volatility related research.

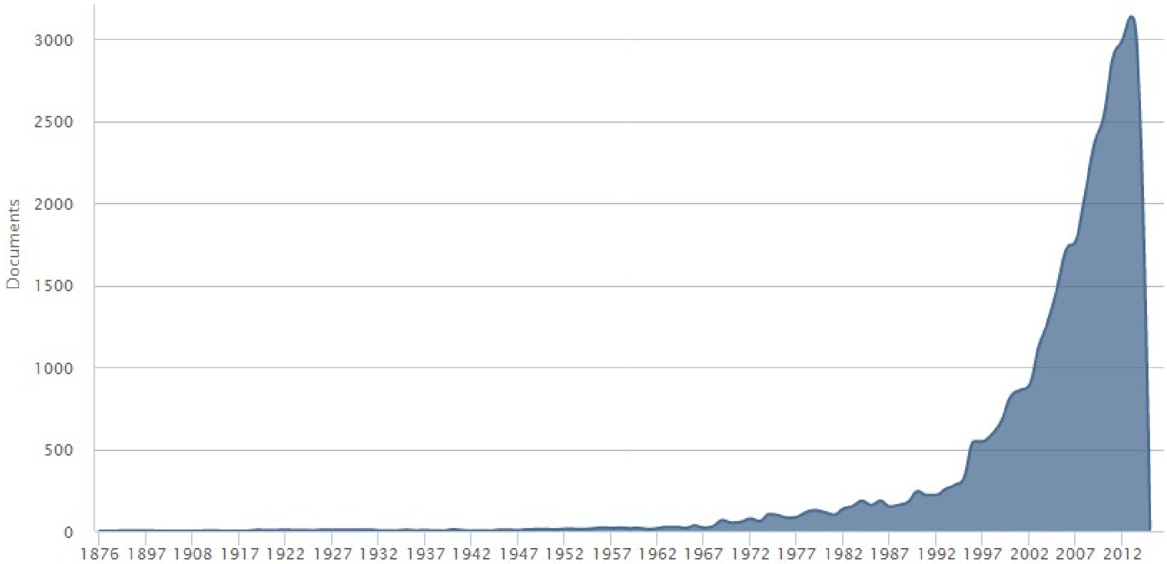

Figure 3: Publications on Scopus search query 'volatility' (October 19, 2014)

[24] See Yang/Burns (2003), p.2082
[25] See Kim/Springer (2008), p.173; Springer/Kim (2010), p.380; Kulp et al. (2004), p.435
[26] See Branger et al. (2008); Greenwood/Thesmar (2011); Schill (2004)

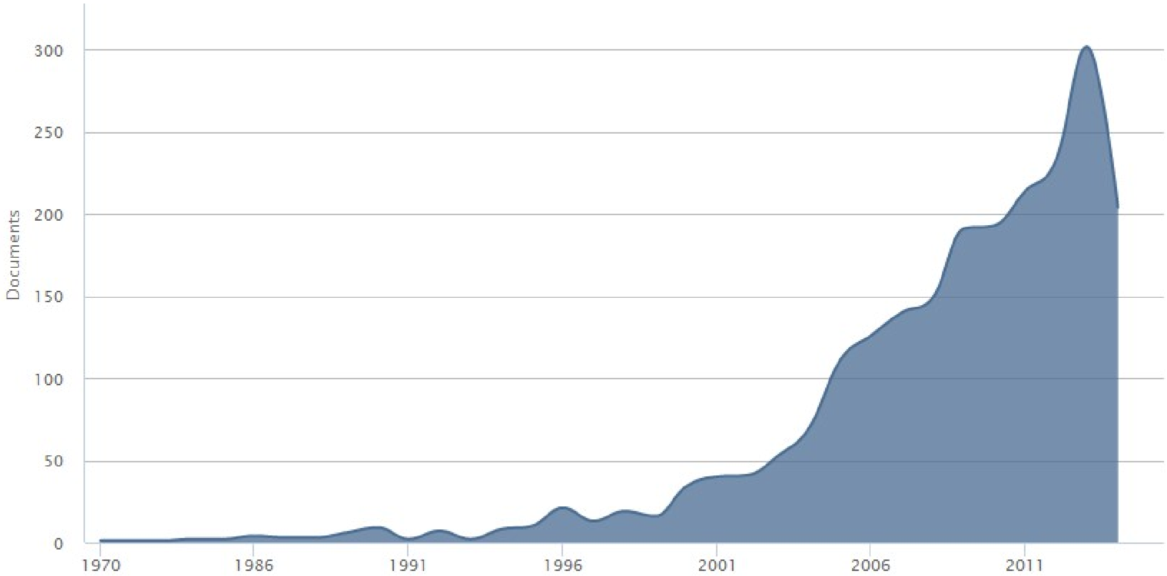

Figure 4: Publications on Scopus search query 'volatility AND business' (October 19, 2014)

Although volatility is often researched in finance related studies, relatively little research is done about the impact of volatility on (production) costs, as figure 5 shows.

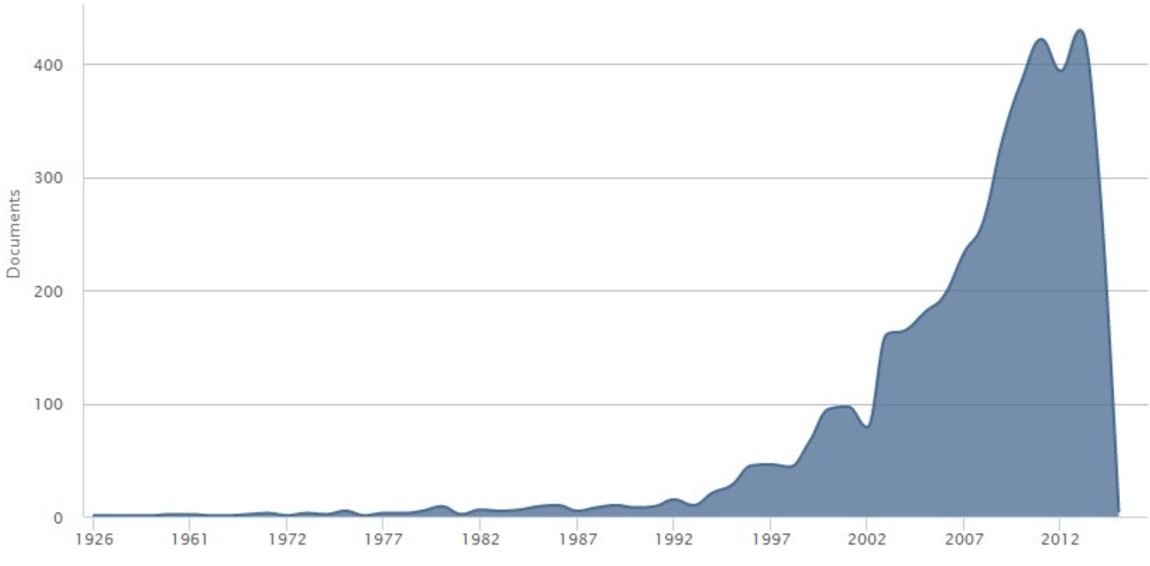

Figure 5: Publications on Scopus search query 'volatility AND costs' (October 19, 2014)

Demand volatility in particular has become a popular research topic from 2000 onwards, as figure 6 shows. Research about demand volatility is frequently done in the touristic and fashion industries and more recently in the (sustainable) energy sector[27]. In academic papers, demand volatility is in the majority of studies taken for granted. In these publications, the adaptor role as described by Gupta and Maranas (2003) is adopted.

[27] See Escobari/Lee (2013); Tashpulatov (2013); Wang et al. (2012); Lin/Prince (2013); Chan et al. (2005)

Therefore, much research about volatility in demand is focused on coping with volatility, and designing the supply chain as robust as possible given the volatile demand.

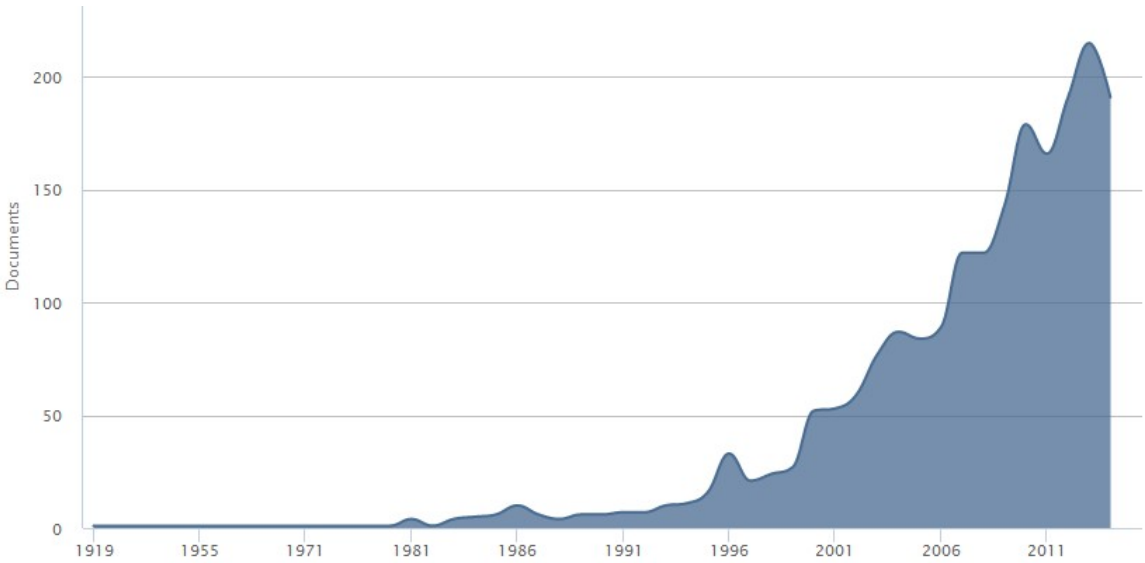

Figure 6: Publications on Scopus search query 'demand volatility' (October 19, 2014)

To cope with uncertainty in the supply chain, often caused by volatility and fragility, the robust supply chain design is extensively researched[28]. However, there are indications, for example in medicine studies, that it is possible to go even beyond robustness. Recent literature focusses on a state even beyond robustness. Taleb (2012) wrote a book called 'Antifragile', in which he states that there are things that gain from disorder. This book addresses the relevance of fragility and volatility and states that academics and business should not protect themselves from volatility; they should learn to gain from volatility. Academics and business should go beyond robustness, they need to become antifragile. Antifragile is the state that goes beyond robustness or resilience. The robust can resist shocks and stays the same, where the antifragile gets even better[29]. The key to handle volatility is to accept it, to embrace it and to understand the influence of turbulence on the business[30].

By combining existing academic findings regarding volatility and data collected at Case company, this thesis will describe the influence of volatility on costs in the FMCG industry. The resulting cost model will provide opportunities to attain a more robust state and maybe even a state with some antifragile elements.

[28] See Baghalian et al. (2013), p.200; Pishvaee et al. (2011), p.637/648
[29] See Taleb (2012), p. 12-13
[30] See Christopher/Holweg (2011), p.77-78

3.2 The history of volatility: findings in the financial sector have triggered volatility related research in the domain of supply chain management, resulting in the bullwhip effect as most often researched phenomenon

The first scientific contributions regarding volatility can be found in the late 1800's, in the Journal of the American Chemical Society and The Analyst. These studies focused on the volatility of different chemicals[31]. Almost a century later, from the 1980's onwards, volatility became a research topic of interest in finance related studies. Exchange rate volatility, stock return volatility, price volatility and interest rate volatility became popular research topics. Many of these financial studies are risk related. They investigate the link between the level of market uncertainty and the associated (stock) price volatility. The higher the uncertainty is, the more volatile the prices will be[32]. Furthermore, volatility became very relevant for asset pricing models and dynamic hedging strategies[33].

In the second half of the 1990's volatility got the attention of management science. Theories of market behaviour were linked to volatility and the influence of volatility on future markets got more and more attention. From 2000 onwards the influence of volatility on the supply chain is investigated extensively. In this supply chain related academic research, different types of volatility are distinguished. An often researched type of volatility is production volatility, uncertainty in the supply chain, also called output volatility. A reduction in this uncertainty will help to improve the performance in the supply chain and to increase value[34]. Commodity price volatility, especially related to oil and energy prices, is extensively researched in academic literature. Price volatility for commodities that serve as an input for production will have a negative impact on the macro economy. Price changes that have an influence on the optimal allocation of labour and capital will be costly, even as the delaying of investments when there is uncertainty about future prices and value of inputs and outputs[35]. The demand volatility related research within the domain of supply chain management focuses mainly on the bullwhip effect. This bullwhip effect is the phenomenon where the variability in demand increases more and more in the upstream part of the supply chain[36]. The order signals of end customers are amplified, resulting in upstream replenishment demand exceeding the original order

[31] See Hehner (1887); Waldbott (1894)
[32] See Kurz/Motolese (2001), p.499; Lazopoulos (2013), p.403
[33] See Bollerslev et al. (1992), p.46
[34] See Ewing/Thompson (2008), p.553
[35] See Regnier (2007), p.408
[36] See Lee et al. (1997), p.546; Chen et al. (2000), p.436; Fransoo/Wouters (2000), p.78

quantity[37]. For this research, it is important to realise that the bullwhip effect is a result of a lack of information about actual customer demand in the upstream supply chain. The variability in orders placed by a retailer at a manufacturer will be higher than the variability in demand from end consumers which the retailer experiences. The variability in orders which the manufacturer places at its suppliers will be even higher than the variability in the orders which the retailer places at the manufacturer[38]. Lee, Padmanabhang and Whang (1997) identified four causes for the bullwhip effect which are considered as the main causes for the bullwhip effect within research:

- Demand signal processing is the first cause identified. All players in the supply chain base their forecasting on orders they receive from the succeeding player in the chain. Increasing orders will lead to higher forecasts, which will lead to increased order quantities at the proceeding link in the supply chain. It works the other way around when demand decreases[39].
- The second cause of the bullwhip effect is the rationing game. In periods of shortage, a manufacturer will ration their products to the retailers in proportion of their orders. When this is known, retailers will order more than they actually need, to ensure they can cover the demand of their customers[40].
- Order batching is identified as the third cause of the bullwhip effect. A retailer faces ongoing demand from its customers. However, it is unlikely that the retailer will also place continuous orders at a manufacturer, often due to fixed order costs, agreed lead times or distribution efficiency. This results in higher variability in the orders the retailer places than in the demand the retailer experiences[41].
- The fourth cause of the bullwhip effect is a fluctuation in price. Promotions or trade deals lead to price fluctuations, which will increase the variability in demand. When the price of a product is low, for example during a promotion, customers will buy more than they actually need. During times of high prices a customer will buy less and use the available stock[42].

[37] See Mc Cullen/Towill (2002), p.165
[38] See Fransoo/Wouters (2000), p.79
[39] See Lee et al. (1997), p.549-551; Fransoo/Wouters (2000), p.79
[40] See Lee et al. (1997), p.551-552; Fransoo/Wouters (2000), p.80
[41] See Lee et al. (1997), p.553-554; Fransoo/Wouters (2000), p.79-80
[42] See Lee et al. (1997), p.554-555; Fransoo/Wouters (2000), p.80

There are studies that have shown that the intensity of the bullwhip effect varies per industry, or even per product family within the same industry or company[43]. In the personal care industry, where the case company for this research belongs to, the bullwhip effect is often very significant. Recent research investigated that the variability in the upstream supply chain is up to four times higher than the variability in the downstream supply chain[44]. Within the personal care sector the bullwhip effect is larger for products with a relatively stable retailer demand, due to sales targets which are very important in this industry. Due to these targets, manufacturers have an incentive to sell at the end of the month, while at the same time retailers benefit from forward buying products with a stable demand[45]. Even for different products in the same product family, for example shampoos, the intensity of the bullwhip effect can differ[46].

3.3 The origins of the highly volatile environment require a high amount of flexibility within the supply chain

3.3.1. Short product life cycles contribute to a volatile environment

Short product life cycles are addressed as one of the origins of volatility, caused by advanced current technology, increased competition and the development of the internet[47]. Characteristics of these products with shorter and shorter life cycles are rapid product substitution, rapid price decrease and an uncertain demand from the market[48]. Because of these shorter life cycles forecasting became more and more important, since non-availability of a product often means that an opportunity of sales is lost forever[49]. These shorter and shorter product life cycles result in volatility because it is never clear when the life cycle will end, how short it will actually be. This volatility caused by short product life cycles can be found especially in the retail and fashion industries. Companies acting in the FMCG industry have to cope with this type of volatility while optimizing their supply chain.

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[43] See Cachon et al. (2007), p.476; Zotteri (2013), p.492
[44] See Zotteri (2013), p.493
[45] See Zotteri (2013), p.496
[46] See Zotteri (2013), p.494
[47] See Tachizawa/Thomsen (2007), p.1115; Balakrishnan/Cheng (2007), p.305; Higuchi/Troutt (2004), p.1097
[48] See Hsu et al. (2008), p.602
[49] See Christopher/Towill (2002), p.2

3.3.2. Delivery time uncertainty leads to volatility in supply

Material requirements planning (MRP) provides a framework to manage production. Demands for the end product are forecasted, demand for the components or raw materials of the end product can be calculated by using the bill of material or recipe and planned lead time. The lead time equals the elapsed time from the release of an order until the delivery of the ordered item. Lead time is also called delivery time in literature. The quantity that is ordered is called lot size or batch size[50]. Lead time uncertainty has various causes, including scheduling issues at the supplier, uncertain material supply, capacity constraints, unstable production processes and quality issues[51]. The risk related to this lead time uncertainty is that the supplier is not able to deliver at the requested date, which will result in lost sales for the buyer. The buyer can cope with the lead time uncertainty by changing the safety stock, which will lead to increased inventory costs and decreasing working capital.

3.3.3. Frequent and unpredictable changes in demand are called demand volatility

3.3.3.1. Client behavior causes significant sales fluctuations

Demand volatility is mentioned as the origin of volatility with the biggest negative impact for the supply chain on both costs and customer service level[52]. The first source of demand volatility discovered in literature is client behaviour. The customers of manufacturers in the FMCG sector are retailers, not the end consumers of the products. Fluctuations in demand are most of the time not caused by changes in the demand of the end consumer, but generated within the supply chain as also discussed in section 3.2[53]. Volatility in demand caused by client behavior is called volume uncertainty, because the actual volume that will be demanded is not clear[54]. Volatility in demand is largely caused by cancelled or rushed orders. This can lead to either excess stock or out of stock situations. Pricing policies from retailers cause significant sales fluctuations and often lead to rushed orders. Fluctuations in pricing behaviour lead to volatility in the demand for the manufacturers' goods. Periodic price discounting for example encourages the end consumer to purchase more than needed in times of discount, they consume their excess over time and purchase

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[50] See Dolgui/Ould-Louly (2002), p.145
[51] See Weng/Mc.Clurg (2003), p.13
[52] See Acar et al. (2009), p.3265
[53] See Zotteri (2013), p.489
[54] See Tachizawa/Thomsen (2007), p.1118

again in another round of discount prices[55]. This volatile demand of retailers can make the bullwhip effect even stronger, when a company purchases more variably than it sells to customers, and can lead to a mismatch in supply and demand[56]. A possible solution to reduce the influence of client behaviour can be to make data on (end) consumer behaviour directly available for organisations further upstream in the supply chain[57].

3.3.3.2. Seasonality causes high peaks in customer demand

Seasonal fluctuations are the second source of demand volatility[58]. Depending on the season, the demand for products can fluctuate. The demand on special ski wear will be highest during the ski season. Sun care products will most likely show a peak in demand during the summer holidays. Seasonality has an extensive influence on supply chain management within an organisation. When supply reliability is low, often caused by poor forecasting management and long lead times, and production capacity is limited during the peak seasons, retailers place early and large orders to avoid out of stock situations at their shops. These early and large orders often create unnecessary extra seasonality, which moves the peak demand forward[59]. Seasonality is not always predictable, during a good summer a lot more sun care products will be sold than during a rainy summer. The influence of seasonality can be reduced by designing a coordinated responsive supply chain. Coordinated responsiveness requires knowledge and capabilities for quick and accurate response, as well as knowledge about providing incentives to change current ordering and risk taking behaviour within the supply chain. For a supply chain that is both volatile and seasonal the strategy should be to coordinate both pre-season orders, and replenishment during the season adequately[60]. Coordination of order behaviour, relocating large orders from large clients and shorter lead times can make a supply chain more coordinated responsive[61].

3.3.3.3. Changes in consumer preferences lead to volatility in demand

Although the end consumer is not the direct client of an FMCG company, the behaviour of end consumers is the third source of demand volatility identified in literature. In dynamic

55 See Hamister/Suresh (2008), p.443
56 See Bray/Mendelson (2012), p.771
57 See Fransoo/Wouters (2000), p.79
58 See Gupta/Maranas (2003), p.1220
59 See Wong/Hvolby (2007), p.409
60 See Wong/Hvolby (2007), p.417
61 See Wong/Hvolby (2007), p.410

environments, as FMCG is, customers' shopping behaviour, buying criteria and segments change often[62]. These changes in preferences can lead to fluctuations in demand and therefore cause demand uncertainty[63]. Volatility in demand caused by changing customer preferences is called mix uncertainty, because it is not clear which specification of the product will be demanded[64]. Related to this research this means that it is more or less clear what the demand for deodorant will be, however the demand for the various types of deodorant can differ a lot. Product preferences can be influenced by several factors. Changes in the financial situation can force consumers to buy other products or brands than they normally do[65]. Branding, creating a unique name and image for a product in the consumers' mind, is an opportunity the manufacturer has to influence customers' product preferences. The awareness of brand names and information on products highly influences consumers' buying behaviour[66]. Numerous other factors that influence consumer preferences have been found in psychological and marketing related studies; among others loyalty programs, previous experience with a product or brand, promotions and (electronic) worth-of-mouth influence consumer preferences[67].

3.3.4. Competitor behavior

The fourth source of volatility found in literature is the continuously changing behavior of competitors. Intense competition and short product life cycles resulting in an ever increasing change in products make the environment more and more volatile[68]. In order to attract as much customers as possible, manufacturers have to continuously benchmark their competitors, in order to find a demand vacuum to gain competitive advantage. To supply the customer with higher valued products than those of the competitors, all departments within a demand driven organisation should be better and more efficient than those of competitors[69]. Notable differences between market leaders and market followers have been found. A market leader rarely practices a price fighting strategy to stay competitive, whereas this is the most common used strategy among market followers. Market leaders tend to follow a more complex and hybrid competitive strategy. Complex means that they

[62] See Yang/Burns (2003), p.2083
[63] See Huang et al. (2008), p.3237
[64] See Tachizawa/Thomsen (2007), p.1118
[65] See Chan et al. (2005), p.459
[66] See Philiastides/Ratcliff (2013), p.1213
[67] See Lewis (2004), p.281/p.292; Wang et al. (2012), p.204/205; Kim/Chung (2011), p.42
[68] See Huang et al. (2008), p.3223
[69] See Brondoni (2009), p.9

focus on a different market variable like price or product differentiation than their competitors. In a hybrid competitive strategy more than one marketing variable is involved[70].

3.4 Consequences of volatility for the supply chain: influence on inventory levels, production plans and a company's product offerings lead to increasing costs and an ineffective coordination of the supply chain

Volatility affects forecast accuracy, inventory levels, production plans and output, a company's product offerings (service level) and even product prices[71]. This results in an ineffective coordination of the supply chain and high supply chain costs. Downstream supply chain members spread their volatility upstream, resulting in high capacity and inventory costs[72]. Volatility directly affects the marginal value of storage. When demand becomes more volatile, there will be a greater demand for inventory to have a buffer available that enables a manufacturer to deliver the requested products at all times. If demand would be stable a smaller safety stock would be sufficient. Therefore, an increase in volatility can lead to inventory build-ups[73]. The increasing inventory will result in higher costs. Physical costs, the so called storage or inventory costs, are higher when there are more products on stock. Next to that, the financial costs like insurance, taxes and interest will also be higher when inventory levels rise[74]. Nowadays many supply chains are forecast driven, this means that manufacturers periodically revise their supply chain plans based on a forecast of future demand over a specified planning horizon[75]. Volatility in demand has an influence on forecasting. When demand is highly volatile it is hard to forecast sales and market trends, resulting in a poor forecast which leads to an inefficient operations schedule[76]. The inefficient operations planning can lead to an ineffective coordination of the supply chain. A continuously changing operations planning has an influence on the raw material planning and replenishment decision[77]. Usually, the manufacturer signs contracts with suppliers for the purchase of raw materials in a certain period. If the manufacturer faces a volatile environment he does not have clarity on the

[70] See Shankar (2006), p.277, 290
[71] See Germain et al. (2008), p.560
[72] See Balakrishnan et al. (2004), p.163
[73] See Pindyck (2004), p.1030
[74] See Hendricks/Singhal (2009), p.511
[75] See Schoenmeyr/Graves (2009), p.657
[76] See Germain et al. (2008), p.560; Huang et al. (2008), p.3324
[77] See He/Zhao (2012), p.106

amount and time of raw materials needed and might therefore contract a sub-optimal quantity of raw materials at a sub-optimal time. A too high contracted quantity might force the supplier to buy material that is not needed in production, a too low contracted volume might lead to a shortage in supply which forces a manufacturer to buy on the spot market against an often higher price. The poor forecast and related inefficient operations schedule can result in either excess stock (too much stock) or out of stock situations, both indicators of a demand-supply mismatch[78]. Excess stock results in high inventory costs, squeezed profit margins due to selling at bargain prices, and even scrapping or write-off costs. Out of stock situations can be costly because they influence the service level if a manufacturer is not able to deliver the requested products. Volatility and the related poor forecasts make it necessary to consider the contribution margin to support decisions related to investments in lead time reduction and/or excess stock buffers when (re)designing the supply chain[79].

3.5 Costs of volatility: a general cost model for the calculation of volatility costs

Information about the history, the origins and the consequences of volatility can be found in literature as described in the previous sections. Academic literature provides a lot of models that are related to volatility. Like the volatility related literature, these models are mainly finance related. They address stochastic volatility, often related to return on assets, pricing derivatives, calculating measures of risk, and hedging[80]. From 2000 onwards volatility models in supply chain related literature where developed. These models focus on the positioning of the order penetration point, the predictability of volatility and forecast optimisation[81]. Chen and Samroengraja (2004) address the influence of order volatility on costs by showing that a reduction in the volatility of orders received by a manufacturer will not necessarily lead to a cost reduction[82]. However, a model that shows the influence of volatility on (supply chain) costs cannot be found yet. In order to assess the influence of volatility on costs and to establish the cost estimation model for volatility, sell-out data, promotion pressure, stock coverage, supply chain costs and VAS costs of the case company are analysed. Figure 7 illustrates the volatility cost model and shows the influence of the various cost types related to volatility. The remainder of this section will provide more details on the analysis.

[78] See Hendricks/Singhal (2009), p.509
[79] See Wong et al. (2006), p.712
[80] See Hansen/Lunde (2005), p.873
[81] See Olhager (2003), p.323; Ewing/Thompson (2008), p.555-556; Hosoda/Disney (2009), p.740-744
[82] See Chen/Samroengraja (2004), p.707

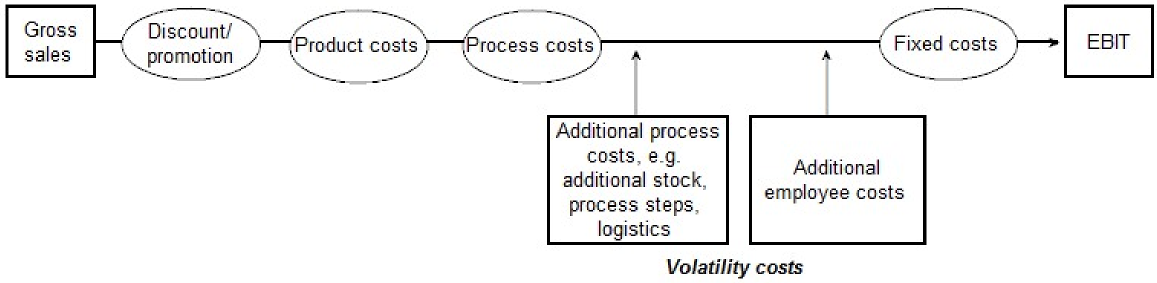

Figure 7: Volatility cost model

The sale of Brand A Deodorant is stable over the year, as figure 8 shows. The peaks are caused by promotions at the retailer. A small lift in base sales is visible during the summer weeks due to the warm and sweaty weather, all other peaks are fully caused by promotions at the retailer. The promotion pressure at Retailer A, the percentage of articles sold during promotions, was 61% in 2012.

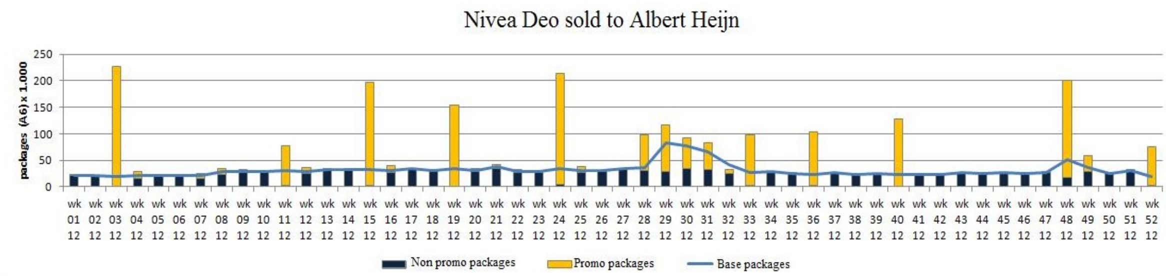

Figure 8: Sell-out data 2012, Brand A Deodorant at Retailer A

The sell-out data for Brand A Deodorant at Retailer B displayed in figure 9 show a similar pattern. However the base line is less flat, most likely caused by the high amount of promotions at this retailer. The promotion pressure at Retailer B was 73% in 2012.

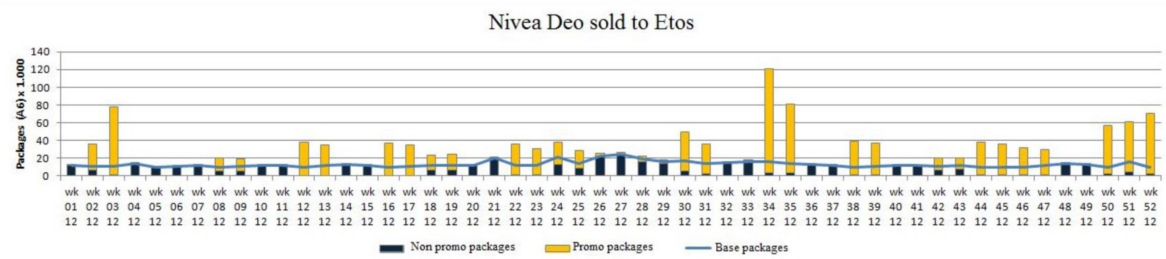

Figure 9: Sell out data 2012, Brand A Deodorant at Retailer B

As shown in previous sections, volatility has an influence on various costs. Among others inventory costs, raw material costs and working capital. The current VAS process, that will be discussed in detail in section 5.1, is subject to volatility because it involves a lot more handlings than a standard product and has a longer lead time that results in more inventory.

In 2013 four million repacked VAS articles were sold to Customer A, resulting in subcontractor repack costs of €339.736,98. To get a clear view on the influence of volatility on costs some calculations with data obtained from the case company have been done. Sales of one pallet of a specific type of deodorant to two customers, one buying standard products and one buying products made with the VAS process, are analysed. Table 2 shows the influence of the repack process on the cost model of the case company. The standard process is compared to the VAS process for Customer A, for the standard situation and a situation where products are sold during a promotion. Next to that a minimal process is added. This process shows an analysis of the absolute minimum of process steps and related costs Case company has to deal with. This minimum process is applicable for retailers in the so-called budget channel.

	Minimal process	**Standard product**	**Product in promo (2+1), no VAS**	**AH, no promo, VAS process**	**AH, promo (2+1) and VAS process**
Gross sales	List price: €2,37	List price: €2,37	List price: €2,37	List price: €2,37	List price: €2,37
Price promotion	N/A	N/A	33%	N/A	33%
Product sales	€2,37*1728 = €4095,36	€2,37*1728 = €4095,36	(€2,37*1728)*0,66= €2702,94	€2,37*1728 = €4095,36	(€2,37*1728)*0,66= €2702,94
Conditions	N/A	The discount for the supplier is 17% of net sales	The discount for the supplier is 17% of net sales.	The discount for Retailer A is 18% of net sales.	The discount for Retailer A is 18% of net sales.
Net sales	€2,37*1728 = €4095,36	€4095,36 *0,83= €3399,15	€2702,94*0,83= €2243,44	€4095,36*0,82= €3358,20	€2702,94*0,82= €2216,41
Cost of product	€0,58*1728 = €1002,24	€0,58*1728=	€0,58*1728= €1002,24	€0,58*1728= €1002,24	€0,58*1728= €1002,24

		€1002,24			
VAS cost (Repack is €7,07 per 100 pieces. Transport is €353,25 for a full truck (33 pallets).	No VAS costs involved.	No VAS costs involved.	No VAS costs involved.	17,28*7,07 = 122,17. Transport is €353,25/33= €10,70. 10.7*2= €21,41 per pallet. Normally, only full trucks are sent to and from subcontractor. However in case of high volatility, trucks might not be full (and therefore more expensive). VAS costs = 122,17 +21,41 = €143,58.	17,28*7,07 = 122,17. Transport is €353,25/33= €10,70. 10.7*2= €21,41 per pallet. Normally, only full trucks are sent to and from subcontractor. However in case of high volatility, trucks might not be full (and therefore more expensive). VAS costs = 122,17 +21,41 = €143,58.
Margin and Contribution 1	€4095,36 - €1002,24,- = €3093,12	€3399,15 - €1002,24, -= €2396,91	€2243,44 – 1002,24 = €1241,20	€3358,20 – 1002,24 – 143,58 = €2212,38	€2216,41 – 1002,24 – 143,58 = €1070,59
DCS (includes transport from Case company Warehous	This product is (on average) 6,5 months on stock. 1	This product is (on average) 6,5 months	This product is (on average) 6,5 months on stock. 1 pallet 1 month on stock costs around	This product is (on average) 5,5 months on stock. 1 pallet 1 month on stock costs around	This product is (on average) 5,5 months on stock. 1 pallet 1 month on stock costs around

e to customer and storage costs).	pallet 1 month on stock costs around €10,- (including outbound fee). 6,5*10= €65,-. On average, a delivery counts 20 pallets. Transport of 20 pallets to supplier DC costs €153,69, so €7,68 per pallet. DCS costs = €72,68.	on stock. 1 pallet 1 month on stock costs around €10,- (including outbound fee). 6,5*10= €65,-. On average, a delivery counts 20 pallets. Transport of 20 pallets to supplier DC costs €153,69, so €7,68 per pallet. DCS costs = €72,68.	€10,- (including outbound fee). 6,5*10= €65,- . On average, a delivery counts 20 pallets. Transport of 20 pallets to supplier DC costs €153,69, so €7,68 per pallet. DCS costs = €72,68.	€10,- (including outbound fee). 5,5*10= €55,- . On average, a delivery counts 20 pallets. Transport of 20 pallets to Retailer A costs 158,08, so €7,90. DCS costs = €62,90	€10,- (including outbound fee). 5,5*10= €55,- . On average, a delivery counts 20 pallets. Transport of 20 pallets to Retailer A costs 158,08, so €7,90. DCS costs = €62,90.
Margin and Contribution 2	€3093,12 - €72,68 = €3020,44	€2396,91 – 72,68 = €2324,22	€1241,20 – 72,68 = €1168,52	€2212,38 – 62,90 = €2149,48	€1070,59 – 62,90 = €1007,69

Table 2: Influence of the repack process on the cost model

The data in table 2 shows that the minimal process, the standard product and the products sold under special circumstances, either in promotion, repacked, or both, differ on various costs. All VAS costs can be assigned to the non-standard process. Next to that, part of the

DCS costs can be assigned to that process, because all storage that is hold for repacked products would not have been there when the products where sold as a standard product. On average one time the lead time of the repack process will be held as safety stock. As will be explained in detail in section 5.2 the average lead time of the repack process is nineteen days. This means there will always be around three weeks of stock for every pallet that would have not been there when the product was sold as standard product. Monthly storage costs are €10,- per pallet. A month has on average 30,5 days. This results in €6,23 of additional safety stock storage costs for every pallet of repacked products. This results in the following volatility costs table:

	Minimal process	**Standard product**	**Product in promo (2+1), no VAS**	**AH, no promo, VAS process**	**AH, promo (2+1) and VAS process**
Gross sales	€2,37	€2,37	€2,37	€2,37	€2,37
Discount on product	N/A	N/A	€0,79 – 33% of gross sales	N/A	€0,79 – 33% of gross sales
Product costs	€0,58 – 24,47% of gross sales	€0,58 – 24,47% of gross sales	€0,58 – 24,47% of gross sales	€0,58 – 24,47% of gross sales	€0,58 – 24,47% of gross sales
Repack costs	*N/A*	*N/A*	*N/A*	*€0,07 – 2,98% of gross sales*	*€0,07 – 2,98% of gross sales*
Extra logistics	*N/A*	*N/A*	*N/A*	*€0,012 – 0,52% of gross sales*	*€0,012 – 0,52% of gross sales*
Additional safety stock	*N/A*	*N/A*	*N/A*	*€0,0036 – 0,15% of gross sales*	*€0,0036 – 0,15% of gross sales*
Sum	€1,79	€1,79	€1,00	€1,70	€0,91
Volatility costs	*N/A*	*N/A*	*N/A*	*3,65%*	*3,65%*

Table 3: Volatility costs excluding overhead costs

After Margin and Contribution 2 in table 2 the fixed costs need to be allocated to be able to calculate the income before interest and taxes (EBIT). Fixed costs consist mainly of office rent and employee wages. Office rent is considered as a real fixed cost, because these costs are not influenced by the production process being standard or a VAS process. For employee wages the calculation provided above becomes complicated, since information about the total overhead costs and employee wages is not provided by the case company. Therefore an estimation has to be made. It is known that overhead costs are around 10 percent of gross sales. It is likely that the overhead costs for the minimal process are the lowest, since the lowest amount of employees will be involved. Furthermore it is expeted that the adjusted VAS process involves more overhead costs than standard products, since more people spend their time on the VAS products.

As can be seen in figure 1, around one third of sales (31 percent) go to Customer A, which means all these items are repacked. For the comparison that will follow in the remainder of this section the assumption has been made that available FTE are allocated based on the size of the customer they are mainly working for. This means that if the customer covers twenty percent of sales it is assumed that twenty percent of available FTE spend their time on this customer. Within the sales department two out of six FTE account managers are managing the Customer A account. They indicate that they do not spend additional time on the repack process, this is done by other departments. This means that one third of available account management FTE is managing on the customer that delivers one third of sales. Seventeen percent of sales goes to the budget channel. Only 0,5 FTE account management is responsible for these sales, which means that 8,33 percent of available account management FTE is managing 17 percent of sales. This is 8,67 percent less than expected. The employees working for the Customer A account within the customer service department clearly indicate that about one third of their time is spent on managing the specific repack process. Three out of nine FTE working at the customer service department are dedicated to the Customer A account, which means that around one third of the available FTE is managing one third of sales. However, since the employees indicate one third of their time is spend on the repack process a standard process for Customer A will result in a saving of one FTE at the customer service department. This means that with a normal process two out of nine FTE could manage one third of sales, which results in 22 percent of available customer service FTE managing one third of sales. 0,5 FTE at the customer service department is managing the budget channel customers. This means that

5,56 percent of customer service FTE is managing seventeen percent of sales, which is 11,44 percent lower than expected. Within the supply chain department 1 FTE of two supply planners is fully dedicated to manage the availability of repacked products for Customer A. This means that 50 percent of supply planning time is spend to manage one third of sales. Given the expectation that one third of available planning FTE should manage one third of sales in a normal process the normal process will result in a saving of seventeen percent, which is the difference between half of the available time spend on Customer A or one third of available time spend on Customer A. Just 0,1 FTE of the two FTE available for supply planning is allocated to the customers in the budget channel. This means that five percent of available planning FTE is managing seventeen percent of sales, which is twelve percent lower than expected. Since Case company does not plan specific availability of products for this channel the supply planner mainly spends his time on allocating products that are not sold to regular customers.

It can be concluded that in the supply chain department as well as in the customer service department specific resources are used to manage the repack process compared to the amount of sales that goes to Customer A. This can be explained by the fact that having the right quantities of repacked material available at the right moment causes most of the time that employees spend on managing the repack process. As mentioned before information about the total overhead costs and employee wages is not provided by the case company. Therefore a distinction between volatility process costs and volatility overhead costs has to be made. Table 3 has shown that 3,65 percent of gross sales can be considered volatility process costs. Investigation on time spend at the various departments provides information about the differences in overhead costs spend on the normal process, the adjusted VAS process and the minimal process used for the budget channel. The normal process is used as a reference to make the comparison showed in table 4. As the calculations provided above show the minimal process will consume 3,21 percent less overhead costs than the standard process. The minimal process consumes 8,67 percent less FTE as expected on account management, 11,44 percent less on customer service and twelve percent less on supply planning. The adjusted VAS process consumes a higher part of available FTE than a normal process does. As mentioned above the amount of customer service FTE managing the Customer A account is eleven percent higher as it would be for the normal process. Next to that FTE used for supply planning are seventeen percent higher than expected. Because volatility process costs are expressed as a percentage of gross sales, this has been done for the overhead costs as well. Since overhead costs are ten percent of gross sales this results in the comparison shown by figure 4.

	Minimal process	Standard product	Product in promo (2+1), no VAS	AH, no promo, VAS process	AH, promo (2+1) and VAS process
Volatility process costs	*N/A*	*N/A*	*N/A*	*3,65%*	*3,65%*
Overhead costs vs. reference process (in % of gross sales)	- 3,21%	Reference	Reference	+ 2,8%	+ 2,8%

Table 4: Volatility costs including overhead costs

3.6 Conclusion: volatility is costly and requires a high amount of flexibility within the supply chain

Based on the literature review that describes the origins and the consequences of volatility the first two research questions can be answered. The first research question is: *What are the origins of volatility?* In the beginning of this chapter four origins of volatility that are relevant for the FMCG business are discussed. Volatility can have its origin in the upstream as well as the downstream part of the supply chain and can influence both the demand and supply a specific organisation faces[83]. Short product lifecycles contribute to a volatile environment, because the rapid product substitution, rapid price decrease and an uncertain demand from the market result in an environment where it is never clear how short a lifecycle will actually be and when it will end[84]. Delivery or lead time uncertainty is an upstream origin of volatility. This origin of volatility can be caused by scheduling issues at the supplier, uncertain material supply, capacity constraints, unstable production processes or quality issues[85]. The third origin of volatility discussed in this chapter is the intense competition in the market[86]. In order to attract as many customers as possible, manufacturers have to continuously benchmark their competitors, in order to find a demand vacuum to gain competitive advantage. The most extensively discussed origin of volatility is demand volatility. Continuously changing demand influences the production

[83] See Yang/Burns (2003), p.2082
[84] See Hsu et al. (2008), p.602
[85] See Weng/Mc.Clurg (2003), p.13
[86] See Huang et al. (2008), p.3223

planning, stock levels, costs and profit margins[87]. Client behaviour, seasonality, changing customer preferences and competitor behaviour are the four sources of demand volatility identified. Academic research about volatility in the domain of supply chain management mainly focuses on the bullwhip effect. The bullwhip effect is the phenomenon where variability in demand increases more and more in the upstream part of the supply chain[88]. To cope with volatility that cause turbulence in the supply chain organisations have to design their supply chains in a flexible way[89]. The next chapter will describe in detail how this should be done.

The second research question is: *What are the consequences of volatility for the business?* Volatility results in an ineffective coordination of the supply chain and high supply chain costs. Volatility has an influence on forecast accuracy, inventory levels, production plans and output, service level and even on prices[90]. The more volatile demand is, the higher the influence on inventory will be. Not only inventory costs rise when stocks are build-up, financial costs like insurance, taxes and interest will also be higher when inventory levels rise[91]. A highly volatile demand makes it difficult to forecast sales and market trends, which leads to an inefficient operations schedule and in the end an ineffective coordination of the supply chain[92]. The inefficient operations schedule can result in either excess stock (too much stock) or out of stock situations, both indicators of a demand-supply mismatch[93]. Volatility and its consequences make it necessary to consider the contribution margin when (re)designing an efficient and profitable supply chain[94].

By building the volatility cost model the third research question, *"Which costs in the supply chain can be related to volatility?"*, can be answered. This chapter has shown that volatility does increase costs. Volatility has an influence on among others inventory costs, raw material costs and working capital. The examples provided in this chapter, in which a normal process and an adjusted process within Case company are compared, show that the adjusted process is subject to volatility because it involves more different handlings than the standard process. Next to that the adjusted process has a longer lead time due to the extra process steps, which results in higher inventory levels. These costs linked to the

[87] See Kim/Springer (2008), p.173; Springer/Kim (2010), p.380; Kulp et al. (2004), p.435
[88] See Lee et al. (1997), p.546; Chen et al. (2000), p.436; Fransoo/Wouters (2000), p.78
[89] See Christopher/Holweg (2011); Mason-Jones et al. (2000);
[90] See Germain et al. (2008), p.560
[91] See Hendricks/Singhal (2009), p.511
[92] See Germain et al. (2008), p.560; Huang et al. (2008), p.3324
[93] See Hendricks/Singhal (2009), p.509
[94] See Wong et al. (2006), p.712

process are called volatility process costs. These volatility process costs are 3,65 percent of gross sales. The adjusted process also requires more time from people, which means an increase in employee costs. In the examples provided in this chapter the employee costs are called overhead costs. These Overhead costs can be lowered by 2,8 percent of gross sales if a normal process instead of the adjusted process would have been used. The volatility cost model provided in this chapter needs to be verified in follow-up studies.

4 A flexible supply chain design is required to handle volatility – The rigor cycle

4.1 Technical solutions

4.1.1 Supply chain flexibility to handle volatility: three drivers of flexibility to mitigate the risks related to demand volatility

It is widely recognised in academic literature that supply chain flexibility is required to deal with increasing uncertainty in the marketplace. In uncertain environments, like the FMCG business, organisations with a highly flexible supply chain perform better than organisations that lack this flexibility. In environments that are certain and stable the opposite is the case[95]. Nowadays, a supply chain is often spread over multiple functions within various organisations. Furthermore, the supply chain is characterised by numerous activities. This leads to coordination challenges to design a supply chain that results in increasing profit margins, a better service level and a faster response time[96]. The biggest challenge in supply chain design is to forecast market demand, since decreasing product life cycles and ongoing innovation make the demand extremely volatile[97].

Tachizawa and Thomsen (2007) have identified three drivers, reasons to obtain flexibility, that can help organizations to handle demand volatility. The first is volume uncertainty, this is the uncertainty related to the actual volume that will be demanded[98]. Especially during new product introductions and peak season demand is uncertain, which justifies a hybrid supply chain design[99]. A hybrid supply chain design includes both agile and lean elements and will be discussed in the next section. The second driver of uncertainty is mix uncertainty. This is related to the exact specification of a component, which variant will be demanded[100]. This mix uncertainty results in capacity planning challenges. A

[95] See Merschmann/Thonemann (2011), p.43
[96] See Arshinder et al. (2008), p.317
[97] See Xu/Zhai (2010), p.130
[98] See Tachizawa/Thomsen (2007), p.1118
[99] See Wong et al. (2006), p.712
[100] See Tachizawa/Thomsen (2007), p.1118

manufacturing plant often consists of several processing lines that can produce a variety of products. Because processing time, costs and profit margins are different for each product (variant), the allocation of capacity to the different products is of utmost importance for a manufacturer[101]. Delivery uncertainty is the third driver of uncertainty, and is related to the moment of demand[102]. Delivery uncertainty does not only concern the demand of the end user of a product, it includes demand across the supply chain. As the bullwhip effect shows, variability in demand increases in the upstream part of the supply chain[103]. The more upstream an organisation is located in the supply chain, the more challenging delivery uncertainty is. Delivery uncertainty can be mitigated by acquiring control over resources to minimise dependency over other firms in the supply chain[104]. The three drivers of uncertainty have to be mitigated in order to design a supply chain that has the flexibility to handle volatility.

An organisation faced with demand volatility can adapt two roles to handle uncertainty[105]. It can act like a shaper of, or as an adaptor to demand volatility. A shaper of uncertainty tries to restructure the demand so that the risk in the downstream supply chain is limited, while potential in the upstream supply chain is retained. Contracting agreements with the customer are a good way to shape the demand of the customer. For example, a contract with minimum/maximum order quantities commitment in return for a price discount might be useful. An adapter does not aim to influence the uncertainty in the market. The adapter tries to control the risk exposure of its assets, inventory levels and profit margin, by adapting the operations to the demand realization[106]. Two stage stochastic programming models are often used by adapters to include the uncertainty variable in their optimisation models. Gupta and Maranas (2003) developed such a two stage stochastic programming model to optimise the midterm production planning. The two stages of the model are determined as manufacturing variables and logistics variables. The first stage of the model are so called here-and-now decisions, which are the manufacturing variables. The second stage of the model are the wait-and-see decisions, in this particular model the logistics variables. Manufacturing decisions are made before the demand is realised, due to the lead times. Logistics decisions are postponed until the moment the demand is realised and no

[101] See Azadegan et al. (2011), p.262
[102] See Tachizawa/Thomsen (2007), p.1118
[103] See Lee et al. (1997), p.546; Chen et al. (2000), p.436; Fransoo/Wouters (2000), p.78
[104] See Yew et al. (2011), p.614
[105] See Gupta/Maranas (2003), p.1222
[106] See Gupta/Maranas (2003), p.1223

longer uncertain[107]. Using postponement as a resource to mitigate volatility will be further discussed in section 4.1.4.

4.1.2 Lean versus agile supply chains: differences and similarities

When organisations determine their supply chain strategy it is key that they take customer satisfaction and market understanding as the two crucial determinant factors. Customer satisfaction is key to retain and win customers, to stay competitive. Understanding the marketplace is necessary to be able to develop a supply chain strategy that both serves the needs of the end customer and the various actors within the supply chain[108]. Two main paradigms to design a supply chain have been identified in academic literature, the lean supply chain and the agile supply chain. 'Leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule[109]. The goal of lean is doing more with less, a zero inventory just-in-time approach[110]. The lean supply chain has been optimised in the Asian car manufacturing industry, mainly by Toyota. The lean designed supply chain relies on what might be demanded, production is done on a make-to-stock basis[111]. Designing a supply chain according to the lean approach makes sense when the demand is predictable, the product mix uncertainty is low and volumes are high. This supply chain strategy is often linked to commodity goods, products with a relatively long life cycle and a predictable demand pattern. The market qualifiers, the minimum standard to enter the marketplace, for this type of goods are quality, lead time and service level. The market winner for commodity goods is price[112]. Therefore, a lean supply chain strategy has a focus on minimising costs. If demand is volatile, the product mix variety is high and volumes on the various product variants are relatively low, the need for a different supply chain design arises[113]. In the 21st century organisations have to respond to increasing levels of volatility in demand, they have to focus on achieving agility. Supply chains that are designed according to the agile principles have the ability to respond fast to changes in markets and customer demand and therefore bear competitive advantage in a highly competitive market like the FMCG market[114]. Agility is defined as 'the ability of an

[107] See Gupta/Maranas (2003), p.1226
[108] See Mason-Jones et al. (2000), p.4061
[109] See Naylor et al. (1999), p.108
[110] See Christopher (2000), p.37
[111] See Goldsby et al. (2006), p.58-59
[112] See Mason-Jones et al. (2000), p.4063-4064
[113] See Christopher (2000), p.38
[114] See Ambe (2010), p.5

organisation to respond rapidly to changes in demand both in terms of volume and variety'[115]. Flexibility is key in the agile supply chain strategy. This supply chain strategy is often linked to so-called fashion goods, products with short life cycles and a high demand uncertainty. This type of products requires the development of a strategy that on one hand improves the match between supply and demand and on the other hand enables organisations to respond faster to the market. Two of the market qualifiers for the fashion goods are the same as for commodity goods, quality and lead time. The third market qualifier is price. Service level is the market winner for fashion goods[116]. The focus of the agile supply chain strategy is on flexibility and short delivery times to be able to meet the demand of the customers[117].

Characteristics	**Lean supply chain strategy**	**Agile supply chain strategy**
Products	Commodity goods	Fashion goods
Demand	Predictable	Volatile
Product life cycle	Relatively long	Relatively short
Product variety	Low	High
Market drivers	Quality, lead time, service level	Quality, lead time, price
Market winners	Price	Service level

Table 5: Key characteristics of lean and agile supply chain strategies[118]

As table 5 shows, the differences between lean and agile supply chain strategies are notable. They have similarities as well, both the lean and the agile supply chain strategy demand a high product quality and minimal lead times to enable an organisation to successfully enter the market. Leanness and agility can co-exist, some authors even argue that leanness and agility can be combined[119]. From 2000 onwards, the combinations of lean and agile supply chain elements got attention in academic literature. The combination of lean and agile elements is called the leagile supply chain strategy.

[115] See Christopher (2000), p.39
[116] See Mason-Jones et al. (2000), p.4063
[117] See Qian (2014), p.697
[118] Based on Mason-Jones et al., 2000; Christopher/Towill (2000), p.208
[119] See Mason-Jones et al. (2000), p.4068; Ambe, 2010, p.10; Kisperska-moron/Haan (2011), p.134

4.1.3 The leagile supply chain: a best of both worlds strategy with the decoupling point as key characteristic to compete in volatile markets

Within the FMCG business, supply chains rather than individual organisations compete to satisfy the demand of the final customer best. The demand changes over time, due to the stage of the product life cycle, changing customers' individual circumstances or developments in society. As a consequence of this changing demand supply chains have to adapt their strategies, to keep their customers and attract new ones as well[120]. This ongoing adaptation of supply chains has resulted in a hybrid strategy covering both lean and agile elements. The leagility concept aims to develop synergies in leanness and agility through decoupling and by making strategic use of stock in the product delivery process[121]. Leagile has been defined as 'the combination of the lean and agile paradigms within a total supply chain strategy by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the marketplace'[122]. In a volatile environment the supply chain needs to be designed backwards with a focus on demand pull, instead of a focus on supply push from the factory outwards. By doing so the supply chain will be transformed into a demand chain[123]. This demand chain requests a focus from managers on both service level and price, therefore the demand chain has to be both lean and agile. The leagile supply chain can be seen as a best of both worlds supply chain design to satisfy the volatile customers' demand.

The research about leagility has been extended since 1999, by building conceptual models and testing in numerous case studies in different businesses. The key characteristic of the leagile supply chain strategy is the decoupling point. The decoupling point is the separation point between the part of the organisation oriented towards customer orders and the part of the organisation based on planning[124]. In practice the decoupling point separates the lean and agile part of the supply chain[125]. Originally the part of the supply chain oriented towards customer orders (downstream) was defined as agile, while the part of the supply chain based on planning (upstream) was defined as lean to obtain an optimal leagile design. The concept was first described by presenting a case study in a manufacturing environment, with a focus on material flows and postponing the assembly of standardised

[120] See Kisperska-moron/Haan (2011), p.127
[121] See Naim/Gosling (2011), p.348
[122] See Mason-Jones et al. (2000), p.4065 based on Naylor et al. (1999), p.117
[123] See Christopher/Ryals (2014), p.29
[124] See Naylor et al. (1999), p.108
[125] See Krishnamurthy/Yauch (2007), p.589

components or systems into customised products[126]. Over the past fifteen years different variants of the hybrid leagile supply chain strategy have been developed. Many manufacturing organisations use the mixed model approach, where some production lines are designed for mass production to produce the fast moving products while others are designed for quick and frequent change overs that support the production of small batches[127]. Another often used strategy is the use of capacity outside the focal organisation. This strategy is often used by organisations that have a stable base demand over the year. They design their operations in a lean manner to meet this demand. However in times of seasonal demand or heavy promotions the organisation buys external storage, manufacturing capacity or logistics to meet the demand. This is seen as the agile part of this hybrid strategy[128]. The third leagile approach often addressed in literature is the use of form postponement, which means delaying the use of inventory for the final product as long as possible[129]. This approach requires lean operations to produce the generic semi-finished goods and an agile design during the customization process[130]. Because this approach in particular is very relevant for the research done at Case company the next section will elaborate in detail on this approach.

Research has shown that over time alternative types of leagility have been identified outside the manufacturing area. Examples are the decoupling of sales and service activities from the production facilities and the use of transhipments to obtain service and inventory improvements at the same time[131].

4.1.4 Form postponement is the leagile approach to obtain maximum flexibility to meet the customers' volatile demand

As mentioned before, form postponement means the delay of operational activities until customer demand is known and demand is no longer uncertain, rather than completing activities in advance and waiting for orders[132]. Postponement can improve operational efficiency for organisations that operate in uncertain environments and have to deal with volatile demand[133]. The most extreme variant of postponement is backordering, where an

[126] See Naylor et al. (1999), p.116
[127] See Goldsby et al. (2006), p.61-62
[128] See Goldsby et al. (2006), p.62
[129] See Trentin et al. (2011), p.1977;
[130] See Mason-Jones et al. (2000), p.4065
[131] See Naim/Gosling (2011), p.351
[132] See Krishnamurthy/Yauch (2007), p.592
[133] See Che et al. (2010), p.365

organisation only produces after receipt of an order from the customer. Backorder works best in an environment where demand is extremely volatile[134]. By making use of postponement an organisation tries to overcome the risk that the demand of the customer cannot be met, because the wrong product mix has been produced when the orders were still unknown. Various opportunities for form postponement can exist within one supply chain. Form postponement consists of two components that need to be taken into account when an organisation starts to identify the opportunities for form postponement. The first component necessarily requires product and/or process transformation redesign. The second component can be executed by only changing the sales forecasting and master production scheduling process[135].

Positioning the decoupling point is key in a leagile supply chain design, to be able to respond to a volatile demand downstream and to provide level scheduling upstream from the decoupling point[136]. There are three factors that influence the position of the decoupling point, market, product and production characteristics. Market characteristics include the lead time requirements that indicate how far backwards the decoupling point can be positioned. Furthermore it includes volatility in demand, which indicates if a make to order or make to stock strategy would be preferred. Product characteristics are referring to the customisation opportunities a producer provides in the product design. The later customisation enters the production process the closer to the customer the decoupling point can be. Production related characteristics mainly refer to lead time. Lead time reductions can lead to a change in the positioning of the decoupling point. The bottleneck of a sudden production process is preferably located upstream of the decoupling point, so that the bottleneck does not have to deal with volatility and a variety of products[137]. To move the decoupling point closer to the end customer and to improve the efficiency and effectiveness of a supply chain postponement can be used[138].

In forecast driven manufacturing environments, like the FMCG business, product mix decisions are triggered by the master production scheduling process. In these environments just delaying product differentiation activities might not be sufficient to implement form postponement. A product differentiation activity is a redesign of products and/or manufacturing and supply chain processes to defer activities that specialise work in

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[134] See Che et al. (2010), p.366/390
[135] See Trentin et al. (2011), p.1977
[136] See Naylor et al. (1999), p.116
[137] See Olhager (2003), p.321-322
[138] See Yang/Burns (2003), p.2078

progress inventory into finished goods. Organisations that operate in forecast driven environments need to determine what time fence should be associated with each possible outcome of a product differentiation activity, how often the master production schedule should be re-planned and at what time the demand for each product differentiation should be forecasted. By doing this organisations can keep working on a to forecast basis, however closer to the moment of customer order receipt which makes their supply chain more flexible[139].

4.2 Commercial solutions

4.2.1 Demand profiling to segment and target customers to meet their needs best

The previous sections showed there is no one size fits all principle to design the supply chain so that the demand of the end customer will be met as efficiently as possible. The previous sections provided technical solutions to design the supply chain. However, there are commercial solutions that can be implemented to meet the volatile demand of the end customer as well. To set the optimal supply chain strategy an organisation should carefully research which demand it wants to meet, the so called demand profiling. This is a relatively new and not yet extensively researched topic. Section 4.1.2 shows the market qualifiers and market winners for specific types of goods. Identifying the market qualifiers and market winners is the first step to profile demand and target customers. The second step an organisation should take is identifying which of the so called DWV-3 criteria, duration of life cycle, time window for delivery, volume, variety (in products) and variability (in demand) are most important to profile the demand they face[140]. To identify the dominant DWV-3 criteria an organisation has to identify which of these criteria are influencing the supply chain strategy directly and which of the criteria are or can be mitigated. For FMCG organisations the two most important variables seem to be volume and variability in demand of individual stock keeping units (SKU's)[141]. Demand profiling is the analysis of volume and the variability in demand for each individual SKU. Demand profiling at individual SKU level provides a link between customer segmentation and product characteristics[142]. After the analysis the SKU's can be grouped, for example according to their various demand volatility coefficients as proposed by Godsell et al.

[139] See Trentin et al. (2011), p.1993
[140] See Childerhouse et al. (2002), p.679
[141] See Godsell et al. (2011), p.296-297
[142] See Godsell et al. (2011), p.309

(2011). After profiling the different groups of SKU's the impact of such a profile on the supply chain strategy can be investigated by considering the margin, growth and strategic alignment[143]. A demand profile combined with the influence on the supply chain strategy will clarify whether a lean or an agile supply chain design would be most suitable.

An extra constraint for organisations operating in the FMCG business is selling via retailers, which means that the demand FMCG organisations are facing is not the demand of the end user of the products. The demand creation, the planning and the fulfilment functions have to be aligned successfully to target customers so that their needs are met efficiently. By segmenting customers based on their behaviour marketing can determine which retail channel a customer will choose. Next to that, order winning criteria for the retail channel can be determined, resulting in a value proposition to target specific needs. Thereafter the marketing function has to position products to specifically target each retail channel and customer group. The demand planning function forecasts volumes and has to understand the predictability of each SKU[144]. This can be done by demand profiling as explained in the beginning of this section. The demand profiles can be used to decide if a lean, agile or leagile supply chain design should be implemented to meet customer needs most efficiently.

4.2.2 Sourcing flexibility

As mentioned before a flexible supply chain design helps organisations to cope with the volatile environment they are facing[145]. The way in which organisations are sourcing has an impact on the flexibility of the supply chain. Therefore sourcing flexibility is an important factor to take into account when designing a supply chain that will meet customers' needs efficiently. Dual sourcing, having alternative sources available for key raw materials, components or services, enables an organisation to switch quickly between the different sources and therefore increases flexibility within the supply chain[146]. Close supplier relationships can deliver greater agility resulting in more flexibility within the supply chain. To achieve this flexibility a number of pre-requisites have to be met. It is impossible to maintain a close relationship with many suppliers. Therefore a limited number of key suppliers have to be identified, with which manufacturers can work together

[143] See Godsell et al. (2011), p.307-308
[144] See Roscoe/Baker (2014), p.152-153
[145] See Christopher/Holweg (2011); Mason-Jones et al. (2000)
[146] See Christopher/Holweg (2011), p.71

like partners. Next to that, sharing of information is key to create a more agile supplier base. Sharing of downstream demand information is especially important. This means data on real demand has to be captured as far as possible down the supply chain to be shared with upstream suppliers. The most important pre-requisite is connectivity amongst the partners. This means strong cooperation, in various ways, cross functional and amongst all organisational levels[147]. Supplier development is strongly related to the cross functional cooperation between buyer and supplier. Supplier development can be any activity that is carried out by the buyer to improve the suppliers' capabilities and competencies to make sure buyers' supply needs are met on a short-, mid- and long term horizon. Supplier development will only be set-up for key suppliers. Supplier development activities aim to result in an improved buyer-suppliers relationship[148]. Outsourcing has become common practice in manufacturing environments to obtain flexibility. Outsourcing provides access to additional capacity when required and converts fixed costs into variable costs[149]. Organisations that apply a near sourcing strategy are sourcing and manufacturing in countries that are as close as possible to the market. This strategy makes it possible to configure the final products at the latest possible stage, due to the short lead times to get the products on the market[150].

5 Current situation and options for change: demand volatility and the current repack process cause inflexibility and high costs

5.1 Current situation – The relevance cycle

5.1.1 Design of the current repack process: it takes on average 19 days to get the product from the warehouse via the subcontractor to the customer

To carry out the repacking process for Customer A, Case company makes use of the service of a subcontractor. The design of the repack process is shown in table 6.

[147] See Christopher (2000), p.44
[148] See Chiang et al. (2012), p.54
[149] See Christopher/Holweg (2011), p.72
[150] See Christopher/Holweg (2011), p.73

Activity	Day
Stock at warehouse	X-19
Delivery request to subcontractor (SC)	X-18
Picking of goods	X-17
Transport to SC	X-16
Production at SC	X-15
Delivery request (back to warehouse)	X-5
Transport to warehouse	X-4
Inbound (receiving and storage of goods)	X-3
Order from a Case company customer	X-2
Picking of goods	X-1
Transport and delivery to customer	X

Table 6: Shortest path description of the current repack process

All products that are to be delivered to Customer A need to be transferred from the warehouse in ‘s Heerenberg (Gelderland) to the subcontractor in Stadskanaal (Groningen), and vice versa. Getting the products from the warehouse to the subcontractor normally takes four days. First, the supply planner responsible for these VAS articles that are delivered to Customer A prepares a request to send the items to the subcontractor. The day after the goods are picked at the warehouse and prepared for transport to the subcontractor. The third day is the day of transport to the subcontractor. The subcontractor has on average ten working days to perform the repacking activities. After the repacking activities the goods are transported back to the warehouse, where they will stay until an order from Customer A comes in. This whole repacking process takes on average nineteen working days, which makes the supply chain inflexible to respond to volatile demand. Furthermore, this means that two additional transports, to and from the warehouse, need to be arranged. Next to that, the warehouse has always two types of stock for every article, the standard variant and the repacked Customer A variant which will cause additional inventory costs.

5.1.2 Costs of the current repack process: additional transport costs, subcontractor costs and higher storage costs

It is clear that the repack process involves more costs than the normal process Case company has designed to deliver their products to their customers. First, two additional transports are made, from the warehouse to the subcontractor and vice versa. For 2013 these transport costs were between €91.957,34 and €66.057,75. The €91.957,34 is the actual number of transport costs paid, however this includes products for one other customer than Customer A and products for the Belgian market. The €66.057,75 is the amount of transport costs paid in the ideal situation where a truck was totally filled with repacked products for only Customer A, this is the minimum of transport costs caused by the repack process for Customer A. Next to transport costs, the subcontractor has to be paid for the repacking, this costs €7,07 per 100 repacked products. In 2013 4.006.372 products were repacked for Customer A, as table 7 shows. This resulted in €283.250,50 subcontractor costs.

Month	Number of repacked products
January	178.056
February	254.424
March	395.138
April	187.560
May	308.400
June	198.528
July	333.030
August	609.642
September	540.002
October	333.864
November	475.986
December	191.742
Total	**4.006.372**

Table 7: Number of repacked products for Customer A

The third additional cost this repack process causes are the costs for additional stock, especially safety stock, which the warehouse holds for the repacked variant of an article. On average one time the lead time of the repack process will be held as safety stock, in practice this means the volume for three weeks should be held as safety stock. For 2013 this resulted in a continuous average safety stock of 231.137 products of 65 unique items. For most of the repacked items, 1728 products fit on one pallet. This results in 134 pallets average safety stock. It costs €10,- including inbound and outbound (picking) costs to hold one pallet one month on stock. This result in average safety stock costs of €16.080,- (134 *

10* 12) for the year 2013. Total additional costs for the repack process for Customer A in 2013 where at least €365.388,25.

5.2 Change proposals – The design cycle

5.2.1 Technical solution: three scenarios to create a more robust repack process

In order to design the described process of repacking more robust, less vulnerable for volatility and less costly three scenarios have been designed. These scenarios are related to each other, and need to be carried out in consecutive order to obtain the most robust process. The scenarios are based on findings in literature described in this research, the developed volatility cost model and knowledge obtained within Case company about the requirements of the customer, Beirsdorf's capabilities and those of their partners involved. Table 8 shows a comparison of the various scenarios with the current situation. In section 3.3 four origins of volatility have been presented, short product life cycles, delivery time uncertainty, frequent and unpredictable changes in demand and competitor behavior. Short product life cycles are not causing the volatility Beiersdof NV is facing. Products are on the market for several years. Delivery time uncertainty is causing some volatility for Case company, since they depend on the products produced by Case company head quarter. Getting the products from Germany or Poland to the Netherlands results in a lead time that needs to be taken into account. Next to that Case company head quarter sets some minimum order quantities which are sometimes higher than the actual demand of Case company. To cope with this uncertainty flexibility is required. During this research it became clear that the repack process for Customer A that Case company has designed is vulnerable to frequent and unpredictable changes in demand, the third origin of volatility. Therefore the main focus of the improvement scenarios will be on demand volatility. Competitor behaviour leads to uncertainty as well. If a competitor cannot deliver additional volumes for a promotion a customer wants to plan Case company is requested to deliver additional volumes. Since this additional demand is an opportunity for extra sales it will result in competitive advantage if the improved process will be able to deal with this.

The first scenario designed is called 'inhouse VAS, make-to-stock'. In this scenario the repacking will no longer be done by a contractor, it will be done at the same facility as the warehouse. This means the transport costs, which are at least €66.057,75 per year, will be eliminated. Next to that the full repack process can be shortened with five days, which will result in a repack process that takes fourteen working days. This means the average safety stock on repacked products can be reduced to fourteen working days as well, resulting in a cost saving of €4.231,58 ((16.080,-/19)*5). Besides that the situation will stay the same as it currently is, as figure 10 shows. Because the process becomes shorter Case company will be better able to cope with volatility in demand. Due to a shorter process Case company will be better able to take opportunities for extra sales. A remark that needs to be made is that the location for repacking is at the same premises, but in another building than the warehousing activities are done. The repacking area can store a limited amount of ADR products, which will result in small repacked batches.

Criteria	**Current situation**	**Scenario 1 – Inhouse VAS, make-to-stock**	**Scenario 2 – Inhouse VAS, moving to make-to-order**	**Scenario 3 – From VAS to LAS**
Repack costs	X	X	X	X
Stock of two variants of an article	X	X	X	
Reduced safety stock			X	X
Sales forecasting done on two variants of an article	X	X	X	
Risk of OOS	X	X	X	X
Risk of excess/obsolete stock	X	X	X	X
Reduced transport costs		X	X	X
Lead time reduction		Five working days	Scenario 1 + three working days	Scenario 2 + two working days
Total cost saving		€70.289,33	€77.906,17	€77.906,17

Table 8: Comparison of scenarios resulting in a more robust supply chain

'Inhouse VAS, move to make-to-order' is the second scenario designed. This scenario seems to be equal to the first scenario described, however three improvements will be made. These improvements allow Case company to better cope with the consequences of volatility, mainly the influence on inventory. First of all urgent repacking can be done because orders are known prior to the repacking, this will decrease the out of stock (OOS) risk. Next to that the safety stock on repacked products can be further decreased. A safety stock of five working days should be sufficient, because forecasted demand that is shared between Customer A and Case company shows that the prognosis given five working days prior to the order is at Case company forecast accuracy level. This results in an additional cost saving of €7.616,84 ((16.080,00/19)*9). The third improvement is reduction of the lead time of the process by another 3 working days. Demand is known 48 hours prior to delivery to the customer, which is too short at this stage to perform all repack activities. However Customer A shares a rolling forecast which is proven to be as reliable as Case company's forecast five working days prior to the order. If Case company uses this forecast to plan the repack operations there are seven working days to repack the order and ship it to the customer. Scenario 2 results in a repack process of eleven working days. The remark that needs to be made for this scenario is that the warehousing party must be flexible in upscaling production to be able to decrease the OOS risk and to further decrease the safety stock of repacked products. This flexibility is not proven yet.

The third scenario designed is the implementation from Value Added Services to Logistics Added Services, 'from VAS to LAS'. This means that repacking is done after the order has been picked. This scenario is far less complicated than the previous two and results in a more flexible supply chain. Because repacking is done after the order has been picked there is only one article code that has to be forecasted and there is only one article on stock, the standard variant. There is no additional safety stock reduction expected compared to scenario 2, since the safety stock on the standard product needs to be higher to serve as a buffer in case urgent repacking needs to be done. Compared to scenario 2 the third scenario will result in a decrease in lead time of the full process of two working days, because the extra steps of picking and administration of repacked products will disappear. This will result in a process of nine working days. This new process will allow Case company to better and faster cope with volatility in demand, which is the origin of volatility that has the biggest influence on Case company.

5.2.2 New process: Implement the three scenarios one after another to make the process more robust and shorter, to have a more flexible supply chain and to obtain a cost saving of at least €77.906,17

From the theoretical part of this research it becomes clear that Case company will benefit from elements of the leagile supply chain design to maximise the flexibility. Especially the positioning of the decoupling point has been taken into account during the redesign of the repack process. As mentioned before, the three scenarios designed should be implemented in consecutive order to make the process step-by-step more robust and shorter, to make the supply chain more flexible and to obtain the maximum saving. The first scenario can be implemented within three months, when the contract with the current subcontractor ends. Scenario 1 focuses on the lean elements of the repack process, eliminating unnecessary process steps and minimising waste, including time[151]. By moving the repack activities to the same site as where the warehousing activities take place two transports are eliminated, resulting in a process that is 25 percent shorter. The shorter the repack process is the easier it becomes for Case company to cope with demand volatility, because the requested products can be made available faster.

The second scenario builds on the first one, by further reducing the safety stock on repacked products and therefore resulting in an additional saving. The focus of the second scenario moves towards the agile elements of the supply chain. The focus of the agile supply chain strategy is on flexibility and short delivery times to be able to meet the demand of the customers[152]. Agility means the ability of an organisation to respond rapidly to changes in demand both in terms of volume and variety'[153]. Because the demand is known with a forecast accuracy of 65 percent prior to the repack activities, Case company will be able to better cope with volume uncertainty and mix uncertainty on a shorter term.

Especially the third scenario is based on principles from the leagility supply chain concept, which aims to develop synergies in leanness and agility through decoupling and by making strategic use of stock in the product delivery process[154]. Form postponement, as discussed in section 4.1.4, will be crucial for this scenario. Form postponement means delaying the use of inventory for the final product as long as possible[155]. This approach requires lean operations to produce the generic semi-finished goods and an agile design during the

[151] See Naylor et al. (1999), p.108
[152] See Qian (2014), p.697
[153] See Christopher (2000), p.39
[154] See Naim/Gosling (2011), p.348
[155] See Trentin et al. (2011), p.1977;

customisation process[156]. Until the repacking starts the process will be mainly lean. The products will be produced in several Case company factories and delivered to the warehouse in the Netherlands, there the agile elements (repacking) will be added during the customisation process. Inventory will only be used for customisation after demand is known. When the third scenario is implemented the decoupling point will move as much as possible upstream in the process, which makes the process less vulnerable to volatility in demand. In this scenario Case company minimises the risk that a type and amount of products is repacked that will not be demanded by the customers.

5.2.3 Short term: implement the repacking process at the warehouse, long term: move towards a vendor managed inventory process to further minimise the risk on obsolete stock or out of stock situations

As the volatility cost model developed in this research shows, additional process steps, additional logistics and additional inventory influence the volatility costs. The three scenarios described in the previous sections minimise process steps and logistics, however the risk of obsolete stock will remain. The risk on out of stock situations will remain as well, although the risk will be less as it is in the current situation. Therefore, Case company has to improve the ability to adapt to volatility by developing the repack process as described in the previous sections on the short term. On the long term Case company can further minimise the risk on obsolete stock or out of stock situations by developing a partnership with the organisation contracted for the warehousing and repack activities. When implementing the three scenarios the repack process is still forecast driven and fully controlled by Case company. Organisations that operate in forecast driven environments need to determine what time fence should be associated with each possible outcome of a product differentiation activity, how often the master production schedule should be re-planned and at what time the demand for each product differentiation should be forecasted[157]. Since the decision has been made by Case company head quarter not to perform repack activities inhouse, Case company is not in charge of the day-to-day repack operations. To make sure the repack process is managed as efficient as possible a partnership with the organisation that is in charge of the day-to-day repack operations has to be developed. If the implementation of the three scenarios indeed results in a stable

[156] See Mason-Jones et al. (2000), p.4065
[157] See Trentin et al. (2011), p.1993

process and the warehousing and repack organisation proves to be a reliable partner, more responsibilities can be shifted. Preferably, the partnership results in a situation where the warehousing party manages and controls the inventory position of Case company's customers, a so-called vendor managed inventory (VMI) approach. In this situation Case company's customers will share their real-time inventory level with the warehousing and repack partner chosen by Case company[158]. The replenishment decision, how much and how often to replenish the retailer, will be made by the warehousing party instead of Case company. Within a year Case company has to tender their warehousing and repack activities, which is a perfect moment to search for the most reliable service provider that can become a long term partner to further improve the business.

6 Conclusions and recommendations – The design cycle

6.1 Conclusion: how FMCG organisations should deal with demand volatility and its related costs in their supply chain

The problem statement for this research has been *"How should FMCG organisations deal with volatility of customers' demand and its related costs within their supply chain?" The* goal of this research has been to provide a better understanding of the impact of volatility on costs. First of all insights in the origins, consequences and costs of volatility needed to be obtained. Volatility can have its origin in the upstream as well as the downstream part of the supply chain and can influence both the demand and supply a specific organisation faces[159]. Short product lifecycles, delivery or lead time uncertainty, competitor behavior en frequent and unpredictable changes in demand are the four origins of volatility identified. These four origins are all applicable on the FMCG business, however it depends on the type of goods produced which origins will have the biggest influence. This research has focussed on the production of deodorants. For deodorants frequent and unpredictable changes in demand is the origin of volatility that has the biggest impact, resulting in either excess stock or out of stock situations. Client behaviour, seasonality, changing customer preferences and competitor behaviour are the four sources of demand volatility identified. Consequences of volatility are increasing costs and an ineffective coordination of the supply chain. Volatility has an influence on forecast accuracy, inventory levels, production

[158] See Chen et al. (2012), p.42
[159] See Yang/Burns (2003), p.2082

plans and output, service level and even on prices[160]. Volatility has an influence on among others inventory costs, raw material costs and working capital. The volatility cost model developed during this research shows that volatility influences process related costs as well as overhead costs. From this research it becomes clear that costs that are related to additional steps in a process are influenced most by volatility. In the particular case that has been analysed the costs influenced by volatility are costs for additional stock, additional process steps to customise a product, additional logistics and additional employee costs. Research questions about the origins, consequences and costs of volatility have been answered extensively in section 3.6.

The fifth research question is *"How is the current repack process for Customer A influenced by volatility?"*. After identifying all stages of the repack process for Customer A it became clear that this process is influenced by all origins of volatility, besides short product life cycles. The main influencer is volatility in demand. The biggest impact of volatility is on inventory, because of demand volatility sufficient safety stocks for both the standard variant as well as the repacked variant of an article need to be in place.

The last research question to be answered is *"What are successful (re)designs for upstream supply chain processes within FMCG, to be as little as possible influenced by volatility?"*. Redesigning the supply chain, in this research called technical solutions, is the first step organisations have to take to better deal with volatility and its related costs. Previous research has shown that eliminating all additional process steps, the so called lean paradigm, will not necessarily lead to a robust, less costly and more efficient supply chain. In uncertain environments like the FMCG industry organisations with a highly flexible supply chain outperform their competitors[161]. To obtain a highly flexible supply chain the so called leagile supply chain design has been developed, a design combining both lean and agile elements. The positioning of the decoupling point is key in a leagile supply chain. The bottleneck of a sudden production process is preferably located upstream of the decoupling point, so that the bottleneck does not have to deal with volatility and a variety of products[162]. In a volatile environment the supply chain needs to be designed backwards with a focus on demand pull, instead of a focus on supply push from the factory outwards. To design the leagile supply chain organisations should identify all their product differentiation activities. A product differentiation activity is a redesign of products and/or

[160] See Germain et al. (2008), p.560
[161] See Merschmann/Thonemann (2011), p.43
[162] See Olhager (2003), p.321-322

manufacturing and supply chain processes to defer activities that specialise work in progress inventory into finished goods. The later customisation enters the production process the closer to the customer the decoupling point can be.

During this research it became clear that the first step to cope with volatility of customers' demand is to analyse the full process to get clear on which process steps volatility has the biggest impact. This research, especially the volatility cost model, provides some guidance on that. The supply chain process has to be analysed and costs need to be allocated to the various process steps. When the influence of volatility on the various process steps is clear organisations can start to redesign their processes. The leagile paradigm provides directions to design a flexible supply chain. The key take away is that additional process steps need to be eliminated as much as possible, without losing the opportunity to customise the process. By carefully placing the decoupling point this can be obtained.

6.2 Recommendations for Case company: a redesign of the repack process that is more flexible, less costly and makes the organisation less influenced by demand volatility

Quite early in the research process it became clear that Customer A will not change its requirements. Next to that, the Case company facilities producing for the Dutch market are not going to adjust their processes to meet Customer A's requirements. This means that repacking will stay part of the process to deliver to Customer A. The investigation of technical solutions to make the organisation less vulnerable to volatility of their customers and to make the repack process more flexible and less costly has been done in this research. Three scenarios have been designed, which are a short term solution to improve the current repack process in the coming two years. Case company has to make sure as soon as possible that their warehousing partner has sufficient capacity available to take over the repack process from the current subcontractor on the short term. If this is proven, the implementation of the first scenario can almost start immediately, since the contract with the current subcontractor for repacking has to be renewed in the coming months. To have a phase introduction of the new process, the classification of products into the three classes, A, B and C can be used.. A classified products are the fast movers, that are less than a month on stock on average. B classified products are one to three month on stock. C classified products are longer than three months on stock on average (see table 9).

A	B	C
133	74	37

Table 9: Number of SKU's per class identified

It is recommended to start with the C classified products. If something goes wrong the impact on the market will not be as big as with B or A classified products. If the process seems to work a new class of products can be introduced every two months. If the capacity proves to be sufficient to repack all products Case company can can implement scenario 2 to after half a year. One year after the start of the process the organisation has to decide whether or not to move on with the third scenario. For the third scenario it is recommended to implement it in two phases. Implement the LAS process first for the base line orders. As mentioned before the base line orders are quite stable over the year. If this works well the promotion orders can be included as well.

On the mid- and longer term Case company has to work on the so-called commercial solutions to become more flexible and less vulnerable to volatility. The organisation has to investigate if the warehousing party they work with can be developed into a real partner that can handle the responsibility of the full repack process, resulting in the implementation of a VMI model. Next to that an extra step has to be set towards the customer to become less vulnerable to volatility. Case company has to carry out the demand profiling analysis as described in this research to get more insights in their demand they want to serve. Negotiations with the customer in order to shape their demand should get the ongoing focus of the account managers to become a shaper of instead of an adaptor to volatility.

6.3 Relevance: this research examines the sources, the consequences and the costs of volatility and provides Case company with hands-on recommendations to improve the repack process

The origins of volatility within supply chains are not often examined, neither is the impact of volatility on supply chain costs. This research therefore contributes in the first place to existing scientific literature by examining the sources of volatility in demand for FMCG manufacturers, especially in the skin care industry. Second, insights in the costs of demand volatility have been provided by analysing the costs related to the sales of deodorants in various selling formats. This has resulted in a cost estimation model for volatility. This volatility cost model provides two types of costs, volatility process costs and volatility overhead costs that are vulnerable to volatility, which can be a basis for supply chain (re)design.

Next to academic relevance this research has managerial relevance as well, especially for Case company. First of all, it improves the general understanding of volatility and its implications on business since the origins, sources and consequences of volatility that have the highest impact on the FMCG business have been identified and discussed. Furthermore some proposals to deal with volatility by designing a more flexible supply chain have been done. If organisations manage to become less vulnerable to volatility this can provide them with a competitive advantage. Second, this research provides insights in the costs and shortcomings of the current process and shows opportunities for improvement. Last but not least, the case organisation has been provided with hands-on recommendations to improve their current repack process. The new process will result in more flexibility within the supply chain, lower costs and it will make the organisation less vulnerable to volatility. The proposed changes in the process will be implemented step-by-step, to minimise the risk that Case company cannot serve the market as requested. The proposed improvements cover both short- and long term elements, with some evaluation moments included.

6.4 Limitations and suggestions for further research

Notwithstanding the contributions that this research has, it also has its limitations. First of all the findings are based on analysis done in one case company, operating in a specific context. This implicates the findings cannot be generalised across organisations and across industries. This limitation was clear from the beginning of the research, it has never been the intention to develop a generalizable theory. Second, some assumptions about the financial structure and figures of Case company had to be done, since part of the real data is confidential and therefore unavailable. If these assumptions are proven to be incorrect, some modifications to the cost model have to be made. Third, some assumptions have been done about the capacity and costs to be charged if Case company moves their repack operations to the warehousing party they are doing business with. Direct contact with this party was not possible, because of the confidentiality of the project. Although defined carefully these assumptions might be incorrect. This might result in savings that differ from the savings calculated in this research.

The limitations identified provide opportunities for further research. The volatility cost model developed in this research has to be validated and optimised in future studies to develop it into a general model that can be used across organisations and across industries. This can be done by setting up a multiple-case study with a longitudinal design, across several organisations operating in the FMCG industry. However it might be even more interesting to see how valid the model is in other industries well known for their uncertain markets, like the car industry and the electronics industry. Next to that, additional research on the relationship between the origins of volatility and volatility costs might help to determine if the current overview of origins is complete, and which of the origins has the biggest influence on volatility costs. This can lead to new insights regarding the design of robust supply chains.

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