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FrieslandCampina

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Demand Management at FrieslandCampina Vietnam

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Industrial Engineering and Management

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I. Management Summary

This research focuses inventories in the distribution chain at FrieslandCampina Vietnam (FCV). At this moment the local warehouses suffers from high variations in demand and stock out situations occur regularly. To prevent stock outs and assure a high service level, FCV wants to reduce the high fluctuations in inventories at the distributor and the high variability this causes in demand at the local warehouses. Therefore the objective of this research is "*to optimize the inventories at the distributors".*

In this research we developed a general policy to reduce inventories and variability what we have tested onto five distributors in region east. For those distributors we selected eight SKUs, five key SKUs as defined by FCV and three slow moving and high value SKUs.

Currently FCV has target stock levels for the distributors of 40% of the value of their monthly sales. This should be enough to cover nearly two weeks demand, but the target stock is an average over all SKUs. It happens often that some SKU has near zero stock while another SKU has enough stock for a month. Replenishment orders are triggered mainly by the regional offices and goods are pushed into the chain. The performance is measured by the order line fill rate to the distributors. There is currently no performance measure for the distributors to the outlets.

There is a high variation in inventory at the distributor and demand at the local warehouse because the lack of rules and because targets are set monthly based on sales to the distributor (sales in). At the end of each month, there are high inventory positions at the distributors and many stock outs at the local warehouses.

We developed an (R, s, S) model which can calculate reorder points and order up to levels to create a stable inventory at the distributor and what reduces the variability. This will reduce variability in demand at the local warehouse and will allow FCV to push on targets and let the market pull on inventory. This advanced inventory control policy can easily be implemented in the DMS system that FCV is currently testing and installing at test group distributors. In this system all necessary information to make the calculations is already available. It only has to be linked and used by the distributors.

To implement the suggested policy, FCV should start which changing the behavior of the sales organization by setting all targets based on sales out (sales to the outlets). This will make it less interesting to have high inventories, while it will also make sure that there are enough inventories to fulfill demand and reach targets. Second, the forecasts need to be translated into sales out, and becomes more accurate per week in order to reduce necessary safety stock. We estimate the potential savings on stock quantities around 25 percent and the reduction in standard deviation of demand of 35 percent with a fill rate at the distributors of 99 percent. This fill rate is currently not measured. Currently is only the order line fill rate measured for the performance of the local warehouses, which is much lower. Another decision needed is in the fill rate level. FCV said that they want to have a 99 percent fill rate which is very high. Even when the fill rate is 95 percent, it is most likely that products are near 100 percent availably in the outlets, while inventories decline with 40 percent.

In this research we have tried to test the solution with a simulation, but this simulation is modest due to a lack of available information. Only information for the East region was available and therefore tested. Further research should therefore investigate the reliability of this research in other regions.

Another point for further research is to investigate the possibilities forecast the sales more accurate. It will be possible to lower stock levels when the forecasts become more accurate and at the same time it will be easier to plan the production scheme.

Last point for further research is the bonus structure. As already mentioned, for a successful implementation it is very important to change behavior. Currently there are different targets, on sales in and on sales out. This causes high inventory positions and high variation in demand. This can be solved through changing the bonus structure into a system that supports the sales out solely.

II. Management Summary (Dutch)

Dit onderzoek richt zich op de voorraden in de keten gereed product van FrieslandCampina Vietnam (FCV). Op dit is de vraag van de distributeurs aan de lokale magazijnen instabiel, waardoor er veel voorraden nodig zijn en geregeld niet kan worden geleverd doordat er geen voorraad beschikbaar is. Om te voorkomen dat voorraden opraken, om productie te stabiliseren en hoge leveringsgraden te garanderen wil FCV de variatie in de voorraden van de distributeurs en de variabiliteit die hier gecreëerd wordt in de vraag bij de lokale magazijnen aanpakken. Het doel van dit onderzoek is daarom als volgt geformuleerd: *"to optimize the inventories at the distributors".*

In dit onderzoek hebben we een algemene regel geformuleerd om de voorraden bij de distributeurs te stabiliseren en reduceren. Deze regel hebben we getest op vijf distributeurs en acht SKU's, waarvan vijf door FCV zijn gecategoriseerd als sleutelproducten en waarvan drie SKU met een lage omloopsnelheid en een hoge waarde.

Momenteel heeft FCV als doelstelling voor distributeurs om 40% van de waarde van de maandomzet op voorraad te hebben. Dit zou ongeveer genoeg voorraad moeten zijn voor twee weken vraag, maar deze doelstelling is geaggregeerd over alle producten. Daardoor komt het geregeld voor dat sommige producten niet aanwezig zijn en andere in veel te grote getale. Order voor de distributeurs worden geïnitieerd door de regionale verkoopkantoren en producten worden door hun in de keten gedrukt. Doelstellingen zijn gebaseerd op verkopen aan de distributeurs (sales in) en het serviceniveau wordt gemeten op basis van de order regel vulgraad. Er is momenteel geen serviceniveau bekend voor de distributeur naar de winkelier.

De variatie in voorraadhoogte bij de distributeur en vraag bij de lokale magazijnen is hoog omdat er geen harde regels zijn over voorraden en omdat de doelstellingen voor het regionale kantoor en de distributeur zijn gesteld op basis van verkopen aan de distributeur. Hierdoor ontstaat aan het eind van de maand een hoge voorraad bij de distributeur en een lage vraag aan het begin van de volgende maand.

We hebben een (R, s, S) model ontwikkelt om goede niveaus te bereken om opnieuw te bestellen en tot waar de voorraad aan te vullen. Deze niveaus zullen een stabiele voorraad bij de distributeur creëren. Hierdoor zal ook de variabiliteit in de vraag bij de lokale magazijnen dalen en het geeft FCV de kans om verkopen te sturen op basis van verkoopdoelstellingen en voorraden op basis van de marktvraag. Dit model kan gemakkelijk worden geïmplementeerd in het DMS systeem wat FCV momenteel aan het aanpassen en instaleren is bij een groep testgebruikers. In het systeem hoeven alleen een aantal links in informatie te worden aangebracht en de distributeurs moeten het systeem gaan gebruiken.

Om het voorgestelde model succesvol te kunnen implementeren zal FCV moeten starten met het veranderen van het gedrag van de verkoop organisatie door alle doelstellingen te baseren op de verkoop aan de winkels. Hierdoor wordt het oninteressant om een te hoge voorraad bij een distributeur neer te leggen. Er moet wel voorraad zijn, omdat anders de verkoopdoelstellingen niet behaald kunnen worden, maar een buffer creëren aan het eind van de maand zoals nu gebeurd is niet interessant. Als tweede zal de verkoopvoorspelling moeten worden vertaald in sales out. Ook moet de voorspelling nauwkeuriger worden om veiligheidsvoorraden te kunnen verlagen. Wij schatten een potentiële reductie van 35% op de standaard afwijking van de vraag bij het lokale magazijn en 25% op de voorraadniveaus bij de distributeurs bij een vulgraad van 99% bij vraag van de winkeliers.

In dit onderzoek hebben we geprobeerd om het model te testen door middel van een simulatie, maar de simulatie is erg beperkt door beperkt beschikbare informatie. Het was alleen mogelijk om te testen voor de regio Oost. Daarom zal vervolgonderzoek eerst moeten aantonen of dit onderzoek representatief is voor het hele land. Een tweede mogelijkheid voor

vervolgonderzoek is naar de vraagvoorspelling. Wanneer deze betrouwbaarder wordt, zullen voorraden en variaties in de vraag beide afnemen.

Een laatste punt voor vervolgonderzoek is een verandering van de bonusstructuur. Omdat voor een succesvolle implementatie een gedragsverandering noodzakelijk is waarbij gekeken gaat worden naar de verkoop aan de winkeliers in plaats van de distributeur, zal ook de bonus van deze verkoop af moeten hangen.

III. Preface

Ho Chi Minh City, Vietnam

March 2010,

In this report I represent the result from my bachelor graduation project I have performed during the first three months of 2010 at the head office of FrieslandCampina Vietnam in Binh Duong Province. This will be the final project for me to graduate for the bachelor study Industrial Engineering and Management at the University of Twente in Enschede, the Netherlands.

It was very nice to see all theory of the last years in college become practice, especially because it was in a great company, in a terrific country. All colleagues were very nice and helpful, for all questions I had regarding my assignment as well for all questions besides that.

There are a few people I like to thank in particular. First of all, my company supervisor Ms. Thu, although she was very busy she always tried to help me in finding information or answering questions. Also I like to thank Mr. An and Mr. Jan Wegenaar for their time and the discussions. I'm very thankful that I could make use of their expertise in logistics to bring this research to a successful end. There are many other people I want to thank, the people who showed me around the distribution centers, regional offices and answered patiently all questions I had about the subject and last but not least, I like to thank my direct colleagues from the Consumer Service Department who take me out for lunch and helped me wherever they could. Special thanks to Mr. Hieu, who took very good care for me during my time at FCV.

From the University of Twente I want to thank my supervisors. Especially Matthieu van der Heijden. He had always some time available to comment my reports and answer my questions. Even unless the distance and time difference, he often found some moments to call and explained me all questions I had.

My stay in Vietnam makes me realizing that there is a whole world that can be discovered. There are huge markets to sell goods, with highly skilled and motivated labour, where it is very comfortable to work and live and which gives great opportunities for the future.

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IV. Table of Contents

1 Introduction

This research is performed at FrieslandCampina Vietnam. FrieslandCampina Vietnam is a milk processing company, with two factories in Vietnam. De head office and biggest factory are in the South of Vietnam, near Ho Chi Minh City in Bin Duong. The second factory is in Ha Nam, near Hanoi in the North of Vietnam.

To get started, this chapter contains an introduction to the company in section 1.1, after that we use section 1.2 to elaborate on the research design. The last section will summarizes this chapter.

1.1 FrieslandCampina Vietnam (FCV)

In this section we will start in subsection 1.1.1 with getting a general picture of the company and its products in subsection 1.1.2. Secondly we use subsection 1.1.3 to get into the supply chain of FCV and after that we describe how the distribution system is managed in subsection 1.1.4.

1.1.1 The company and its history

FrieslandCampina is a huge international company, with Dutch origins. In 2008 Friesland Foods (where Dutch Lady Vietnam was a part of) is merged with Campina and so they became together one of the largest dairy companies of the world. FrieslandCampina Vietnam is a part of the "Consumer Products International" pillar, which is one of the four pillars of the company like Figure 1.1 displays. In this part of the company there are 12 companies that operate mostly independent, around the world, like in Thailand, Malaysia and Indonesia.

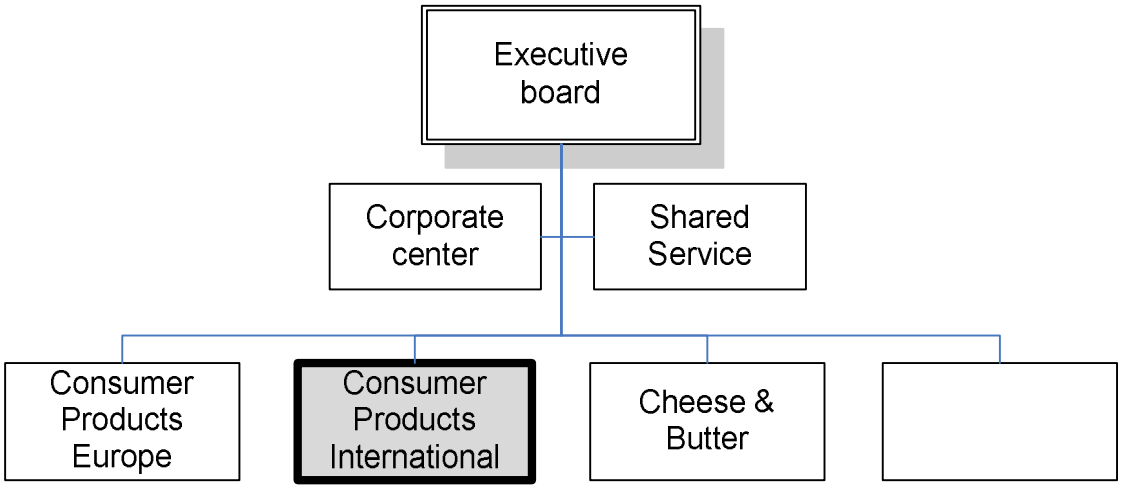

Figure 1.1: Organization chart FrieslandCampina (FrieslandCampina, 2010)

Dutch Lady Vietnam was established in 1924, when the first 150 cartons with sweetened milk were imported and sold in Vietnam. This all was part of a dream, "to build a healthy community". This dream can still be seen in the current vision: "Improve life". To accomplish this vision the mission statement is: "develop, produce and market a broad range of reliable, natural and nutritious dairy products that should contribute to the well-being and vitality of life".

Nowadays almost all products are produced in Vietnam and Dutch Lady is now one of the in total six brands of FCV. There are two factories, in Binh Duong (near Ho Chi Minh City) and in Ha Nam (near Hanoi) and three local warehouses, where in total are 1,487 employees working,

over 1.5 billion cartons per year and this volume is growing with an average rate of 15% per year. The yearly turnover in Vietnam is US$350 million.

1.1.2 Products

FCV's products can be subdivided into three categories: Instant Milk Powder (IMP), Sweetened Condensed Milk (SCM) and Ready-To-Drink dairy (RTD). Figure 1.2 shows the different categories and different products. The numbers between brackets are the different tastes for each product. In total there are 39 different products produced and because of different packaging there are at least 65 SKUs. When there is a promotional campaign with a different package or when something is added to a SKU (i.e. promotional card), this becomes a new (temporary) SKU.

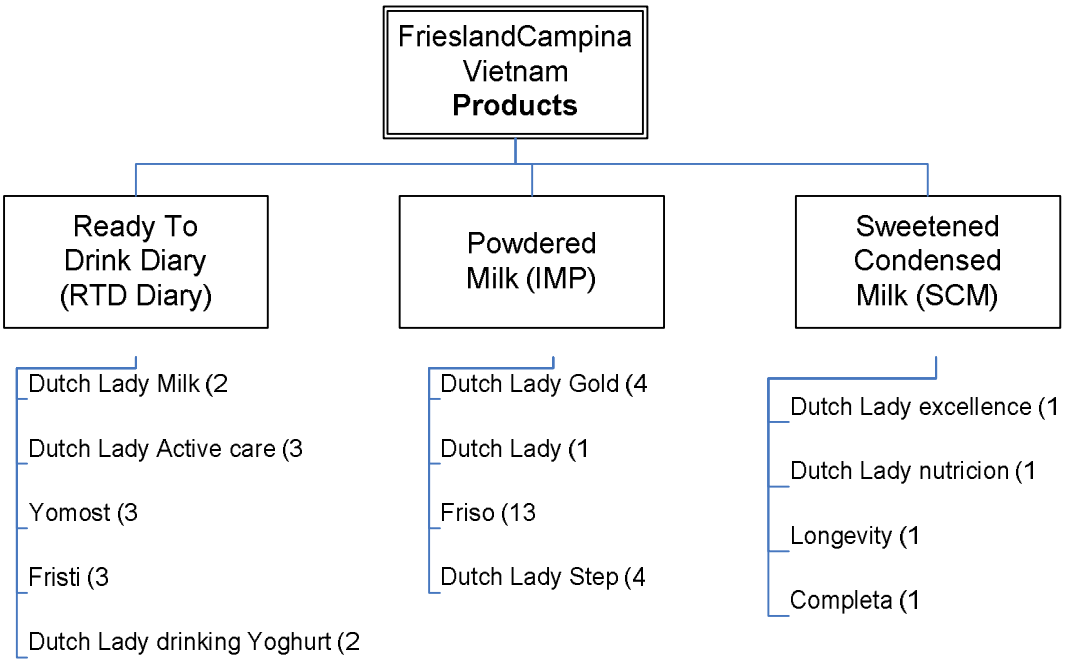

Figure 1.2: Products

All the products have a limited preservability. Table 1.1 shows the preservability for each product category. Also shows the table the incubation time. FCV prevents every product from sales for a short period; this is called the "incubation time". In this period there is a sample product tested, so FCV is sure that there are no unwanted bacteria in the products and the high quality standards are reached.

1.1.3 Market

FCV uses two roads to the end-consumer, "General Trade" and "Modern Trade". First, and most important with 90% of total sales, is General Trade, small traditional outlets, everywhere in Vietnam, where in general the consumer points out the product of choice and then he is served by the shop employee. General Trade is divided into six regions as in Figure 1.3 is displayed at the right part. Every Region has a regional office that coordinates the sales in that area. The regional office has no stock, but they are responsible for creating sales orders and for reaching the regional targets. All regions together sell products to 150 distributors among Vietnam, who sell the products to the 100.000 outlets.

Each Regional Offices is allowed to sell the forecasted amount of products and delivers goods directly out of the warehouses to distributors. The distributor has a small warehouse, where the goods are stored and buffered before distributed to the outlets. The distributors are paying FCV and so they are the actual customers of FCV.

PRODUCT	PRESERVABILITY	INCUBATION
Ready To Drink Dairy		
Milk	6 months	7 days
Drinking Yoghurt	8 months	2 days
Powdered Milk		
Tin Can	2 years	5 days
Carton	1 year	5 days
Sweetened Condensed Milk		
All products	1 year	5 days

Table 1.1: Preservability and incubation time of products

The distributor is allowed to sell more SKUs, from other factories, only they cannot sell other dairy products. Also controls FCV sales of the distributor. They developed an administration system, called DFD, what is used by the distributors, to record their inventory and sales. The distributors get a weekly target from the FCV Regional Office. When this target is reached, the distributor gets a bonus.

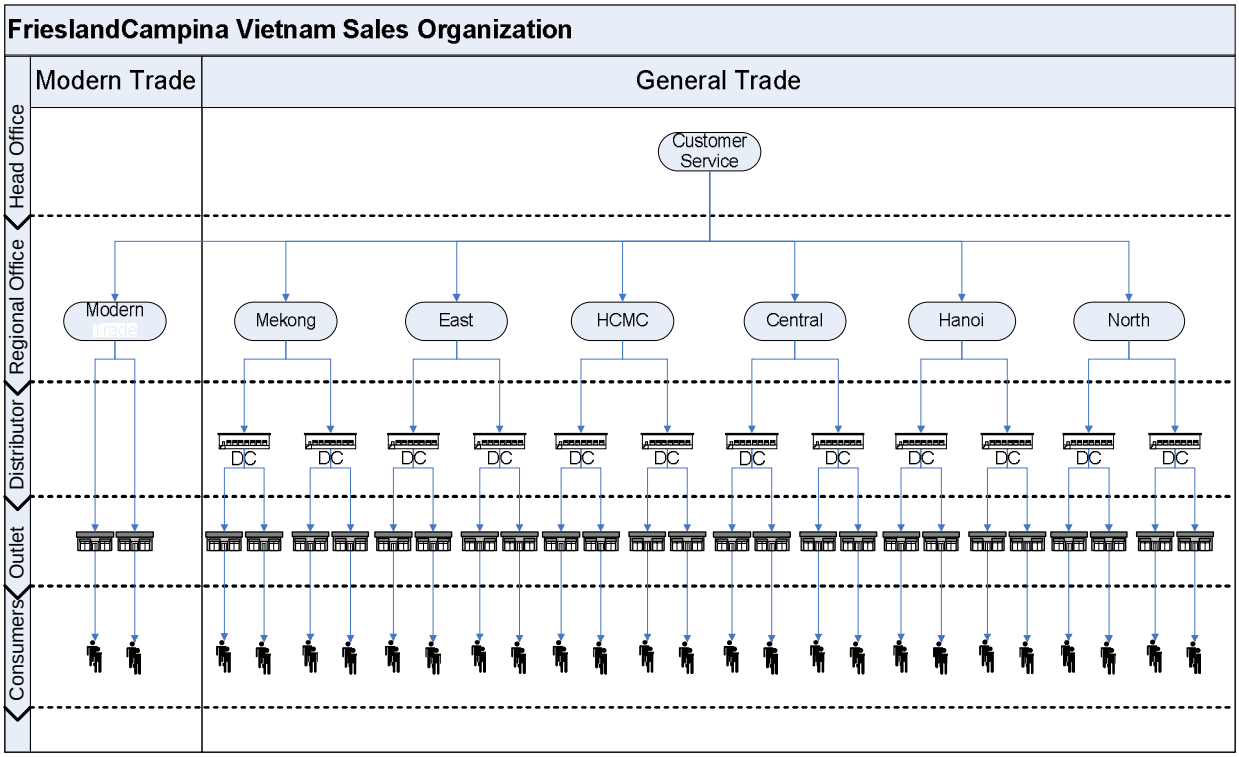

Figure 1.3: FrieslandCampina's Sales Organization

The other road-to-market is the so called "Modern Trade". The outlets in Modern Trade can be divided into four types: first there is the *hypermarket;* this is a large market which sells everything, from food to motorbikes. Shopping becomes a day out. Second is the *Supermarket.* In a supermarket the main product is food and the store is designed to have a large choice of different brands and get your products fast. Third is the *Wholesaler,* which also sells to other businesses. Therefore they usually sell large amounts. The last category is

the *convenience store.* This is a small shop, which is mostly opened 24/7. It has a smaller selection of products and sells only small amounts. Because of the larger quantities the Modern Trade stores are directly delivered from the three main warehouses. The Modern Trade is completely organized from one office, on the same location as the regional office of Ho Chi Minh City.

1.1.4 Supply Chain Finished Goods

The Supply Chain finished goods of FCV is hierarchic and complicated because SKUs pass many levels and these levels are different as the levels in the sales organization.

After production, the goods are stored in the local warehouse and during the incubation time they cannot be delivered. At the end of the incubation time the product is released when all the tests are negative. For the incubation times, see Table 1.1.

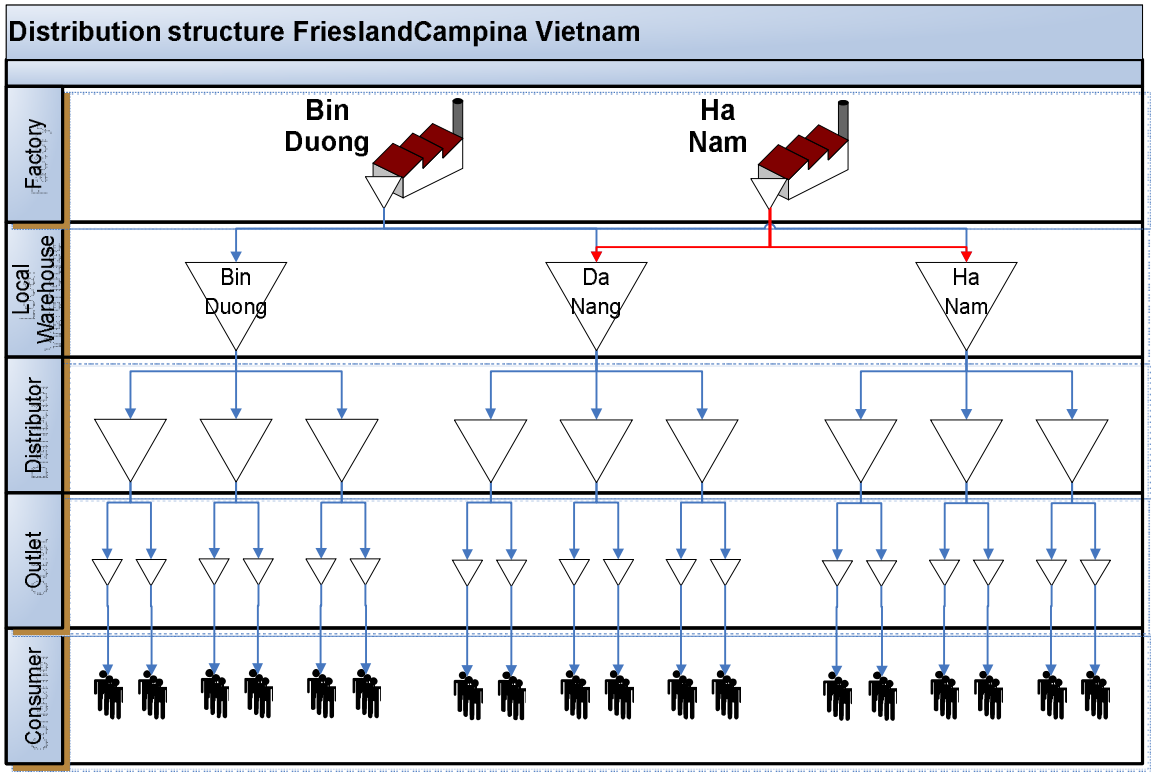

Figure 1.4: Distribution structure of FrieslandCampina Vietnam (General Trade)

Figure 1.4 shows distribution structure for General Trade. Modern Trade is no part of this research and therefore left out completely. This figure shows the stock in its incubation time as stock at factory level and it also shows that the factory in Bin Duong produces all products and ships products to all three warehouses. The factory in Ha Nam is only producing goods for the North and Central region. FCV can influence the stock levels at the local warehouses and the distributors, but the stock at the distributors is not owned by FCV. We can describe the supply chain according to (Axsäter, 2006, p. 187) as a multi-stage or multi-echelon structure.

The local warehouses should contain stock for on average two weeks, but this period wherefore stock is available can differ per SKU. Some products are sold in only small quantities, but because of the minimum batch quantity there is after a production batch for more than two weeks stock available.

The distributors have a target stock level of 40% of the monthly sales. The target is based on the value of the monthly target of sales to the distributor over all products. So there is not a target per SKU. This means that it occurs often that there is too much inventory of some SKU and no inventory of others.

The inventory at the outlets is not recorded, but in general there is only a small amount of stock available at the outlets, because most outlets have very limited storage space. Also are most outlets delivered multiple times a week and therefore they do not need a lot of stock.

1.2 Research design

In this section we will draw the research design. Because this research is part of the Demand Management Project of FrieslandCampina, there is also some information added about the objectives of this project.

1.2.1 Research motivation

FrieslandCampina Vietnam (FCV) suffers currently from high demand variations at factory level. At the same time the forecasts of the sales in (sales to the distributors) are 88% accurate (FrieslandCampina Vietnam, 2009), when calculated over all SKUs on average per month and there is a large variation in inventory levels at distributor level. So to reduce the variations at factory level, FCV first wants to reduce the variation at distributor level.

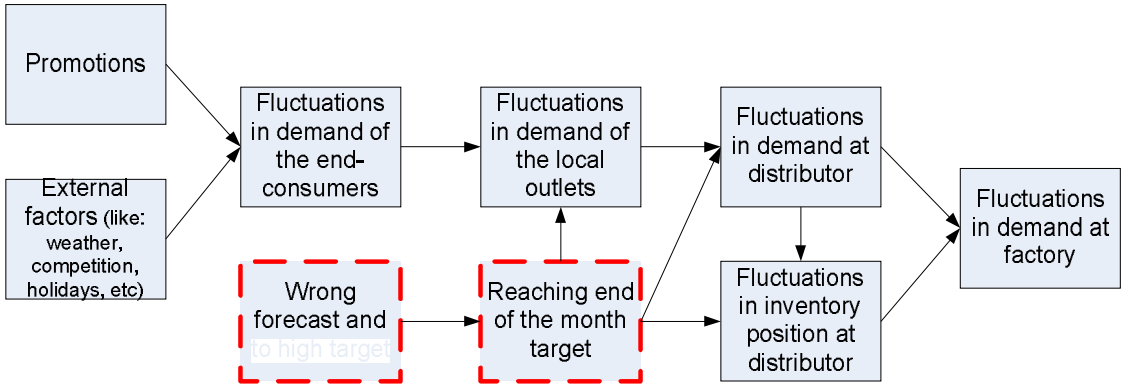

Figure 1.5: Problem tree

When we evaluate Figure 1.5 we see that there are two major reasons of the fluctuations. First we have the upper bracket with fluctuations at the demand at the distributor itself. It is very difficult to prevent these fluctuations, because as we can see they originate in external factors like the end-consumer and competition. On the lower bracket in the figure we see that the fluctuations in the inventory position are very high.

When we evaluate the problems that cause these high fluctuations in the inventory position, we can distinguish two reasons; fluctuations in the demand and reaching of targets and get their bonus. For the distributor as well for the salesmen there are monthly targets and sales and inventories are rising at the end of the month to reach those targets. Figure 1.6 displays this phenomenon. The dotted line shows every end of a month and it is clear that inventory levels at the distributor rises. FCV has put their focus currently on the fluctuations in inventory at the distributor. When this fluctuation is reduced, the idea is that also demand at the factory will become more stable.

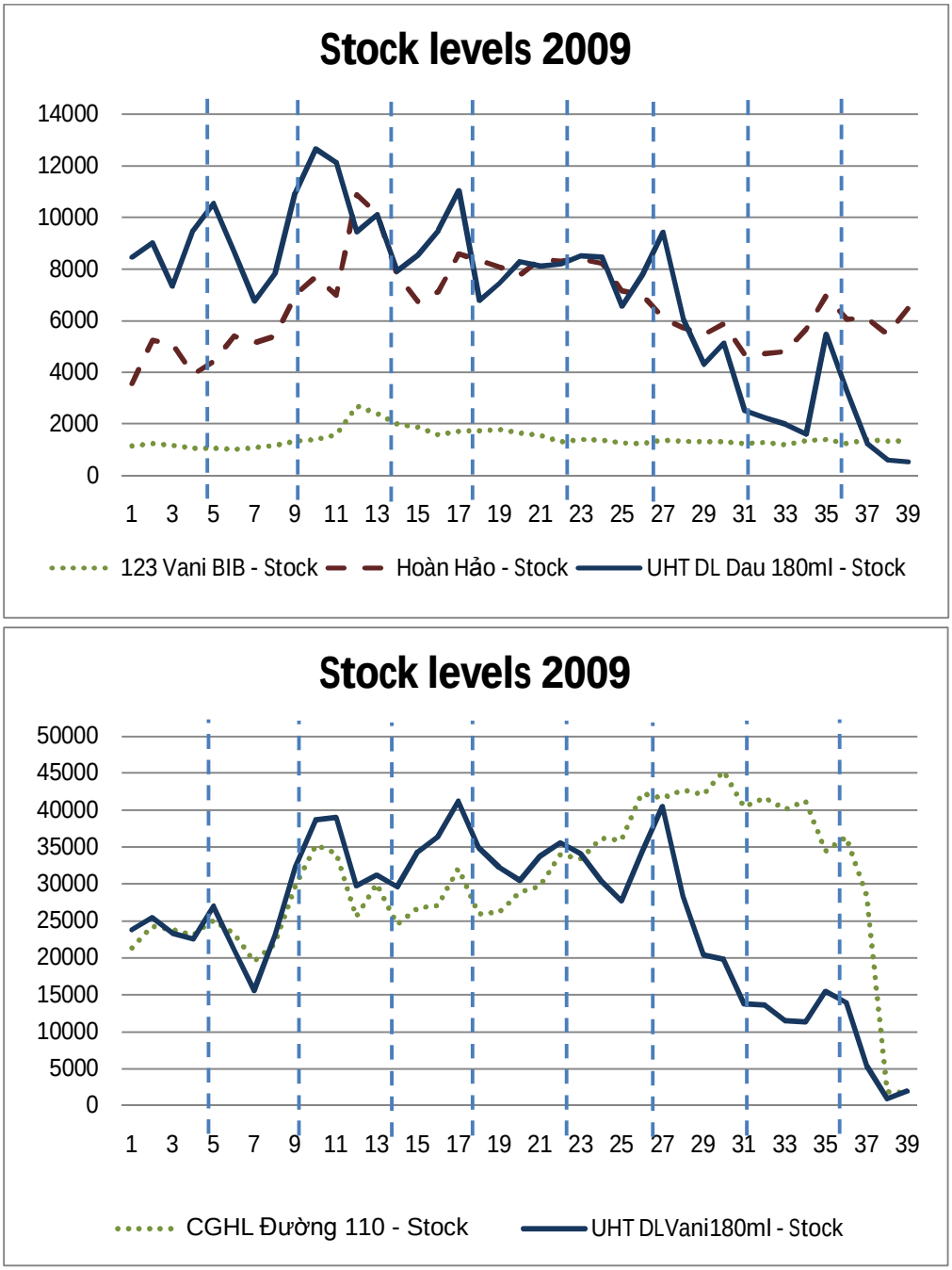

Figure 1.6: Stock pattern five key product in region East

1.2.2 Research problem and objectives

Based on the research motivation in section 1.2.1 the research problem can be formulated as:

"Inventory levels at the distributors are high and have high fluctuations. This causes unnecessary high use of working capital and use of warehouse space at the distributor and high fluctuations at the local warehouses and many stockouts. To create a more stable demand pattern at the local warehouse FrieslandCampina Vietnam wants to start optimizing inventories at the distributors."

1.2.2.1 Project objectives

The project objectives are as follows:

1. Improve distribution / route to market effectiveness and customer service
2. Optimize inventory in the extended supply chain

In the first objective, route to market, is the route from released stock till distributors' warehouse, as Figure 1.7 also displays. The Customer Service which is mentioned is therefore the order line fill rate at the distributor. The improvement planned to be made is less stock in the chain, so that it will be easier to put new products into the market. For example is a new year promotion, what causes that all distributors has a lot of stock of the normal SKUs in the warehouse, what is getting closer to the expiration date and causes low sales (and high fluctuations) at the local warehouses after any promotional campaign.

The second objective is to optimize the inventory in the extended supply chain, which is defined as the sum of the inventory at the distributors and the local warehouse. This should be as low as possible, to prevent the distributor and local warehouse of a waste of warehouse space and high working capital.

Goal of the project is to deliver a model for auto replenishment of distributor's stock based on selling out, which is defined within FCV as the sales from the distributor to the outlets.

1.2.2.2 Research objectives

FCV has already decided to use a periodically review and variable lot sizing ordering system. FCV also prefers a clear reorder point and prefers not to order each SKU each week. This leads us automatically to a (R, s, S) policy, which means that that there is a review period R, when the inventory position will evaluated. When the inventory position is below s at that moment, an order will be released to raise the inventory position back to level S. Therefore the objective of this research is to:

> "Implement an (R, s, S) policy to optimize the inventory levels at the distributors of FCV and therefore reducing the variability at the local warehouses and the production facilities, with maintaining a high Customer Service Level."

The Customer Service Level (CSL) is the degree in what the outlets are served by the distributors and the target set by FCV is 99%.

1.2.3 Scope

In the Demand Management Project the scope is limited to General Trade and all finished goods at the warehouse and distributors. The finished goods consist of all SKUs that are produced by FCV, what are at this moment around 65. Out-of-scope is phasing-in and phasing-out of products, modern trade and the stock at the factory, local warehouses and retailers. Figure 1.7 shows the project scope in the distribution structure of FrieslandCampina Vietnam. The gray areas are out of scope and the white areas mark the scope of the project.

We will only review singe-echelon models, because it will be difficult to share costs among distributors and FCV, because it are different entities and FCV has no experience in using (complex) models yet, so it will probably better to start with an easy understandable policy, that will be easy to explain to all parties involved. Still it is expected that a single-echelon model will be a good start because when inventory will be smoothened at the distributor, it will create a more stable and better predictable demand at the local warehouse. This means that we are dealing with demand from the outlets at the distributor and therefore a single stock point system.

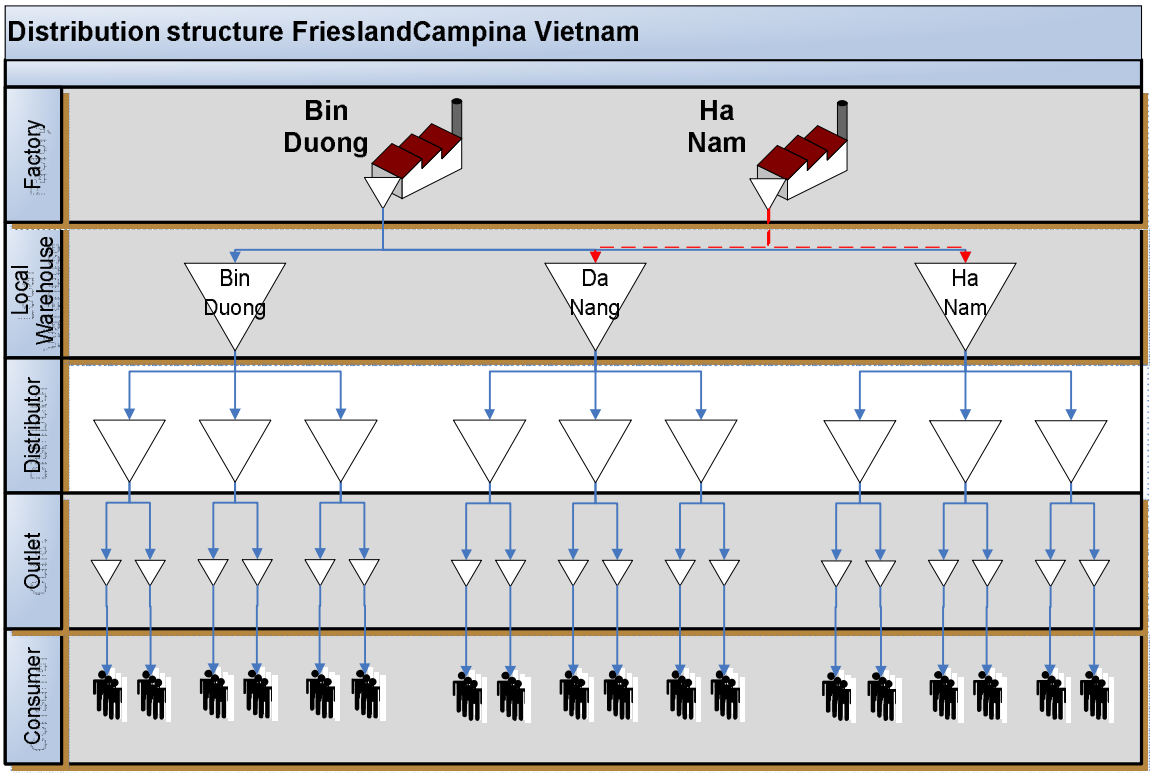

Figure 1.7: Project scope

Because we have limited time for this research, we will start with calculating the levels for 8 SKU (the five key SKU as defined by FCV and three high value and slow moving SKU(Vietnam, 2010)), so we can test the (general) rule we will develop during this research and what can be build into a supporting IT tool. The rule will be one of the deliverables of this project. Table 1.2 displays the turnover in cartons[1] of the five key products, based on sales information of 2009.

We also choose for a limited number of distributors to test. Because the planning is to use the results of this research in the new Demand Management System (DMS), we had planned to use the same distributors which participate in the concept phase of that project, to test on. These are distributors chosen in all regions, of different sizes and rural as urban located. Unfortunately there was no information available for those distributors. Because we have information available over region east, we decided to test first on five distributors in region east. The five distributors are chosen by turnover, the two biggest and the three smallest distributors from this region.

1.2.4 Assumptions & limitations

There are a few assumptions and limitations that will have effect on our research. In this section we discuss them all briefly.

[1] A carton is a box in which the products are sold to the distributors and outlets. This measure is used in all forecasting and performance measures, because the size stays equal and there will not be any differences because of price changes.

	Cartons	% cartons	Value (in million VND)	% value
UHT Đường110-VG	6,498,898	21.37%	744,416.27	11.63%
UHT DL Dau 180ml	2,517,561	8.28%	439,427.68	6.87%
UHT DLVani180ml	7,519,784	24.73%	1,312,540.70	20.51%
Hoàn Hảo	1,116,843	3.67%	414,247.12	6.47%
Ovaltine BIB300	19,368	0.06%	8,662.78	0.14%
123 Vani BIB	149,593	0.49%	174,615.87	2.73%
Friso3 1500g	15,798	0.05%	26,222.15	0.41%
Friso Gold1 900	14,886	0.05%	56,269.08	0.88%
Region East	***5,120,312***	***16.84%***	***1,164,890.00***	***18.20%***
Total all SKU	**30413247**	**100%**	**6,399,572.14**	**100%**

Table 1.2: Turnover selected products in carton and value

1.2.4.1 Separate entities

FCV is a different entity as the distributor. FCV is the owner of the sales organization, including employing the salesmen. The distributors buys the product from FCV, provides credit to the outlets and send the products (that are sold by the FCV sales force) to the outlets. Therefore distributors will only allow some interference with their inventory management if they gain any benefits from the interefence.

	Cartons	% cartons	Value (in million VND)	% value
3.06 Nhà phân phối Thành Bước CN	136,232	0.45%	29,069.91	0.45%
3.09 Công ty TNHH Lâm Thuận	458,651	1.51%	109,371.62	1.71%
3.18 Nhà phân phối Tân Bảo An	171,186	0.56%	35,822.40	0.56%
3.19 DNTN Phương Ánh	381,587	1.25%	84,404.33	1.32%
3.23 Nhà phân phối Hoàng Hà	78,071	0.26%	15,245.89	0.24%
Region East	***5,120,312***	16.84%	***1,164,890.00***	18.20%
Total all SKU	**30413247**	100%	**6,399,572.14**	100%

Table 1.3: Turnover selected distributors in carton and value

It is important that the system will reduce costs for the distributors without any additional investments.

1.2.4.2 Limited scope

Most likely the best performance in the chain will be reached by implementing a multi-echelon system, what manages stocks at the local warehouse and at the distributors. This is a more difficult system and more important, it will be difficult to implement because the distributors are not owned by FCV.

1.2.4.3 Product mix

The suggested policy is mainly based on fast-moving SKU. Main goal of the research was to optimize inventory for those SKU. Facing in and facing out of products is not taken into account.

1.2.5 Research Questions

To reach our goal as is stated in section 1.2.2, we need to answer the research question:

"What is a good order policy that can be implemented at FCV which minimize inventories for the distributors and minimizes the variation in demand at the local warehouse with a high service level for sales to the outlets?"

To simplify the answering process, the question can be divided into the following four research questions:

1. What is the current policy and performance regarding to the ordering process?
2. What would be a good policy for single-echelon systems according to literature?
3. How will the policy found in literature perform in the situation of FCV?
4. How should the proposed policy be implemented?

1.2.6 Milestones

To get a solid answer on the research question, we will use the research plan as Figure 1.8 shows. In Chapter 1 we will get an introduction to the company and we draw the research design. The organization of the ordering process as it is used now and their performance are discussed in Chapter 0, which will provide an answer on research question 1 (Q1).

In Chapter 3 we will start reviewing literature and try to find an answer to research question 2 (Q2).

This answer from literature has to be adapted to the situation at FCV in Chapter 4. This is the model description and will also be the answer on research question 3 (Q3). With this model we can give some recommendations for implementation (Q4) for FCV and give are final conclusions and recommendations in Chapter 5.

1.3 Summary

In this chapter we have first introduced the company, its customers and products. This research takes place at FCV, which is part of Royal FrieslandCampina, one of world's largest Dairy companies. In Vietnam FCV sells their Dairy products via 100,000 outlets that are supplied by 150 distributors.

In section 1.2 the research design is explained. The deliverable of this research is a policy to control the inventory at the distributors, so high stocks are prevented and demand at the factory becomes more predictable.

In the next chapter we will describe the current situation. This will make clear the problems FCV is suffering now.

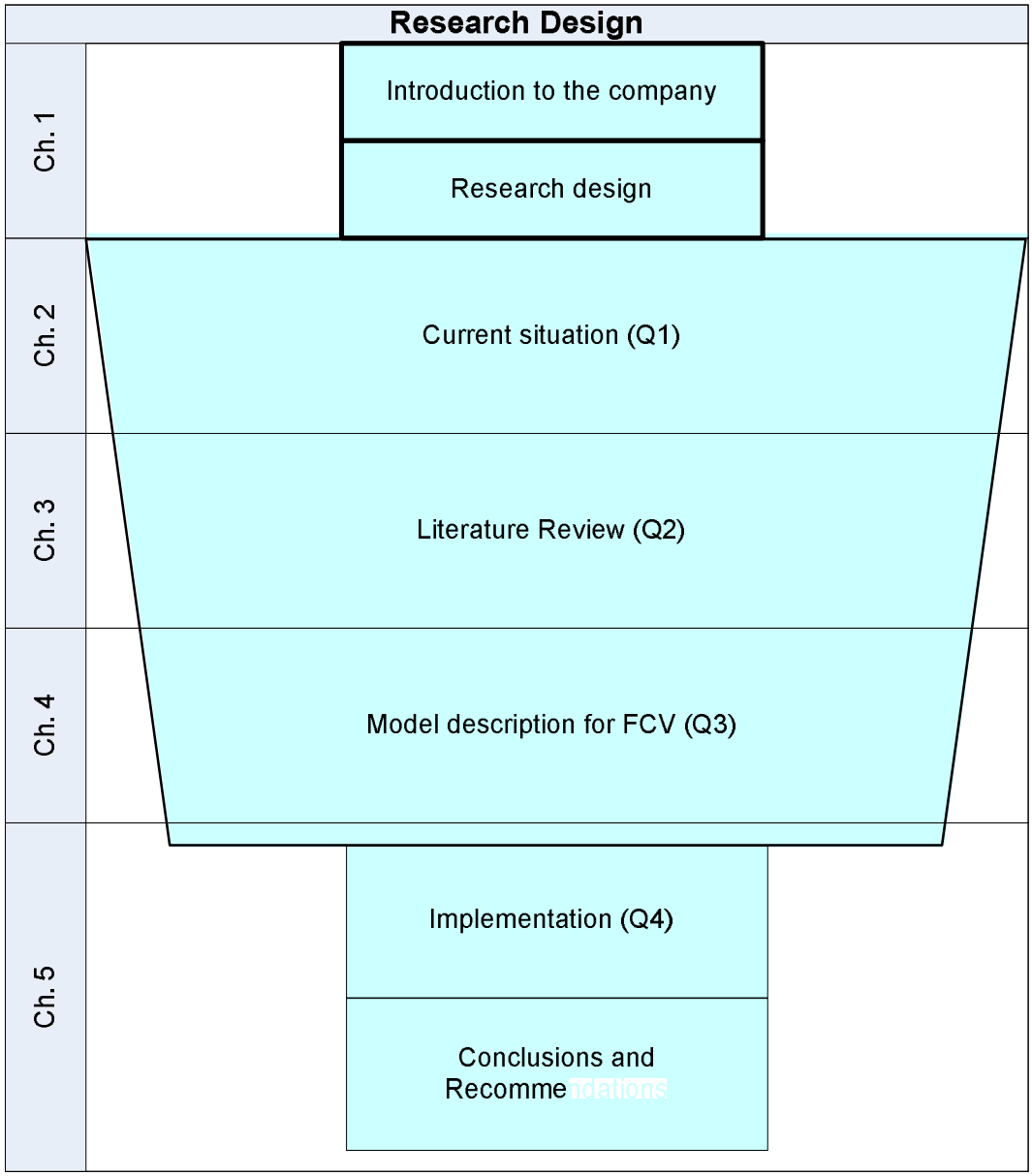

Figure 1.8: ***Research Layout***

2 The ordering process

In this chapter we try to get an answer on research question 1:

What is the current policy and performance regarding to the ordering process?

To get a proper answer on this question, we will start in section 2.1 with exploring the process of how the forecasts and targets are made within FCV. Secondly, we use section 2.2 to explore the demand FCV has on all levels. We start down in the chain, at the level of the end-consumer and we will work up to the distributors.

In section 2.3 we explain the difference between the sales and distribution organization. The flow of goods will become clear in this section, what brings us to section 2.4, where we will evaluate the current performance. We declare multiple Key Performance Indicators (KPI) and their performance.

2.1 Forecast and target setting process

In this subsection we discuss the forecast and target setting process. First, the forecast is made at the head office by the Consumer Sales Manager and is based on historic sales data per region. When the forecast has been made, it is adjusted to the planning of any promotional campaigns of the Trade Marketing Department and Consumer Marketing Department about promotional campaigns. Trade marketing develops campaigns to promote the products to the shop owners, by goodies, free products or dressing up the shop, while consumer marketing focus on the end-consumer. The Management Team will confirm the target, but they do normally with adding a growth rate, which is based on historical growth. When this information is included, the forecast becomes a target.

Each month, this target has to be approved by the management of FCV. When the targets are approved, they will be sent to every department that uses them and to the regional offices. It has to be remarked that the monthly target is also used as the forecast. Later we will discuss how accurate the forecast is, or the target is reached.

In Figure 2.1 the other departments are left out, because they do not change anything about the forecasts. As the figure shows, at the regional office the monthly target is split into weekly targets per distributor. This is done by the Regional Sales Officer (ROSA) and is based on promotional plans, current stock levels and historic data.

The next step is a little different per Region. For example, in the Ho Chi Minh Region, the weekly target is sent to the distributor and that is all. In the East Region the weekly target will be divided into forecasted deliveries and those are sent to the distributor.

In general it does not make a huge difference. In both regions, the distributors split the weekly targets among the outlets. Again, this is based on the target, historic data and current stock levels of the outlets.

During the month, the salesmen (who are employed by FCV) visit the outlets one till three times a week. Before they left the distributor's office in the morning, they get a briefing. During the briefing the status of the targets are discussed for different SKU and there is a focus set for some SKU, based on current stock levels at the distributor and the targets. The salesmen can use this information to push the outlets to sell more (or less) of a SKU or try to motivate an outlet to sell other SKU.

It is interesting to notice that forecasts are made top-down based on sales in and only translated into sales out at salesmen level. These are different measures and it means that in the sales in forecast also increases and decreases in stock are taken into account. This makes an accurate forecast more difficult.

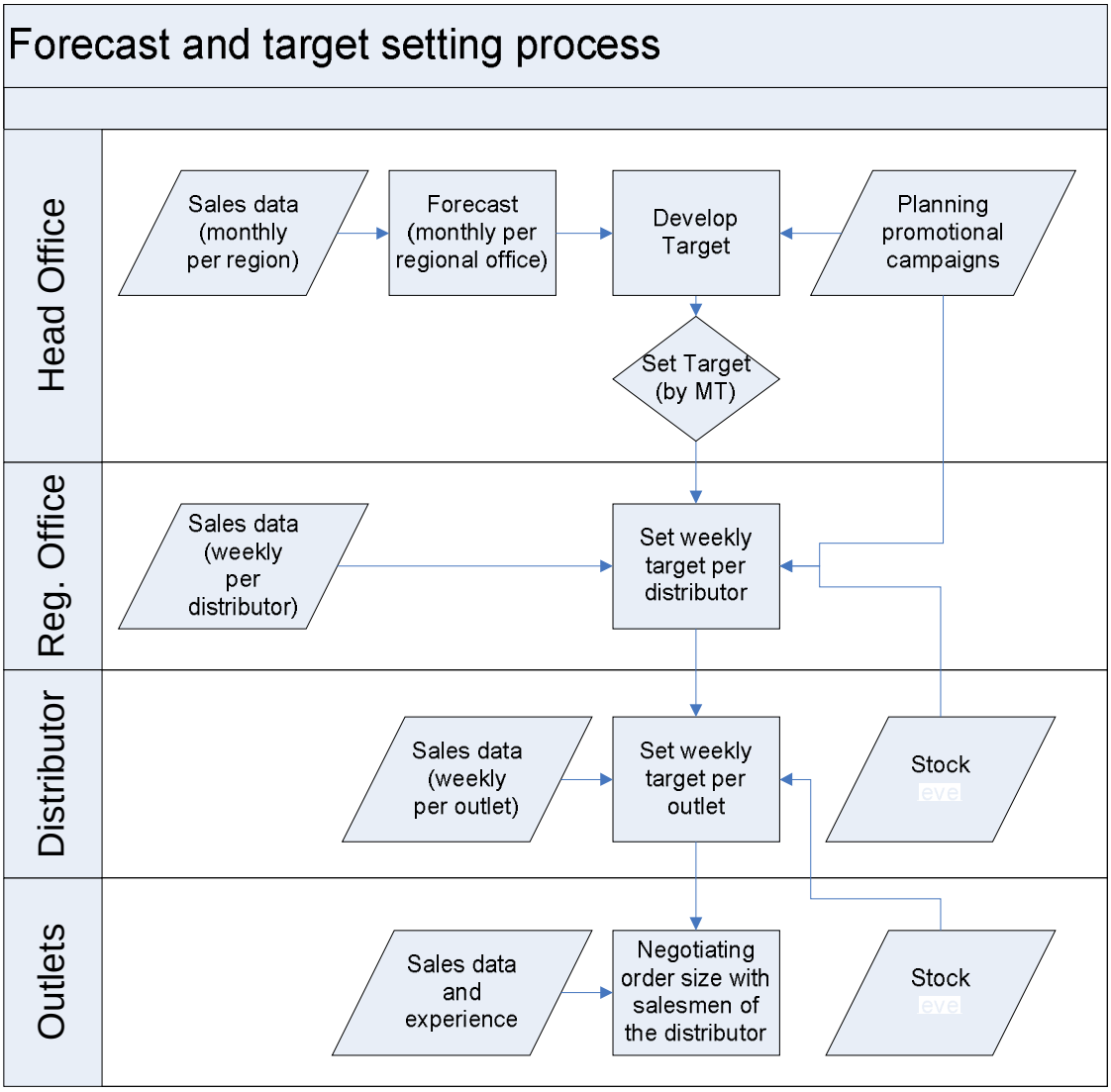

Figure 2.1:Forecast and target setting process

2.1.1 Forecast error

The forecast error can be measured by Equation 2.1:

$$FC_{error} = \frac{\sum_{SKU} \left| Sales_{Forecasted} - Sales_{actual} \right|}{\sum_{SKU} Sales_{Forecasted}} \times 100\%$$

Equation 2.1: Forecast error

This formula is used to calculate a monthly error measure. The measurement is in cartons of the SKUs, so that price differences not influences the measure. The formula in Equation 2.1 is in literature also called the Mean Absolute Percentage Error (MAPE) (Silver, Pyke, & Peterson, 1998, p. 110).

Unfortunately we only have sales information available and not the forecast information. Therefore we cannot calculate the forecast error per distributor and per SKU. Because we do have information about the aggregated forecast and sales, we calculate the general forecast

error per SKU. Figure 2.2 displays the forecast error of 2009 over all SKUs. The dashed line is the forecast error and the solid line is the absolute forecast error. We can see that the forecast is within a 5% bound, except for January and for September till November. This last period can be explained by bad publicity and the withdrawal of a few SKUs like already is explained in section 2.2.2. This is the average accuracy and a drawback of this measure is that the forecast bias is not visible. The bias shows a tendency for the forecast error to be always in a particular perspective. For example, if the forecast is structurally too high, it is called biased. To check whether the forecast is biased or not we use the forecast error without the absolute value (Silver, Pyke, & Peterson, 1998). When sales are higher than the forecast, the blue dotted line in Figure 2.2 will be above zero. We can see that the forecast accuracy is near zero, with an average of 0.42%[2] (Customer Service Department FrieslandCampina Vietnam, 2009).

We assume that the forecast for each SKU is not biased, because of the small difference over all SKUs. Still it can be possible that the forecast of some SKUs are biased, but this are forecast matters which are considered out of scope for this research.

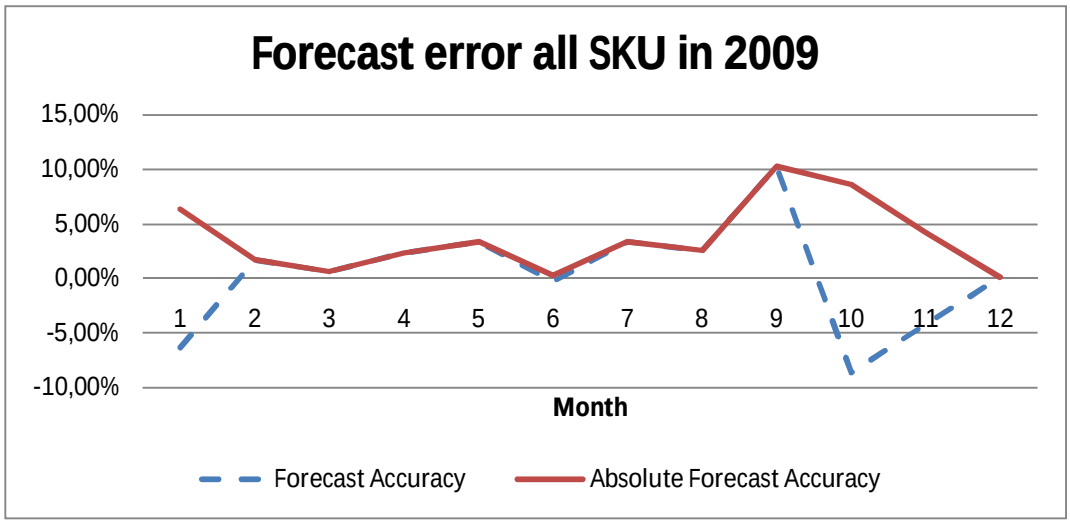

Figure 2.2: Average Forecast Accuracy sales in over all products

2.2 Demand

Demand has a multiple level structure. In this subsection we elaborate shortly on all levels in a bottom-up way.

2.2.1 Sales of the end-consumers

The demand of milk products generated by the end-consumer is considered as very stable. Consumers will not drink a lot more milk in this week, as they did last week. Differences in demand at the end of the chain are mostly triggered by promotional campaigns or problems in supply, by FCV as well their competitors.

[2] Measured over all SKU and all distributors. When we zoom in more closely, we will see that forecast accuracy is lower (see also: section 1.2.1)

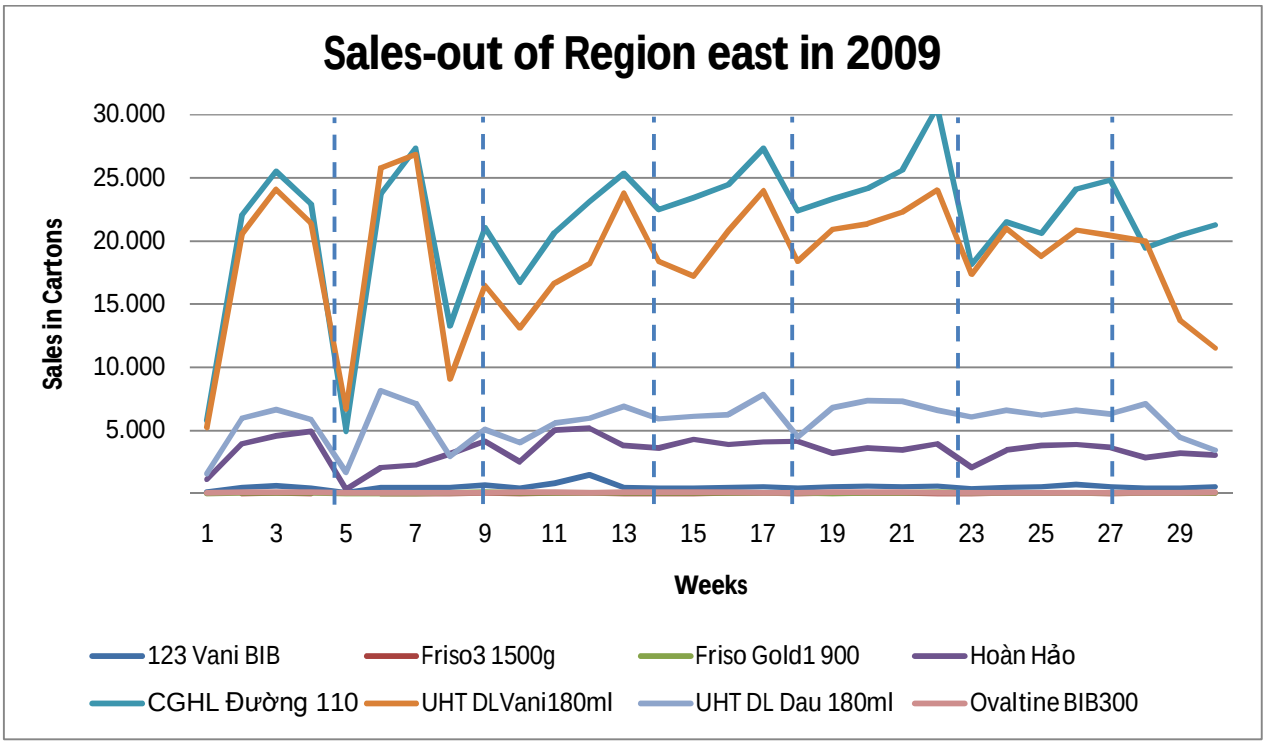

Figure 2.3: Weekly sales out (sales to outlet) of region East 2009

2.2.2 Sales of the retail-outlets

Although the demand of the end-consumers is considered to be very stable, this started to change at the outlets, the first place in the chain where stocks are held. Next to the demand differences from their customers, the outlets are also triggered by trade marketing campaigns. FCV and its competitors are all fighting for the best place in the shop and extra attention to their products.

Next to this, the distributor's salesmen have a monthly target to reach. So they will push the outlets at the end of the month to buy the products needed to reach the target. Therefore is demand from the outlets less stable as we might expect. Figure 2.3 shows very clearly that at the end of every month (the dotted vertical lines show end of the months) sales are significantly growing. To get their bonuses the salesmen and distributors are very keen on reaching the target. But after a week of high sales, the sales declines again. We can a few other remarks on this figure. First the big decline in sales in week 5, this is because of Tet holiday[3]. Also in the period between weeks 37 till 47 the sales of many products declined drastically. This was due to bad publicity on a change of a recipe and a new additive, what forced FCV to withdraw all units of some SKU from the market and replace them with the old SKU. Therefore we only take sales until week 30 into account.

[3] Tet is the Vietnamese New Year. During Tet almost all shops in Vietnam are closed for almost a week.

2.2.3 Sales of the distributors

Because of those sales targets, at the end of the month the distributors try to sell more to the outlets and also take more products on stock their self. This causes high demand at the end of the month and increases the variance of the demand.

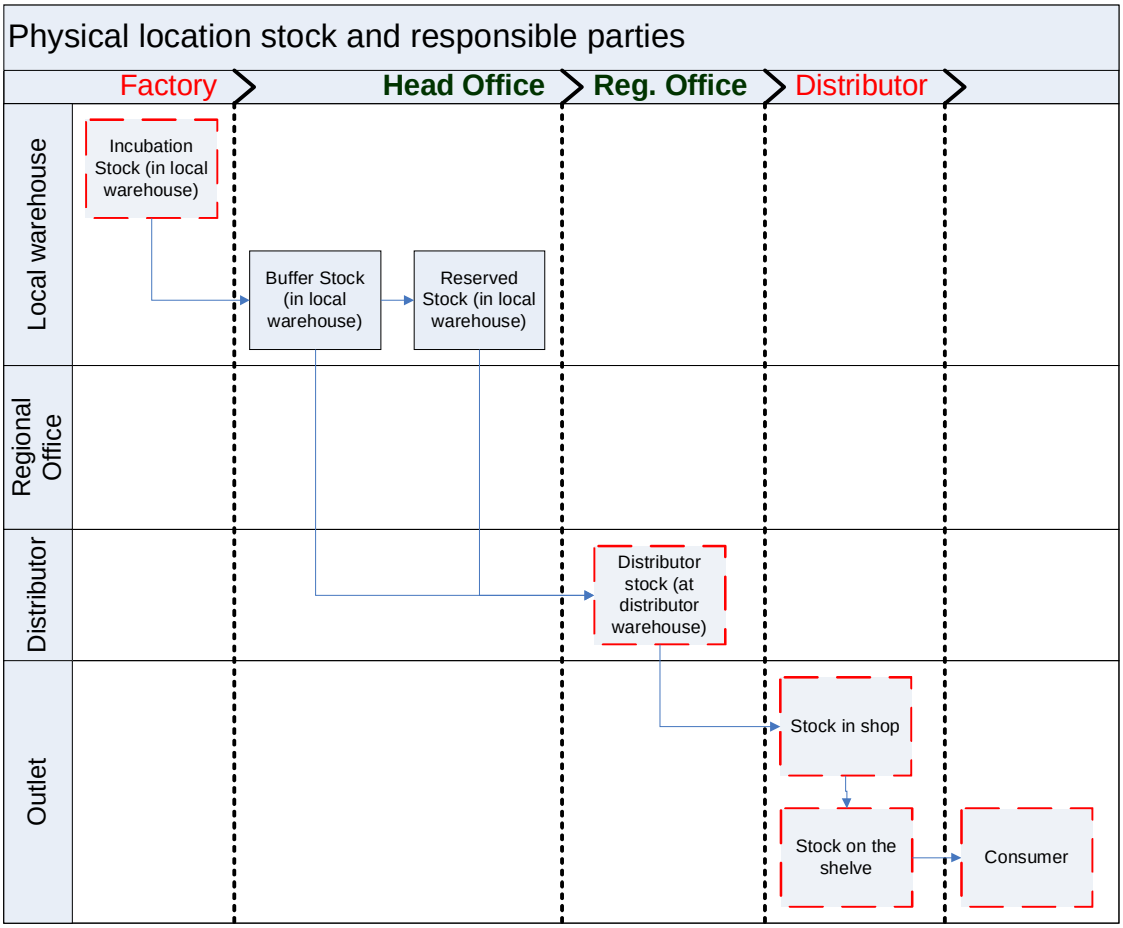

Figure 2.4: Flow of goods

2.2.4 Non-stationary

Figure 1.6 and Figure 2.3 are showing differences within each month, but also display a difference between different periods during the year. This difference is due to promotional campaigns and seasonal demand. Demand that is not stable during a longer period is called non-stationary demand (Silver, Pyke, & Peterson, 1998, p. 342). Demand changes during promotional campaigns and seasonal changes in demand should both be predictable. Therefore should the model be able to adapt to the non-stationary demand.

2.3 Flow of goods

The goods are following another way to consumer than the forecast. Figure 2.4 displays on the horizontal axle the responsible party and on the vertical axle the location. Before a product leaves the system (i.e. is bought by a consumer), it visits three locations.

After production, the product is stored in the local warehouse at the factory site. The products are stored, but still locked and it is not allowed to sell them already. After the incubation time (see also 1.1.2), the products are available for distribution at the local

warehouse. At this time there are also products shipped to the warehouse in Da Nang. In the local warehouses are also products that are reserved for special customers. These products are physically in stock, but not freely available for distribution. The incubation time can be included at the production time, but this is disputable because sometimes shipments take place during the incubation time. Therefore we assume that this is an extra stock location.

The regional office makes an order for the distribution center and these goods will be shipped from the local warehouse, directly to the distributor's warehouse. From the distributor's warehouse the products are shipped to the different outlets. This happens by truck or motorbike.

In Figure 2.4 are the stock at the local warehouses blue and other places red, because that is the only part of chain that is controlled by FCV in the current situation. The regional office is pushing the distributor to buy products, but they are not fully in charge at the distributor.

2.4 Current performance

FCV only measures their performance to the distributors. Because we will manage inventories at the distributor, it will be interesting for us to measure their performance. The KPIs we will use are: Customer Service Level, Forecast Accuracy Inventory Level and Standard Deviation of demand.

2.4.1 Customer Service Level

The most important KPI will be the Customer Service Level (CSL), which will determine how often it occurs that an outlet is not able to order the products it needs and when shelves possibly become empty. There are different CSL that possibly can be used. Most often used is the fill rate, the percentage demand that can be fulfilled directly from shelve (Silver, Pyke, & Peterson, 1998). In literature this measure is often called P_2 and therefore we will also use this name.

A second measure for CSL that is regularly used is the P_1 measure. This is the change of getting out of stock before the start of a new replenishment cycle (Silver, Pyke, & Peterson, 1998). Under this measure it is not important how big the shortage is.

At FCV we will use the fill rate approach. Because this will give lower inventories and it will be sufficient, because when we supply a shop with 95% of its order (for example 95 cartons from the 100 ordered), than it is most likely that the end-consumer never notice any shortage, so a performance of 95% will be more in place than a performance of 0% (on this specific situation).

Unfortunately we do not have any information about these measures from distributor to outlet, but we do have some measures for the orders from distributors to FCV. It is not possible to calculate the P_1 measure afterwards because we do not have enough information for that. What we can do, is calculating the order line fill rate and the fill rate.

In Table 2.1 we can see a clear difference between Service Level indicators, but the difference is smaller than was expected. This can be explained by the fact that the regional offices often only orders allow to a distributor when the complete order can be delivered from stock. When we evaluate the three most expensive products (Friso Gold1 and 3 and Ovaltine BIB), we see that there service levels are worse than others. This can be explained by the target stock rate for a distributor. It is set by value and when a distributor is under its desired stock value, the easiest way to increase the stock value is purchasing expensive SKUs. For those SKUs there is only a small amount forecasted, so when a large amount is ordered, it is logic that the order cannot be fulfilled.

Performance 2009		
	OLFR	**P_2**
Completa	94.98%	96.67%
DL Straw 180	88.66%	91.78%
DL Swe 180	91.84%	92.48%
DL Vani 110	90.79%	93.80%
123 Bib	92.91%	92.36%
Friso Gold1 900	80.80%	88.08%
Friso 3 1500g	87.80%	89.55%
Ovaltine BIB300	89.89%	82.64%
All products:	**88.42%**	**92.59%**

Table 2.1: Percentage delivered to distributor

When we analyze the no-fill situations, there are many reasons why an order is rejected. In 2009 there were 90% of all rejections caused by five reasons. As Table 2.2 shows, the two most important reasons for rejection are "out of stock" and "stock reserved for other customers". This means that on the moment of ordering, the sales administrator decides not to allow the order, and to give priority to some other distributors, because of promotions or low stock levels or not yet near the target.

Errors 2009						
ERROR	**1**	**75**	**84**	**88**	**94**	
Completa	1	113	72	46	78	*01 Delivery date too late*
DL Straw 180	9	144	139	79	155	*75 Out Of Stock*
DL Swe 180	195	315	166	24	112	*84 Stock reserved for other customers*
DL Vani 110	5	50	180	31	90	*88 Exceed Customer Allocation*
123 Vani Bib	82	45	117	83	17	*94 Product not ready*
Friso Gold1 900	0	49	55	41	18	
Friso 3 1500g	5	170	1	23	0	
Ovaltine BIB300	0	0	0	5	0	
Total:	**2,499**	**9,532**	**5,319**	**2,178**	**2,712**	
% orderlines	0.95%	3.63%	2.03%	0.83%	1.03%	
% errors	10.15%	38.71%	21.60%	8.84%	11.01%	

Table 2.2: Reasons no fills

The out of stocks can be caused by too low production capacity or wrong forecast. The fifth error is "exceed customer allocation", what means that a distributor wants to buy more than is forecasted, but the company does not allow exceeding of more than 10%.

2.4.2 Inventory levels at distributor

An important KPI is the average stock level. On this moment the target stock level is 40% of monthly sales value. This should be around two weeks, but this is based on total value, so when a distributor buys many expensive SKUs (like the Milk Powders) then it looks like the stock level is on target, but in reality the stock levels for some SKUs only enough to cover a few days of demand, while others can cover sometimes a month's demand.

These unbalanced inventories also cause irregular demand at the factory, where the high variation causes high costs and high stock levels or many stock outs.

2.4.3 Standard Deviation of Demand at the Factory

Because the high difference in the sales of distributors during the month, the standard deviation in demand is high at the factory. At the end of the month there are many more orders generated than earlier in the month, which will cause many stock outs.

2.5 Summary

In this chapter we evaluated the first research question:

What is the current policy and performance regarding to the ordering process?

First we found in section 2.1 that targets equals the forecast and are top-down generated. Noticeable are the different forecast levels. Forecasts are made at the top on sell-in level, instead of the sell-out level. The forecasts of the sell-in are pretty accurate, but there is no information available to check the sell-out forecasts and we expect this to be less accurate. Section 2.4 tells about the KPIs we will use: CSL, Inventory levels at the distributors and the standard deviation of demand of the distributors. For the Customer Service Level we like to use the fill rate because that is what will fit best to the company's situation.

Now we are familiar with the current policies regarding the inventories, we will use the next chapter for our search through literature for a policy which we can use to optimize our inventories.

3 Literature Research

In this chapter we try to find an answer to the second research question:

What would be a good policy for single-echelon systems according to literature?

To get a proper answer we have to search through literature. In section 3.1 we start with adapting the forecast to make it easy to use the forecast in our policy and we explain how to estimate the standard deviation of our forecast. In section 3.2 we will shortly explain which review policies exist for a single-echelon inventory system and why the choice of FCV for a (R, s, S) policy will fit the purpose.

Section 3.3 shows us how to determine the Review Period and explains the lead time, followed in section 3.4 by determining the safety factor that fits the with the service level. Finally at the end of this section we can calculate the reorder point and order up to level.

3.1 Forecast

Before we can adopt a review policy, we need to have an idea of our future demand. Therefore we have to make a forecast, based on historic demand, planned marketing campaigns and targets. It is out of scope for this research to elaborate extensively about forecasting, but before we can use the forecast in our calculations, we need to make some slight changes and we need to cope with the non-stationary of demand.

3.1.1 Non-stationary demand

The forecasted demand rate will vary over time due to different reasons, already explained in section 2.2.4. The changing demand will have an impact on the control parameters, R, s and S. According to Silver et al (1998) an exact analysis is far too complicated for use in practice. Also it will be undesired to change R, because often routes and production schedules are depending on R and it will become costly to change R regularly. Therefore it will be easier to change the expected demand and standard deviation for every period and recalculate the values for s and S.

The demand is easy to change, the forecast is updated on a regularly basis already, but to calculate the standard deviation is more difficult. In section 3.1.3 we will give the calculations to calculate the standard deviation. In practice we calculate the necessary days of safety stock and use this as a value for s. In the situation of FCV we have chosen to calculate the safety stock in cartons, because this is more accurate and because FCV is busy implementing a new information system where we can implement these calculations.

3.1.2 Expectation of demand

The forecast gives an expectation of the amount of cartons that will be sold. This forecast can be used in our equations further in this section. Equation 3.1 shows the relationship between the mean Forecast and the expected demand.

$$E\left[D(L+R)\right] = FC(L+R)$$

E[D(R+L)]: *Expectation of the demand during review period and lead time*

FC(L+R): *The forecast for lead time and review period*

Equation 3.1: Expectation of demand

3.1.3 Standard deviation of demand

It is less straightforward to get the standard deviation for the lead time and the review period. One option is to calculate the Mean Absolute Deviation (MAD) and use this as basis to calculate the standard deviation.

$$\sigma = MAD \times \sqrt{\Pi/_2} = MAD \times 1.25$$

σ: *Standard deviation*

MAD: *Mead Absolute Deviation*

Equation 3.2: Standard Deviation under normal demand

Equation 3.2 is only valid when demand is normally distributed. At FCV we can expect demand to be normally distributed, because the products under consideration are fast running consumer goods, in our case this is will not be optimal. As is explained in section 3.1.1, demand is non-stationary, which means that demand varies over time. When we use the standard deviation based on the MAD as in Equation 3.2 we also include seasonal effects into the standard deviation.

In order to prevent this error, we don't use the MAD but the Mean Average Percentage Error of the forecast multiplied with forecast itself. Now we get a high standard deviation when the forecast is high and during low forecasts, we will have also a low standard deviation.

Equation 3.3 shows the relationship between both measures and gives us a standard deviation we can use.

$$\sigma = MAD \times \sqrt{\Pi/_2} \Leftrightarrow \sigma\left[D(L+R)\right] = MAPE * FC(L+R) * 1.25$$

MAPE: Mean Average Percentage Error

Equation 3.3: Standard Deviation of demand

3.2 Choose a review policy

In literature there are multiple inventory review policies. In section 1.2.3 we already concluded that we are dealing with a single stock point system, with inventory at the distributors. According to Silver et al (1998, pp. 237-241), this means that there are five rules that are commonly used in practice. When we evaluate those different rules that Table 3.1 displays, we can see that there are two important decisions we need to make. First we need to decide if we want to review inventory continuously or only periodically. Second is the choice in lot size. We can replenish always a fixed quantity or we can use variable lot sizes.

Before we evaluate Table 3.1 we need to distinguish the difference between stock levels and inventory position (IP). Stock level is the amount of products that are physically available at the warehouse. The inventory position is the amount of stock available in the warehouse plus the outstanding orders minus the backlog, the orders that still need to be delivered.

$$IP = Stock + Order - back\log$$

3.4: Inventory position

At FCV the IP will mostly equals the available amount of stock in the warehouse because when a distributor cannot deliver, there is no order. At a later time, the outlet has to order again. Orders from the factory are mostly less than one day in transport, so this is also a small amount. Still, to get proper results, it is necessary to use the IP instead of the stock levels. In Table 3.1 the different possibilities are shown and the symbols are explained.

Lot Size	Inventory Status Review	
	Periodically	*Continuous*
Fixed	(R, s, Q)	(s, Q)
Variable	(R, s, S) or (R, S)	(s, S)

Table 3.1: Order systems for single stock point based on Silver et al (1998, pp. 237-241)

R: Review period, the time between two consecutive moments where stock levels are review and an order is possibly released. In a continuous review system, R equals zero and is therefore excluded.

s: Reorder point, when the inventory position becomes below this point, a new replenishment order will be released (in a periodically system, only at the review point).

Q: Fixed lot size, the amount what have to be ordered. It is common to multiply this with a variable n, to let inventory position rise above reorder point s.

S: Order-up-to level, when an order is released, the size of the order will be determined based on the order-up-to level S minus current inventory position.

Because FCV sell fast moving consumer goods and only wants to transport full truck loads, we will use a periodically review. This is also the reason to choose for a variable lot size, it will be easier to add up the different SKU to reach a full truck load.

3.3 Periodically review period and variable lot sizes

In this section we will look how we should determine the correct values for a feasible inventory control policy. For this section we use Silver, Pyke and Peterson.

3.3.1 Lead time (L)

The lead time is the time from the moment the order is placed until the physical products arrive at the customer. It includes administrative time as well time needed for order picking and transportation.

3.3.2 Review period (R)

In the book by (Silver, Pyke, & Peterson) the review period (or Review Interval) is expected to be given, often based on external factors. For the distributors at FCV we have to calculate the review period first. We developed therefore a calculation based on the order frequency. The order frequency will be determined based on multiple conditions.

1. Every distributor has to be delivered at least once a week.
2. The logistics department wants to use as big trucks as possible, because this will minimize transportation cost, which is more important than the holding cost at the distributor.
3. For some distributors there are only small trucks allowed. For example in Ho Chi Minh City trucks are only allowed when smaller than 5 tons.

Also the truck sizes are predetermined. There are trucks sizes of: 5, 10, and 20 tons. To find the truck size we will use, we need to calculate the weight of all forecasted SKUs for a period, and divide this by the minimum number of deliveries desired. The minimum number of deliveries is at least once a week.

$$Trucksize = \frac{\sum_{SKU} FC_D}{\min[deliveries]}$$

FC_D: *Monthly forecast for distributor D and all SKUs in tons.*

Equation 3.5: Calculating optimal truck size

The truck size determined in Equation 3.5 is not yet adapted to the available truck sizes. The truck size that will be chosen is the truck near the calculated truck size. To get the review period, we now divide the forecasted monthly tonnage through the chosen truck size as can be seen in Equation 3.6. This will give the number of deliveries per month and when we divide this number through the days of the month, as is shown in Equation 3.7, we know the review period in days.

$$\lambda_{order} = \frac{\sum_{SKU} FC_D}{Q}$$

Q: *Chosen truck size.*

FC_D: *Monthly forecast for distributor D and all SKUs in tons.*

λ_{order}: *Number of orders per month.*

Equation 3.6: Order Frequency

$$review\_period = \frac{Days\_per\_month}{\lambda_{order}}$$

Equation 3.7: Review period

3.4 (R, s, S) policy

Before we can continue and calculate a proper safety factor, we need to choose a measure for the service level. There are three measures determined by Silver, Pyke and Peterson (1998) as Table 3.2 shows. The P_1 shows the chance off one stock out during a replenishment cycle, but doesn't say anything about the size of the stock out. A stock out situation of 1 carton is evenly hard punished as a stock out of 100 cartons. The second measure, P_2 is aiming on delivering a percentage of the requested volume. The third measure does not gives directly information about the Customer Service Level, because it is no problem when stock is unavailable, as long there is no demand.

In section 3.4.1 we will discuss only the P_2 measure, because this measure gives us information about the size of the shortage.

	Measure:	Description:
P_1	Stock out probability	Probability that stock out occurs in a replenishment cycle
P_2	Fill rate	Fraction of demand that will be fulfilled directly from stock
P_3	Ready Rate	Fraction of time that stock is available

Table 3.2: Performance measures

3.4.1 Safety factor (k)

To calculate the correct Safety Stock, we need to determine the safety factor (k) first. The safety stock and therefore the safety factor determine the customer service level.

Under fill rate constraint (P_2) we are not interested in how often a stock out occurs, but we want to know to what degree our demand is fulfilled. To calculate this, we need to predict

the size of the actual demand that cannot be fulfilled. Therefore we use J(k), which is another special function of the unit normal distribution (Silver, Pyke, & Peterson, 1998, p. 339).

$$\frac{\frac{\sigma_{R+L}^2 J(k)}{2\hat{x}_R}}{\left(S - s + \frac{\sigma_R^2 + \hat{x}_R^2}{2\hat{x}_R}\right)} = 1 - P_2$$

$$With: J(k) = (1+k^2)\left[1 - \Phi(k)\right] - k\phi(k)$$

J(k): special function of the unit normal distribution

Q: *Order Quantity*

P_2: *Target customer service level under fill rate constraint*

Equation 3.8: k under the P_2 measure (Silver, Pyke, & Peterson, 1998, pp. 339-340)

When we rewrite Equation 3.8 we get an expression for J(k) and when we fill in the formula for J(k), we get the equation as in Equation 3.9. When we use Excel for example to solve this equation, we can find k with trial and error, or using the goal seek function.

$$J(k) = \frac{2\hat{x}_R(1-p_2)\left(S - s + \frac{\sigma_R^2 + \hat{x}_R^2}{2\hat{x}_R}\right)}{\sigma_{R+L}^2}$$

$$(1+k^2)\left[1 - \Phi(k)\right] - k\phi(k) = \frac{2\hat{x}_R(1-p_2)\left(S - s + \frac{\sigma_R^2 + \hat{x}_R^2}{2\hat{x}_R}\right)}{\sigma_{R+L}^2}$$

Equation 3.9: Calculate k (Silver, Pyke, & Peterson, 1998, pp. 339-340)

Equation 3.8 shows how k can be calculated under fill rate constraint. This is a difficult calculation, but in software package like MS Excel it is easy to implement.

3.4.2 Safety Stock

Now we know the safety factor, we can calculate the safety stock. The safety stock is the amount of stock needed to cover uncertainty in demand. In the FCV case it is the stock to buffer the forecast inaccuracy. The safety stock consists out of two parts. First the expected (or forecasted demand) and second the standard deviation multiplied with safety factor k.

$$SS = k \times \sigma_{R+L}$$

SS: *Safety Stock*

Equation 3.10: Safety Stock

3.4.3 Calculating reorder point and order up to level

In a (R, s, S) policy we review the stock every period R and if the inventory level is below s, we release a replenishment order to increase the inventory position back to S. As already described in section 3.3.2 we have determined the size of R and Q and now it will be possible to calculate Safety Stock with Equation 3.10. Equation 3.11 shows that the order-up-to level is based on the optimal order quantity and the reorder point, but there is also an additional amount E(z) that should be subtracted to get an average order quantity of Q. E(z) is also

called the undershoot and it is the quantity that the inventory position is below s when a new order is released after time R.

$$S = s + Q - E(z)$$

s: Reorder point

Equation 3.11: Order-Up-To level

To calculate the undershoot we can make use of the property that only every period R a new order is released. Therefore E(z) is only depending on the demand. In Equation 3.12 we can how we can calculate the undershoot for an (R, s, S) system.

$$E(z) \approx \frac{E\left[D_R^2\right]}{2E\left[D_R\right]} = \frac{\sigma_R^2 + \hat{x}_R^2}{2\hat{x}_R}$$

Equation 3.12: Undershoot

In this policy we only order if the inventory position drops under the reorder point. It can happen that within a minute after a review the inventory position drops below the reorder point. Than we still need to have enough stock to cover the review period and any uncertainties. We calculate the reorder point in Equation 3.13, which consist of the expectation of the expectation of the demand during the lead time and review period and a safety stock to cover uncertainties in this period.

$$s = \hat{x}_{R+L} + SS = \hat{x}_{R+L} + k \times \sigma_{R+L} \text{ (SS from Equation 3.10)}$$

Equation 3.13: Reorder point

In this policy the average inventory at a distributor will be the reorder point plus halve of the average order quantity Q as Equation 3.14 shows, with Q the expected demand in the replenishment cycle, as shown in Equation 3.15.

$$Inv_{average} = \tfrac{1}{2}(Q) + s$$

$Inv_{average}$: Average inventory position

Equation 3.14: Average inventory (R, s, S) policy

$$Q = S - s + E(z) = S - s + \frac{\sigma_R^2 + \hat{x}_R^2}{2\hat{x}_R}$$

Equation 3.15: Expected demand in replenishment cycle(Heijden, 2009, p. 28)

3.5 Summary

In this chapter we used section 3.1 to show how the MAD can be used to adapt the MAPE so we can determine a feasible standard deviation that is not too high and takes into account the non-stationary characteristic of demand. Next in section 3.2 we explained the choice for using a (R, s, S)-policy. Section 3.3 and 3.4 gives us subsequently the review period, lead time, safety factors, reorder point and the order up to level. In these calculations we do not take into account that FCV wants to deliver full pallet loads. In the calculation in chapter 4, we do take this into account and our advice is to include these calculations into the DMS system.

In the next chapter we will use the formulas we have found here in a tool to calculate the order up to levels for a selected group of SKUs and distributors.

4 Model description

In this section we will use the model we found in chapter 3 and we will apply it to the situation at FCV. After this section we will have a tool which we can use to get an answer on sub question 3:

How will the policy found in literature perform in the situation of FCV?

The tool is an MS Excel file named: "tool.xls". This file has 11 tabs, which contains information and calculation. The last tab, "summary", is a summary of the tool. All the calculations are shown in one sheet. The other sheets are used to do the calculation for seven products and five distributors at once. The first part of the tool is dedicated on analyses and tries to come up with good reorder points and order up to levels, while the second part of the tool a modest simulation generates which us helps to understand the solution and its implications. Also have we included one sheet in where the calculations are entered on one row, to generate a good overview over the working of the policy.

In this chapter we explain how the tool calculates the different values. To perform the calculations we expect that the correct information is already copied in the tool. Which information and how to copy it in the tool is described in Appendix C.

Finally in section 4.5 we show the results we found. We also analyze the results, so we will be able to draw conclusions in the next chapter.

4.1 Forecast and MAPE

The first step is to calculate the forecast and the Mean Average Percentage Error (MAPE). The forecast is out of scope of this project and we could not get any accurate forecast information on distributor level. Therefore we generate a forecast, by multiplying the actual sales information of 2009 with multiple random variables, so that when we calculate the MAPE based on this information, we get a forecast accuracy of 85%. This is in line with the figures as presented by the Customer Service Department of FCV (2009)[4].

Because the weekly sales are rather unstable and we do not want inventory start fluctuating because of forecast inaccuracies, we calculate all values on a monthly base. Also the Reorder points will be calculated monthly, this time span assures that seasonal influences can be taken into account, but inventory will not suffers high variation in demand due to the changing reorder points.

4.2 Review period and Lead time

The review period and lead time should be calculated for every distributer separate. Next, we should determine for every SKU to be determined if it should be reviewed every replenishment cycle or only once every *n* periods in order to get sufficient large order size.

4.2.1 Review period

The review period is based on an optimal order quantity and the total forecast and at FCV it is also based on a minimum delivery frequency. In the tool we can calculate an optimal delivery frequency, but we are not capable to make a decision on the optimal truck size and therefore for an optimal length of the review period.

[4] Those figures showed an average accuracy of 88%, ranging from 71% to 96% for different product groups.

In our analyses we have therefore chosen for a review period of one week for fast-moving items and for slow-movers we choose a review period of two weeks. Especially for the fast-moving SKU this period is probably too long, but for our simplified simulation purposes it will fit because we have only information based on weeks.

4.2.2 Lead time

The lead time is based on the time necessary for administrative tasks, arrange transportation, order-picking and transportation. Because the east-region is near the factory, transportation does not takes a lot of time and all lead times are expected to equals one day.

4.2.3 Order quantity

No we have the review period and lead time we can calculate the order quantity. In the tool this is done in tab: "Order Frequency". There is an optimal value given and it can and has to be adopted by hand. Doing this, we can decide if we want to order full pallet loads or smaller amounts.

4.3 (R, s, S)-policy

FCV adopts a (R, s, S) policy. This can have a good fit, because most of SKU are fast-moving and request therefore a more sophisticated policy (Silver, Pyke, & Peterson, 1998, pp. 240-241). To calculate the proper reorder point we need to determine the safety factor k.

4.3.1 Safety factor (k)

To calculate the safety stock under the P_2 measure, we have to make some calculations. In our tool, under tab "safety factor" there are three tables. First table is the table with the k values. These k-values are used in the second table where the J(k) is calculated. In the last table, there are the calculations from the other side of the Equation 3.8, also based on the demanded fill rate. The values per distributor and per SKU have to be made equal by changing k. This can be done with the solver in Excel, or by using the blue button on the left side of the screen.

The values we found for k after this process will be used to calculate the reorder points and order up to levels.

4.3.2 Safety Stock

Now we know the safety factor, we can calculate the safety stock. The safety stock follows from Equation 3.10 are depending on the varying safety factor k.

When we also includes the expected demand over the review period and the lead time (see: Equation 3.13) we get the reorder point. In our tool these values are in tab "Safety Stock". First are the safety stocks given under a P_1 measure and second the safety stocks under a P_2 measure.

4.3.3 Order up to level

To determine the order up to level, we add the optimal order quantity to our reorder point and we subtract the expected undershoot. These calculations can be seen in Equation 3.11 and Equation 3.12. The order up to values are not visible in the tool, but are directly build when generating an order.

4.4 Order

In tab "Order" we check every week the stock level of the previous week. This level we compare with the reorder point given earlier and if it is below the reorder point we will generate an order. This order is of size: S – inventory position. It is feasible to assume that an order arrives almost immediately, because the review period is set on a week, while the lead time is only one day.

	123 Vani BIB	Hoàn Hảo	CGHL Đường 110	UHT DLVani180ml	UHT DL Dau 180ml	Friso3 1500g	Friso Gold1 900	Ovaltine BIB300
Decline in Standard Deviation								
Decline SD (P2)	28.4%	23.6%	9.1%	21.3%	27.4%	23.6%	25.1%	28.0%
Service Level								
SL (P2)	99.5%	98.9%	100.0%	99.7%	99.8%	100.0%	99.3%	99.5%
Decline in average inv.								
Decl. Av. Inv. (P2)	24.0%	18.7%	0.7%	-15.7%	-18.5%	-98.0%	-18.3%	0.3%

Table 4.1: Results P_2 measure for 99% fillrate

4.5 Results

The results we get are visible in the last tab "results". For every distributor and every SKU we have a graph with the old stock levels and the new generated stock level by the new policy.

For each distributor we also generate a table. The total stock outs, fill rates, average stock level and standard deviation per SKU are given. This tab also represents the results as in Table 4.1. This table shows the relative decline or increase of the inventory and standard deviation and the service levels, measured for the new policy.

The P_2 Service Level measure is defined as the percentage of shortage. In Table 4.1 we can see that in a few cases more inventories are needed to reach a high service level. But in all cases there is a decline in standard deviation and is a high service level expected. In Appendix A there are a few graphs shown which displays the stock levels during a year with the new and old policy.

4.6 Validation

In discussions with different people on different departments in the organization we get the feeling that de results we got are accurate. The safety stocks are around seven days of inventory and this seems logical to the people at the company who can be seen as experts on this area. Also when we take in account the delivery frequency of once a week, a safety stock of seven days seems to be logical. Because of the high fluctuations, it is difficult to get more evidence to validate the results.

Before implementing the results should be tested in a small group of distributors, for example the test group for the DMS system. This will make clear of the given solution give results as we state.

4.7 Summary

This chapter is a description of the working of the Excel tool and shows in section 4.5 some of the results, represented in Table 4.1. The (R, s, S) policy we use seems to perform well, even with a very high CSL.

In the next chapter we will draw our conclusions about the new policy and give some remarks that help us to implement the policy successfully.

5 Conclusions and recommendations

In this chapter we evaluate our research and we will give an answer on the last sub question:

How should the proposed policy be implemented?

This will be done in section 5.1.2. When we have answered that question we answered all research questions and we can find an answer on our main question:

"What is a good order policy that can be implemented at FCV which minimize inventories for the distributors and minimizes the variation in demand at the local warehouse with a high service level for sales to the outlets?"

This chapter is build up in chronologic order. We start with some remarks about the implementation of the system; secondly we will discuss some other conclusions. Thirdly we will elaborate about the implication of the proposed system and as last we will discuss some areas for further research that can strengthen the conclusions of this research.

5.1 Conclusions

In this section we will give the answer on the main research question: *"What is a good order policy that can be implemented at FCV which minimize inventories for the distributors and minimizes the variation in demand at the local warehouse with a high service level for sales to the outlets?"*

First we will discuss the policy we have chosen, than we continue with behavior, the forecasts and finally we will discuss the service level chosen by FCV.

5.1.1 Policy

The use of an (R, s, S) policy will be beneficial for FCV. Inventories will decline, variation in demand at the local warehouse will decline and the service level will get very high. An (R, s, S) policy will fit because FCV wants to lower variation at the local warehouses. Therefore it is important to use a policy that orders on predetermined times and make it possible to generate a more or less stable order pattern over time. Unless that for some products a (R, S) policy would also fit, we have chosen for an (R, s, S) policy. FCV wants to order as much as possible full pallet and full truck loads. In an (R, s, S) policy it will be easier to create a full pallet load. We have not chosen for an (R, s, Q) policy because there are also SKUs where the order size is smaller than a full pallet load and the order size will be more variable under an (R, s, S) policy.

5.1.2 Implementation

Managing the inventory at the distributor demands good information availability. In section 5.3.1 we will conclude that the DFD is not completely reliable. At this moment there is a project at FCV to implement a new software package called Distributor Management System (DMS) which will support the distributors by gathering data about sales orders to the outlets, forecasts and inventory levels. It is important to implement the DMS system because it will help to make the data more reliable. Next to the system will it be important to support the distributors in the functionality of the system. They need to enter correct data into the system otherwise it will stay as unreliable as the DFD is now.

The DMS system already contains a module to manage the distributor's inventory. This system is now too simple to gain huge benefits, but all information to implement an (R, s, S) policy is available in the system. Therefore it will be relatively easy to implement this system. To support programmers of the DMS with the implementation, we made a blueprint of the system and its connections to the underlying data, available in Appendix B.

5.1.2.1 Change of behavior

It is necessary to change behavior to let the system perform well. As already stated it is important to have accurate information in the system, but also on other places in the organization there is improvement potential.

All levels in the sales organization have now their own targets and push sales to reach them. This is good, because it supports sales, but the targets are based on two levels: Sales in and sales out. This causes that at the end of the month the Regional offices and the distributors release replenishment orders to reach targets. These orders cause high stock and high variability at the local warehouse. Targets are useful, but they all should be based on sales out, after all we want to sell products to end-consumers, not increase inventories at the distributors' warehouses.

Currently the distributors have a target based on sales in. Under the new policy, they are not allowed to influence their sales in. Therefore the targets have to move away from sales in. This will prevent unnecessary inventories at the distributors. The only tasks the distributors have are giving credit to the outlets and distributing goods from its warehouse to the outlets. When the distributor performs well on those tasks, he should get a bonus. The first task is easy to measure, as long as all bills from the local warehouse are paid within the term of payment his performance is good. The second is slightly more difficult, because the outlets register less information. Nevertheless are the salesmen of FCV visiting all stores on a regular base, so it should be possible to get information about these distributors its task.

5.1.3 Forecast

The forecast is more than 90% accurate on a high aggregation level. Taking a closer look at lower levels, we see that every forecast aggregation level gets less accurate. When customer demand is really as stable as expected we should be able to forecast on a weekly basis per SKU and per distributor with an accuracy of at least 90%. This will gives us lower variation in demand and therefore lower safety stocks. When the forecast becomes 5% more accurate, the average decline in inventory levels will increase with 40%.

To reach these benefits, first FCV should start with forecasting on sales-out level so in- and decreases of distributors' inventory are excluded and the forecast will be more accurate.

Secondly, the forecast is now completely top-down based and when FCV starts using more advanced software to forecast, it will become possible to get a clearer view on the differences between SKUs and to forecast bottom-up. That enables FCV to follow customer demand and grow at the same time, instead of deny almost 1% of all orderliness because the distributor orders more than is allowed by the head office (see also section: 2.4).

5.1.4 Service Level

In the calculations we have used the P_2 measure. In literature is stated that P_2 will perform better, because it measures on each unit instead of punishing 100% when only 1% or less is not fulfilled. Also will it be more logical to measure as far as possible downstream, instead of measuring the service level for local warehouses. This will help in to get more insight in the performance at the consumer site. When a distributor has a small stock out, this is not a problem, even when an outlet receives his order partly there is no problem. It is only a problem when the product is not available to the consumer.

So we advise FCV to drop the DIFOT[5] that is used now in favor for the P_2 measure. This can be explained through the fact that the DIFOT aims to prevent stock out situations completely and that in the DIFOT is also a punishment for logistic errors, which have nothing to do with the availability of inventory. P_2 allows stock out situations, as long as they are within given bounds compared to the total volume.

The last advice is for the height of the service level. The service level was set by FCV on 99 percent. This is very high and in Table 4.1 we can see that there is a significant decline in inventory levels for a few products, but that some other need higher inventory levels to reach the desired performance. When the service level at the distributors will become 95 percent, the decline in inventory will become much larger, as Table 5.1 shows. Therefore we will advice FCV to think about the strategy they prefer and decide what the fill rate is that will fits their strategy.

	123 Vani BIB	Hoàn Hảo	CGHL Đường 110	UHT DLVani1 80ml	UHT DL Dau 180ml	Friso3 1500g	Friso Gold1 900	Ovaltine BIB300
Decline in Standard Deviation								
Decline SD (P2)	29.4%	24.8%	11.9%	20.8%	34.7%	38.4%	18.0%	29.6%
Service Level								
SL (P2)	97.2%	98.1%	99.0%	97.6%	97.5%	99.8%	97.8%	98.3%
Decline in average inv.								
Decl. Av. Inv. (P2)	40.9%	40.1%	31.6%	21.0%	15.5%	-66.1%	-4.1%	18.2%

Table 5.1 Results P_2 with 95% service level

5.1.5 Reorder point

The reorder point changes over time, depending on the forecasted demand. We choose to adapt the reorder points on a monthly base. Using this longer period we prevent ourselves from overreacting on peaks or valleys in the forecast in a certain week. Still this period is short enough to adapt to changes in demand. The month period is also the period in which FCV can forecast their demand best.

5.2 Implications

This research focus on the implementation of inventory management rules at the distributor. The main conclusion is that implementing a policy as suggested in section 3 to manage the inventory at the distributors will improve performance slightly, but will give an enormous decrease in inventory cost at the distributors.

The average stock levels per SKU will decline with up to 24% (see:Table 4.1). Because the stock levels will follow the predicted sales, the variation in the stock levels will also decline. This is especially important to reduce uncertainties and therefore inventories at local warehouse level.

[5] Delivered In Full On Time. When an order is delivered in full and before the delivery time, it gets a value of 100%. When one of both is not true, the value will become 0%, nevertheless the amount that is not fulfilled.

5.3 Further research

There are a few points in this research that deserve some further investigation. Mostly due to limited availability of information, mostly because of the DFD system, but before the system is implemented nationwide there need to be some more research so we can be sure that the system will work.

5.3.1 Information systems

FCV is a company which is a big company which has very extensive systems for recording and managing information. The two most important systems are the SAP system, which records all information at the head and regional offices, and the DFD system which is used by the distributors to record their inventory levels and orders from the factory.

This second system is not considered as very reliable because distributors sometimes fill in the wrong information or nothing at all. In this research the information from the DFD system is leading in the comparison and therefore the results are as reliable as the inventory levels recorded in the DFD-system.

5.3.2 Availability of information

Both system, but especially the DFD system is difficult to enter for information. Due to this reason it was not possible to gain information about all regions and all distributors and check the result on multiple distributors around the country, which would make the results more reliable then it is now, only tested on the east region.

5.3.3 Forecast information

Similar for the forecast information, although regional offices make a weekly forecast for each SKU, for each distributor. The tool we developed expects that information to calculate accurate forecast accuracy. Unfortunately this information was not available for us and we had to made estimations for the weekly forecast accuracy.

5.3.4 Limited simulation horizon

When we want to do a real simulation, we should do it for a multiple year horizon. At the DFD system only information of 2009 was available. Information from years before was not available or has serious gaps in it, so it became useless. During the last few months of 2009 there were serious problems with many SKU, which caused a very uncommon demand and sales pattern. So we only simulated a period of 39 weeks, which is too short to draw reliable conclusions, but it do gives us a good estimations of the benefits that can be gained and the fit of the chosen policy.

5.4 Recommendation

As a follow up on this research, there are a few logical areas to discover. First is the revision of the bonus structure. The salesmen and sales administrators should keep their bonuses, but all the targets have to be translated into sales-out. With this change the total sales force is concerned with sales-out (which will trigger the sales to the consumers) instead of the current situation where distributors and regional sales administrators are rewarded for high inventories.

The second area is forecasting. This becomes especially interesting when the all sales information on outlet level is available from at least one year. With the implementation of advanced software it should be possible to increase the forecast accuracy and decrease

inventory levels and variation in demand at the factory. At FrieslandCampina Thailand SAP APO is in use and gives good results, so it can be worthwhile to investigate the purchase of such a system.

Thirdly, it will be interesting to see if the supply chain can be more optimized by steering it centrally. A good starting point can be linking inventories of the distributors and local warehouses in a multi-echelon model (Axsäter, 2006) & (Silver, Pyke, & Peterson, 1998). These kinds of models will optimize inventory in the supply chain and therefore lower inventory in the chain. The difficulty will be to find a model to share the benefits of these kinds of systems, but in literature there are some solutions given to overcome these problems.

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Appendix A. Results

In this appendix we show some of the graphs that show the results from the proposed policy for week 1 to 40 of 2009. In the most graphs we see that inventory of the new policies is lower, especially under the P_2 service level constraint. Still there are a few moments that differ, there we can see second pro from the new policies, inventory levels are much more constant than in the old situation. The peaks are removed. Also unnecessary high stock of expensive slow movers (like Friso 1.5 KG, see: Figure A.5) is prevented.

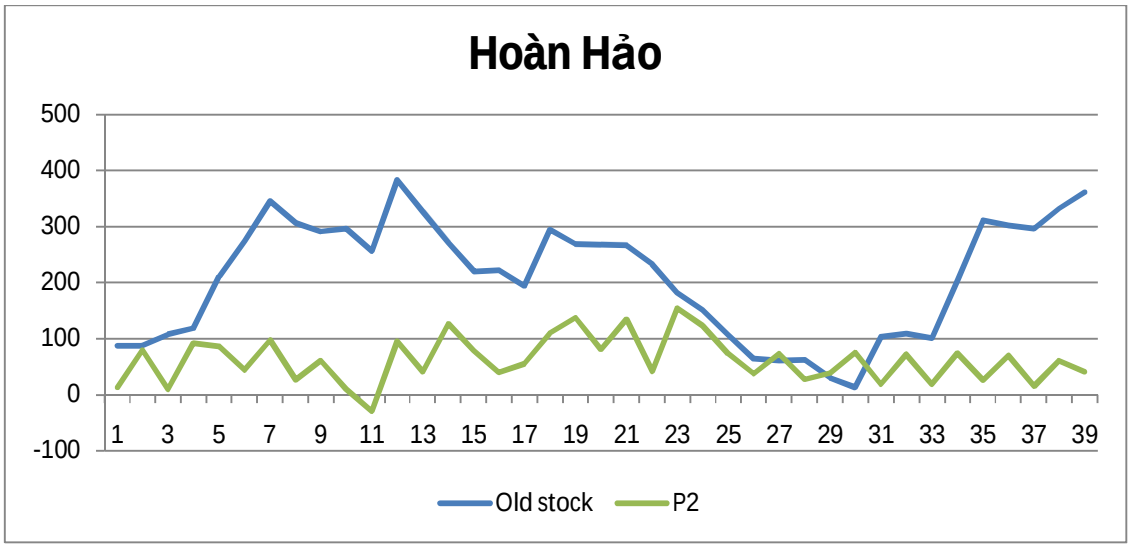

Figure A.1: 3.06 Nhà phân phối Thành Bước CN

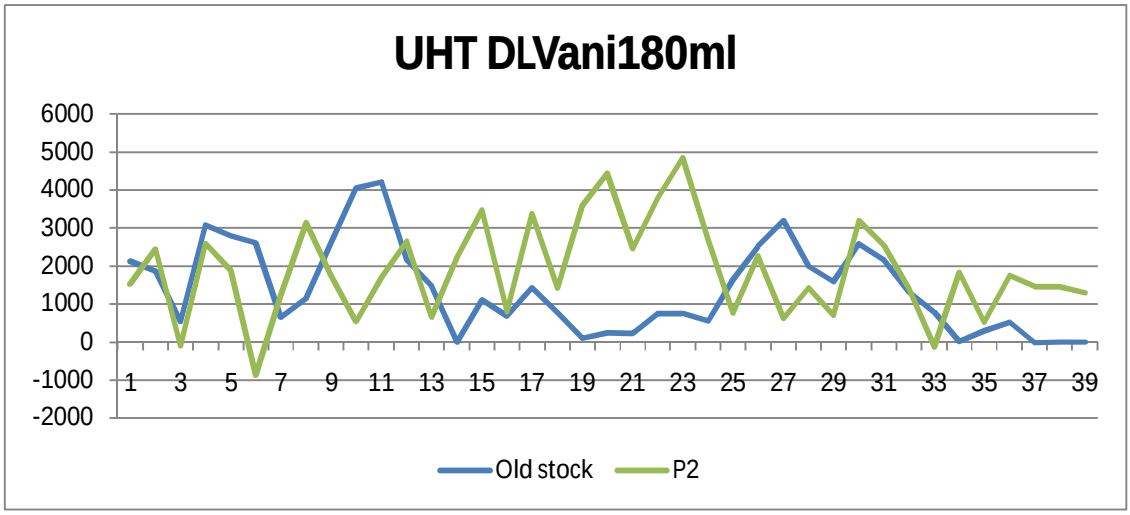

Figure A.2: 3.09 Công ty TNHH Lâm Thuận

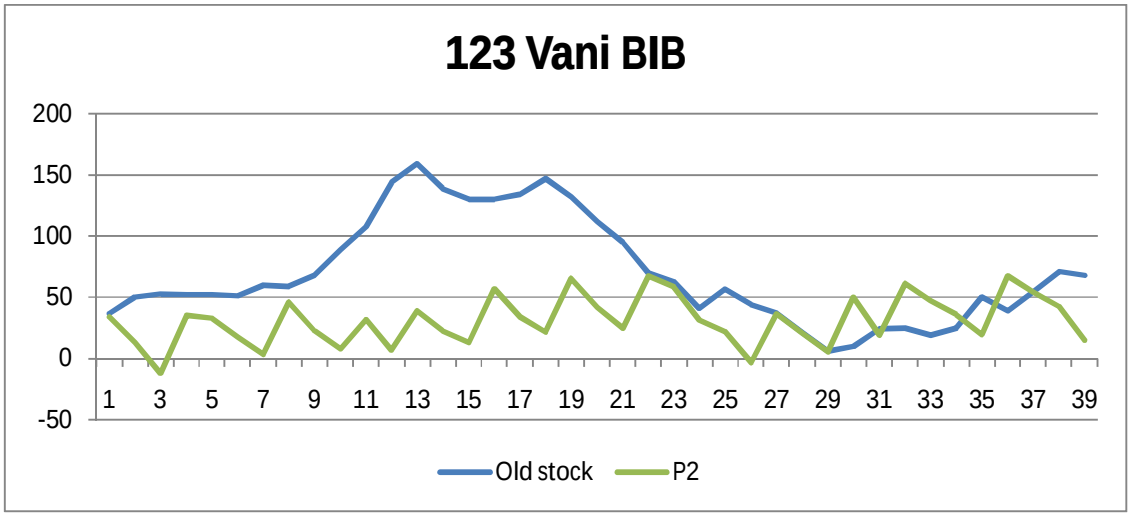

Figure A.3: 3.18 Nhà phân phối Tân Bảo An

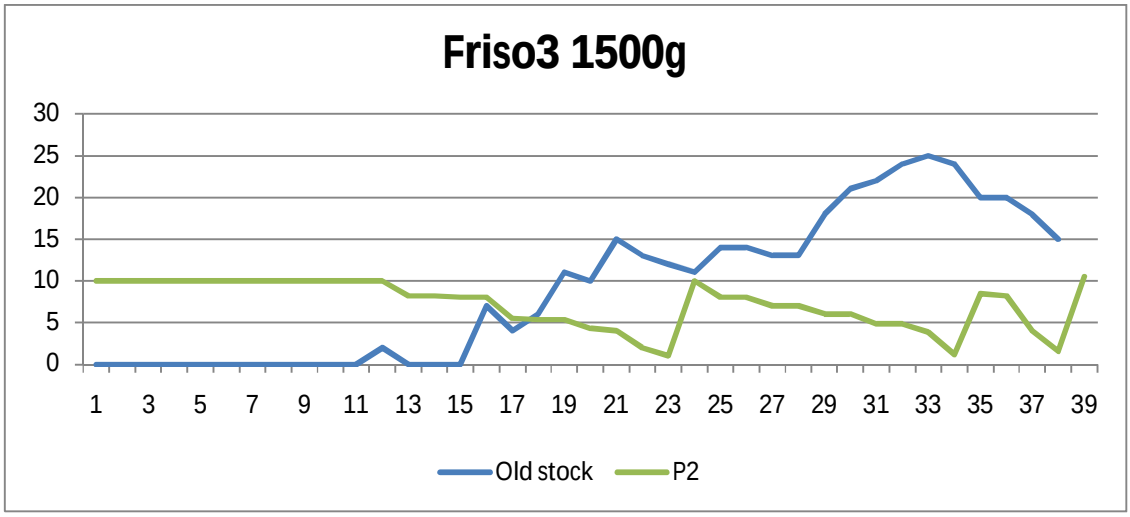

Figure A.4: 3.19 DNTN Phương Ánh

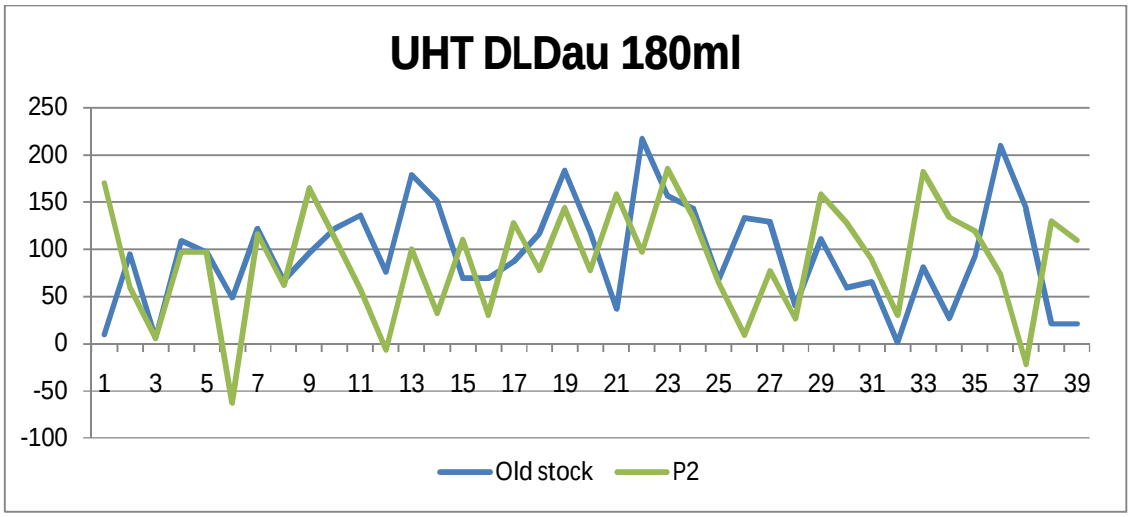

Figure A.5: 3.19 DNTN Phương Ánh

Appendix B. Implementation policy

To implement the (R, s, S) policy a few steps should be taken. In this chapter we like to suggest how to start with the implementation.

The first important remark is that we make, is that we assume that the following information available is in the DMS:

1. Forecast information of previous periods per week per distributor per SKU
2. Actual demand information of previous periods per week per distributor per SKU
3. Forecast information for upcoming year (including peaks during promotions and seasonal influence)

Further we have multiple decision variables that management needs decide on. These are the following:

4. Service level per distributor per SKU
5. Truck size
6. Deliver frequency (based on truck size and total expected demand)

When this information is available, we can use Equation 2.1 to calculate monthly forecast error for each SKU and each distributor. The forecast error can be used as the Mean Average Percentage Error (MAPE) together with the new forecast as proposed in Equation 3.3 to determine the standard deviation.

After determining the standard deviation, we use the forecast and the desired deliver frequency to make a decision on the truck size as Equation 3.5 shows. Now we can use Equation 3.6 and Equation 3.7 to calculate the optimal review period. Together with the target service level we can now use Equation 3.8 to calculate the safety factor. Using this safety factor, the service level and truck size in Equation 3.11 and Equation 3.13 gives us the reorder level and order up to levels.

Appendix C. Using the tool

In this appendix we explain how the tool can be used to check is the new proposed policy gives good new values. Before we start with the explanation, a few remarks should be made. This tool calculates the real reorder points and order up to levels, but the simulation that is made is limited. It can only work with review periods of a week or multiples of a week and it only gives one year results.

We will explain the excel file tab by tab, we describe which information is needed on that tab and what becomes visible.

Forecast

The forecast is the information that the distributor creates for each SKU. The numbers are in cartons and are sales-out information per week. The numbers can be paste on the grey areas. Scrolling down, shows us a summary of data per distributor, per SKU, per month.

Actual Sales

This sheets looks like the previous one, only this data is the actual sales-out demand. This data can be subtracted from the DFD system. The Sales Information department at FCV has helped me in gathering this information.

Old Stock

Again a comparable sheet, in this sheet the end of the week inventory levels of a SKU is entered. This information is necessary for the comparison of the new policy with the old situation.

Forecast accuracy

In this sheet we calculate the actual forecast accuracy, which will be used to value the new forecast. When there is now actual sales information available, but there is an estimation of the forecast accuracy, it can be entered in cells F9:AW9. This is the forecast accuracy per month, which we will use in the calculations.

Order Frequency

To calculate the order frequency, first the total weight, based on the forecast is calculated. In our previous sheet we only have the information for the SKU we review, therefore the number of cartons for each SKU has to be entered in this sheet.

After that, the system proposes a truck size on line 139 for a standard two deliveries per week. In the grey cells these values can be adopted to creates the best fit.

Safety factor

The safety factor needs a lot of input information. First the target service level, second the lead time, given in months and third the pallet size for the specific SKU. On line 9 and 10 are the proposed quantities per delivery and order frequencies per week given as calculated in the previous sheet. These values can be adopted to the desired values in the next two grey lines.

Than is first the P_1 safety factor calculated and underneath the P_2 safety factors are given. The upper table (line 18 till 29) gives the k value. To calculate the correct values, we need set the values on line 17 to 1 for every SKU we want to calculate and press the blue button.

Safety stock

In this sheet the safety stock for each distributor, for each SKU and for each month are calculated. In the first two tables the safety stock is given in cartons for the P_1 and the P_2 measure, secondly the safety stock is given in days for both service level measures.

Stock Levels

This sheet will calculated the new stock levels. The first table is the P_1 service level measure and the second is the P_2 measure.

Order

Orders are generated based on the current stock level, the safety stock level, order up to level and order quantity in this sheet. In this sheet we make use of the minimal order quantity as is determined in the safety factor sheet and we will order always a multiple of this level.

Results

Finally we can see the results of our values in this sheet. For each distributor are tables created for all SKUs we tested with the stock levels in the old situation and under the new policy.