Uitgerekend !

Calculation of additional complexity for innovations in Danone baby milks operations division

Public version

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DANONE

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Calculation of additional complexity for innovations in Danone baby milks operations division

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DANONE

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Public version

To construct this public version, from the original version all (financial) data (in chapter 8 and 9), the numbers of innovations as given in chapter 5 and the attachments are excluded.

Management summary

Groupe Danone is a multinational which produces dairy products, baby food, bottled water and medical nutrition. Within the baby food category of Danone, the operations department is responsible for the planning, production and delivery of the baby milk products to sales units in Europe. Key in running operations efficiently is to continuously reduce complexity in order to keep down costs. Complexity can be seen as the combination of the number of activities and their mutual dependency. Besides, part of Danone's mission is to obtain and secure leading market positions. To enable growth the sales units find new possible products, called innovations. These innovations require often introduction of new recipes or raw materials, which increases the complexity.

This leads to a complexity paradox: each innovation let the complexity of the operations increase, while the complexity has to decrease to save costs. It is not the goal to find innovations without additional complexity, but the complexity added has to be either in harmony with the profit of the new product or the product should fit in Danone's strategy.

Requests for innovations in baby milk products are presented to several departments by using the *freeway process*. This is the Danone decision tool on choosing for a possible new product. The department *Product sourcing milks* has to decide whether these innovations are possible within the operations. Objective of this research is to develop a model that makes visible where an innovation leads to extra complexity and that can be used as decision tool. All innovations of the last year are divided in five categories to gain a better understanding on the possible innovations.

The complexity research contains two parts. The first part attends to the preparation process of an innovation. This process contains all the activities that are needed before a new product can be produced. The preparation process is divided in seven steps: *product development, set up codes, production planning, purchasing preparation, design of artwork, changing artwork* and *coordination*. For each step there is determined which activities are required depending on the kind of innovation. The additional complexity on each activity is expressed as the cost of this activity.

The main conclusion from this part of the research is that the most costs are at product development which is only necessary for innovations with recipe changes. Other categories of innovation have compared to recipe changes only small preparation costs. The preparation costs of a new dry mix, new premix and new final recipe are more or less the same. The preparation costs of a new base powder differs maximum fourteen percent of this. There is also founded that there is no substantial difference in the preparation costs between innovations in can or eazypack.

Next to these preparation costs, an innovation makes also the production process more complex. This is the second part of the complexity research. According to the value chain model of Porter, the production process is divided in several steps. These steps are: *inbound logistics/procurement, production, outbound logistics* and the supporting activities *quality control* and *coordination*. For each step is determined what the costs are of the additional complexity for an innovation on this step. This includes extra setup, quality control and overhead of the production.

There was no useful model available to calculate setup cost per hour. So in this research is a cost diving tool developed using theory about activity levels and cost allocation. This tool is used to calculate the setup cost per hour, per batch, per product and per contamination group. This gives estimation of the yearly setup cost for the production of an innovation. From this calculations of the complexity costs in the production process appeared that the most additional complexity (so highest costs) is in setups. The complexity increasing in coordination at different departments is negligible compared to the other costs.

The costs of the additional complexity in the preparation process and the production process are summarized in a complexity model. Depending on some characteristics of an innovation, the preparation costs of this innovation can be given in a cost report. This cost report gives as well the onetime costs (for the preparation process) of an innovation as an indication of the costs per year in the production process. The costs are three times given in three divisions. First on the chosen characteristics, second on the preparation or production steps and third on departments.

In order to improve reliability, the model gives for each cost a minimum, maximum and average. Sensitivity analysis on the result shows that small variances of the data have only small impacts on the given complexity costs. Nevertheless, it is recommended to update the average personnel cost, the budgeted production costs and the activity levels regularly.

Finally this report gives some recommendations to improve the complexity model and for further research on the complexity subject. The model can be improved by adding other factories, take into account the links of products between factories and study cannibalization and other impacts of innovations on existing products.

Due to the relative small costs or cost differences it is recommended to not focus anymore on the preparation costs at the factory and central level or at the differences in packaging formats.

From this research appeared that there is a lack of useful theory of operational complexity. For this reason an own cost dividing tool and complexity model is constructed. It is recommended to execute a benchmark study on another food producing company to learn more about the way other companies deal with the complexity paradox.

Preface

The book can be closed, end of a nutritious year and a fruitful period. Me of all people, Rens van Grunsven, expects to gain the master title *Industrial Engineering & Management* at the University of Twente. I have finished calculating on my final research at Danone. I have made inquiries into the additional complexity for innovations to support the Danone department *Product sourcing milks*. This report describes the research structure, the researched company and the results.

I would like to thank the company Danone that gave me the opportunity to design and execute the assignment in my own way. I had a great time working at Schiphol, including lunches and sweet boxes. I enjoyed all the times I was in Cuijk where I got acquainted with the factory and production process. Besides I am glad that I had the opportunity to work at home accompanied by the radio, coffee and all my study books on my desk. But I spent much more time on this research. Almost every night when I woke up to go to the toilet, my mind was all over complexity.

Thanks to all the employees that supported me in my work and gave me information, both at Schiphol and in Cuijk. Special thanks for Olav and Mark. Every time when I got stuck with my research proposal or execution, Mark was there to discuss it with me.

Also thanks for the supervisors from the university, Peter and Henk. It was nice to tell Peter every time again that my research is not about Danoontje, but about baby milk and I hope he will finally understand.

I would like to thank Gian (my sister) who have corrected my bad tottering English. And off course thanks to Shelitha (my girlfriend) and Anton and Joke (my parents) for all the financial and moral support during my study.

It was an interesting and exciting graduation assignment and study period, but now I am happy to have finished calculating.

Rens van Grunsven

January 2009

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1 Introduction

In order to obtain the master title *Industrial Engineering & Management* at the University of Twente, I have researched the additional complexity for innovations at Danone powder baby milks.

Groupe Danone is a multinational which produces dairy products, baby food, bottled water and medical nutrition. The company's ambition is to bring health through food and beverage to as large a number of people as possible throughout their lives.

The division *Baby food* produces milk, meals and cereals under brands as Nutricia (Dutch, with sub-brands Nutrilon, Olvarit and Bambix), Milupa (Germany, Eastern Europe), Cow & Gate (United Kingdom), Blédina (central and Southern Europe) and Dumex (Asia).

Within the baby food category, the operations department is responsible for planning, production and delivery of the baby milk products to sales units in Europe. Manufacturing takes place in seven factories in The Netherlands, Ireland, Germany and Poland. The operations costs are an important point to be considered for Danone. Key in running operations efficiently is to continuously reduce complexity. Complexity can be seen as the combination of the number of activities (for example: numbers of recipes, suppliers or setups) and their mutual dependency.

Besides, part of Danone's mission is to obtain and secure leading market positions. To enable growth the sales units find new opportunities (new or improved products). These new products are called innovations. For example a different taste or a new packaging design. These innovations require often introduction of new recipes or raw materials, which is an addition to the complexity.

As can be seen in figure 1, there is a complexity paradox. Innovations let the complexity increase, while the complexity has to decrease to save expenses.

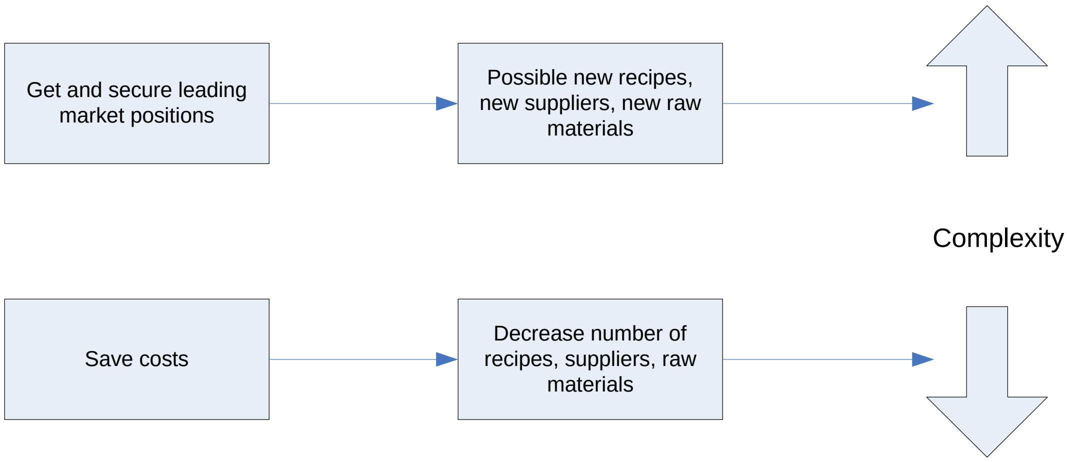

figure 1: Complexity paradox

Each innovation adds some complexity (and costs) to the operations. Next to the straightforward costs in raw materials and production, there are a lot of less tangible costs at for example procurement (new suppliers), production (setups), planning, warehousing and management. It is not the goal to find innovations without additional complexity, but the complexity added has either to be in harmony with the profit of the new product or the product should fit in Danone's strategy (for example a new market).

Requests for innovations in baby milk products are presented to several departments by using the *freeway process* (a decision tool self-developed by Danone). The department *Product sourcing milks* has to decide whether this innovation is possible within the operations. To make these decisions, the department wants to gain a better understanding on costs of the complexity added. That is the starting point for this research.

To reach this goal I have divided my research in two parts. First I have looked to the preparation process of an innovation. This process contains all the activities that are needed before a new product can be produced, for example: product development, purchasing of new materials and changing of artwork. I have made a model in order to calculate these preparation costs for an innovation. An innovation can also decrease the complexity in the production process. This forms the basis of the second part of my research. I have determined the costs of this extra complexity for an innovation. This includes extra setup and overhead of the production.

The next chapter gives an overview of the company Danone. The third chapter describes further how the research is structured and how this structures the report. The results of the research can be found in chapters 4 till 10. Chapter 11 give the main conclusions and my recommendations for further research.

Because of the confidentiality of some information, from the original version all (financial) data (in chapter 8 and 9), the numbers of innovations as given in chapter 5 and the attachments are excluded to construct this public version.

2 Danone

Danone is a worldwide company with more than 90,000 employees in more than hundred countries over all the five continents. The ambition of Danone is to bring health through food and beverage to as large a number of people as possible throughout their lives. This is reached by rapid growth and by strong brands.

To offer a better understanding for reading the report, in this chapter the company Danone is briefly described. The first paragraph describes the history of Danone. The second paragraph gives an overview of the products and the third and fourth paragraph go more into detail with respectively the *Baby nutrition* category and the milk sub-category. The last paragraph shows the organization structure.

2.1 History

This paragraph gives the history of Danone and Numico.

2.1.1 Danone

Danone is founded in Spain in 1919, when Doctor Isaac Carasso started a business in milk products made of yoghurt ferments. He used his products to treat children in Barcelona from intestine infection. In 1967 a merger with Gervais took place. Gervais was a French company, founded in 1850, which produced products made of fresh cheese. In 1973 the company merged with the French glass and packaging manufacturer BSN.

2.1.2 Numico

In 1894 the German professor Alexander Backhaus developed a way to produce special food for babies. Two years later the Dutchman Martinus van der Hagen, founder of a little steam milk factory, gained the exclusive right to produce baby food from cow milk according to the Backhaus-method. In 1901 the N.V. Nutricia is founded. Later the firm started producing medical food and cans with baby meals (Olvarit). Nutricia did not only focus on The Netherlands but also acquired for example Cow & Gate (United Kingdom, 1981), Milupa (Germany, 1995) and Mellin (Italy, 2003). In 1998 the name of the overall company is changed to Numico (an union of the brands Nutricia, Milupa and Cow & Gate) to make clear the difference between mother and daughter companies.

In November 2007 Danone took over Royal Numico N.V.

2.2 Products

The products of Danone are divided in four categories:

- Baby nutrition
- Fresh dairy
- Packaged water
- Medical nutrition (or clinical nutrition)

The category of *Baby nutrition* is described in more detail in the next paragraph.

The brands in the category *Fresh dairy* have each a benefit of health. Like Danonino (in Dutch: Danoontje) for growth, Actimel for protection, Activa for digestion and transit and Vitalinea for weight management.

In the *Packaged water* category there are pure waters (with brands as Evian, Volvic and Font Vella) and water-based drinks (with brands as Volvivc, Vitalinea and V).

The *Medical nutrition* category is divided in two segments. One with nutrition for people who cannot eat or are sick and one with nutrition for diseases, such as cow's milk allergies and people with epilepsy.

These four categories are also visible in figure 2. Here it can be seen that Danone makes products for people throughout their lives. *Fresh diary* and *Packaged water* is in the picture indicated as *Active Health and Foods & Drinks*.

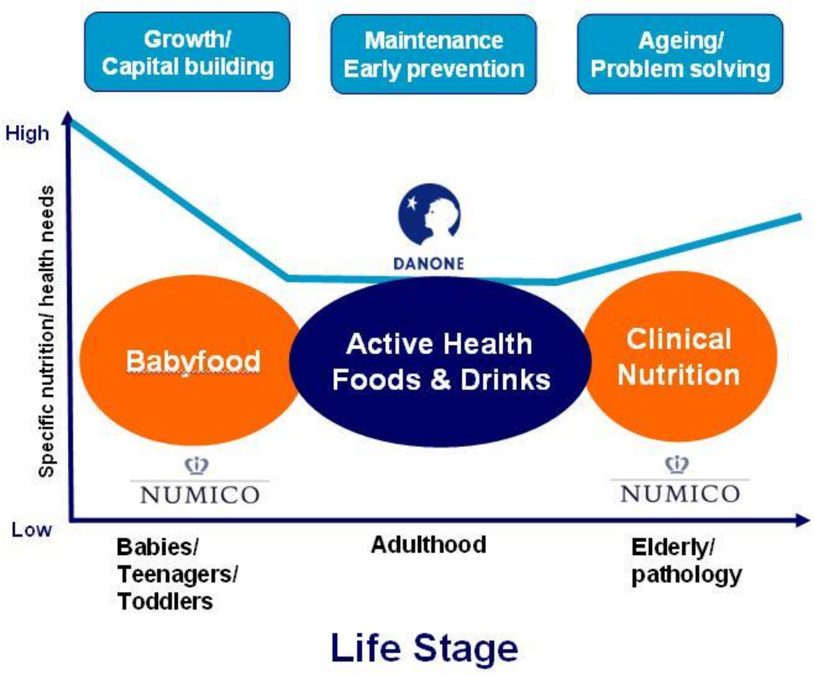

figure 2: Life stage model with four product categories of Danone

2.3 Baby nutrition

Within the *Baby nutrition* category there are four sub-categories:

- Milks: this is the largest category, see paragraph 2.4
- Meals: like the well known bowls of Olvarit (Dutch brand)
- Cereals: to make porridge (in Dutch Bambix)
- Fruits, drinks and desserts

Figure 3 gives the most important baby brands and their markets.

figure 3: Brands and markets baby food products

2.4 Baby Milks

The milk sub-category is again divided in the categories *Infant formula and follow-on milk* (IFFO) for babies till one year and *Growing up milks* (GUM). Within IFFO there is made a distinction in *Base milk* and *Specialties* (like for babies with cow milk disease or poor sleep).

About twenty percent from IFFO is liquid milk and eighty percent is powder milk (which has to be made liquid with water at home). For the *Growing up milks*, this division is more or less reversed.

The production process of the powder baby milk products consists of drying the milk to a powder, mixing it with other ingredients and packaging. In chapter 7 we will see this production process in detail.

2.5 Organization

Danone is partly organized globally and partly locally. Globally the company is organized per product category. Each category has its own departments for marketing, finance, research & development, operations and human resources. After that, sales and marketing are organized locally. Each country has its own sales unit, which can choose for new products. Each sales unit is responsible for own results and profit. The operations department of each category is divided in departments for purchasing, production, supply chain and quality.

The global departments for *Baby nutrition* are located in the office at WTC Schiphol, The Netherlands. Figure 4 gives an organization chart which only focuses on the management structure of the department *Product sourcing milks*. This department is colored yellow in the figure.

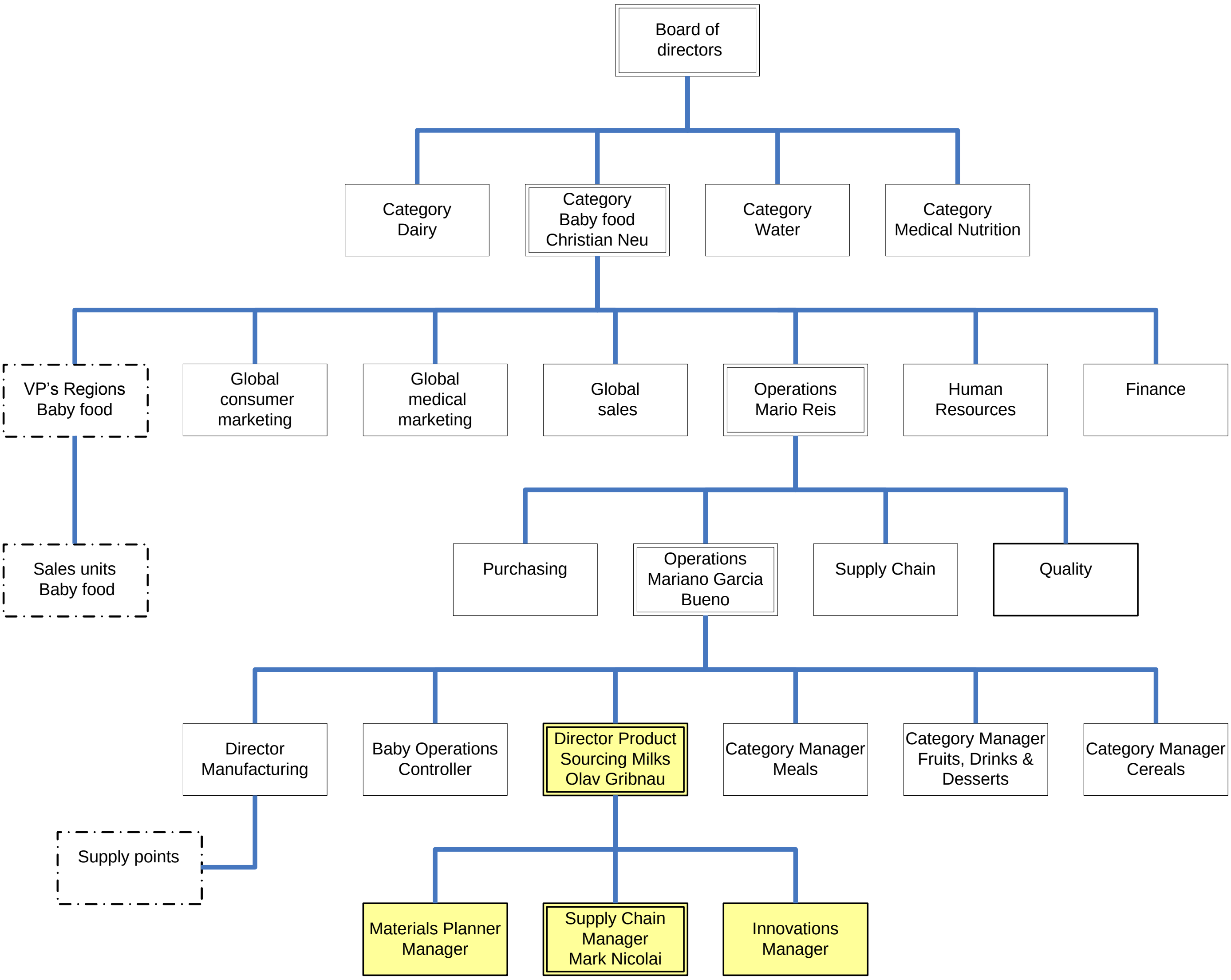

figure 4: Organization chart

3 Research structure

This chapter describes the structure of the research, which consists of the following elements:

- Objective and scope (3.1)
- Research model (3.3)
- Research questions, material and strategy (3.4)
- Deliverables (3.5)
- Definitions (3.6)

In paragraph 3.2 I explain the concept complexity, the core definition in this research.

3.1 Objective and scope

As mentioned in the introduction, the operations department wants to gain better insight in the costs of the additional complexity of an innovation. This leads to the objective of this research:

> *To visualize the costs of additional operational complexity for Danone of an innovation by making a model to determine these complexity costs*

I have separated the research in two parts. First the research focuses on the onetime costs for setting up an innovation, like development and registration. Secondly it points to the complexity during production like extra management and extra setups.

The research is practice oriented, meaning that the research aims to contribute to an actual problem in an organization. Verschuren and Doorewaard (2000: 36-37) distinguish five stages in solving a problem: problem description, diagnosis, design, intervention and evaluation.

In this case the problem is already determined (the complexity paradox) and a diagnosis of a possible solution is made (a model to visualize this complexity). This research focuses mainly on the design stage. After this research some intervention and evaluation will be necessary.

The research is about the period between the moment the decision about the innovation is made until the moment the transport to sales units take place. This excludes the research & development and the costs at the sales units.

Only the powder milks sourced from Europe will be taken into account. So although the model could be eventually useful for other products or regions, this is not in the scope of the research. Due to the time available for this research, only costs for the factory in Cuijk are calculated. These are presumed to be representative enough for the whole company.

Each one or two years all products are updated on recipe and/or artwork. These centrally coordinated recipe changes are upgrades of the total portfolio. As a side effect there is tried to harmonize the portfolio, to decrease the complexity (as stated in the introduction).

Next to these changes, the sales units desire extra changes for specific products which fit in their markets. As much as possible these requested changes are involved in the central programs. This research is only about these extra changes that do not fit in the central coordinated change programs.

3.2 Complexity

This research is about complexity. Complexity is a vague and broad word. It could be understood at very different ways. Within the company Danone I have spoken with various people about my research and about complexity. Everyone appeared to have a different opinion about the meaning of complexity and so about this research. Because it is so important for this research to have a clear view of complexity, I explain what my understanding of complexity is for this research.

According to Oxford advanced learner's dictionary (1995) complexity means "the state of being complex", wherein complex means "having many parts connected together in a particular pattern". The other given meaning of complex is "difficult to explain". That is so true.

I will use the term complexity as the combination between the number of activities and their mutual dependency. I have chosen to determine the costs of the complexity added of an innovation as the costs of the extra activities that are needed for this innovation.

3.3 Research model

To structure the research I have used the research framework of Verschuren & Doorewaard (2000: 45-64). This framework gives a global view of the necessary steps to reach the objective of the research. Figure 5 shows this model.

At the right side (column 4) the framework shows the objective of the research, namely the complexity model. In order to make this model the different steps in the preparation process and in the production process are evaluated on complexity (column 3). The information that is used for the research in column 3 can be found in column 2. This information is derived for example from interviews and financial data. The first and third part in column 1 are the information, which I have used to split respectively the preparation and production process in different steps. Finally the second part of this column shows the literature subjects needed to get the research view for the complexity. The research view, a term used by Verschuren & Doorewaard (2000: 47), is the way you approach the researched object, in this case the complexity.

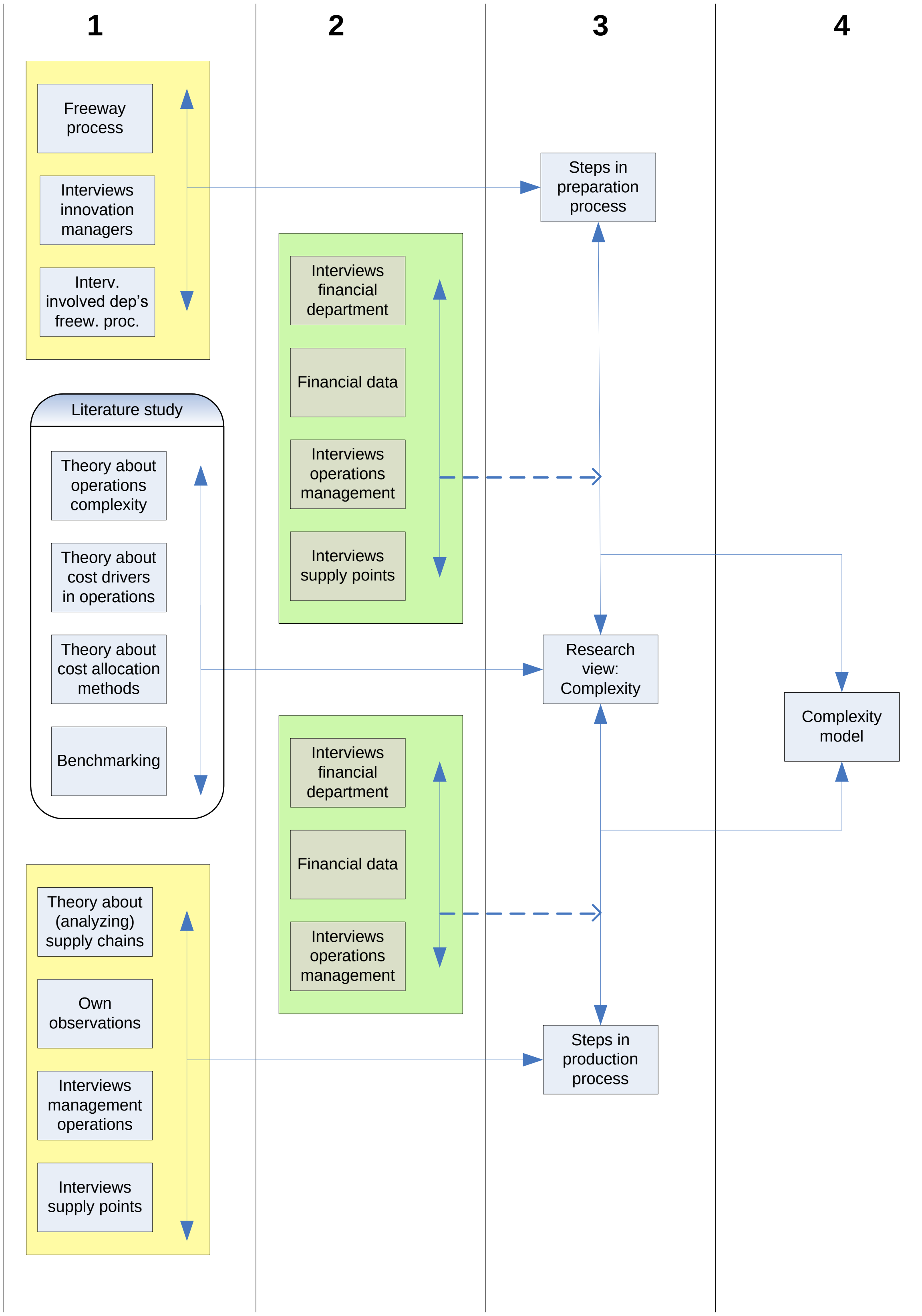

figure 5: Research framework

3.4 Research questions, material and strategy

Each part of the research model has its own research question and if necessary sub-questions. At each question is indicated which material I have used to answer the questions and how this material is gained and used.

3.4.1 Innovations

The first research question is necessary to gain a better understanding for the research:

1. *What types of innovations can be distinguished and in which categories can these be divided?*

To answer this first question I have interviewed an innovation manager and have gone into detail with a list of innovations and all submitted *freeway forms* of the period between January and August 2008. This question will be answered in chapter 5.

3.4.2 Analysis of preparation process

The research question of the first part of the model is:

2. *In which steps can the preparation process of an innovation for Danone baby milks be divided?*
    a. *What is the freeway process?*
        i. *Which steps are undertaken in the freeway process?*
        ii. *How do the innovation managers treat the freeway process?*
        iii. *What are the roles and responsibilities in the freeway process?*
    b. *Which departments are involved with the preparation of an innovation?*
    c. *What kind of activities are carried out by these departments for the preparation of an innovation?*

To answer this question I have looked to the *freeway process* of some innovations to find out which steps are necessary. I have interviewed people of the different departments which spend time on preparation. This question will be answered in chapter 6.

3.4.3 Analysis of production process

Like the preparation process, also the production process is divided in several steps.

3. *In which steps can the production process of Danone baby milks be divided?*
    a. *What are the (possible) (production/logistic) steps a product will take?*
    b. *What kind of overhead is necessary to let the product take these steps?*

To answer this question, I have studied some theory about supply chain models. I wanted to use an existing model to visualize the supply chain. I have divided the production process in several steps by using information from the management of the operations department at Schiphol Plaza and from supply point Cuijk.

At supply point Cuijk I have spoken to several managers and I observed the production process myself. This question will be answered in chapter 7.

3.4.4 Literature study

In order to form the research view on complexity, the literature study focuses on the following questions:

4. *Which research view will be used to approach the complexity of the production process and the preparation process of Danone baby milks?*

    a. *What theory is available about operations complexity?*

    b. *How do other companies deal with the complexity paradox?*

    c. *Which models are available for calculating the costs in a supply chain and allocating them over products?*

    d. *Which model(s) will (possibly) fit to the Danone baby milks production process and preparation process?*

To answer these questions I have searched for relevant literature on this subject on internet and in the university library. I was confronted by a lack of relevant information, also from other companies on this subject. A small benchmark study on another company in the food business belonged to the possibilities if no information could be found and if there would be time available. Unfortunately there turned out to be not enough time for this benchmark study.

Because I didn't find an existing useful tool to calculate the production cost and to allocate them over the products, I have developed an own cost dividing tool. Chapter 4 will give an overview of my review of the literature searching and this tool.

3.4.5 Complexity in the preparation process

For each step in the preparation process (resulting from the answering of question 2) the following questions have to be answered:

5. *What are the costs of the additional complexity on this step of the preparation process, depending on the kind of innovation?*

    a. *Which activities are required on this step?*

    b. *How much time is spent on these activities?*

    c. *What costs are related to these activities?*

Sub-question 5a will be answered in chapter 6 and is more or less the same as sub-question 2c.

To answer sub-questions 5b and 5c, I have looked at available financial data and I had interviews within the financial department, operations department and the departments involved in the preparation process. The complexity of the preparation process will be described in chapter 8.

3.4.6 Complexity in the production process

For each part in the production process (resulting from the answering of question 3) the following questions have to be answered:

6. *What are the costs of the additional complexity of an innovation on this step of the production process depending on the kind of innovation?*
    a. *What extra setups are required?*
    b. *What cost these extra setups?*
    c. *Which other costs are incurred?*

As with question 5 I have used financial data and had interviews with various departments to answer this question. Next I have put financial and production data in the cost dividing tool as defined in chapter 4 to calculate the cost of setups. The additional complexity for the production process and the answers on the questions above can be found in chapter 9.

3.4.7 Complexity model

Based on the information of the previous questions, finally the complexity model has to be constructed. In the complexity model all the costs are brought together. The following question about the model has to be answered:

7. *How should the model be implemented and used?*

The complexity model (both for the preparation process and the production process) is described in chapter 10.

3.4.8 Recommendations

Chapter 11 gives the conclusions of this research and discusses the recommendations for further research. It answers the last research question:

8. *What are recommendations for possible further research?*

3.5 Deliverables

The deliverables of this research exist of an Excel model and a report. The model is meant to calculate the preparation costs of an innovation and the costs of the additional complexity in the production process. It is not the aim of this research to design an advanced or fancy looking model.

The report contains the motivation and relevance (chapter 1) and structure (chapter 3) of this research, a description of the company (chapter 2) and all the research results (chapter 4 till 10). At the end of the report I give the conclusions and recommendations for further research (chapter 11). Also assumptions made for the complexity model (chapter 8 and 9) and the explanation of the model (chapter 10) can be found in this report.

3.6 Definitions

The core definitions in this research are:

Innovation:	A new or improved product for which a sales unit has started the *freeway process*. Innovation is a typical Danone term.

The most easiest improvements (for example changing a telephone number on the packaging) do not need permission from the headquarters, so don't need a *freeway process* and are not taken into account in this research.

Preparation process:	All the steps that are needed before a (new) product can be produced. This include the product development, purchasing, planning etc., but not the research of possible new products. These are all the steps that can be assigned to one specific new product and that are made after the *freeway process* is started.
Operations:	All the activities managed by the baby food operations department. In particular the production process and the preparation process.
Production process:	All the steps that are taken within Danone when a (new) product is actually produced, from entrance of the raw materials to the factory, to and including departure of the products for shipment to the distribution centers in the countries. By Danone mostly called "supply chain".

Definitions of other used terms can be found in the glossary at page 67 of this report.

3.7 Summary & conclusion

To reach the objective of the research (to visualize the costs of additional operational complexity for Danone of an innovation by making a model to determine these complexity costs) in this chapter the following questions are formulated:

1. *What types of innovations can be distinguished and in which categories can these be divided?*
2. *In which steps can the preparation process of an innovation for Danone baby milks be divided?*
3. *In which steps can the production process of Danone baby milks be divided?*
4. *Which research view will be used to approach the complexity of the production process and the preparation process of Danone baby milks?*
5. *What are the costs of the additional complexity on this step of the preparation process, depending on the kind of innovation?*
6. *What are the costs of the additional complexity of an innovation on this step of the production process depending on the kind of innovation?*
7. *How should the model be implemented and used?*
8. *What are recommendations for possible further research?*

In this chapter was described how these questions will be answered in the report. The result of this research is a simple Excel model (to calculate the costs of additional complexity) and a report. In the further of this report answers are given on the questions above.

4 Literature study

This chapter describes the literature and models that are used in this research. In the first paragraph I describe the value chain model of Porter (1985) which will be used (in chapter 7) to analyze the supply chain of Danone baby milks. The rest of this chapter is about the research view on complexity. This answers the fourth research question (*Which research view will be used to approach the complexity of the production process and the preparation process of Danone baby milks?*).

First I have searched for available information (also from other companies) on this subject on internet and in the university library. The key words I used were among others: supply chain, complexity (reduction), cost models, cost allocation, (dividing of) setups and assortment pricing. It was hard to find useful information. I did not found any relevant information from other companies on this subject. Paragraph 4.2 describes some theories I came across about subjects closely linked to the subject of complexity, but which I considered not useful enough.

Because I did not find an useful tool for calculating the production cost (including cost for setups) and divide them over the products, I have developed my own. This cost dividing tool is described in paragraph 4.4. Paragraph 4.3 gives an overview of the theories (among other things utilization, activity levels and costs) used in this tool.

4.1 Value chain model

The value chain model of Porter (1985: 37) will be used to describe the production process of Danone powder baby milks (in chapter 7). A value chain is a chain of activities. Products pass through all activities of the chain in order and at each activity the product gains some value. The value chain is used for an individual company. When value chains of suppliers and buyers are linked, Porter speaks about a value system. Figure 6 shows the value chain model of Porter.

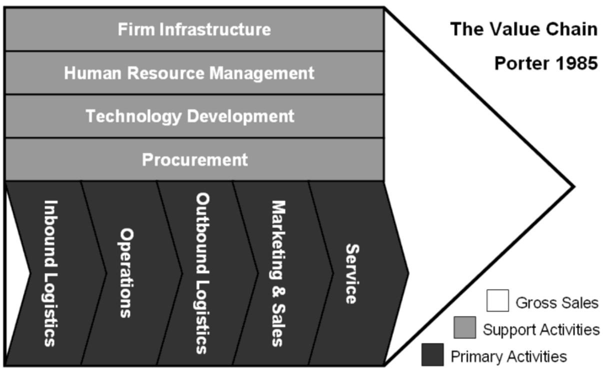

figure 6: The value chain model of Michael Porter (1985)

The value chain model differs between primary and support activities. The primary activities are those involved in taking the raw materials and making the products for the customers. This includes *inbound logistics*, *operations* (production), *outbound logistics*, *marketing &*

sales (demand), and *service* (maintenance). The support activities include: *firm infrastructure* (administrative activities), *human resource management*, *information technology* and *procurement*.

The primary activities *marketing & sales* and *service* fall outside the scope of the complexity model, because these are activities of the sales units.

So the value chain in this research consists of three primary activities:

- Inbound logistics
- Production
- Outbound logistics

Because only the activities of the operations department are taken into account, the only relevant support activity is *procurement*. I have combined this activity with *inbound logistics*. There are two other relevant support activities, *quality control* and *coordination*. These activities will be described in chapter 7.

In this research these activities altogether (*inbound logistics/procurement, production, outbound logistics, quality control* and *coordination*) are called “production process”.

4.2 Not useable literature

MacDuffie et alii (1966) wrote an article about the impact of product variety on the performance of production. Among others they thought that the impact of different kinds of product variety on performance varies and that it is generally much less than the conventional manufacturing wisdom would predict. There is more research about this subject. These researches focus however on the way the production should be designed to deal with this complexity, like Dabbene et alii (2008), who wrote an article about the optimization of supply chains in uncertain environments. They make a trade-off between logistic cost and performance like food quality. Or like Escobar-Saldívar et alii (2007) who wrote about the painted sheet metal industry. They observed that having a lot of different colors is an important competitive factor, like the different products for Danone, but that this also can lead to excessive setup cost. However they deal not with the same problem as in this Danone case, but with calculating the optimal number of colors.

There are also many papers written about assortment pricing, but these are all on the side of the customers. These researches deal with subjects as selecting and pricing an optimal assortment (McIntyre & Miller, 1999), the influence of price differentiation on customer decisions (Chernev, 2006) or the influences of competitors on prices (Shankar & Bolton, 2004). Pricing models on the producers side were not available, so I have developed my own tool for calculating the (setup) cost of a product.

4.3 Cost theory

Paragraph 4.4 explains the cost dividing tool which I have developed. In this paragraph the underlying theories are described which are used in this tool.

4.3.1 Activity level

The activity level is necessary for the utilization calculation (sub-paragraph 4.3.2). There are four different activity levels that can be used (Drury, 2000: 215):

- Theoretical maximum capacity is the total available time for a production line.
- Practical capacity represents the maximum capacity that is likely to be supplied by the machine after taking into account unavoidable interruptions arising from machine maintenance and plant holiday closures.
- Normal average long-run activity is a measure of capacity required to satisfy average customer demand over a long term period.
- The budgeted activity is the activity level based on the capacity utilization required for the next budget period.

4.3.2 Utilization & Efficiency

The utilization of a workstation is the fraction of time it is busy (Hopp & Spearman, 2000: 292). This time includes production but also setups. It is calculated as total time used (for production, setups etc.) divided by the activity level (see sub-paragraph 4.3.2).

Efficiency of a workstation or machine is defined as total production time assigned to products divided by the total working time (Reid & Sanders, 2002: 304). The working time is the total time used (for production, setups etc.) as used for the utilization calculation. Efficiency refers how well the machine is performing while it is being used (Chase & Aquilano, 1995: 606).

So the time spent to setups is calculated in the utilization, but falls outside the efficiency. This difference is important to allocate some costs in the tool.

The utilization multiplied by the efficiency gives the fraction production time of the activity level.

In the model I use practical capacity utilization (defined as total working time divided by the practical capacity) and budgeted activity utilization (defined as total working time divided by the budgeted activity).

4.3.3 Measurement of costs

There are many ways to measure costs. Different purposes need different costs (Rosen, 1974). Because the goal of the model is to give the total setup cost, all costs are necessary, including overhead costs. In the next sub-paragraphs the different kinds of costs are described.

4.3.4 Fixed and variable costs

The terms fixed and variable are used to describe how a cost react to changes in activity (Drury, 2000: 25-26). To understand how costs behave, it is necessary to understand the nature of costs (Berry & Jarvis, 1997: 296-297). Some costs are essentially fixed, like depreciation of a machine and hiring of a building.

Other costs vary with usage or activity, like the used electricity of a machine. These are variable costs. Variable costs are the same per unit of activity. In the model the unit of activity is time (hours). Fixed costs do not change in response to changes in the level of activity. Unfortunately, not all costs fall neatly within these two categories. A fixed cost will only be fixed over a limited range of output. If output exceeds capacity, new equipment could be necessary which will increase the fixed cost. Also variable costs are not always total variable. For example, direct labor costs will not vary on the short term because of labor agreements.

Kaplan (1998) argues that virtually all costs are variable in the long term, because people can be fired and plants can be closed.

4.3.5 Direct and indirect costs

A direct cost is one that is traceable and thus attributable to a product (Berry & Jarvis, 1997: 319). These can as well been variable as fixed. Indirect costs are those that cannot be easily identified with a particular product. These are also called overhead costs.

4.3.6 Setup cost

Machines have to be reconfigured and/or cleaned between jobs. This process is known as a changeover or setup. Setup times are sequence-dependent when the length of the setup depends on the job just completed and on the one about to be started. In that case the setup time is a function of the differences in machine settings for those two jobs and is determined by production standards (Pinedo & Chao, 1999: 18, 214). Setup cost consists for example of labor, waste of raw material and machine time.

Several of these cost factors become quite complicated. For example the wages of the personnel who have to set up the machine. These personnel is on salary, so they will be paid no matter if they are busy with setup. If they are included in other activities when they are not working on a setup, the salary cost should be included in the setup cost. However, if there is no setup there is no generating of actual money in the short term. So in the short term, these costs are fixed and you could argue that they are not part of the setup cost. Silver et alii (1998: 47) suggest that these costs should be included in the setup cost if there is a long-term decision (like a year) being made. Because this is the case in this research, I include the salary cost in the setup cost.

Once a setup is completed there often follows a period of time during which the facility produces at lower quality or slower speed while the equipment is fine-tuned (Silver et al., 1998: 46). This is called the “learning effect” and the resulting costs are considered to be part of the setup cost. The real cost of this effect is very difficult to measure. Because of this and because the learning effect is small in the Cuijk factory, I excluded this effect from the cost dividing tool.

Setup is a batch-related activity. The cost of setup is fixed for all units within the batch. There is no difference in cost to set-up a machine for five or ten thousand items (Drury, 2000: 345).

4.3.7 Opportunity cost

The opportunity cost of a resource is defined as the maximum benefit which could be obtained from that resource if it were used for some alternative purposes (Berry & Jarvis, 1997: 352). During the setup period an opportunity cost is incurred, because production time on the equipment is being lost during which another item could be manufactured (Silver et al., 1998: 46). In other words, opportunity cost represents the lost contribution to profits arising from other use of resources. An opportunity cost only applies when there is a scarce resource (Drury, 2000: 31).

In this research this is relevant for the base powder production. The full capacity in Cuijk is in use for making base powders. All the time that is used for setup, there can be no base powder produced, so the possibly revenue from producing base powder or the purchasing cost of a base powder at a third party has to be added as opportunity cost.

4.3.8 Cost allocation

There are three main methods for cost allocation (Drury, 2000: 337):

- Direct costing
- Absorption costing
- Activity-based costing (ABC)

Under direct costing (sometimes also called variable costing or marginal costing) only production costs which vary in proportion to the output are calculated in the cost of a product (Sutton, 2000: 260). So only the variable costs are used.

In absorption costing (or full costing) all fixed manufacturing overhead costs are allocated to products (Drury, 2000: 202). In the cost dividing tool the overhead costs (fixed indirect costs) are divided according to absorption costing. The absorption unit is time.

If a large proportion of an organization’s cost is unrelated to volume measures, the risk arises that traditional product costing systems will report inaccurate product cost (Drury, 2000: 340). In particular it is claimed that traditional systems tend to over-cost high volume products and under-cost low volume products. Therefore in the tool the overhead costs are not only divided over production hours, but also over setup hours. To avoid that a decrease in total setup hours will increase the cost of a production hour, there is a cost of non used capacity.

An activity based costing system assigns overhead to each major activity, rather than departments (Drury, 2000: 338). In the considered company, generally the activities fall together with the departments. Within the departments there is not much difference between the activities. For that reason I have not used an activity based costing system.

4.4 Cost dividing tool

At this moment all factory costs are allocated over the production lines using budgeted activity. This means that each hour of production gets the same setup cost. The main disadvantage of this allocation is that a product which is produced in large batches gets more setup cost than a product in a small batch.

To gain good insight in the real cost of setup, the costs have to be allocated at a different way. Because there was no useable tool available, I have constructed an own tool to calculate the setup cost for a product on a certain production line. The underlying concepts of this tool were described in the previous paragraph. In this paragraph I explain this tool which is shown in figure 7.

Attachment 1 gives an example of this tool with fictive numbers.

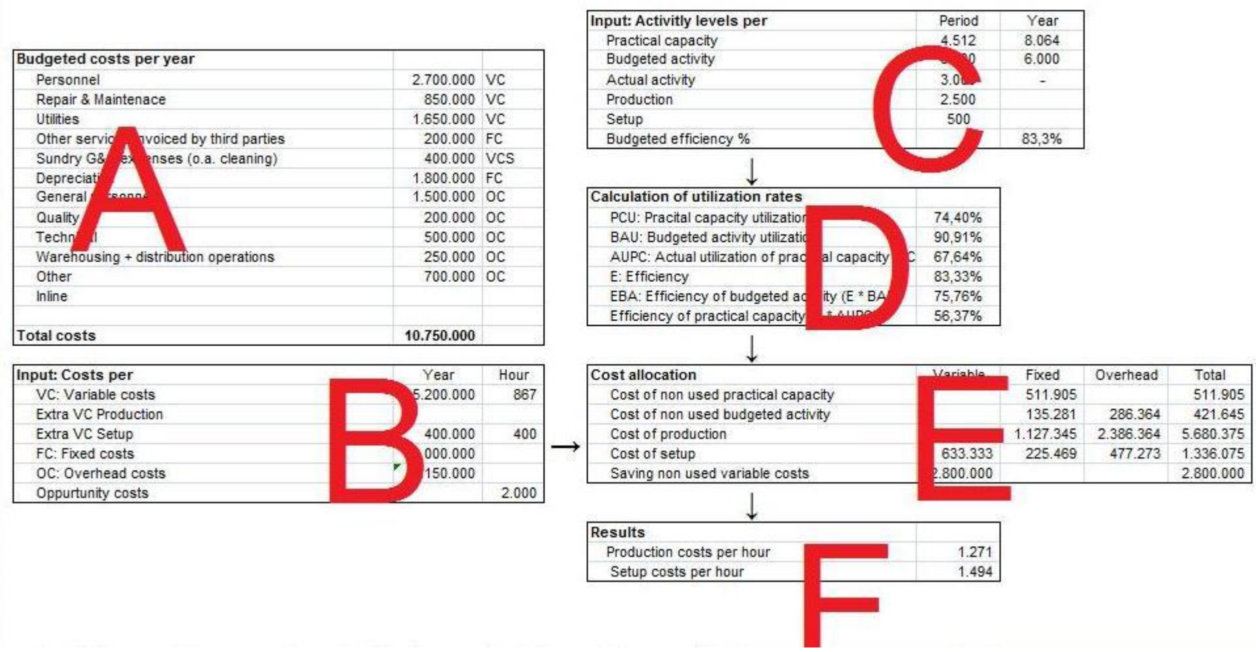

figure 7: Cost dividing tool

The tool needs two kinds of input: activity levels (4.4.1) and costs (4.4.2). These are visible on the left and on the top side of the picture of the tool. The activity levels are used to calculate utilization rates (4.4.3). Besides the utilization rates are used to allocate the costs and so calculate the total setup cost (4.4.4). The output (4.4.5) of the tool is the setup (and production) cost per hour.

4.4.1 Input: activity levels

The first group of inputs are the different activity levels (block C in figure 7). These are necessary to calculate the utilization and efficiency rates. The following activity levels are needed:

- Practical capacity
- Budgeted activity
- Actual activity
- Number of production hours

Practical capacity and budgeted activity have to be measured over the same period, likewise budgeted activity and actual activity have to be measured over the same period. Otherwise they have to be intra- or extrapolated to calculate the utilization rates.

If the variable costs are not per hour, the budgeted efficiency is necessary for dividing the variable costs over the number of hours.

4.4.2 Input: costs

The second group of inputs are the costs (block A in figure 7). These can be derived from the budget. The costs have to be divided over the following groups (block B in figure 7):

- Variable costs (VC) which are the same for each business hour no matter if this is production or setup, like personnel and repair & maintenance.
- Extra variable costs for production hours like quality controls.
- Extra variable costs for setup hours, like cleaning materials.
- Fixed costs (FC) for the department, like depreciation.
- Overhead costs (OC) allocated to the department, like general personnel.
- If relevant the opportunity cost per hour

Variable and opportunity costs are per hour, fixed and overhead costs have to be per year.

4.4.3 Calculation of utilization rates

The tool calculates the following utilization rates (block D in figure 7):

- PCU: Practical capacity utilization (budgeted activity / practical capacity)
- BAU: Budgeted activity utilization (actual activity / budgeted activity)
- AUPC: Actual utilization of practical capacity (PCU * BAU or actual activity / practical activity)
- E: Efficiency (production hours / actual activity)
- EBA: Efficiency of budgeted activity (E * BAU or production hours / budgeted activity)
- EPC: Efficiency of practical capacity (E * AUPC or production hours / practical capacity)

According to these rates, the costs are allocated.

4.4.4 Cost allocation

The calculated utilization rates are used to allocate the costs (block E in figure 7).

The fixed department costs, like depreciation, are allocated over the practical capacity. The overhead costs are in the budget calculated over the budgeted number of fte, so they are allocated over the budgeted activity level. Both allocations result in a cost for respectively non-used practical capacity and a cost for non-used budgeted activity. If the actual activity is higher than the budgeted activity, this results in a revenue.

The cost of non-used practical capacity is the percentage of non-used practical capacity (1-PCU) multiplied by the fixed costs.

Because the base powder production uses more or less the total practical capacity, also an opportunity cost has to be incurred. The opportunity cost per hour is the cost of purchasing from a third party as much base powder as normally could be produced in one hour. In this case the cost of an hour setup is the setup cost per hour plus the opportunity cost minus the production cost per hour.

4.4.5 Outputs

The outputs of the setup cost dividing tool (block F in figure 7) are the production and setup costs per hour. Further on in chapter 9 these costs will be used to estimate the yearly setup cost for an innovation.

4.5 Summary & conclusion

This chapter described the review of the literature. It gave an overview of some available literature of subjects closely linked to this research. The value chain model of Porter will be used in chapter 7 for the description of the production process. Because there was no useable tool available for calculating setup cost per hour, I have developed an own tool using theories about activity levels and cost allocation. This tool will be used in chapter 9 to estimate the setup cost for an innovation.

5 Innovations

A new or improved product for which a sales unit has started the *freeway process* is called an innovation. In this chapter some general information about innovations is given. This gives an answer on the first research question (*What types of innovations can be distinguished and in which categories can these be divided?*).

There are different types of innovations. I have divided them in the following five categories:

- Change in artwork (5.1)
- Introduction of existing product in new market (5.2)
- Change of weight in existing packaging type (5.3)
- Change in packaging type (5.4)
- New recipe (5.5)

For each type of innovation I give an example. These examples will be used to clarify the complexity description and calculation in the course of the research.

5.1 Change in artwork

A change in artwork could mean a (total) different layout of the packaging label (called new design) but could also mean the changing of some aspects of the label within the current design.

As competition intensifies, design offers a potent way to differentiate and position company's products (Kotler, 1984: 16-21). To ensure or enlarge market positions it could be necessary to change the design sometimes.

Changing the artwork within the current design could be the case in the following situations:

- Change of address or telephone number of the sales unit (as we saw at the definition of innovation in paragraph 3.6, this falls outside the research, because no *freeway* is necessary).
- Change of the claims on the label, for example "This product is good for babies with intestine complaints".
- Change of brand names, see the example below.
- Also for all other described types of innovation a change in artwork is necessary.

Example: In Hungary similar formulas are existing within different brands. The Hungary sales unit wants to simplify the product portfolio by discontinuing some of these products and renaming other ones. Some products sold under brand names Aptamil and Nutrilon remain the same, but are sold under Milupa brand. This implies an artwork change.

5.2 Introduction of existing product in new market

A frequently used innovation is the introduction of an existing product on a new market. This will be the case if a sales unit believes that there is a demand for a product. Because an already existing product is used, there is no cost for development of a new product, so this is a less intensive innovation than a new recipe.

Example: The Greece sales unit wants to introduce the products Almiron AR and Aptamil AR1 on the market in Greece and Cyprus. These are special baby milk products meant for babies when they vomit. These products are already produced for other European markets. The sales unit wants to introduce these in order to further strengthen Nutricia's and Milupa's position in the specialties AR segment and to stop loosing consumers from six months onwards.

5.3 Change of weight in existing packaging type

It is possible to decrease or increase the weight of a product in the same packaging. This could for example be the case for promotions: "Temporarily ten percent more powder milk for the same price".

For powder baby milks the calculating unit is weight. A same weight of powder milk has not always the same volume, due to techniques which put more air in the powder milk. So a decreasing or increasing in weight does not inevitably mean a decreasing or increasing in volume. This can help for the customer satisfaction of the amount of powder milk in a packaging.

Example: Because of a global innovation program (EC 2008), research and development has developed a new formula for the product Aptamil HN-25. At the moment, Italian HN-25 has a weight of 250 gram. The new developed formula has a different density, with as result that the 250 gram can will be filled only at fifty percent. This is not good for consumer satisfaction. The Italy sales unit wants to change the weight of the product to 400 gram. In that case the can will be filled at eighty percent.

5.4 Change in packaging type

It is a strategic decision of Danone to have fixed possibilities of packaging types. So changing in packaging type is only possible for one of the existing types. For the considered factory , Cuijk, this is only a can or an eazypack. In other factories also cluster packs, carton box packs, stick packs and tetra packs are possible.

Example: A sales unit wants to change the packaging of product X from can to eazypack. This is because the competitive advantage of having a new packaging type. The eazypack is easy to open for a parent even when having a baby in her/his arm. The product remains exactly the same.

5.5 New recipe

Recipes change for various reasons. For example because of new insights in the best baby milk or to add a different taste. If a sales unit wants a new product on their market and this product does not exist at the company, a new recipe is necessary.

A new recipe could occur at different levels in the production process. As we will see in chapter 7 when it describes the production process, there are four semi-finished products (base powder, dry mix, premix and final recipe). These are shown in figure 6. See also paragraphs 7.2.2 and 7.2.3 for a description of the production process and the adding of ingredients. Each of these four semi-finished products could be changed. As can be seen in figure 8 some changes automatically results in other changes. For example a new base powder means automatically a new dry mix and a new final recipe.

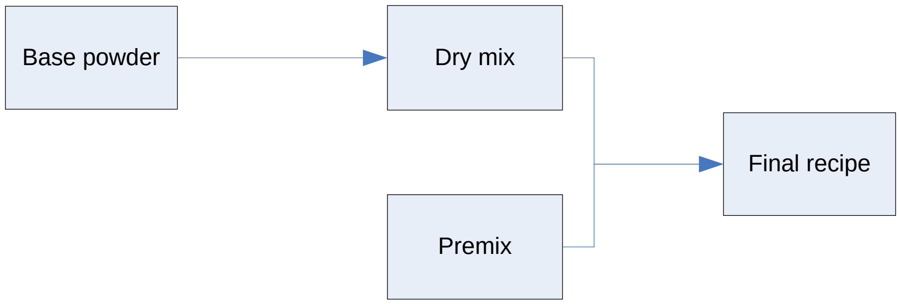

figure 8: Semi-finished products

Recipes can also change to make the production process more efficient, i.e. sharing the same base powder. This is called harmonization and is centrally organized. However this research is about innovations requested by sales units, so these changes fall outside the scope of the research.

A change in one of the recipes can be with existing ingredients, but also with one or more new ingredients.

Example 1: On the Turkey market there is a specialty product for babies with diarrhea, Bebelac LF. The base powder used for this product contains LCP and nucleotides, while all other Bebelac products do not contain LCP and nucleotides. The Turkey sales unit wants to switch to another existing base powder without these ingredients in order to bring more consistency. To keep the specialty the premix remains the same. This implies a new recipe with an existing base powder, existing dry mix and existing premix.

Example 2: In Egypt the food authority has forbidden the use of rape seed oil in baby products. So all the recipes for Egypt have to change by replacing rape seed oil for soy oil. This decision had big impact, since till then all products (for all markets) contain rape seed oil. Because soy oil is more expensive than rape seed oil, it was no option to change this for all recipes. Consequently for this change a new base powder (in a new contamination group) is necessary.

5.6 Number of innovations

I have looked to all individual *freeway forms* submitted in 2008 so far. Most forms contain innovations of more products. In the table below these are divided over the different kinds of innovations and a percentage of each category is given. Some innovations fall in more categories (for example new recipe and change in packaging type). These are counted twice, once in each category, so the percentages do not sum up to 100 percent.

The category called *discontinuation* is used to track delisted products (products that are taken out of production and sales), but falls outside the scope of this research.

Category of innovation	Percentage of total number of innovations
Discontinuation	30 %
Only change in artwork	12 %
Introduction of new product in existing market	49 %
Change in weight	5 %
Change in packaging type	5 %
New recipe	9 %

table 1: Number of innovations per category

As we can see in the table, half of the number of involved products attends to introductions of a new product in an existing market. As we will see in chapter 8 and 9 these are not the kind of innovations with the highest complexity impact. We will see that recipe changes have the most impact.

5.7 Summary and conclusion

In this chapter an overview of possible innovations is given. For each innovation category a specific example is outlined for better understanding of the further research. Chapter 6 will describe how the preparation process looks like and which steps are necessary for each of these five categories of innovations. Chapter 8 will give the costs for each preparation step and a model to calculate the costs for each innovation category. At the same way chapter 7 will describe how the production process looks like and chapter 9 will describe which costs are related to the complexity added on the production process depending on the category of innovation.

6 The preparation process

This chapter describes how the preparation process is structured. As in the introduction is mentioned, the preparation process contains all the steps that are needed before a (new) product can be produced. This includes for example the product development, purchasing and planning, but not the research of possible new products. Answers are given on the question: *In which steps can the preparation process of an innovation for Danone baby milks be divided?* Which is divided in the sub-questions:

a. *What is the freeway process?*
    i. *Which steps are undertaken in the freeway process?*
    ii. *How do the innovation managers treat the freeway process?*
    iii. *What are the roles and responsibilities in the freeway process?*
b. *Which departments are involved with the preparation of an innovation?*
c. *What kind of activities are carried out by these departments for the preparation of an innovation?*

In the first paragraph sub-question 2a is answered by giving an overview of the *freeway process*. The second paragraph describes the most important stage of the *freeway process* (the act stage). In the following paragraphs I give brief descriptions of all the preparation steps by answering sub-questions 2b and 2c.

6.1 The freeway process

The way to achieve a possible new product is called *freeway process*. This is a by Danone developed decision tool. As can be seen in figure 9, the *freeway process* is divided in three stages: *prepare*, *confirm* and *act*.

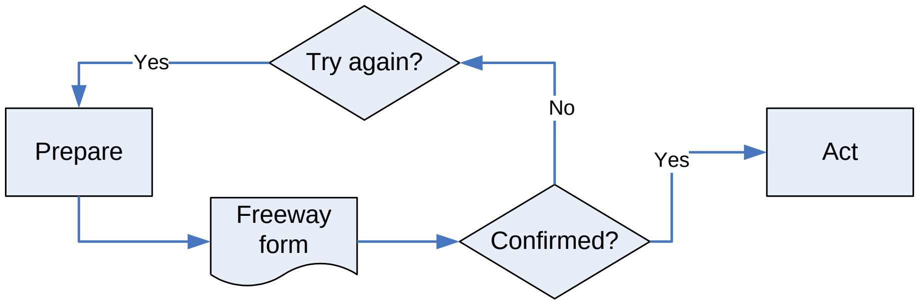

figure 9: The freeway process

A sales unit prepares an innovation by figuring out what the specifications of the innovation are. After this exploration the innovation has to be confirmed. Therefore the sales unit fills in a *freeway form* with information about the new product, marketing, operations and finance.

In a weekly meeting with the departments *global marketing*, *operations*, *product development* and *finance* the submitted *freeway forms* are discussed. These are checked on fitting in the strategy, feasibility, financing and timing.

If the innovation is well prepared the confirmation is just a formality, because the sales unit has already discussed with the different departments if the innovation can be confirmed. If the *freeway form* is not confirmed, the sales unit can decide to prepare the innovation again and to fill in a new *freeway form*. See attachment 1 for an example of a *freeway form*.

If the innovation is confirmed, the preparation process (the *act* stage in the figure) can begin. The *prepare* and *confirm* stages are for the department *Product sourcing milks* not so labor intensive to be included in the complexity model, so only the *act* stage is relevant for the model.

6.2 The act stage

After there is decided to introduce a new product or to change an existing product, there are a lot of preparation activities. They are made visible in the next model (figure 10). The different colors refer to the responsible departments: red to the factory, yellow to the central overhead and blue to the sales unit, orange (red + yellow) is a cooperation between factory and central overhead, green (yellow + blue) is a cooperation between central overhead and a sales unit.

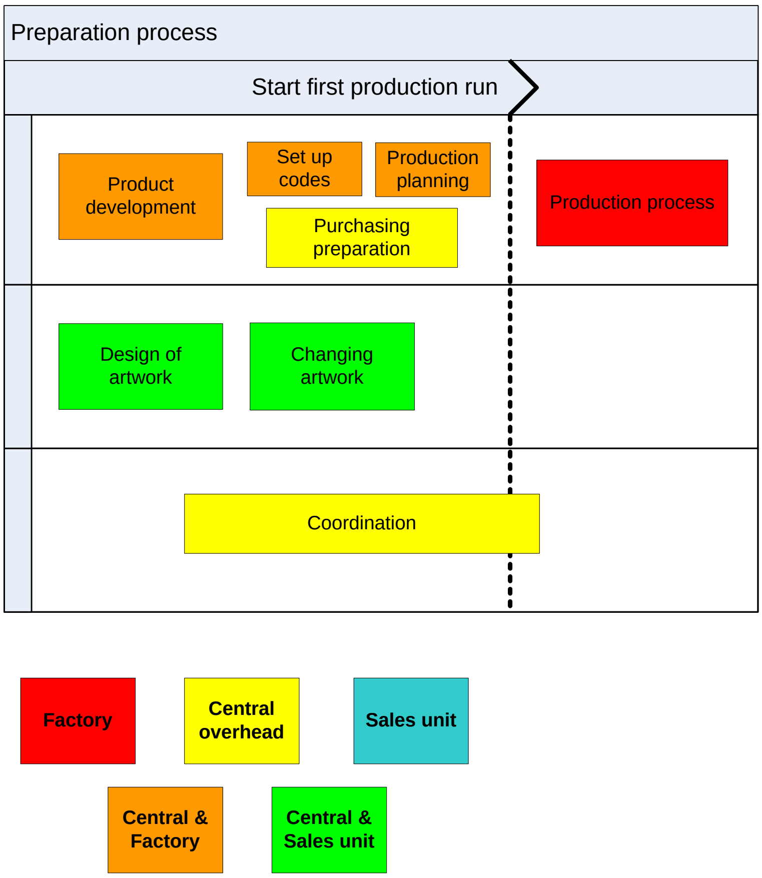

figure 10: The preparation process

The field in the middle, before the vertical line, shows the real preparation process. On the right side of this line the first production run is pointed out. This is the actual production process which will be described in the next chapter. Only the extra activities needed for first production runs are taken into account for the complexity calculation of the preparation process. The activities and costs that are equal for each production run are taken into account in the calculation of the additional complexity in the production process.

Table 2 gives an overview of the necessary preparation steps (as in figure 10) for each category of innovation (as described in chapter 5). A “x” means that (part of) this step is always necessary, a “p” means that (part of) this step could be necessary.

	Categories of innovation				
Preparation steps	Artwork	Ex.product new mark.	Weight	Packaging	Recipe
Product development					x
Set up codes	x	x	x	x	x
Production planning	p	x	x	x	x
Purchasing preparation					p
Design of artwork	p	p	p	p	p
Changing artwork	x	x	x	x	x
Coordination	x	x	x	x	x

table 2: Preparation steps per innovation category

In the next paragraphs all the steps in the preparation process are described. There is also indicated whether a certain preparation step is necessary for an innovation category.

The right side of the model in figure 8, the production process, will be described in the next chapter.

6.3 Product development

If an innovation comes from the category *new recipe*, there is work for the product development department, before the new product will be taken in production. The kind of work depends on the kind of recipe change. If a new recipe contains a new ingredient, the effect of this ingredient on other ingredients and production facilities has to be tested.

The product development department has some test facilities, but test productions have to be scheduled within the normal production schedule, so will affect the normal operations. The department is financed on project basis. Also the technology department in the factory has control on the test production.

The preparation step *product development* is only relevant for new recipes, so not for the other four categories of innovation.

6.4 Set up codes

A SKU (stock keeping unit) is a specific product at a particular geographic location (Reid & Sanders, 2002: 361). Each combination of recipe, packaging, artwork, production location and sales unit causes an additional SKU. Because each of the categories of possible innovations (see chapter 5) means at least a change of the artwork, each innovation makes a new SKU.

Set up codes refers to setting up various codes in all the different company systems, like forecast, production planning, production, warehousing, finance, reporting and quality. This is necessary for each new SKU, so the preparation step *set up codes* is relevant for each innovation category. If an innovation is a total new product, all information has to be filled in. If it is a replacement of an existing product, the information in the systems can be copied and possible changed. There are as well central as local systems at the production location. The most important system is MRDR. Most of the other information systems are linked to this.

The factory sets up all information of a new product in the factory systems and in the system MRDR. Through MRDR the information can be found by other company systems as the advanced planning system, the billing tool and the data warehouse.

At the production location (Cuijk), the following relevant systems exist:

- BAAN (enterprise resource planning system)
- Nutristar, for the production of eazypack products
- Excel, for the production of can products
- Manguistics (advanced planning system)
- Quality system
- Finance system, cost prices

6.5 Production planning

For each new SKU (so each innovation) *production planning* is a necessary step except when a new SKU exactly replaces an existing SKU. Exactly replacing means that there is another SKU (with same characteristics) that will be delisted and that there is no period where old and new product are produced and/or stored together. Exactly replacing is only possible for innovations of the categories *change in artwork*, *change of weight in existing packaging type* and *change in packaging type* (see paragraphs 5.1, 5.3 and 5.4).

For the first production run there have to be made a launch plan. This launch plan consists of all the appointments about the launching of the new product. For example, when the first products have to be ready to ship to the stores, whether it has to be in the stores at the same time as some other new products and whether all retailers do have to get the new product at the same time or one after another. There can be a soft launch (product B should be ready after product A) or a hard launch plan (product A should be in stores at a certain date). After that the first production run and possible test production should be scheduled in the production plan.

6.6 Purchasing preparation

If a recipe needs a new ingredient, a supplier for this ingredient have to be found. This could be an existing supplier or a total new supplier. For new ingredients trials are always necessary. A new supplier gets a quality audit in order to decide whether to buy from this supplier. The necessary tasks depend on the needed raw material and the postulated requirements. They could exist of:

- Call of sample products
- Analyzing of samples
- Asking for supplementing information of supplier
- Make first draft specification
- Evaluate results sample analyzing
- Defeat results and specification with product development
- Defeat sample results and specification with supplier
- Make second specification
- Sample production
- Depending on feedback supplier make new specification
- Confirm specification by quality analysis
- Complete specification en send it to supplier for signing

The purchasing department is responsible for the contact with the supplier. Most of the tests are performed by the product development department and fall in the preparation step *product development* (see paragraph 6.3).

6.7 Design of artwork

Designing a packaging label is necessary if a product is totally new. This can be a very time-consuming process. This process is outsourced to the design bureau DSN. Different departments (like the sales unit and marketing) in the organization have to react to and discuss about the new design. When the design is made, also the preparation step of *changing artwork* is necessary.

The preparation step *design of artwork* is possible in each category of innovation, but also each category is possible without a new design.

6.8 Changing artwork

For each innovation, some information on the packaging label has to be changed. Mostly not the whole design is changed (see 6.7), but only some text on the label within the current design. Consequently for each category of innovation, the preparation step *changing artwork* is necessary. This could be for changing the language (existing product in new market) or the bar code.

If weight (see paragraph 5.2) or recipe (see paragraph 5.4) changes, this has also to be changed on the packaging label. This is because the producer is obligated to give a list of ingredients and the net amount on the packaging (Boekema et al., 1995: 323).

The preparation step *changing artwork* consists of three sub-steps. First the artwork has to be adjusted (changing the list of ingredients, the weight or a product claim) by DSN. Next the made artwork have to be separated in files for each color. This is called *prepress*. At third in the tooling process the real printing is prepared. This is like fitting the artwork in print plates (called *stepping*) and making these plates.

For can printing, there are two options. Mostly empty cans are used with a label that will be placed on the can during the packaging process. But there are also preprinted cans. The disadvantage of the latter is that it takes a lot of storage space because each can can only be used for one specific product.

Both the can and eazypack printing make use of offset print technology: the print plates are used only once. This means that the preparation costs are lower, but the setup cost for each printing batch is higher.

The information for artwork changes are delivered by the sales units. The central marketing department coordinates the changes themselves.

6.9 Coordination

The preparation process is both coordinated by the sales unit that has submitted the *freeway form* and by the innovations managers. Coordination means triggering and monitoring the preparation activities. This is necessary for each innovation.

6.10 Summary and conclusion

In this chapter the preparation process is described. This consists (depending on the category of innovation) of the following steps:

- Product development (only for recipe changes)
- Set up codes (for all innovations)
- Production planning (for nearly all innovations)
- Purchasing preparation (only for new ingredients)
- Design of artwork (only for totally new designs)
- Changing artwork (for all innovations)
- Coordination (for all innovations)

Each of these steps means that the complexity will increase with more innovations. In chapter 8 for each of these steps will be described what the costs of this complexity added are.

7 The production process

In this chapter the production process of Danone powder baby milks is described. The answer is given on the third research question (*In which steps can the production process of Danone baby milks be divided?*) with the following sub-questions:

a. *What are the (possible) (production/logistic) steps a product will take?*

b. *What kind of overhead is necessary to let the product take these steps?*

According to the value chain model of Porter as described in chapter 4, the value chain of Danone baby milks which is relevant for this research, consist of three primary activities: *inbound logistics*, *production* and *outbound logistics*.

Because only the activities of the operations department are taken into account, the only relevant support activity is *procurement*. I have taken this together with *inbound logistics*. There are two other relevant support activities, *quality control* and *coordination*, which will be described in chapter 7.

In this research these activities together (*inbound logistics/procurement, production, outbound logistics, quality control* and *coordination*) are called "production process". In figure 11 the production process is structured in the same way as with the preparation process. The paragraphs of this chapter describe the different steps.

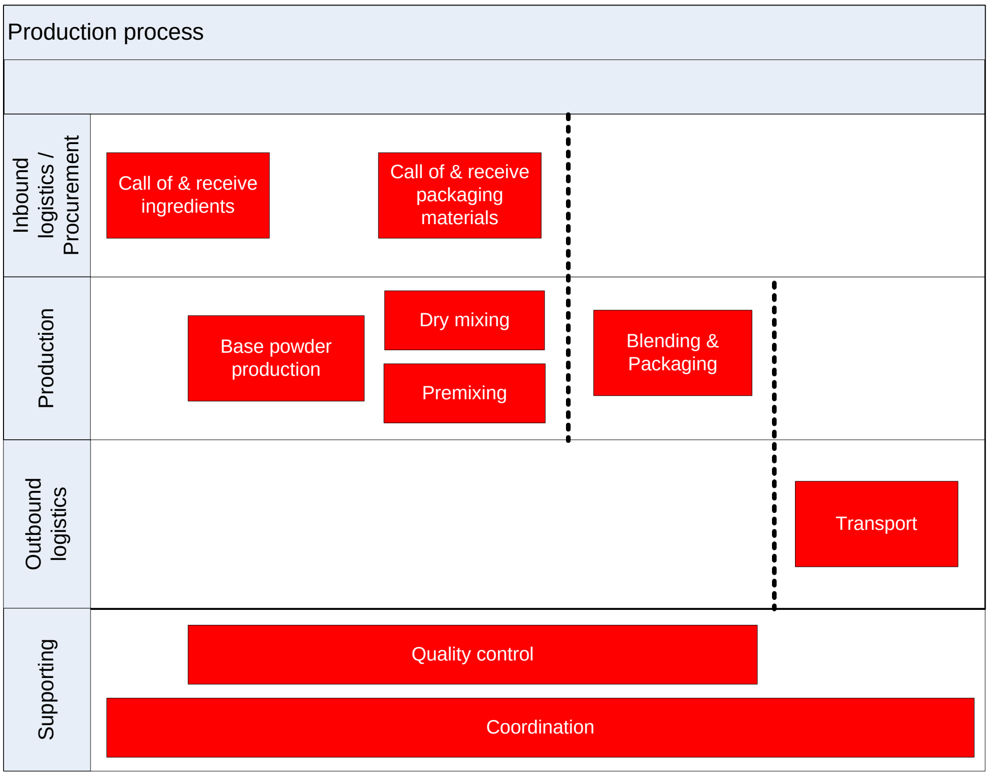

figure 11: The production process

Table 3 gives an overview of the production process steps (as in figure 11) where the complexity will increase for a certain category of innovation (as described in chapter 5). A “x” means that in this step the complexity will increase, a “p” means that the complexity could be increased.

Categories of innovation					
Production process steps	Artwork	Ex.product new mark.	Weight	Packaging	Recipe
Inbound logistics / Procurement	p	x	p	p	x
Production: Base powder prod.					p
Dry mixing					p
Premixing					p
Blending & packaging	p	x	x	x	x
Outbound logistics	p	x	p	p	X
Quality control	p	x	p	p	X
Coordination	x	x	x	x	X

table 3: Production process steps per innovation category

For each new SKU (so each innovation) that not exactly replaces an existing SKU there is an increase in complexity at *inbound logistics*, *packaging*, *outbound logistics* and *quality control*. Exactly replacing means that there is another SKU (with same characteristics) that will be delisted and that there is no period where old and new product are produced and/or stored together. So first the whole old inventory will be sold before new products are produced. Exactly replacing is only possible for innovations of the categories *change in artwork* (see paragraph 5.1), *change of weight in existing packaging type* (see paragraph 5.3) and *change in packaging type* (see paragraph 5.4).

7.1 Inbound logistics and procurement

The central procurement department (at Schiphol) determines suppliers (see also the *purchasing preparation* in paragraph 6.6) and makes framework contracts. Factories are responsible to call off the ingredients and packaging materials. The suppliers deliver products to the factories. In the factory there is a quality control on entrance. The products are stored till they are used in production.

7.2 Production

In this paragraph the production of Danone powder baby milks is described. This process consists of the production steps as in the second row of figure 11.

7.2.1 Factories

The base powders are made in Cuijk, Fulda, Krotoszyn, Macroom, Wexford and at some third parties. Each factory has its own specialization in specific base powders or volume of batches. All the premixes are made in Cuijk.

Packaging lines for the different packaging types (like cans, bags in boxes and eazypacks) are divided over the factories in Cuijk, Fulda, Oppole and Wexford. The factory in Cuijk has packaging lines for cans, eazypacks and big bags. Big bags are used for transport of semi-finished products to other factories.

7.2.2 Production process

In figure 12 the production in Cuijk is modeled. The production process in Cuijk is unique for Danone. In other factories dry mixing and premixing is not possible. For these factories, the factory Cuijk makes a premix or a master batch (containing dry mix ingredients and premix). The next sub-paragraphs of this paragraph describe the steps in figure 12.

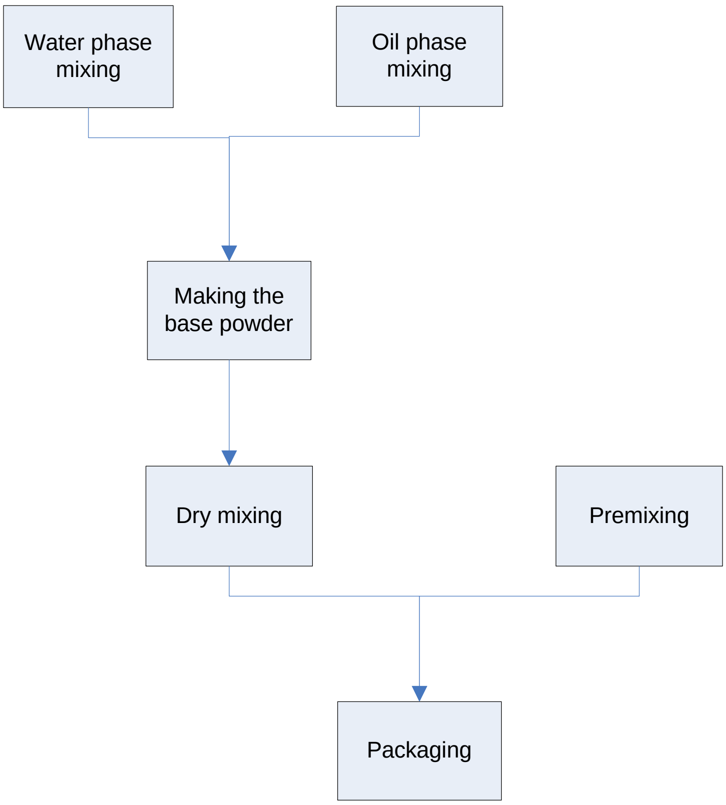

figure 12: The production of Danone powder baby milk products in factory Cuijk

7.2.3 Base powder production

The *base powder production* consists of *water phase mixing*, *oil phase mixing*, blending these two mixes and *spray drying*. The *water phase mixing* brings water, milk powder and possible other liquid ingredients together. This mixture is concentrated to the desired volume. In the *oil phase mixing* oil dissolvable products are mixed. These two processes take place at the same time. Finally the water phase and oil phase are mixed to an emulsion trough homogenization, condense pasteurization and a high pressure pomp. In the spray dry tower, this emulsion is made to a base powder.

7.2.4 Dry mixing

In the *dry mixing* phase, the base powder is (if necessary) mixed with other dry ingredients. Dry mixing is only possible in Cuijk.

7.2.5 Premixing

Premixing is mixing different dry ingredients (normally in small amounts) together. Only the factory in Cuijk can make premixes. Other factories use premixes made in Cuijk. These are normally called master batches and include as well the ingredients which are added in the *dry mixing* phase in Cuijk as premix ingredients.

7.2.6 Blending & Packaging

The base powder and a premix are blended and at the same time packed. In Cuijk only packaging in cans or eazypacks is possible. The individual packing units (like eazypacks or cans) are packed together in packs of normally six, twelve or 24 units. These are again packed on pallets.

7.2.7 Adding ingredients

There are four stages where ingredients can be added to the product:

- Water phase
- Oil phase
- Dry mixing
- Premix / master batch

Figure 13 is the same as figure 12, but here red arrows indicate the stages where ingredients can be added.

At which stage a specific ingredient will be added, is defined in the recipe. There are various reasons for determining at which stage an ingredient has to be added, like:

- Costs (adding later on in the process is cheaper, sharing same base powders) or ingredients differ depending on the stage to mix (vitamin in oil can be cheaper than dry vitamin for example)
- Product technical (for example ingredients that are oil based, heat (in)stability of certain ingredients)
- Quantity (in dry mixing it is more difficult to ensure the right small quantity)

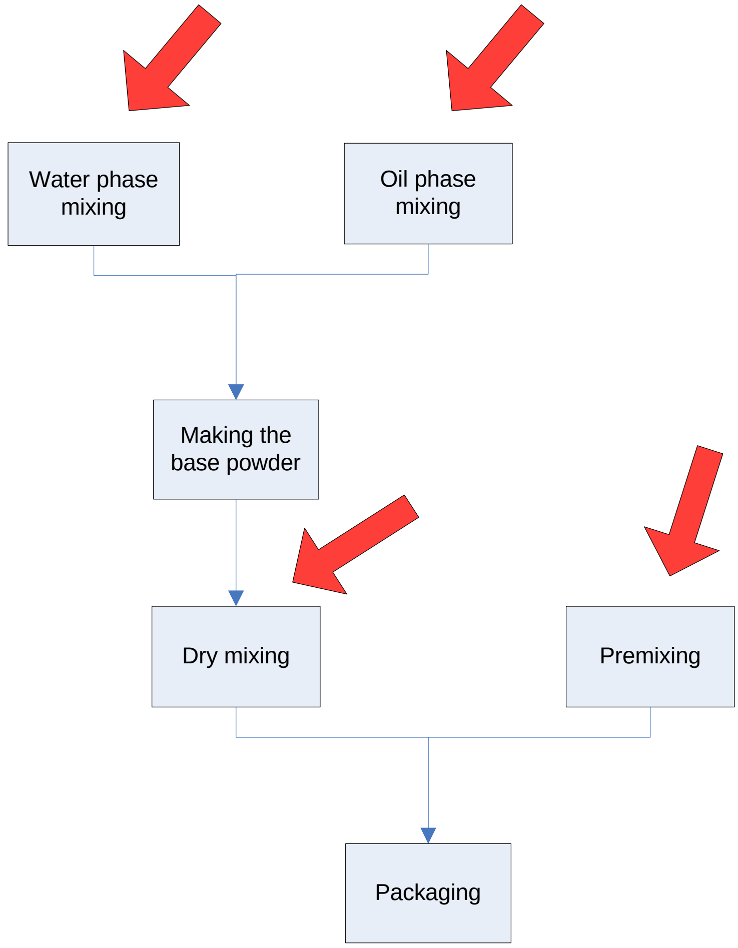

figure 13: The production of Danone powder baby milk products in factory Cuijk with arrows indicating in which stages ingredients can be added

7.2.8 Setup / Cleaning

Between the production of different products and in different steps of the production process, cleaning and other setup activities are needed. The amount of these activities depends on for example the products before and after setup and the length of the production run. By effective planning it is possible to shorten the total setup times.

Complexity (of setups) is in the number of products that can not contaminate with each other, not in the real number of different products. If all products are in the same contamination group, no setup is necessary. So the number of contamination groups determines the amount of complexity.

7.3 Outbound logistics

The activities of *outbound logistics* depend on the wishes of the customers or sales units. The tariffs for transport are calculated yearly and are inherited in the cost prices. If there is not enough storage space available in the factory, the products are stored in other warehouses.

7.4 Supporting activities

In this paragraph the two supporting activities (*quality control* and *coordination*) are described.

7.4.1 Quality control

Food safety and quality is a very important issue in baby food production. Through the entire production process eighty till hundred different analyses will be made, depending on the product. These analyses are divided over the several steps, like *making the base powder*, *premixing* and *blending & packaging*. Analyses are made on microbiological, chemical and physic sensory ground (smell, taste, size of parts).

In a quality information system, all the quality controls are monitored. When there is agreed about a certain base powder after production, there are fewer testes required later on in the production process.

When a new (or changed) product will be produced, the first three batches are subject to a total analysis.

7.4.2 Coordination

The production process is coordinated and planned by different departments. The most involved departments in Cuijk are Technology and Production for the production and Supply Chain for the transport and storage. Quality has its own department.

7.5 Summary & conclusion

In this chapter all the steps in the production process of Danone powder baby milks are described. This results in the following steps:

- Inbound logistics/Procurement: Call of and receive materials
- Production:
    - Base powder production
    - Dry mixing
    - Premixing
    - Blending & packaging
- Outbound logistics: Transport
- Supporting activities:
    - Quality control (trough whole production process)
    - Coordination

In chapter 9 for each of these steps will be described what the additional complexity for an innovation is and will be calculated what the costs of this complexity increasing are.

8 Complexity in the preparation process

In chapter 6 we saw that the preparation process is divided in seven steps (*product development, set up codes, production planning, purchasing preparation, design of artwork, changing artwork* and *coordination*). Figure 14 displays this model again.

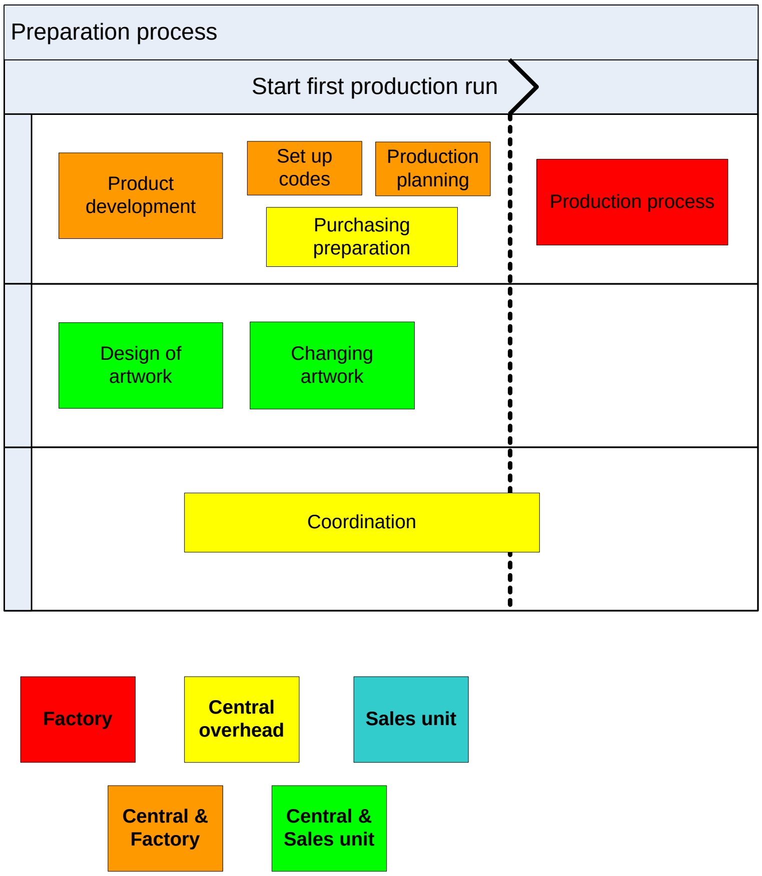

figure 14: The preparation process

This chapter describes for each preparation step which additional complexity each step (possibly) will have and what the costs are for this complexity added. This answers the questions:

> *What are the costs of the additional complexity on this step of the preparation process, depending on the kind of innovation?*
>
> a. *Which activities are required on this step?*
>
> b. *How much time is spent on these activities?*
>
> c. *What costs are related to these activities?*

The answer on sub-question 5a is already given in chapter 6 where was outlined how the preparation steps look like and which activities are required per preparation step.

In the first paragraph of this chapter we see the explanation on the calculation of the complexity. The following paragraph describes per preparation step the assumptions that are made to express all activities in time and/or costs. These costs are summarized in the complexity model, which will be described in chapter 10. For each of the five examples of innovations described in chapter 5, I have calculated the costs of the additional complexity on preparation. These costs are given in paragraph 8.3. Finally in paragraph 8.4 I give some conclusions of the complexity added and costs I have found in the preparation process.

8.1 Calculation

The additional complexity on each preparation step is expressed in costs. Each cost exists of two elements: the number of activities and the cost per activity. Mostly the number of activities is expressed in time units (minutes or fte). A full time employment (fte) is 52 weeks * 36 hours per week equals 1,872 hours. In that case, the cost per unit is the (average) personnel cost. This average personnel cost include salaries, social security contributions and post employment benefits.

Table 4 gives the used average personnel costs for the different departments.

	Per hour	Per fte	Source
Schiphol			
Cuijk			
Product development			

table 4: Average personnel cost

Some preparation steps also have other costs, like cost for materials or fees for activities outsourced to other companies.

A minimum, maximum and average cost is calculated for each activity. For some activities an estimation of the time or cost is used as average and the minimum and maximum cost are a certain deviation of this average cost. For other activities the minimum and maximum are an estimation of the bandwidth, wherein the time or cost for this activity should fall. Consequently the average cost is the calculated average of minimum and maximum.

All costs in the preparation process are onetime costs, expressed in Euros.

8.2 Assumptions

In this paragraph per preparation step the assumptions and substantiation are described that are made to express all activities in each step in time and/or costs. These assumptions are used to fill the complexity model with data. This model will be described in chapter 10.

8.2.1 Product development

For each change in recipe, there is work for the product development department. For a new recipe (in each level) this is about X hour. For a new raw material this could be a lot more work because several aspects have to be tested like the effects of the raw material on the machines and on other ingredients. At the preparation step *product development* a new ingredient could take up to X hour.

Next to salary cost each test-production have some costs for production and ingredients. If a test production is successful, the produced goods can be used and so the cost could possibly be absorbed. For the cost model however I have added this cost.

A test production is necessary for a new base powder. For a new final recipe this is only necessary when the recipe change is significant or if the market desires a test production, for example for test panels or for registration of the product. This counts for circa seventy percent of the new recipes. I have added this cost in the model for each new final recipe.

Next to the department *product development*, also the technology department in the factory spends time on testing new recipes. This could take from X hour to X hour for a new base powder and from X hour to X hour for a new dry mix, premix or final recipe.

8.2.2 Set up codes

Different departments have to set up codes in different systems. In the factory there are checklists for the technology and supply chain departments. These are given in attachment 2. The users of these checklists and other employees who have to set up codes estimated the required time per checklist.

8.2.3 Production planning

The preparation step *production planning* is done at central and factory level. Centrally this takes approximately X per innovation. Estimation for the time spent on production planning in the factory is X.

8.2.4 Purchasing preparation

The *purchasing preparation* for a new ingredient can be very time consuming. The amount of time depends for the greater part on the specifications of the new ingredient. An indication for this time is X from begin to end with an effective time consuming of X for the purchasing department.

8.2.5 Design of artwork

Making a new design is a very time consuming activity. It can take years till the desired design is made which fits the requirements of the sales unit and the marketing department and that is considered good enough for the market. Because it is very difficult to give an indication of this cost, the model indicates only that the cost of a new design could be very high.

8.2.6 Changing artwork

For the steps in *changing artwork* (including *prepress* and *tooling*) are standard fees from purchasing to DSN, the design bureau. These fees include some possibilities for corrections. Extra work is calculated on X per hour. On an average each artwork and prepress needs X hour extra. So these costs are more or less exactly calculated. Next to this one person spends averagely X on each change in artwork on central level.

8.2.7 Coordination

The preparation process is both coordinated by the sales unit that has submitted the *freeway form* and by the innovation managers. Considering the *coordination* only the innovation managers are relevant, because only the costs on central level and factory are taken into account in this research. There are X innovation managers. In the period January till September 2008 X changes in products took place. Extrapolated over 2008 this is X. These are as well innovations as centrally driven changes. A rough estimation of the coordination cost is X fte / X products = X hour per innovation.

8.2.8 Production process

As mentioned in chapter 6, the model for the preparation process takes into account the costs during production which only occur in the first production run(s). The only cost of this kind that I have found is for quality controls. Each new product gets a total quality control on the first three production runs. This takes the average of X percent more testes. This cost is called *quality* in the model.

8.3 Examples

Chapter 5 described five categories of innovations. For each category is given an example. The Egypt example is the most expensive one. In table 5 we see for each of these six examples the average preparation costs as percentage of the Egypt example. Although some examples involve more products, for each example only the costs for one product are taken into account in order to improve comparability.

Category of innovation	Example	Preparation costs
Change in artwork	Hungary: brand harmonization	0.7 %
Introduction of existing product in new market	Greece: introduction of products for vomiting babies	1.0 %
Change of weight in existing packaging type	Italy: weight increasing due to density change	1.0 %
Change in packaging type	Change from can to eazypack	1.1 %

New recipe	Turkey: other combination of base powder and premix	10.9 %
New recipe	Egypt: products with soy oil instead of rape seed oil	100 %

table 5: Preparation costs for the examples per innovation category

8.4 Analyzing of the results

From the results of the complexity research for the preparation process the following conclusions can been drawn:

- There is no substantial difference in the preparation costs between cans and eazypack. The only differences are in the cost of changing the artwork. The difference is at maximum X percent of the artwork cost. For an innovation with only a change in artwork this difference is at maximum X percent of the total preparation costs. For each other (more extensive) innovation, this percentage is even smaller.
- The preparation costs of a new dry mix, new premix and new final recipe are more or less the same (maximum difference of X percent). The preparation costs of a new base powder differs maximum X percent of this.
- The preparation costs for all innovation categories except the category *new recipe* are more or less the same. Compared to new recipes, these innovations have no much preparation costs.
- For an innovation with a new recipe the most costs are made on preparation step *product development* (from X to X percent of total preparation costs).
- The preparation costs made at other central departments or at the factory could be low compared to the product development department. The most extensive innovation (new artwork, other packaging type and all possible recipe changes) has on average X percent of the preparation costs at the factory and X percent at central level, where the costs at product development are X percent of the preparation costs.

8.5 Summary & conclusion

In this chapter was described how the costs of the additional complexity in the preparation process are calculated. The assumptions made for this calculation are described. All the preparation costs will be summarized in the complexity model, which will be outlined in chapter 10. Depending on some characteristics of the innovation, the onetime costs for preparation of the innovation are given in a cost report together with the costs of additional complexity in the production process (as will be calculated in chapter 9). This model can be used as decision tool for the confirmation of a *freeway form*. In the last paragraph I have given some general conclusions on the found complexity added and costs.

9 Complexity in the production process

After the calculation of the costs of the complexity of the preparation process (the onetime costs) in chapter 8, this chapter is about the additional complexity in the production process (continuing costs).

In chapter 7 the production process of Danone powder baby milks is divided in the following steps:

- Inbound logistics/Procurement: Call of and receive materials
- Production:
    - Base powder production
    - Dry mixing
    - Premixing
    - Blending & packaging
- Outbound logistics: Transport
- Supporting activities:
    - Quality control (trough whole production process)
    - Coordination

In this chapter the additional complexity for the production process is described. I give for each step answer on the following questions:

> *What are the costs of the additional complexity of an innovation on this step of the production process depending on the kind of innovation?*
>
> a. *What extra setups are required?*
>
> b. *What cost these extra setups?*
>
> c. *Which other costs are incurred?*

The structure of this chapter follows first the different steps of the production process as stated above. All information will be combined in a complexity model in the next chapter. The estimation of the costs used in this model are described in this chapter. After this description some conclusions are given on the complexity in the production process.

9.1 Inbound logistics

The cost of transport of raw materials is inherited in the cost of a raw material, so not in the scope of the research. The only cost that is not in the purchasing prices, is the cost for quality control on entrance, namely X fte per year for circa X different ingredients at this moment. So an approximation of this cost can be given by (X * X) / X = X euro per year for a new ingredient. For an innovation that uses only existing ingredients, there is no increasing in quality control on entrance.

9.2 Production

For all the production steps I have used my self-constructed cost dividing tool (described in chapter 4) for calculating the setup cost per hour. The financial data is diverted from the budget of 2008. In this budget all factory costs are allocated to the different production departments. I have deleted from this allocation the cost of quality, which I have allocated at another way.

As actual data I have used production data of the period 1 January till 31 July 2008.

The kind of cleanings (and so cleaning times) between two production batches depends on a lot of aspects. For each department, the products are divided over contamination groups. Products in the same group have many common characteristics. Between each of two contamination groups a specific cleaning is necessary.

9.2.1 Base powder production

The setup in the production step *base powder production* is a little different from the other departments. Next to the specific cleanings between different products, after maximum X hours of production, the tower has to be cleaned anyway. This standard cleaning takes X hour. So each cycle of X hours contains at least X hour of cleaning. This cleaning time has nothing to do with complexity but with the normal production routine. Even if there is only one product, this cost will occur, so this cost is allocated to the production instead of the setup.

At this moment the *base powder production* in Cuijk is at their maximum level for inbound production. Part of the production of base powders is outsourced to third parties. So each extra SKU or base powder that creates more production or more setup, will lead to extra outsourced production. Because of this reason also an opportunity cost is taken into account for the base powder production. This means that each hour of setup have a cost consisting of the setup cost per hour plus the cost of buying an hour volume at a third party minus the production cost per hour. The tool takes the opportunity cost only in account if the purchasing cost of a base powder at a third party is higher than the cost of production. If the production cost is higher, it could be more profitable to outsource the production.

These two aspects means that the cost dividing tool for the *base powder production* slightly differs from the cost diving tool for the other production steps. Attachment 4 gives an overview of this specific cost dividing tool.

9.2.2 Results setup cost

In table 6 we see the results of the cost dividing. The setup cost per year is divided over the number of batches, the number of products and the number of contamination groups. The most expensive setup occurs at the *base powder production*. Because of the confidentiality of the data, for each production step is given the percentage of the setup cost compared to the setup cost of the *base powder production*.

	Setup cost per batch	Setup cost per product	Setup cost per contamination group
Base powder production			
Dry mixing			
Premixing			
Blending and packaging cans			
Blending and packaging eazypack			

table 6: Setup cost

As mentioned in chapter 7 cleaning and other setup activities are needed between production of different products and in different parts of the production process. The amount of these activities depends on for example the products before and after setup and the length of the production run. So no setup is exactly the same. This implies that it is not straight forward which setup cost is related to which product. The values in table 6 give an indication of the setup cost.

For a new recipe in an existing contamination group, the setup cost per batch multiplied by the amount of batches per year gives an estimator of the yearly setup cost. The setup cost per product gives an other estimation. With these two values minimum and maximum setup costs are calculated to be used in the complexity model.

If a new recipe (in a certain stage like base powder, premix etc.) is in such a way different from existing recipes, so that it needs a new contamination group, the setup cost per contamination group gives an estimation of the yearly setup cost.

9.3 Outbound logistics

The activities of *outbound logistics* depend on the wishes of the customers or sales units. The tariffs for transport are calculated yearly and inherited in the cost prices. So for this research there is no extra complexity on *outbound logistics*.

9.4 Supporting activities

This paragraph describes the supporting activities, *quality control* and *coordination*.

9.4.1 Quality control

All quality tests are stored in the quality system. I have used this information together with financial information to determine the average cost of quality per batch. The quality cost depends on salary cost and cost for test materials, like chemicals. The cost for the products that are tested are not incorporated.

The quality tests per batch base powder are the most expensive. Because of the confidentiality of the data, for each production step table 7 gives the percentage of the quality cost per batch compared to the quality cost of a batch base powder.

	Quality cost per batch
Base powder production	
Dry mixing	
Premixing	
Blending & packaging	

table 7: Quality cost

As we saw in sub-paragraph 7.4.1, when there is agreed about a certain base powder after production, there are fewer testes required later on in the production process. This explains why the average quality cost per batch decreases with the progress of the production.

The average quality cost per batch times the number of batches per year gives an estimation of the yearly quality cost for an innovation.

9.4.2 Coordination

Next to the described extra complexity in production, also the overhead will become more complex with more products. This is very difficult to measure, so I give only an indication of the extra costs.

From interviews with various departments in the factory appeared that the technology department spends the most time on product changes (as well innovations as centrally driven changes). The technology department spends in 2008 approximately X on all changes during production. In Cuijk there were X changes in final products from January till September 2008. Extrapolated over 2008 this is X. There are final products that are not produced in Cuijk, but also products produced in Cuijk that are packet at other factories. This should balance each other. A very rough estimation of the extra costs for the technology department per changed final recipe is X / X = X euro per product. This is negligible compared to the setup cost. Because of this and because of the reliability of the coordination cost, I have decided to let this cost outside the complexity model.

9.5 Examples

In chapter 5 five categories of innovations were formed. For each category was given an example. In chapter 8 we saw that the Egypt example is the most expensive one in the preparation process. The same holds for the complexity in the production process. In table 8 we see for each of the six examples the average complexity costs in the production process as percentage of the Egypt example. Although some examples involve more products, for each example only the costs for one product are taken into account in order to improve comparability.

Category of innovation	Example	Complexity costs in the production process
Change in artwork	Hungary: brand harmonization	2.9 %
Introduction of existing product in new market	Greece: introduction of products for vomiting babies	2.9 %
Change of weight in existing packaging type	Italy: weight increasing due to density change	2.9 %
Change in packaging type	Change from can to eazypack	3.3 %
New recipe	Turkey: other combination of base powder and premix	2.9 %
New recipe	Egypt: products with soy oil instead of rape seed oil	100 %

table 8: Complexity costs in the production process for the examples per innovation category

In table 8 we see that four examples of innovations have the same complexity costs (2.9 percent of the Egypt example). This is because these innovations all have only costs for having a new final product.

9.6 Summary & conclusion

This chapter described which extra complexity occurs during production and what the costs of this additional complexity are. These costs will be summarized in a complexity model together with the complexity added on the preparation process in the next chapter. The most additional complexity (highest costs) is found in setups. Also in quality some extra complexity comes up. The complexity increasing in coordination at different departments is negligible compared to the other costs. If an innovation contains a new ingredient, there is a cost for the complexity added on receiving the materials.

10 The complexity model

In chapter 8 and 9 was calculated what the costs are of the additional complexity for an innovation on the preparation process and the production process. All these costs are summarized in the complexity model. This model can be used as decision tool (on innovations) for the department *Product sourcing milks.* This chapter described this model and gives answer on the seventh research question:

> *How should the model be implemented and used?*

The complexity model is an easy workable Excel model containing of five sheets. In the paragraphs of this chapter these sheets are outlined. In paragraph 10.6 I discuss the reliability of the data and the results. Finally, paragraph 10.7 gives some suggestions on the maintenance of the complexity model.

10.1 Characteristics

On the first sheet there is a form to fill in some characteristics of the innovation. Choices can be made by typing a one or zero. See figure 15.

Characteristics innovation

Innovation name	Example1		
New SKU	1	1	
Exact replacing		0	
New design		0	
Change in artwork	1	1	
New ingredient		0	
New base powder		0	
New base powder contamination group		0	
New dry mix	1	1	
New dry mix contamination group		0	
New premix		0	
New premix contamination group		0	
New final recipe		1	
New final recipe contamination group		0	
New final product		1	
Packaging type	1	Can	1 for can, 2 for eazypack
Expected number of batches per year	13		

figure 15: Screenshot of complexity model, sheet characteristics

The characteristics are:

- New SKU
- Exact replacing of an existing SKU
- New design
- Change in artwork
- New ingredient (give the number of new ingredients)
- New base powder
- New contamination group base powders
- New dry mix
- New contamination group dry mixes
- New premix
- New contamination group premixes
- New final recipe (is a new combination of a dry mix and a premix)
- New contamination group final recipes
- New final product (could be an existing recipe, but in a packaging with a new artwork)

The model fills in some boxes automatically, depending on other ones. For example a new design automatically implies a change in artwork and if there is a new premix, this means automatically a new final recipe.

Next there have to be chosen between the packaging types can (fill in a 1) and eazypack (fill in a 2). Finally the expected number of batches have to be given.

10.2 Cost report

The chosen characteristics result in a cost report with the onetime costs of the preparation of the innovation and the yearly costs in the production process. This cost report is on the second sheet of the Excel model. For each cost a minimum, average and maximum is given, as is described in chapter 8 and 9. The costs are given three times in three different divisions.

All given values in the pictures of the cost report in this paragraph are fictive due to the confidentiality of the data.

10.2.1 Cost report on characteristics of the innovation

In the first overview (see figure 16) the costs are divided over the characteristics of the innovation, as chosen at the first sheet.

Characteristics innovation	One time costs Min	Average	Max	Production process Yearly costs Min	Average	Max
New SKU	500	750	1.000	-	-	-
Exact replacing	-	-	-	-	-	-
New design	-	-	-	-	-	-
Change in artwork	700	1.000	1.300	-	-	-
New ingredient	-	-	-	-	-	-
New base powder	11.000	17.000	23.000	20.000	30.000	40.000
New base powder contamination group	-	-	-	-	-	-
New dry mix	13.000	16.500	20.000	5.000	6.000	7.000
New dry mix contamination group	-	-	-	-	-	-
New premix	-	-	-	-	-	-
New premix contamination group	-	-	-	-	-	-
New final recipe	14.000	17.000	20.000	-	-	-
New final recipe contamination group	-	-	-	-	-	-
New final product				2.000	3.000	4.000
Total	**39.200**	**52.250**	**65.300**	**27.000**	**39.000**	**51.000**

figure 16: Screenshot of complexity model, cost report divided on characteristics

10.2.2 Cost report on steps

The second part of the cost report exists of two parts. First it gives the same preparation costs as in the view before, divided over the steps in the preparation process, as defined in chapter 6. Second it gives again the costs of the production process divided over the different production steps as defined in chapter 7. See figure 17.

Steps in preparation process	Min	Average	Max
Product development	37.500	50.000	62.500
Set up codes	300	300	300
Production planning	250	500	750
Purchasing	-	-	-
Design of artwork	-	-	-
Changing artwork	700	1.000	1.300
Coordination	200	200	200
Quality	250	250	250
Total	**39.200**	**52.250**	**65.300**

Steps in production process	Min	Average	Max
Inbound logistics / Procurement	-	-	-
Base powder production	15.000	25.000	35.000
Dry mixing	4.000	5.500	7.000
Premixing	-	-	-
Blending and packaging	3.000	3.500	4.000
Outbound logistics	-	-	-
Quality	5.000	5.000	5.000
Coordination	-	-	-
Total	**27.000**	**39.000**	**51.000**

figure 17: Screenshot of complexity model, cost report divided on steps in preparation process

10.2.3 Cost report on sub-divisions

The last part of the cost report (as can be seen in figure 18) gives an overview of the costs divided over the relevant sub-divisions of Danone (factory, central overhead and product development).

Subdivisions of Danone	Min	Average	Max	Min	Average	Max
Factory	1.000	4.000	7.000	27.000	39.000	51.000
Central	1.200	1.750	2.300	-	-	-
Product development	37.000	46.500	56.000	-	-	-
Total	**39.200**	**52.250**	**65.300**	**27.000**	**39.000**	**51.000**

figure 18: Screenshot of complexity model, cost report divided on steps in preparation process

10.3 Substantiation of preparation costs

On the third sheet there is a substantiation of the preparation costs given. It shows all the costs including calculation and assumptions as outlined in paragraphs 8.1 and 8.2. These costs are used to generate the cost report as shown in sub-paragraph 10.2. In figure 19 is as example a part of this substantiation shown. These are the activities and costs for the preparation step *set up codes*.

Steps in preparation process	Place	Department/ person	Time (minutes)			Costs/ Unit	Costs (€)		
			Min	Average	Max		Min	Average	Max
Set up codes									
Company width systems	Central	Elvis Roach		60		0,89	53,42	53,42	53,42
BAAN (ERP)	Factory	Roland de Jong		10		0,58	5,83	5,83	5,83
MRDR	Factory	Roland de Jong		10		0,58	5,83	5,83	5,83
Nutristar (production easypack)	Factory	Roland de Jong		10		0,58	5,83	5,83	5,83
Excel (production cans)	Factory	Roland de Jong		10		0,58	5,83	5,83	5,83
Manguistics (APS)	Factory	Roland de Jong		10		0,58	5,83	5,83	5,83
Set up new base powder	Factory	Technology		240		0,58	140,00	140,00	140,00
Set up changed base powder	Factory	Technology		120		0,58	70,00	70,00	70,00
Set up packaging line	Factory	Technology		60		0,58	35,00	35,00	35,00
New packaging contamination group	Factory	Technology		90		0,58	52,50	52,50	52,50
Logistic systems	Factory	Technology		10		0,58	5,83	5,83	5,83
Codes "make known" in tools	Factory	Technology	15	23	30	0,58	8,75	13,13	17,50
Calculation of cost price and fill in BAAN	Factory	Ellen Cooijmans		10		0,58	5,83	5,83	5,83
CCP (cost price) data in MRDR	Factory	Ellen Cooijmans		1		0,58	0,58	0,58	0,58
Extern systeem vullen met gegevens	Factory	Ellen Cooijmans		1,5		0,58	0,88	0,88	0,88

figure 19: Screenshot of complexity model, part of sheet substantiation

10.4 Substantiation of production costs

The fourth sheets has the same structure as the third sheet and contains the substantiation of the complexity costs in the production process. It shows all the costs including calculation and assumptions as outlined in chapter 9. It contains among others summarized information of the cost dividing tool for each production step (*base powder production*, *dry mixing*, *premixing* and *blending & packaging*). This information is get from the filled in cost dividing tools which are stored in another Excel file. The information is used to generate the cost report as described in paragraph 10.2.

10.5 Some values

The last sheet shows some values that are necessary to calculate the preparation costs on the third sheet. These are values like the average personnel cost as described in paragraph 8.1.

10.6 Reliability of the data and results

The used (financial) data in the model is mostly based on estimations. This raises the question how reliable the results are. For this reason I have used minimum, maximum and average time estimations and costs. For the preparation process, see paragraph 8.1 and for the production process see paragraph 9.2.

The most activities in the preparation process are expressed in time, where the time corresponds to costs using the average personnel cost. This means that the correctness of this personnel cost is important. However, a deviation of five percent of the personnel cost results in a deviation from 1.3 till 4.2 percent of the total preparation costs, depending on the kind of innovation.

The used data in the cost dividing tools (budgeted costs and activity levels) are exact data if the production and setup times are registered correct. Small variances of the data have even smaller impacts. For example if the used personnel cost in the budget increases with five percent, the total yearly complexity costs in the production process for an innovation with a new dry mix and so a new final recipe increase maximum 1.4 percent. An increasing of five percent of the actual setup time leads for the same innovation to an increasing of maximum 2.9 percent of the yearly complexity costs in the production process.

10.7 Maintenance of the data

The complexity model is filled with (financial) data acquired in 2008. In the previous paragraph we saw that an increasing in costs or other data results in a smaller increasing in total complexity costs. However, in order to keep the model useable and reliable, this data should be adjusted regularly. The most difference will be in costs, not in time estimations.

I recommend to update the following (financial) data each year:

- The average personnel cost for the different sub-divisions (last sheet of the model). This is easy to update and has impact on lot of preparation costs and some of the costs in the production process.
- The budgeted costs for the production steps (*base powder production*, *dry mixing*, *premixing* and *blending & packaging*) in the cost dividing tools, got from the factory budget.
- The activity levels in the cost dividing tools for the production steps (*base powder production*, *dry mixing*, *premixing* and *blending and packaging*).

The last two require some time to acquire and adjust, but have impact because the setup cost is the most important complexity cost in the production process.

10.8 Summary & conclusion

This chapter outlined the complexity model as meant in the research objective. All costs which were described in chapters 8 and 9 are summarized in this model. Depending on some characteristics of an innovation a cost report for this innovation can be generated. This cost report gives the onetime costs for the preparation process and the yearly costs for the production process. The complexity costs are given three times in three different divisions. First on the chosen characteristics, second on the preparation or production steps and third on departments.

11 Conclusions & recommendations

The objective of this research was to develop a tool in order to support the department *Product sourcing milks* with decisions about submitted *freeway forms*. This tool had to give a better view on the costs of the additional complexity of an innovation. The objective was formulated as: *To visualize the costs of additional operational complexity for Danone of an innovation by making a model to determine these complexity costs.* In this chapter is described whether this objective is reached. This chapter gives the most important conclusions of the research. From these conclusions I have drawn recommendations for further research on the complexity subject.

11.1 Conclusions

The research was divided in two parts. The first part is the preparation process. This process contains all the activities that are needed before a new product can be produced: *product development* (only for recipe changes), *set up codes* (for all innovations), *production planning* (for nearly all innovations), *purchasing preparation* (only for new ingredients), *design of artwork* (only for totally new designs), *changing artwork* (for all innovations), *coordination* (for all innovations). The second part is the production process. We saw that the production process is divided in several steps using the value chain model of Michael Porter. These steps are *inbound logistics/procurement*, *production*, *outbound logistics*, *quality control* and *coordination*.

11.1.1 Preparation process

For each step in the preparation process is described what extra activities are needed for a innovation and is calculated what the costs are of these activities. Figuring out these activities and the costs, gives the conclusion that there is no substantial difference in the preparation costs between innovations in can or eazypack. The preparation costs of a new dry mix, new premix and new final recipe are more or less the same. The preparation costs of a new base powder differs maximum X percent of this. An innovation without recipe changes (so the examples of weight, artwork or packaging changes) have only some small preparation costs compared to innovations with new recipes. For an innovation with a new recipe the most costs are made on preparation step *product development*. For the division in departments (the third part of the complexity model) the costs of an innovation with a new recipe on the department *product development* vary from X to X percent of the total preparation costs.

11.1.2 Production process

Also for the production process is calculated what the costs are of the additional complexity for an innovation. From this calculation appeared that the most complexity (highest costs) is in setups. The average setup cost per batch, product and contamination group gives an indication of the suspected setup cost for an innovation. Also in quality is some extra complexity. The complexity increasing in coordination at different departments is negligible compared to the other costs.

11.1.3 Complexity model

The costs of the additional complexity in the preparation process and in the production process are joined to one complexity model. Depending on some characteristics of an innovation, which can be filled in, a cost report is generated. This cost report gives as well the onetime costs (for the preparation process) of an innovation as an indication of the costs per year in the production process. The costs are three times given in three divisions. First on the chosen characteristics, second on the preparation or production steps and third on departments.

In order to improve reliability, the model gives for each cost a minimum, maximum and average. Small variances of the data have only small impacts on the given complexity costs. Nevertheless, it is recommended to update the average personnel cost, the budgeted production costs and the activity levels regularly.

This model is the model meant in the objective of this research. It gives insight in the costs of additional operational complexity for an innovation.

11.2 Recommendations

Resulting from the conclusions as described in the previous paragraph, this paragraph gives some recommendations. I have split them in three parts. The first sub-paragraph contains some recommendations, which are easy to implement, in order to improve the complexity model. Next I give recommendations on further research. Finally there are some other recommendations.

11.2.1 Improve model

This sub-paragraph gives recommendations to improve the complexity model, which was described in chapter 10. These recommendations are relatively easy to implement.

As we saw in chapter 8, there is no substantial difference in the preparation costs between cans and eazypack. The only differences are in the cost of changing the artwork. The difference is at maximum nineteen percent of the artwork cost. For an innovation with only a change in artwork this difference is at maximum X percent of the total preparation costs. For each other (more extensive) innovation, this percentage is even smaller. In order to simplify the complexity model without removing correctness, the choice between can and eazypack could be removed, because of the small differences.

For my research I have focused only to the factory in Cuijk. Other factories have other working methods and for that reason other costs. The model can be extended by adding a choice for factory (for each production step) with specific costs for each factory. For the setup cost, the cost dividing tool can again be used. Only new data is needed.

11.2.2 Further research on complexity

In this sub-paragraph I give recommendations for further research on the complexity subject. It are comments which fall outside the scope of my research or which are not possible within the given time, but which could be interesting for Danone. It could be a starting point for a next graduating student.

An innovation can lead to cannibalization of existing products. Cannibalization is reduction of the sales volume of a certain product caused by the introduction of a new product (Boekema EA, 1993: 305). This effect is not inherited in the complexity model, because the revenues are on the sales unit side, which falls outside the scope of the research. However, cannibalization leads also to smaller batches and so to higher setup costs per product for the cannibalized product. Also on another way innovations have impact on other products. A move from recipe A to recipe B has impacts for all other sales units that use recipe A. I have not researched these effects on other products. I recommended to first spend attention on this aspect.

Paragraph 8.4 showed us that the preparation costs at the department *product development* for most innovations are high compared to the costs at the factory and at Schiphol. So I recommend not to spend time on the costs in other factories at the preparation process, because the preparation costs made at factory level are low. The preparation costs at the department *product development* and at central level are for all factories the same.

Danone is not the only company that deals with the complexity paradox, as described in the introduction of this report. However, searching for literature on this subject had no results. On advance it was the intention to execute a small benchmark study on another company in the food business. This should answer the question how other companies threat the complexity paradox. Benchmarking refers to a process whereby a company finds how others do something better then they and then try to imitate or improve on it (Daft, 2000: 58). Unfortunately this was not possible within the time available for this research. I recommend nevertheless to plan such a benchmark study. This should be a good project for a next student. The benchmark study should focus on the way other companies calculate the intern costs for a new product.

The most additional complexity (and so costs) I have found in the production process are on setups, and next on quality. On coordination/overhead I have only found small costs compared to the setups. Certainly there are more aspects in the production process that increase complexity. These can for example be at loading trucks with more different products or production planning. It is difficult to determine how the complexity on these activities increase with more products. In the Cuijk factory and at Schiphol lives the thought that the specialties make the commodities more expensive. If there were only commodities, the overhead should be much smaller. For example at the Macroom factory there is much less overhead. This leads to a possible way to calculate the costs for the complexity added on overhead. Two Danone factories can be compared on the overhead costs. The overhead costs for the Macroom factory give an indication for the overhead costs for commodities in Cuijk. Rest of the overhead costs in Cuijk are costs for specialties. For this comparison it is important that other factors are equal. For example Cuijk has lot of clients, because also other factories are client and Cuijk gives more service to his clients, which result in higher costs.

As we saw in paragraph 6.3, the product development department has some test facilities, but test productions have to be scheduled within the normal production schedule. Consequently these productions will affect the normal operations. I have not focused on this aspect, but this could be another increasing in the product development costs.

In paragraph 6.8 we saw that both the can and eazypack printing make use of offset print technology. This means that the print plates are used only once which result in lower preparation costs but an higher setup cost per batch. These setup cost could have an impact on the complexity costs if the packaging is ordered several times per year. Although we saw before that the difference in preparation costs between can and eazypack is small, this could also result in bigger differences with other packaging formats.

The complexity model I constructed, focus on the complexity of an innovation which is totally produced in the Cuijk factory. In reality a lot of products are produced in more factories. For example the base powder is produced at factory A and the product is packed at factory B. These links make the total process more complex. I have not spend attention to this fact, but it could be very interesting. In the previous paragraph I have recommended to add the costs in other factories to the complexity model. To take into account the links between factories, also information about internal transport is necessary. At this moment factories use different internal costs, which can result in the fact that the same base powder could be cheaper to buy from factory A than from factory B. At the moment a global project is undertaken on these internal costs. I recommend to wait for the results of this project and extend the complexity model with the new determined costs.

A logical question arising from this research is if a delisting of a product generates the same revenues as the costs for adding a product described in this research. For the preparation process this is not the case, because these are preparation costs. A delisting has also some costs. These will be more or less the same as the cost for the preparation steps *set up codes* and *coordination*. For the production process there could be a cost saving for a delisting. A new research could focus on these cost savings.

11.2.3 Other recommendations

From the examples at the end of chapter 8 and 9 we saw that high complexity costs only occur when there are recipe changes. This is both at the preparation process and the production process. In the preparation process this is mainly the consequence of high costs at product development. In the production process the setup costs are the cause. Comparing the setup costs at different production levels, gives that the setup cost for the *base powder production* is by far the highest one. An important conclusion from this is that it is worthwhile for an innovation to prevent forming a new base powder. This means also that there could be saved costs by decreasing the number of base powders.

As described in chapter 5, I have looked to several different *freeway forms*. From this search appeared that some innovations are the cause of an global project. This holds among others for the example of change of weight in an existing packaging type in paragraph 5.3. These innovations can be prevented if there are more possibilities for sales units to anticipate on changes in global update programs.

Several people I have spoken in Cuijk told me that just the different products lead not to unbridgeable complexity. The most complexity is in products that cannot contaminate with each other. There are also other things that makes the (production) process more complex. For example the central change programs and the fact that old and new (updated) products have to be produced next to each other, which increase the number of different products and so costs. This means the complexity can be decreased by preventing most as possible producing of old and new products at the same time.

Glossary

The most common used terms in the report, are explained in this section.

Artwork:	The layout of a packaging.
Complexity:	Combination between the number of activities (for example numbers of recipes, suppliers or setups) and their mutual dependency. In this research the costs of the additional complexity of an innovation are measured as the costs of the extra activities that are needed for this innovation (see also paragraph 3.2).
Contamination group	Group with products which have common characteristics. Between each of two contamination groups a specific cleaning is necessary. Between products in the same contamination group no cleaning or only a small cleaning is necessary.
Eazypack:	Packaging format for powder baby milks. The eazypack is easy to open for a parent even when having a baby in her/his arm.
FC:	Fixed costs (see paragraph 4.3.4).
Freeway form:	Form filled in by a sales unit with information about the new product, marketing, operations and finance used in the *freeway process*.
Freeway process:	By Danone developed decision tool on choosing for a possible new product, divided in three stages: prepare, confirm and act, see paragraph 6.1.
Innovation:	A new or improved product for which a sales unit is started the *freeway process*. Innovation is a typical Danone term. The most easy improvements (for example changing a telephone number on the packaging) do not need permission from the headquarters, so do not need a *freeway process* and are not taken into account in this research.
Innovation manager:	Role within the department *Product sourcing milks* with responsibility to confirm and coordinate innovations.
OC:	Overhead costs = indirect costs (see paragraph 4.3.5).
Operations:	All the activities managed by the baby food operations department. In particular the production process and the preparation process.
Preparation process:	All the steps that are needed before a (new) product can be produced. This include the product development, purchasing, planning etc., but not the research of possible new products. This are all the steps that can be assigned to one specific new product and that are made after the *freeway process* is started.

Production process: All the steps that are taken within Danone when a (new) product is actually produced, from entrance of the raw materials to the factory, to and including departure of the products for shipment to the distribution centers in the countries. By Danone mostly called "supply chain". This include the activities *inbound logistics/procurement, production, outbound logistics, quality control* and *coordination*.

Research & development: Creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications (OECD, 2008: 1).

Sales unit: Sub-division of Danone responsible for marketing and sales on a particular market, mostly a country.

Supply point: A factory (sub-division of Danone) where products are produced and/or packed.

VC: Variable costs (see paragraph 4.3.4).

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