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Implementation of Activity Based Costing

– a case study at a make-to-order company

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Abstract

Title Implementation of Activity Based Costing – a case study at a make-to-order company.

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Problematization Four problem areas with FrontPac's previous cost estimation system were identified. First, only a few properly skilled employees are actually able to perform cost estimations due to the system's user requirements. Second, salespersons cannot estimate the cost for orders by themselves which significantly increases the time to approximate price in the sales process. Third, neither can they perform sensitivity analyzes on the cost estimations. Final, the system relies on old and static machine costs that cannot be easily updated as the organization changes.

Purpose The purpose of this master thesis is twofold. The first purpose is to develop a cost estimation system that enables the salespersons to estimate the cost for FrontPac's packaging products, in order to improve the four problem areas stated in the problematization. The second purpose is to develop a suggested procedure for implementation of ABC in make-to-order companies.

Method The thesis is conducted as a single case study at the packaging manufacturer FrontPac. In the thesis multiple research methods have been used in order to collect and process necessary data. Due to the lack of quantitative data, research methods such as interviews and observations have been the predominant choice for collecting data. Internal and external documents have also been utilized in order to collect cost data and to build the theoretical foundation. The largest threat to the validity of the suggested implementation procedure is the generalizability, since it is merely based on a single case study.

Conclusions The developed cost estimation system, which has a higher degree of standardization than the previous system, has led to improvements for FrontPac in four main areas; number of users, time to approximate price, sensitivity analysis and dynamic aspects. This was achieved at the expense of a slight loss in accuracy in the cost figures for approximate cost estimations. The master thesis also resulted in a suggested procedure for ABC implementation, which consequently is customized for make-to-order companies. Its main advantages are that it provides a step-by-step approach with practical guidelines and has a clear project focus.

Key words Activity Based Costing, Implementation, Make-to-order, Cost Estimation System, Packaging Manufacturer, FrontPac.

Preface

This report constitutes the compulsory master thesis carried out for the Master of Science degree in Industrial Management and Engineering. It has been conducted at the Division of Packaging Logistics at the Department of Design Sciences, Faculty of Engineering (LTH), Lund University. Ola Johansson (PhD, Packaging Logistics) has supervised the thesis and we would like to thank him for his help and support during this time. We would also like to thank all the interested and helpful colleagues at the division.

The thesis was initiated by FrontPac AB and large parts of it have been performed at their office and in close collaboration with them. It has truly been an instructive and pleasant time for us. We would especially like to thank our assistant supervisor Martin Enocson (CEO, FrontPac), for providing us with the opportunity to conduct this thesis, but also for his helpful assistance and guidance. We would also like to thank Jörgen Jystrand (Quality Manager, FrontPac) for his kindness and patience in answering all our questions. There are many other employees at FrontPac that also have contributed to this thesis, whose support we indeed are very grateful for as well.

At last we would also like to thank Skånes Livsmedelsakademi for the scholarship we received earlier this fall. It has benefited us in this thesis, but certainly also in a long-term perspective.

December 10th 2010, Lund, Sweden.

Karl-Emil Levin　　Sebastian Sallbring

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Terminology

Activity	Aggregation of company’s actions, performed to generate output.
Activity Based Costing	Complete cost estimation method, focus on activities and drivers.
Carton liner	Paper sheet for package, can modify external appearance aspects.
CE model	Cost estimation system, merely with cost object components input.
CE table	Cost estimation system with user defined cost object consumption.
Corrugated cardboard	Two or more layers of paper, with at least one corrugated layer.
Cost accounting	Includes all cost related activities performed within a company.
Cost estimation	Approach for estimating costs of objects within a company.
Cost estimation system	A somewhat standardized system for performing cost estimations.
Cost object	A work unit for which a separate cost measurement is desired.
Cost system	System that includes all cost accounting information.
Critical Success Factor	A factor that is particularly critical for the success of a certain task.
Deliverable	Something that should be accomplished before a task is complete.
Display	A product, e.g. in paper, used for display purposes in stores, etc.
Resource/cost driver	Factor that causes a change in resource/activity consumption.
Driver volume	The volume basis for allocating resources and activities.
Flowchart	Chart with standardized symbols that clarifies a certain flow.
Flute configuration	Expression for flute height and frequency of flutes in cardboard.
Grammage	Term that specifies weight of a sheet with one square meter area.
Human capital	Company’s intangible resources in employees’ competencies.
Lamination	Machine operation that merges carton and corrugated cardboard.
Litho laminated	Offset printed carton liner merged with single face cardboard.
Make-to-order	Satisfies customers’ requirements upon received customer orders.
Milestone	A sub goal to confirm progress and keep direction of a project.
Operational volume	Volume for resource, resource driver or cost driver; for allocations.
Overhead	Costs that cannot be directly assigned to a cost object.
Packaging blank	Non-separated packages lying flat and unfolded, without glue.
Plano	Separated packages lying flat and unfolded, without glue.
Price quotation	When a seller provides a written price offer to the customer.
Resource	Physical or virtual element applied or used to perform activities.
Sensitivity analysis	To investigate the affect of changing single parameters.
Stripping	Operation that removes waste material to form a plano package.
Structural capital	Company’s resources in standards that reduce human dependency.
Time to price	Elapsed time from customer enquiry until price quotation.
Traditional costing	Complete cost estimation method, allocation based on volumes.
Windowing	Machine operation that adds a thin plastic window to packaging.

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1 Introduction

In this chapter, the aim is to provide a background to the concerned subject, as well as an introduction to the problem areas that will be examined in this master thesis. The problematization together with the purpose of this master thesis will also be described. Additionally, a brief presentation of the company and an outline for the forthcoming chapters are also presented.

1.1 Background

In order to be profitable as a company it is essential to know the cost of the products, before deciding upon a price with the customers (Olsson, 1994, p.109). This is one of the main reasons why accurate cost estimations of products are so important for companies. The more accurately the cost can be estimated, the more certain the calculated profit will be. However, the cost is not the only component that is used or needed in the pricing process. Additional components, such as market analyses, can also play a vital role. These can complement the internal cost perspective with an external perspective, taking either the competitor's prices or the value provided to the customer, into consideration (Schäder, 2006).

For make-to-order companies of customer specific products, such as the packaging manufacturer FrontPac, a cost based pricing strategy can be an appropriate approach to use. However, it should favorably be complemented with either a customer based or competitor based pricing strategy. The price is often negotiated with the customer, which makes it very important to know the breakeven price, i.e. where the price equals the cost.

Cost estimation is a useful tool in pricing and can provide decision bases, guidelines or price floors to the decision maker. In order to establish the cost of an object, different cost estimation methods can be used. The first decision to make is whether all costs should be included and allocated to the object, or not. In literature, it is often referred to as complete cost allocation, i.e. when all costs are taken into consideration (Skärvad and Olsson, 2006, p.261). Based on this basic approach there exist many different cost estimation methods (Karlsson, 1999). It is the actual purpose of the cost estimation that determines which method that is the most appropriate to use. Normally, the preferred method for complete cost allocation is either ABC or traditional costing (Ljung, 1999, p.89).

For many make-to-order companies, both the *price* and the *time to price* are important order-winners. In some situations a rapid price response can be the difference between winning and losing an order. Consequently, standardized cost estimation systems are appropriate to use. These can provide an easy and user-friendly approach for performing cost estimations rapidly. This is especially advantageous for the kind of companies where persons with little or no experience and skill of cost estimations will be expected to answer to customer enquiries and to provide price quotations, both fast and accurately.

Currently, FrontPac is using an in-house developed cost estimation system to calculate the costs for their customer orders. Since the system requires extensive knowledge and experience about FrontPac's products, orders and processes (including the design, manufacturing and warehousing process), there is only a few persons that are actually able to perform these calculations. The implication for FrontPac is that their salespersons cannot by themselves estimate the cost for a specific order when negotiating with their customers. Instead, the salesperson has to provide a cost estimation employee with the order specifications in order for that person to estimate the cost. The salesperson can then, at a later stage, communicate a price to the customer.

1.2 Company presentation

As already stated, FrontPac is a manufacturing company of customer specific products. More specifically it is specialized in manufacturing packaging and displays made from offset printed litho laminated corrugated cardboard. It is a part of the larger FrontPac-group, which comprises several separate but tightly cooperating companies. As a result of an expansion in 2001, it has moved to new premises in Arlöv where it is located in close connection to both FrontPrint and FrontWell. Last year, FrontPac had 100 employees and its turnover was 120 MSEK (2009). FrontPac's logotype and slogan can be seen in Figure 1.1.

Figure 1.1: *FrontPac's logotype and slogan.*

1.3 Problem discussion

The current cost estimation system at FrontPac has several drawbacks. This creates obvious problems when negotiating with customers about products and orders. These problems should then preferably be avoided, which consequently is the aim of this particular master thesis. Below, the four main problem areas are presented and explained carefully.

First, although cost estimation is crucial for FrontPac's business, there are only a few properly skilled and experienced employees at the company who can actually perform these estimations. This kind of dependency is never advantageous, neither for the concerned employee, nor the company. There is thus a clear need for having a simple and standardized cost estimation system that can perform fast and accurate cost estimations.

Second, salespersons are not able to immediately present an estimated price for a specific order, just as it is being negotiated with the customer. Instead, the two parties simply have to come up with a somewhat clearly defined outline of the order, in order to obtain an estimated price from the cost estimation employee. In fact, this process can take up to several days to finish, which is clearly undesirable.

Third, the salespersons are not able to smoothly perform sensitivity analyses for orders that are negotiated with a customer, without contacting the cost estimation employee. It may be suitable for the salespersons to investigate and present a couple of different alternative solutions for a customer, e.g. by changing the dimensions of the product or the ordered quantity, to see how this affects the cost. This is something that both the salespersons and the customers certainly would appreciate during the negotiations; hence, the cost estimation system should preferably have this function integrated.

Fourth, the previous cost estimation system relies on old and static machine costs. There is a clearly limited knowledge about the calculations behind these costs and no convenient possibilities exist for updating these as the organization changes. As a result, there is an obvious need to review these figures and to standardize the procedure for performing updates; thus to create a dynamic cost estimation system.

In conclusion, FrontPac would definitely gain from having a cost estimation system that immediately generates appropriate costs, which is based on a standardized platform that do not require detailed knowledge of FrontPac's products, orders and processes. Hence, FrontPac's overall competitiveness will undoubtedly increase if the salespersons are able to provide fast price quotations, without any significant loss in accuracy in the cost figures.

1.4 Purpose

The purpose of this master thesis is twofold. The first purpose is to develop a cost estimation system that can estimate the costs for FrontPac's packaging products, fast and accurately. Hence, the aim is to improve the four current problem areas that were stated in the problem discussion. The outcome will be an Excel based system, where the user will type in order specific information in order to immediately receive an estimated cost for the concerned order. It should be easy and fast to use, as well as customized according to the future users' opinions. Furthermore, the system should provide possibilities to make easy sensitivity analyzes in order to see how the total order cost, as well as the unit cost, is affected by the chosen parameters. Finally, it should also be a dynamic system where it, to some extent, should be possible to update the activity costs in accordance with changes in the organization.

The second purpose is to develop a suggested procedure for implementation of ABC in make-to-order companies. The procedure should be able to use in future projects, where similar cost estimation systems are developed and implemented. Hence, it should facilitate possible future efforts by providing a step-by-step approach with practical guidelines, clearly defined deliverables and critical success factors. The implementation procedure should also facilitate for FrontPac to revise or expand the developed cost estimation system.

1.5 Focus and delimitations

The main focus of the thesis has been aimed at developing a cost estimation system that is capable of estimating the cost of customer orders fast and accurately. In order to achieve this within the time frame of the thesis, necessary delimitations have been made. The first delimitation has been to only include the implementation of the chosen cost estimation method and development of the belonging cost estimation system. Hence, the actual integration of the system into the organization has been excluded. The second delimitation has been to neglect the administrational activities explicitly in the system, in accordance with FrontPac's pricing strategy. The identification and allocation of administrational activities, cost drivers and resource consumption have however been performed, in order to prepare for future system expansions. Obviously, only resources and activities within FrontPac's organization have been identified and allocated based on the chosen cost estimation method. All other costs are treated as direct costs and are therefore calculated separately, e.g. by using price lists.

The main focus has been put on the packaging products since these constitute a much larger share of FrontPac's products than the displays and their manufacturing process is also somewhat diverse. Second, not all packaging designs that FrontPac provides have been taken into consideration explicitly in the system. The chosen designs are based on occurrence in accordance with an ABC classification, where the classes A and B have been considered explicitly. However, the rest of the offered designs are possible to use in the system as well.

It should also be noted that the suggested implementation procedure for ABC has a clear delimitation. It is merely based on a single case study at one single company. This has on the other hand enabled a very detailed and in-depth study of the procedure to be performed. The focus has been aimed at identifying general phases and activities of such implementation projects, as well as deliverables and critical success factors.

1.6 Outline

The outline of the thesis, including the nine forthcoming chapters, is briefly described below.

Chap 2

Methodology
In this chapter the research methodology is thoroughly explained and evaluated. The chosen research methods are also justified. Finally, the validity and reliability of this thesis are discussed.

Chap 3

Frame of Reference
This chapter provides the reader with a theoretical overview of the economical issues, i.e. the theories behind pricing, cost accounting and Activity Based Costing. These are thoroughly explained, to support the reader in understanding the empirics and the discussion.

Chap 4

Packaging Theory
For the reader who is unfamiliar with box packaging made from carton and corrugated cardboard, this chapter will provide the necessary background information. The description is focused on three main areas; material, design and manufacturing.

Chap 5

Empirics
In this chapter the collected information is objectively presented. It includes a detailed and thorough description of the concerned parts of FrontPac, as well as the identified resources, activities, cost object components and their relationships.

Chap 6

Description of Cost Estimation Systems
This chapter includes a description of the previous and the developed cost estimation system, with the aim to provide an understanding of the principle differences between the systems and their overall structures.

Chap 7

System Results
The system results are presented in this chapter. The validation results are first presented before focus is shifted towards the positive effects with the developed cost estimation system; with a focus on the four problem areas that were stated in the problem discussion.

Chap 8

Suggested Procedure for ABC Implementation
This chapter presents the suggested procedure for ABC implementation in make-to-order companies. The procedure is based on the single case study that was performed at FrontPac and previous ABC research.

Chap 9

Discussion
In this chapter the theoretical information from chapter 3 and 4 are brought together with the collected information from chapter 5 to be analyzed structurally. The results from chapter 7 will also be discussed.

Chap 10

Conclusions
This final chapter briefly concludes the discussion and presents the solutions to the problems that were formulated in the introduction.

2 Methodology

The research process of this master thesis is explained in this chapter. It contains a brief description of the methodological approach and the possible research approaches. The conducted research strategy and methods will subsequently be described carefully, but also be evaluated and justified. Finally, a method discussion treats the reliability and validity, based on the conducted research.

2.1 Methodological approach

In this section the aim is to explain the methodological approach conducted in this thesis or expressed differently, the perspective from which the authors are observing reality. This is crucial to state so that the reader will understand the conducted approaches in this thesis.

Each science pursues its studies from a certain point of view. This should therefore preferably be declared. The *system perspective* is undoubtedly the most commonly implied approach in modern science, due to the basic views on cause and effect in nature that is experienced by humans (Macy, 1991, p.3; Lin, 1999, pp.1-5; Skyttner, 2005, p.3). It has therefore been chosen also in this thesis. The approach consists of separate parts forming a complex whole and it is the basis for holistic thinking. Consequently, systems science aims to understand man and his environment as part of interacting systems by studying the interactions from multiple perspectives, holistically. It therefore strives towards a universal science with the purpose of integrating all scientific knowledge (Skyttner, 2005, pp.3-4). Today, synthesis is a prerequisite for systems thinking. It is considered to be of an explanatory nature, i.e. it creates knowledge about the function of a specific phenomenon (Skyttner, 2005, pp.33-35).

Models are excellent practical examples of what can be achieved with a system approach. A model is namely a simplified depiction of the complex reality. Moreover, researchers often use simplified, well-defined and systematized assumptions about the relation between factors or investigated phenomena. A model is thus considered to be appropriate if it fulfills a specific purpose, is simple and yet has a reasonable explanation value (Lundahl and Skärvad, 1999, pp.64-65).

2.2 Scientific research

The intention with, and requirement for, scientific research is based on the generation of knowledge (Lundahl and Skärvad, 1999, p.14). The relation between scientific research and knowledge will therefore be clarified as it will help the reader to understand the overall thesis approach that has been conducted.

The sophisticated thought is what sets humans apart from other animals. Altogether, voluminous knowledge has been gathered in the world. It is though extremely difficult for humans to explain how a task is performed or why it yields knowledge, even if it is known how it should be performed (Pollock and Cruz, 1999, pp.1-2). Knowledge is actually an incredibly wide concept that favorably can be divided into different categories, depending on the intended perspective. Three categories that separate the knowledge concept are illustrated in Figure 2.1. In one category knowledge can be either to know something or to have ability. The second category expresses that knowledge either can be explicit or quiet. The final category distinguishes between operative, analytical and design knowledge (Lundahl and Skärvad, 1999, pp.10-12).

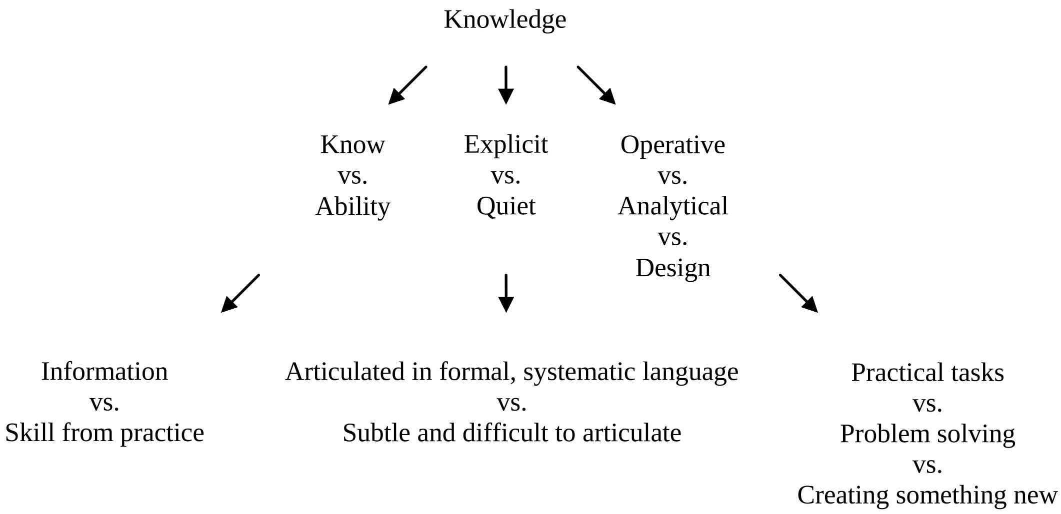


Figure 2.1: *Three categories of knowleage.*

Research simply fulfills the purpose of generating knowledge, referring to some of the categories mentioned above. In today’s society, which is almost entirely based upon knowledge, this has become of great importance. However, it is crucial that focus is put on the generation of useful knowledge, i.e. which adds value to the intended target group (Lundahl and Skärvad, 1999, pp.14-16). In order to do that, the researcher thoroughly has to realize who the actual client is and the actual purpose of the research (Lundahl and Skärvad, 1999, pp.81-85).

Furthermore, it is important to understand that research does not merely try to understand complex structures, but also to explain these (Befring, 1994, p.10). In addition, another purpose with research is that the conducted procedure should be reproducible for other research projects as well (Befring, 1994, p.25), which preferably should not be neglected. The reproducibility of this thesis is thus a great part of the intended purpose.

2.3 Research strategy

The research strategy is the overall approach that should be chosen based on the given research objectives, the extent of existing knowledge and the amount of time and other resources available. Furthermore, it is crucial for the end result that the choice of research strategy is clearly specified and communicated (Lewis, Thornhill and Saunders, 2007, p.135). In fact, this choice is usually made before the actual research begins (Denscombe, 2007, p.2). Several different research strategies exist, which are explained below, but with an evident focus on the strategy conducted in this thesis.

In this thesis, a *single case study* is conducted to investigate the practical procedure for ABC implementation. A case study is defined as (Robson, 2002, p.178):

“... a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence.”

This strategy is therefore frequently used for explanatory or exploratory research. Case studies can namely be a useful way of challenging an existing theory (Lewis, Thornhill and Saunders, 2007, pp.139-140). In addition, multiple case studies are often favorable to choose compared to single case studies. This is simply because it enables more statistically correct comparisons and conclusions (Yin, 2003, p.83). However, it was merely possible to conduct a single case study in this thesis, but it would be of great interest to test the procedure for ABC implementation for other similar cases as well, in order to increase the credibility.

Another possible research strategy, applicable within this scientific area, is *action research*. Then the researcher is part of the organization within which the research, and the change process, is taking place (Coughlan and Brannick, 2005). The *survey* strategy is often a useful approach in social sciences, where information is gathered from a huge number of individuals. Based on the information from the sample, that is considered to be representative for the whole population, it is then possible to draw conclusions (May, 2001, p.113).

2.4 Research method

There is normally a strong connection between certain research strategies and the available methods that are being used in a specific situation. However, many different methods can be chosen in a research project, regardless of the choice of strategy. A specific method should be chosen based on its suitability to solve a given task within the research project. It is therefore common to use a couple of different methods throughout the research project (Denscombe, 2007, p.130). Subsequently, some important concepts linked to the choice of research method will be explained. After that follows a description of the most common methods for data collection and finally the processing of gathered data will be treated.

2.4.1 Concepts

The most important concepts and expressions for understanding the research methods are here divided into three parts. These treat respectively; primary and secondary data, quantitative and qualitative data followed by mono and multiple methods. These concepts are summarized in Figure 2.2 and will be explained below, together with the clarification of how these concepts have been applied in this thesis.

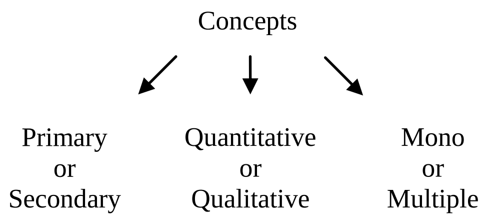


Figure 2.2: *Concepts for research methods.*

Primary or secondary data

Depending on the initial purpose of the data collection, the data can be divided into two different categories, primary or secondary data (Kumar, 2005, p.118). Subsequently, a specific data category is linked to some available data collection method, described in section 2.4.2. Here the data categories will be explained and evaluated by stating the benefits and the drawbacks.

Primary data refers to data that is gathered exclusively for the conducted research. This data is usually collected either through observations or interviews (Befring, 1994, p.64; Kumar, 2005, p.118), which conforms very well to the conducted approach in this thesis. The advantage with observations is that the data collection task is performed in its natural setting (Robson, 2002, p.310), as can be seen in Table 2.1. Interviews on the other hand provide an in-depth insight into the topic and it can be a way to confirm facts from other methods (Denscombe, 2007, pp.163-166). Particularly telephone interviews are a dominant data collection method due to their cost effectiveness (Panneerselvam, 2004, p.14). Similarly, the disadvantages with observations are that it can be very time consuming, observer bias has to be evaluated and the observer has to be present in the research setting (Lewis, Thornhill and Saunders, 2007, pp.293-298). For interviews the data quality may be poor together with possible logistical and resource issues (Lewis, Thornhill and Saunders, 2007, p.311).

All the advantages mentioned above can be confirmed in this thesis, whereby both interviews and observations were conducted frequently in order to obtain necessary data in various situations. For example were manufacturing personnel frequently interviewed and observations were performed in order to obtain insights that were essential for mapping the material flow in the manufacturing. These research methods will be elaborated further in forthcoming sections.

Table 2.1: *Advantages and disadvantages with primary and secondary data.*

Type of data	Advantages	Disadvantages
Primary: Observations	In natural setting	Time consuming Observer bias Observer has to be present
Primary: Interviews	In-depth insight Confirm facts	Poor data quality Logistical and resource requirement
Secondary	Few resource requirements Unremarkable Enable comparisons	Another primary purpose Accessibility Quality control

Secondary data is based on information initially collected for other purposes, yet useful in the research project as well. It includes both raw data and published summaries. The data can be obtained from either internal or external sources. The former refers to all kinds of information that is obtainable from a company's internal computer system, while the latter mainly refers to governmental publishing, books or similar (Panneerselvam, 2004, p.14). Furthermore, an increasing number of documents with secondary data are becoming obtainable because of the growth of internet. Both primary and secondary data are normally necessary to adopt in order to achieve the research objective. If there is a lack of appropriate secondary data provided, primary data has to be collected (Lewis, Thornhill and Saunders, 2007, pp.246-247). The main advantages with secondary data (see Table 2.1) are that it may have fewer resource requirements, is usually unremarkable and can be used as comparative data for validation purposes (Panneerselvam, 2004, p.30; Lewis, Thornhill and Saunders, 2007, pp.257-260). The disadvantages with secondary data are that the initial data collection purpose probably is not equal to the current need, accessibility is difficult and the data quality is uncontrollable (Panneerselvam, 2004, p.30; Lewis, Thornhill and Saunders, 2007, pp.260-263).

Both external and internal sources of secondary data have been used in this thesis, although for strictly different purposes. The internal sources were used to create an empirical foundation required to map the organizational processes as well as creating proper lists and matrices for the ABC concepts to be used in the developed cost estimation system. The external sources were on the other hand used to create a theoretical foundation about ABC in chapter 3 and FrontPac's packaging products in chapter 4.

The first and the last advantage arguments have been the predominant reason for using secondary data throughout this thesis. Given that the secondary data was considered to be reliable, it was used, e.g. for validation purposes of the developed cost estimation system. The overall approach in this thesis has been that primary data merely were collected when the secondary data did not exist or was considered to be inadequate; in order to be time efficient. In several situations all the disadvantages that were mentioned above occurred in the secondary data that were available at FrontPac. If any data were stored, it was difficult to access and control it, because FrontPac did normally not intend for nor expect it to be used as secondary data.

Quantitative or qualitative data

Quantitative data consists of a set of numbers that makes it possible to analyze a certain phenomenon, which enables conclusions to be formulated; frequently equated with the notion of empirical evidence (Norman and Blaikie, 2003, p.15; Lewis, Thornhill and Saunders, 2007, p.145). In order to present the data in graphs, tables or charts; words sometimes need to be suitably transformed into numbers, i.e. quantified (Denscombe, 2007, pp.235-241; Babbie, 2008, p.442). The advantages with quantitative data (see Table 2.2) are that it is scientifically respectable, it enables comparisons, the analysis can be performed quickly and the findings can be communicated conveniently (Denscombe, 2007, p.264). Similarly, the disadvantages are that a careful data input is required, the complexity may become too large and data manipulation possibilities unfortunately reduce the scientifically objective appearance (Denscombe, 2007, pp.264-265).

Both primary and secondary quantitative data were collected as input to the cost estimation system that was developed in this thesis. Some examples of secondary data are that the resources and cost structure at FrontPac were identified based upon the income statements from the previous three years. Similarly, the machine speeds were analyzed based upon the figures set in previous cost estimations. Statistical analyzes were subsequently performed on this data to generate more accurate results. Primary quantitative data was also collected, but rather through interviews and observations. This was then a complement to the collected secondary data in order to ensure that a more reliable outcome was generated, e.g. for the machine speeds. The reason for this was mainly due to the untrustworthy and unfortunate lack of secondary quantitative data that was a result of neglected reporting throughout the manufacturing process.

Table 2.2: *Advantages and disadvantages with quantitative and qualitative data.*

Type of data	Advantages	Disadvantages
Quantitative	Scientifically respectable	Careful input required
	Enables comparisons	Complexity may become too large
	Rapid analyses possible	Manipulation opportunities
	Convenient to communicate	
Qualitative	Established in reality	Less representative
	Provides details	Interpretation dependent
	Tolerance of contradictions	May be decontextualized
	Allows alternative explanations	Explanation may be oversimplified

Qualitative data is a broad term, collected as words or images that are based on human interpretations of activities. However, it is especially the approach for data collection and analysis that makes it distinguishable from its quantitative counterpart (Denscombe, 2007, p.266). The data collection and analysis is normally also intertwined more intimately, which makes it easier to keep the sight of theory (Babbie, 2008, p.416). Some advantages with qualitative data (see Table 2.2) are that it is firmly established in reality, the data is detailed, there is a tolerance of contradictions and it allows a prospect for alternative explanations (Denscombe, 2007, p.281). The disadvantages with qualitative data are that the data is less representative, it is dependent on the researcher's interpretations, the meaning can be distorted from the context and the explanation may be oversimplified (Denscombe, 2007, p.279).

In this thesis, qualitative data was collected primarily to understand FrontPac's organization and business. This was namely used to map the supply chain, the internal processes, etc. A visualization of the pricing strategy as well as the identification and allocation of the ABC concepts were also possible to perform based on this collected data. The second of the disadvantage arguments has been considered carefully in the thesis, in order to ensure that the researcher bias is eliminated. This was treated by gathering data from, and then confirming the conclusions with, several independent interviewees.

Mono or multiple methods

The research choice refers to the choice of combining qualitative and quantitative data. These choices can be categorized into two types, the mono and multiple methods. For the mono method merely one data collection technique and corresponding analysis procedure is used. The multiple method choice is becoming increasingly advocated, enabling quantitative and qualitative procedures to be used in combination as well as the use of primary and secondary data. The approaches are complementing each other whereas they fulfill different purposes in the research. In addition, the credibility will increase due to the offered validation opportunities (Lewis, Thornhill and Saunders, 2007, pp.145-147). For this reason, the multiple method approach has been applied in this thesis; which will be elaborated in section 2.5.3.

2.4.2 Data collection

A couple of different methods for data collection are common within the area of research undertaken in this project. These are interviews, observation and documents, which can be seen in Figure 2.3 with their belonging categories.

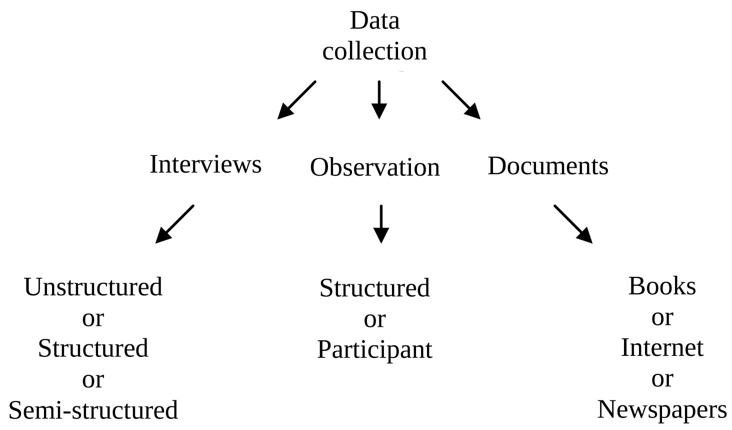


Figure 2.3: *Three data collection methods.*

Interviews

An interview is described as a personal conversation between an interviewer and an interviewee in a given interview environment (Befring, 1994, p.69; Panneerselvam, 2004, p.19). This method can be classified into separate categories, usually in regard to the level of structure and formality. Each of them is used for different purposes (Lewis, Thornhill and Saunders, 2007, p.310), as can be seen in Table 2.3. In addition, the collected data from interviews will be considered as primary (Panneerselvam, 2004, p.14) and it is mainly qualitative, but sometimes quantitative (Denscombe, 2007, pp.164-165).

Table 2.3: *Interview categories for three research strategies (Lewis, Thornhill and Saunders, 2007, p.314).*

Type of interview	Exploratory	Descriptive	Explanatory
Structured		XX	X
Semi-structured	X		XX
Unstructured	XX		

XX = more frequent, X = less frequent

Unstructured interviews occur when no specific questions have been prepared in advance and the situation is rather informal. However, a clear idea about the aspects to explore normally exists, whereby these often are used to collect in-depth qualitative information, as illustrated in Table 2.1 (Lewis, Thornhill and Saunders, 2007, p.312). This alternative was often used throughout this thesis when the objective was to understand FrontPac's organization and business, e.g. in order to map the product components and the material flow in the manufacturing. It also enabled the identification of activities and cost objects as well as the allocation of activities to cost objects.

Structured interviews are on the other hand very formal to their structure. All the questions are prepared carefully on beforehand and the specific order for the questions is also given. Hence, it is considered to be a sort of questionnaire, where the interviewer reads out the questions exactly as written. This kind of interview is usually performed to collect quantitative data (Lewis, Thornhill and Saunders, 2007, p.312). Structured interviews were however not applied in this thesis, since it never was considered to be adequate in this particular case study.

Semi-structured interviews are somewhat a crossing between the ones just mentioned, i.e. questions are prepared in advance although the order is not necessarily predetermined. The structure is somewhere between formal and informal, and the generated data will be qualitative (Lewis, Thornhill and Saunders, 2007, p.312). This kind of interviews was performed as a complement to the unstructured interviews. For example, to gather in-depth responses from the salespersons both about the previous and the developed cost estimation system. Semi-structured interviews were also used to confirm the determined machine speeds in particular manufacturing working stations with the responsible personnel.

Observation

Personal observations are generating primary data, and these are usually divided into two separate categories, i.e. structured or participant observations (Panneerselvam, 2004, p.18; Kumar, 2005, pp.118-119). The former is in particular frequently used within this research area, although the latter also occurs (Lewis, Thornhill and Saunders, 2007, p.282).

Structured observations are systematic and have a high level of predetermined structure, and primarily quantitative data will be collected (Robson, 2002, pp.309-310). The objective is to compare several situations to their structure by analyzing the received quantitative data (Lewis, Thornhill and Saunders, 2007, p.293). This category was applied in many situations in this thesis, e.g. to determine cost driver volumes which is required to enable activity to cost object allocation.

Participant observations are in contrast mainly used in social research, e.g. by analyzing people's actions in order to understand these properly. The researcher participates in the lives and activities of the subjects, and thus becomes a member of the group. The rendered data is then qualitative (Robson, 2002, pp.309-310). However, four different kinds of participant observations exist. One of these is more suitable to use within this research area. It is called complete observer, whereby the researcher does not take part in the activities of the group. This research is consequently of an exploratory nature. This alternative can actually often be a precursor to structured observations (Lewis, Thornhill and Saunders, 2007, pp.283-288). This category was often used in connection with unstructured interviews when the objective was to gain insights about FrontPac's organization and business, e.g. to map the material flow in the manufacturing and to identify the performed activities.

Documents

Documents include all kinds of written sources, but also pictures and music. The collected data will be secondary and depending on the research being performed the data may be both quantitative as well as qualitative (Denscombe, 2007, p.212), since the documents fulfill different purposes (Creswell, 2003, p.46). Below, the most common and appropriate categories within this method will be commented.

First, books and journals are the most common sources of information for the researcher (Creswell, 2003, p.38). It especially creates an initial rigid foundation to the research, where a literature map preferably can be constructed to visualize existing research about the topic (Creswell, 2003, p.40). These documents can sometimes also be input with the latest cutting-edge ideas within a specific research subject. The cost for collecting this information is not overwhelming, although the researcher typically needs to evaluate the various sources' credibility, because the differences normally are quite vast. Fortunately, academic sources generally have their material refereed by experts within the field before the work is published, although it does not provide any guarantees (Denscombe, 2007, pp.212-213). These kinds of sources were used when the theoretical foundation was built. In chapter 3 these were used concerning cost accounting, ABC, pricing, etc. Similarly, these were used for the packaging theory aspects in chapter 4.

Second, information can be collected through the internet, including all types of written sources that are available as electronic formats. The main issue with internet is that there are few restrictions on what is allowed to be published. Hence, a clearly critical attitude to this kind of sources is necessary and preferable (Denscombe, 2007, p.214). These sources were therefore merely used when it was difficult to obtain the information elsewhere and when the required information was not controversial. The websites used were certainly also considered to be trustworthy. Final, newspapers and magazines is another source for collecting documentary information, specifically because it may provide information that is up-to-date (Denscombe, 2007, p.214).

2.4.3 Processing of data

When analyzing the collected data it may become apparent that the difference between quantitative and qualitative data is not mutually exclusive, because the distinction is rather built upon the treatment of data. It should consequently be noted that the source of information does not necessarily have to differ between the two approaches. The difference initially appears when the information is treated and analyzed. Typical associations between quantitative and qualitative research is summarized in Table 2.4. However, it is natural to separate the analysis procedures for these two types of data (Denscombe, 2007, pp.230-234).

Table 2.4: *Common associations for quantitative and qualitative research (Denscombe, 2007, pp.232-234).*

Quantitative	Qualitative
Numbers as the unit of analysis	Words as the unit of analysis
Analysis	Description
Large-scale research	Small-scale research
Specific focus	Holistic
Researcher detachment	Researcher involvement
Predetermined research design	Emergent research design

Quantitative data

Raw quantitative data initially has to be processed and analyzed in order to turn it into useful information, accommodated for the recipients. Typical analysis techniques for quantitative data include tables, charts, diagrams and statistics. These techniques will be helpful both for the researcher's own analysis procedure as well as when presenting the findings. Hence, quantitative data is especially suitable for making comparisons and finding correlations (Robson, 2002, pp.448-450; Panneerselvam, 2004, pp.14-15; Lewis, Thornhill and Saunders, 2007, pp.406-419). Nowadays, the time and cost for analyzing quantitative data is incredibly low due to the introduction of the personal computers, together with the available and powerful software packages, e.g. spreadsheets (Lewis, Thornhill and Saunders, 2007, pp.406-419). Otherwise quantitative data processing is specifically common when the collected results from questionnaires are to be analyzed and presented, although it certainly occurs for other research methods as well (Lewis, Thornhill and Saunders, 2007, pp.406-419). Both secondary and primary data can be quantitative. These can therefore be processed with the belonging analysis techniques. The researcher has to be more careful with secondary data though, because the control of the type, coding and format; is far lower (Lewis, Thornhill and Saunders, 2007, pp.406-419).

For these reasons, various statistical analyzes have been applied comprehensively in this thesis in order to ensure that the most correct numbers were used in the developed cost estimation system. It was for example applied to validate several of the subsystems, such as the machine speeds, that will be calculated automatically by the system, in order to ensure that statistically justified figures were used. The applied secondary and quantitative data was mainly obtained from FrontPac's internal business system, e.g. from previous cost estimations, quick reference guides and rules of thumb. The specified numbers have thus, without exception, been examined critically in order to reduce any uncertainties. This data have normally also been combined with primary and quantitative data collected from interviews and observations in order to increase the credibility.

Qualitative data

Analysis of qualitative data should be seen as a nonnumeric assessment (Babbie, 2008, p.414). Qualitative data arises in various situations and can be primary as well as secondary. The outcome of the data is most appropriate for making descriptions. In fact, analyses of qualitative data should be seen as an extremely demanding task, not to be underestimated. When processing qualitative data, the collected words, pictures or music; have to be interpreted somehow. The researcher's interpretations are hence inevitably an integral part of the analysis and therefore important to consider when questioning the credibility (Denscombe, 2007, p.268). Subsequently, the available procedures enable the researcher to develop theory based on the data, i.e. to create a conceptualization. A possible option would thus be to develop a conceptual framework (Lewis, Thornhill and Saunders, 2007, pp.470-474).

This approach was consequently applied to suggest a procedure for ABC implementation in make-to-order companies, since qualitative data were interpreted to finally generate a complete concept. Additionally, this approach was also applied in order to perform the packaging design classification and to identify the activities in order to subsequently allocate these to the cost objects.

2.5 Method discussion

It is important for any scientific research to question its rigor. Reproducibility will help increase the credibility when similar projects are performed that can support the conclusions. This is especially important when the conclusions are surprising and essential (Befring, 1994, p.25). The credibility of the research findings treats the mission of reducing the possibility of presenting wrong conclusions, because the correct answers currently are unknown (Lewis, Thornhill and Saunders, 2007, p.149; Miller, Strang and Miller, 2010, p.11). It can be difficult to comprehend the actual meaning of these credibility concepts. A project's credibility namely depends both on the reliability and the validity, which is illustrated in Figure 2.4. E.g. the credibility is considered to be high if both the reliability and the validity are high. The basic concepts about a research project's credibility, i.e. the reliability and validity, will be explained carefully beneath. Simultaneously, some comments about these concepts for the conducted approach in this thesis will be performed.

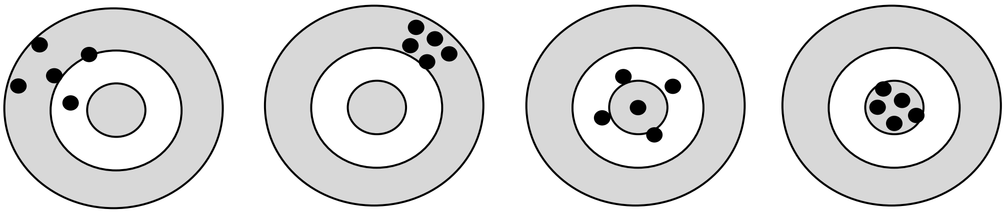


Figure 2.4: *Credibility in terms of reliability and validity (Zikmund, 2000, p.284).*

2.5.1 Reliability

Reliability refers to the extent in which the data collection techniques and analysis procedures will yield consistent findings, i.e. whether the same findings are found in repeated measurements (Miller, Strang and Miller, 2010, p.11). Subsequently, the four threats to reliability and this particular thesis' reliability issues will be commented.

First, *subject or participant error* is a threat that expresses the issue of collecting representative data due to certain events that occur over time (Lewis, Thornhill and Saunders, 2007, p.156). This may for instance become an issue when observations are performed (Lewis, Thornhill and Saunders, 2007, p.301). Due to the relatively short time period, together with the frequency, that data was collected for interviews and observations this is not considered to be the main issue; especially since FrontPac's business were declared to not be all too alternating. Secondary data from a few years back were though collected from previous cost estimations in order to validate different subsystems during the development of the system. Since the preconditions in FrontPac's business may have changed somewhat during this time period, this creates a slight reliability threat. This was however realized when these were collected and treated thereafter, whereby this issue should not be considerable for the final outcome. It should also be stated that the most recent cost estimations were applied when the total cost outcomes from the developed system finally were validated.

Second, *subject or participant bias* is similarly an issue connected to the collection of representative data. Although, in this case, the collected information does not exactly reveal what the researcher thinks it does (Lewis, Thornhill and Saunders, 2007, p.156). This is considered to be the main reliability issue for the figures in the developed cost estimation system. The reason is that some crucial conclusions, drawn from observations and interviews, are difficult to assure with certainty. This is due to the lack of available information, e.g. secondary data that were needed to perform appropriate comparisons and consequently to enable more certain answers to be generated.

Third, *observer error* treats the issue of ensuring that the given conditions are equivalent for situations that are being compared (Lewis, Thornhill and Saunders, 2007, p.157). The situations that were compared through observations in the manufacturing working stations appeared to be very similar over time. This is therefore not considered to be a main issue, although it is difficult to be absolutely certain.

Finally, *observer bias* occurs when the researcher formulates wrong interpretations of the specific situation that is being observed (Lewis, Thornhill and Saunders, 2007, p.157). This issue actually occurred several times when the manufacturing was mapped. It was though treated carefully in order to increase the reliability, e.g. by interviewing several employees to confirm drawn conclusions and using multiple methods, such as interviews and observations. First when conclusions were confirmed by several independent employees these were settled in the map.

2.5.2 Validity

Validity is an indicator of construct concordance, i.e. it is concerned with whether the findings actually reflect the initial intension (Miller, Strang and Miller, 2010, p.11). Several different threats to validity exist, e.g. if the time difference between an occurrence and the research is large, there is a lack of generalizability or false assumptions have been stated (Robson, 2002, pp.100-108). Because of the dynamic and complex nature surrounding us, it is usually difficult to claim that a certain factor caused something to occur. There are normally several other factors affecting the result. A validation is therefore necessary to undertake in order to be more ascertained about the findings. (Lewis, Thornhill and Saunders, 2007, p.150)

In this thesis, a threat to the validity is whether the suggested procedure for ABC implementations in make-to-order companies actually is generalizable for similar situations, i.e. whether the procedure undertaken in this thesis truly is reproducible. It subsequently has to be applied to similar situations in the future in order to increase the validity of the findings.

There are also minor sections of the developed model where the validity is less verified, where mean values have been used to express a somewhat more dynamic phenomenon in order to reduce the complexities. For example, for some of the subsystems this is true, although these however not are considered to be a main validity threat due to their minor impact on the total cost outcome from the system.

2.5.3 Triangulation

The choice of research perspectives should preferably be examined carefully, in order to ensure that a high level of objectivity is reached (Lundahl and Skärvad, 1999, p.74). By observing a phenomenon from a new perspective it is possible to question all the assumptions that are taken for granted. Many problems can therefore be solved by having this approach (Lundahl and Skärvad, 1999, p. 71). The mixed methods approach essentially enables this to occur, which generally is referred to as *triangulation*. This will help increase the assurance of the collected information if the results from all of these methods point in the same direction, because phenomena will then be investigated from different perspectives (Yin, 2003, p.83). It will though not guarantee that analyses are absolutely correct (Denscombe, 2007, p.132; Lewis, Thornhill and Saunders, 2007, p.147). A triangulation approach is actually considered to be necessary for the case study strategy, as the applied methods often are combinations of interviews, observations and documents (Lewis, Thornhill and Saunders, 2007, p.139).

It was thus particularly suitable to use all of these complementary methods throughout this thesis, in order to strengthen the credibility of the findings. All the critical aspects involving the progress of the thesis and the deliverables followed this approach. The background to ABC was for example established carefully based upon available literature, whereas observations and interviews were used during the actual ABC implementation as well as the development of the procedure for ABC implementation. The particularly critical values in the cost estimation system, e.g. the subsystems treating the sheet structure choice and the machine speeds, were settled first after careful and various observations and interviews.

3 Frame of Reference

In this chapter, applicable areas from the theoretical studies are presented. It begins with a brief presentation of the theories behind pricing, before it continues with a fairly general description of cost accounting. It then narrows down into a discussion about different cost estimation methods. A more thorough description of the theories behind Activity Based Costing (ABC) and two procedures for ABC implementation then completes this chapter.

3.1 Pricing

Pricing refers to the decision a company has to take regarding which price it should offer their customers, for the provided products or services. This is actually the only mean of competition that has a double function for the company's business performance. Internally, to ensure that the generated profit is sufficient for survival, and externally, as a marketing instrument required to attract customers from competitors (Englund, 2000, p.14; Schäder, 2006, p.3). Hence, companies should have established long term goals for their pricing strategies, as a way to maximize profitability (Schäder, 2006, p.56). In addition, a requirement for setting the price properly is that demand and cost not are uncertain (Jagpal and Jagpal, 2008, p.94).

The three most common pricing strategies differ in terms of primary focus. It can be based on; costs, competition or customers (Schäder, 2006, p.57). These alternatives can all be favorable in certain situations, which are explained below.

Cost based pricing is commonly used on mature markets where the difference between the products that the companies are offering is negligible. Subsequently, it is the cost that settles the price floor. The common procedure is then to add a profit margin to the cost, which then makes up the final price offer (Olsson, 1998, p.147). Obviously, all pricing decisions are more or less based on costs. However, the value of a product does not entirely depend on the cost for producing it. It is therefore risky for a company to set the price for its products merely based on such cost estimations (Schäder, 2006, p.169).

Competition based pricing is a favorable alternative for markets with a relatively high maturity level, where the offered products are quite similar (Schäder, 2006, p.79). For these products the price is normally the most distinguishable part of the value proposition. However, when the product is somewhat differentiated compared to the competitors' equivalent, this approach definitely becomes inappropriate to use, since the products no longer are comparable (Jagpal and Jagpal, 2008, p.156).

Customer based pricing, which is sometimes also referred to as *value based pricing*, requires a more comprehensive understanding of the customers' needs. In these situations the customer usually values the offer based on the total cost for the service. Accordingly, the price is simply set based on what the customer is ready to pay for the product, together with the provided service. This strategy is therefore usually applied when the products are more differentiated and customized (Schäder, 2006, p.95).

The most suitable pricing strategy, of the ones mentioned above, will also depend on how well-informed the customers on the market are about the product's characteristics and performance. If the customers are relatively uninformed, it may be preferable to give a high quality impression. The approach of signaling a high price is referred to as giving a pricing signal. This approach can then help increase the reservation price, i.e. the price the customers are prepared to pay for the product. Nevertheless, the reservation price for well-informed customers will not be affected by the pricing signals. Consequently, price signaling tends to be an adequate approach when the product is in the introductory phase of the life cycle, since the customers then are relatively uninformed. Equivalently, this approach is inappropriate for products in the maturity phase (Jagpal and Jagpal, 2008, pp.114-125).

3.2 Cost accounting

A company's business can be described as a production process, or more generally, as a refinement process (see Figure 3.1) where supplied resources are refined into products or services (Skärvad and Olsson, 2006, p.254). When these products or services are sold, the company gains revenues that are supposed to cover their costs, and hopefully also generate a profit. Subsequently, cost accounting can be described as a tool, or resource, used to plan and control the business. Hence, it often takes a holistic view of the company and can be seen as a way of transforming the supply chain into financial values (Olsson, 1998, p.10).

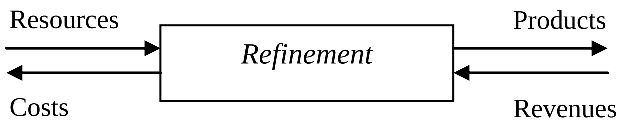


Figure 3.1: *A company seen as a refinement process (Skärvad and Olsson, 2006, p.256).*

As stated above, cost accounting can be seen as a tool. More specifically can it be said to help give an answer to; what purchased goods or services cost, what the refinement process cost or what the cost has been for labor, machine equipment, etc. Hence, cost accounting is often used in order to establish the actual cost of operations, processes, departments or products (Olsson, 1998, p.10).

Furthermore, there exist two principally different cost accounting approaches. These are pre-costing (Swedish: *förkalkylering*) and post-costing (Swedish: *efterkalkylering*). The difference is basically based on what information that is input. In the former approach the input is based on estimated figures in order to make proactive decisions, compared to the latter approach which is reactive and therefore based on ascertained figures. These approaches are therefore suitable to use in different situations (Hanson and Nilsson, 1994, p.36).

3.2.1 The purpose of cost accounting

Cost accounting can be used for many different purposes (Olsson, 1998, Hanson and Nilsson, 1994; Skärvad and Olsson, 2006). A description of the overall purpose of cost accounting would be that it continuously should provide a decision basis for returning assessments of costs, profitability and prices. Consequently, cost accounting can be performed for virtually any object that incurs costs, e.g. market segment, customer, product group, investment, project, etc. However, in general, it is common to distinguish between cost accounting for products and for investments. Furthermore, within companies, cost accounting is often built into so called cost systems (Hanson and Nilsson, 1994, p.30). A company's cost system then primarily has three functions (Cooper and Kaplan, 1999, p.1), which will be elaborated below.

Financial reporting, i.e. the cost system will facilitate manufacturing companies in the procedure of assigning production expenses each period to the output produced. In fact, this function is a legal requirement put on the company by external parties. Hence, this is an elementary prerequisite that is put on the company's cost system. This function of the cost system actually created the initial demand for making proper technological development and investments in these kinds of systems (Cooper and Kaplan, 1999, pp.2-4).

Economic feedback to employees and operators is received from the system about process efficiencies, with an obvious internal focus. Examples of economic feedback are cost control and profitability analysis. Cost control aims to answer questions such as; what was the cost per produced item this period, compared to the last period? This makes it possible to observe and spot deviations and give impulses to change in different regards. Profitability analysis is used with the purpose of understanding profitability by product group, customer or market segment. Managers can use cost accounting to support decision making, e.g. to cut costs or to improve profitability. Hence, it is an essential tool for many strategic decisions (Hanson and Nilsson, 1998, p.31).

Cost estimation of activities, products, services and customers are also internal and can be performed based on the available cost information. Cost estimation is commonly used as a decision basis for pricing. Especially where knowledge about the product cost is required in order to provide a price floor or a price that will give a positive contribution to cover the fixed costs (Hanson and Nilsson, 1998, p.31). Thus, one of the main objectives of cost systems is to produce meaningful product costs for pricing decisions (Zaman, 1997, p.2).

In practice, cost systems can actually have a much wider use than the three main functions explained above. It is not uncommon to use the information received from cost systems in other situations as well e.g. production planning. Information about what products to invest in and which products to terminate can be utilized both in a short term perspective, e.g. production planning, and in a long term perspective, e.g. strategic product choice. Other areas where cost systems are commonly used are in establishing budgets and assessment of inventories. However, it should be noted that in most of these cases, decisions are not made solely based on such cost systems or cost estimations (Hanson and Nilsson, 1998, p.31).

3.2.2 Benefits and drawbacks with cost systems

The obvious benefit with cost systems is that these save time. In reality, it takes too long time to make specific cost calculations other than for certain crucial decisions. Cost systems are therefore built in order to make the work load less time consuming and labor intensive. Additionally, companies may focus more on developing increased shares of structural capital, such as cost systems, as a way to relieve the human capital dependence (see Figure 3.2).

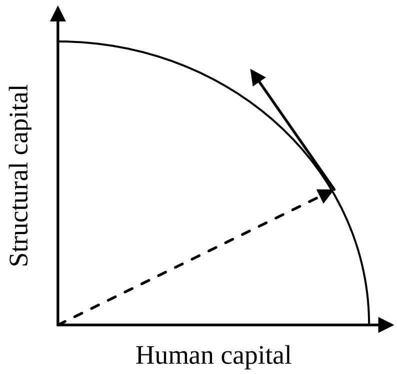


Figure 3.2: *Towards structural capital with cost systems (Ljungberg, 2009).*

For the cost calculations that are more of a routine matter, e.g. cost estimations for pricing, cost systems are appropriate to use (Olsson, 1998, p.25). The main drawback is that such routine cost systems do not always agree with the specific circumstances in a given decision situation. Consequently, a cost system has to be a compromise between the user-friendliness and time-saving on one hand and the loss of accuracy on the other hand (Olsson, 1998, p.25).

The design of cost systems should preferably strive against a minimized total cost that depends on the cost system accuracy. With a decreasing accuracy, the cost of errors in the cost figures causes the cost to increase rapidly. Similarly, the cost of measurement becomes too high for an increasing accuracy. As a result, the optimal consideration between the cost of errors and measurement will generate the minimized total cost (Cooper and Kaplan, 1999, p.59). This theoretically optimal cost system is illustrated in Figure 3.3.

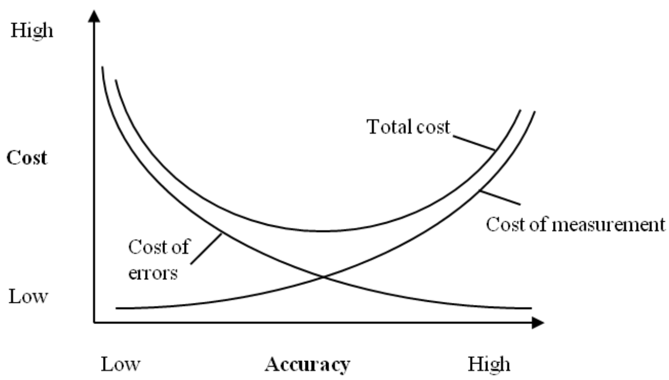


Figure 3.3: *Theoretically optimal cost system (Cooper and Kaplan, 1999, p.217).*

3.3 Cost estimations for pricing

It should be clear that cost accounting and pricing are closely related. Cost based pricing, but to some extent also customer and competitor based pricing, has their source in cost estimations. Therefore, the cost always fulfills a vital role. The following section will describe cost estimations for pricing in further detail by commenting on the available cost allocation approaches and two cost estimation methods.

3.3.1 Two cost allocation approaches

The first decision to make, before deciding upon which cost estimation method to use, is whether all costs should be allocated to the products or not. Which approach to pursue primarily depends on the purpose of the cost estimation, e.g. whether the purpose is to support a long or short term decision (Olsson, 1998, p.12).

As suggested by the name, *complete cost allocation* comprises all costs. The sum of all activities performed within a company should therefore equal the total costs of all the cost objects, during a given time period. This approach is appropriate to use as decision basis for pricing and for profitability analysis in a long term perspective (Skärvad and Olsson, 2006, p.263). Moreover, there are several different cost estimation methods that build upon the ideas of complete cost allocation. Two of the most commonly used methods are called traditional costing and ABC. There are also several other methods, most of which are specialized for specific purposes and appropriate in certain situations, e.g. process costing (Skärvad and Olsson, 2006, p.267).

Incomplete cost allocation implies that only a certain amount of the total costs actually are allocated to the cost objects. This is appropriate to use for pricing decisions and profitability analysis in a short term perspective (Skärvad and Olsson, 2006, p.263). How many and which costs to include varies significantly, it all depends on the purpose of the cost estimation and the decision to be made. There are several cost estimation methods that build upon the ideas of incomplete cost allocation as well. Two commonly practiced methods are contribution costing (Swedish: *bidragskalkylering*) and step costing (Swedish: *stegkalkylering*) (Skärvad and Olsson, 2006, p.288).

Sometimes, merely a limited number of cost objects (customers, product groups, etc.) are included in the cost estimation, or similarly merely a certain part of a company (manufacturing, sales, order processing, etc). The choice of cost allocation approach subsequently depends on the situation and what the information will be used for (Olsson, 1998, p.25).

3.3.2 Two complete cost allocation methods

As explained above, different methods of complete cost allocation exist. The most common ones are called traditional costing and ABC. The fundamental difference between these is linked to the procedure of allocating the overhead costs (Ask and Ax, 1995, p.54). In order to fully understand what has led up to the development of the different methods, it is useful to illustrate how the manufacturing companies' general cost structures have changed during the past decades.

There are mainly two trends in the cost structures of manufacturing companies that has affected the cost estimations significantly. These are clearly linked to the ongoing principle change from mass manufacturing to mass customization. It implies that companies tend to keep larger product portfolios with products that are more customized according to customers' increasing requirements, causing the product life cycles to decrease steadily (Pine and Davis, 1993, pp.3-7). The first trend is that the amount of fixed costs has increased remarkably. The second trend is that also the overhead costs have increased (see Figure 3.4). It is primarily these two trends that created a need for a new, and less distorted, cost allocation method (Ask and Ax, 1995, p.42). The traditional costing method namely tends to favor low volume products at an expense for high volume products (Bhimani, 2006, p.221).

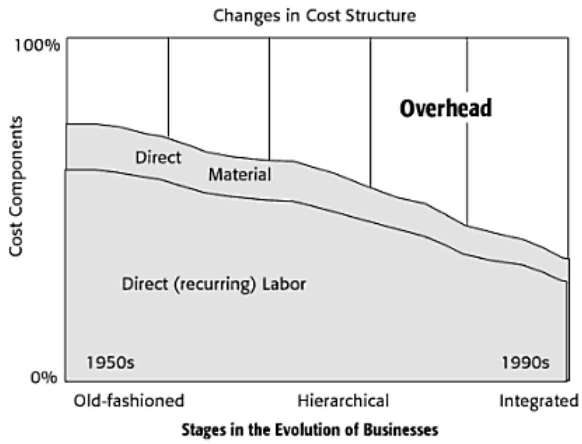


Figure 3.4: *Historical increase in overhead costs (Cokins, 2001, p.5).*

Ever since the traditional costing method was developed, during a time where overhead costs were relatively small in companies, little effort was put into making the allocation of these as fair as possible. The cost of errors was small compared to the cost of measurement. Hence, these were allocated based on volume and nowadays this is obviously not a fair way of allocating these costs (Johnson and Kaplan, 1986, pp.24-37).

However, as the cost structure slowly changed, the need for a new allocation method that could allocate these costs more fairly arose. Companies identified the need to use non-volume related cost drivers to better capture the reality. The result became what we today refer to as the ABC method (Gerdin, 1995, pp.25-27). ABC namely provides more detailed measures of costs, accurate cost information for pricing decisions and cost decisions for management. Hence, if the overhead costs constitute a large share of the total costs, then ABC is the preferred method to use (Zaman, 1997, p.4).

3.4 Activity Based Costing

The fundamental theory behind ABC is actually fairly easy to understand. Basically, the purpose of all activities carried out in a company, is to support the production or distribution of the company's products (Gerdin, 1995, p.62). This implies that all costs should be seen as product costs. However, the news with ABC is not that all costs should be seen as product costs. Instead, the news is linked to the focus that is put on the activities. It is the activities that consume the company's resources (material, labor, capital, etc.), with the purpose of refining the company's products (Gerdin, 1995, p.62).

The purpose of this section is to emphasize the fundamentals of ABC. The basic concepts in ABC will therefore be presented as well as their interrelationship. Then, the choice of approach to determine resource and driver volumes is presented, followed by some overall comments about ABC in contrast to other existing methods.

3.4.1 Main concepts

The main concepts in ABC are; resources, activities, cost objects, resource drivers and cost drivers. Although, it should be noted that the denotations used, linked to these concepts, varies considerably in literature. There is thus an evident need for consensus definitions of the main concepts.

Resources are an economic element that is applied or used in the performance of activities, e.g. salaries and supplies (Baker, 1998, p.4). A cost is therefore the amount of resources given up for a product, service, etc. Normally, the resources are quantified into monetary terms for calculating purposes (Gerdin, 1995, p.65; Lal and Srivastava, 2009, p.325). Maintenance can for instance be seen as a resource, which is spent by the company in order to provide its customers with products or services.

Activities are an aggregation of actions performed within an organization. It is the activities within the company that consume resources in order to produce an output (Baker, 1998, pp.2-4). Activities can be either actual work tasks or processes, performed within a company, by persons or machines. An activity can therefore be seen as a resource transformation process, as can be seen in Figure 3.5, where resources are input (Ask and Ax, 1995, p.55; Gerdin, 1995, p.66).

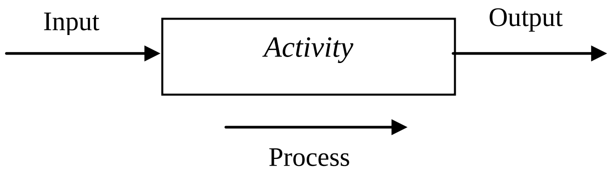


Figure 3.5: *The activity seen as a resource transformation process (Gerdin, 1995, p.66).*

Activities can preferably be classified hierarchically into five different levels; company/factory, production, product, batch and unit. The different levels express to what extent the activity actually is affecting the company (Ask and Ax, 1995, p.57). For instance, the unit level activities are performed each time the unit is produced. Hence, the costs will vary with the number of items produced. Differences in companies' organizational structure imply that the involved activities will vary. If the company structure is more complex, this kind of classification becomes more necessary, in order to understand how the costs will vary when the activities vary (Lal and Srivastava, 2009, p.325). Some examples of activities in a manufacturing company are given in Table 3.1, together with their appropriate activity levels.

Table 3.1: *Possible activities at proper activity levels (Ask and Ax, 1995, p.57).*

Activity	**Activity level**
Corporate management	Company/factory
Maintenance	Production
Product development	Product
Machine set-up	Batch
Manual operation	Unit

Resource drivers trace expenditures, i.e. resources, to work activities (Cokins, 2001, p.5). The basic idea is that the resource driver should express the use of resources for different activities (Gerdin, 1999, p.66). For instance, space is normally an appropriate resource driver for the resource called rent and utilities. Consequently, the actual space usage for an activity will determine the resource consumption. In Table 3.2 some frequently occurring resources are presented together with possible resource drivers.

Table 3.2: *Possible resources with proper resource drivers (Roztocki et al., 1999, p.5).*

Resource	Resource driver
Administration	Time (h)
Rent and utilities	Space (m^2)
Product shipment	Weight (kg)
Business travel	Distance (mile)

Cost objects are any product, service, contract, project, or any other work unit for which a separate cost measurement is desired. It is the cost objects within the company that consume activities. The main objective with cost estimations are to determine the actual cost of the cost objects (Baker, 1998, pp.4-5), e.g. for pricing decisions.

Cost drivers are any factor that causes a change in the cost of an activity. Hence, the driver is the cause of activity and the activity reveals the effect of the driver (Baker, 1998, pp.3-5). A cost driver is something that easily can be described in words, but not necessarily in numbers. However, it is required to be quantitative in order to use measures that apportion costs (Cokins, 2001, p.17). Besides, a company does actually not manage its costs; rather it manages what causes the costs to occur, i.e. the cost drivers (Cokins, 2001, p.10). For instance, set-up time may be an appropriate cost driver for the activity called machine set-up, but the number of set-ups may also be appropriate. The choice depends on the current situation within the company, although merely one cost driver can be chosen for an activity. Therefore, if the set-up time is chosen to be the cost driver, it then is the actual set-up time for a cost object that will determine the activity consumption. As can be seen in Table 3.3, the cost driver is the base for allocating the activity costs to cost objects. In addition, some examples of activities and possible cost drivers are presented.

Table 3.3: *Possible activities with proper cost drivers (Ask and Ax, 1995, p.60).*

Activity	Cost driver
Incoming deliveries	Number of deliveries
	Number of components
Machine set-ups	Number of set-ups
	Set-up time
Material transport	Distance transported
	Number of transports

The overall interrelations of the main concepts in ABC, which were described above, are illustrated in Figure 3.6. The activities consume resources, whereas cost objects on the other hand consume activities. Furthermore, the cost drivers are used to determine every cost object's consumption of activities, i.e. to allocate the activity costs to the cost object. The sum of a cost object's consumption of all the activities equals the total cost for the cost object. Equivalently, the resource drivers are used to determine every activity's consumption of resources, i.e. to allocate the resources to the activities.

Figure 3.6: *The interrelation between the main concepts in ABC (Ax and Ask, 1995, p.61).*

3.4.2 Methods to determine resource and driver volumes

The resource, resource driver and cost driver volumes are initially unknown and therefore have to be estimated properly. A deranged estimation may cause an under- or overestimation of the total available resources within the company, which in addition will provide an ambiguous unit cost for the cost objects. Hence, the effort needed to perform these estimations should preferably not be underestimated (Ask and Ax, 1995, p.66). The resource, resource driver and cost driver volumes will altogether and generically be referred to as *operational volumes* beneath, in order to express the possibility of applying the methods for all of these alternatives.

A couple of methods for determination of operational volumes exist; normal year (Swedish: *normalår*), post-estimation (Swedish: *efterberäkning*), present estimation (Swedish: *nuberäkning*), budget or the practical maximum capacity method. The latter alternative has been introduced especially for ABC approaches, while the former ones are all used in various traditional costing situations (Gerdin, 1995, pp.102-104). These methods will be clarified separately below.

The principal approach for the *normal year method* is that the operational volume spent on a “normal year” should be used in the cost estimations. The challenge then becomes to decide what constitutes a normal year for the company, especially if its business is fluctuating abnormally. It is then common to determine the mean value of the operational volume over the past few years. The main advantage with this method is linked to the fact that irregular fluctuations are evened out smoothly (Gerdin, 1995, p.104). When the cost estimation will be used for pricing, this method is very suitable, because a longer period has been taken into account. In addition, it becomes possible to investigate in what way the financial result is affected when the operational volumes deviate from what was expected to be a normal year (Hanson and Nilsson, 1998, pp.127-129).

In the *post-estimation method* the calculated operational volume for the previous period is used for the subsequent period. It can preferably be used when the variations in operational volume over time, are comparatively small. The *present estimation method* implies that the ascertained costs and operational volumes are used. Hence, these figures can merely be determined at the end of a period. In the b*udget method* the figures from the budget are used in the cost estimations (Hanson and Nilsson, 1998, pp.127-130).

The method called *practical maximum capacity* refers to a situation where the operational volume is considered to be equal to the full capacity utilization (Hanson and Nilsson, 1998, p.131). Normally, there is a difference between the theoretical and the practical maximum capacity, where e.g. the former do not take any machine stops into account. In literature, it is recommended to use the practical maximum capacity method for ABC, because it becomes possible to identify the difference between spent and available resources. The intention is to ensure that customers do not have to pay for anything but the cost for spent resources, by merely including these in the cost estimations (Gerdin, 1995, pp.109-115). The relation between spent and available resources is clarified in Figure 3.7.

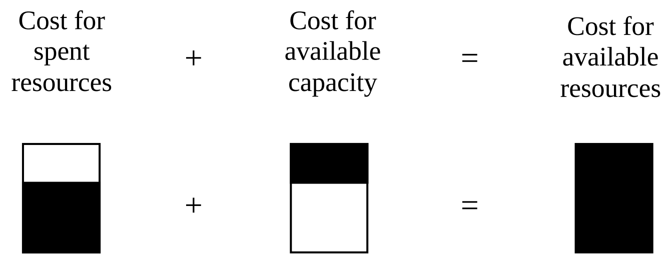


Figure 3.7: *The relation between spent and available resources.*

In conclusion, it is preferable to use the practical maximum capacity for ABC according to literature, since merely the cost for spent resources will burden the products. The excess capacity will then be possible to identify, which is a prerequisite for proper Activity Based Management (ABM). For the other methods the information about the excess capacity will be hidden in the cost object cost. The great advantage with the normal year method is though that the capacity fluctuations will be evened out when taking several periods into consideration. Furthermore, it is crucial to consider all the available resources in the cost estimations for pricing decisions, in order to ensure that the total revenues will cover the total costs. In these situations the normal year method therefore should be superior to the practical maximum capacity; especially if ABM not will be applied within the company (Gerdin, 1995, pp.118-121).

3.4.3 ABC assessment

Quite often, ABC is claimed to be the replacement solution for traditional costing systems. Hence, some overall aspects about the ABC method, compared to other available alternatives, will be briefly commented on.

ABC systems can provide a basis for the important aspects of performance measurement and to bring more awareness among managers and staff of the non-value added concept (Zaman, 1997, pp.1-2), e.g. to help identify more accurate resource and driver volumes. Hence, it may facilitate a company’s performance from an internal perspective (Ax and Ask, 1995, p.76). Moreover, the principles in ABC are not limited to be used merely for cost estimations, i.e. it can be extended to ABM (Activity Based Management) that includes several other purposes. Then the overall goal is to reach more efficient resource utilization by recognizing what actually drives the costs. This has actually also been presented as the main argument for adopting the ABC approach (Ax and Ask, 1995, pp.95-97). Unfortunately, the ABC systems definitely require much effort to be spent on making sure that its supremacy can be maintained by continuously keeping it up-to-date (Gerdin, 1995, p.124).

Furthermore, the expressions used in ABC are clearly linked to the actual daily work tasks, which therefore clearly facilitate the internal communication with all employees, independent of their position (Ax and Ask, 1995, p.77). Then it becomes easier to transform strategic goals and decisions into necessary operational work tasks. Additionally, the method provides stronger cause and effect relations. The actual sources to the costs are therefore revealed more clearly, whereas these can be identified properly. It is namely the activities that cause the costs according to the ABC fundamentals (Ax and Ask, 1995, p.76). As mentioned previously in section 3.4.2, it should be noted that some awareness is required when applying the practical maximum capacity to determine the resource and driver volumes, when the intention simultaneously is to use the ABC approach for pricing decisions. If the cost for all the available resources does not equal the cost for spent resources, then all the costs within the company will not be covered in total. However, a great awareness among managers will help the company avoid these kinds of unnecessary pitfalls (Gerdin, 1995, p.121).

3.5 Procedures for ABC implementation

Several suggestions for ABC implementation procedures exist that basically build upon the same basic ideas. Two somewhat complementary alternatives, which are applicable for all types of companies, are presented below. The first is presented as a five step process from a rather theoretical perspective, compared to the second that contains eight somewhat more practical steps.

3.5.1 A five step procedure for ABC implementation

At least five basic steps have to be performed when implementing ABC. The procedure should be seen as more of an iterative process, since there is dependence between the steps (Ax and Ask, 1995, p.62). The steps that have to be completed are shown in Figure 3.8, and then a brief explanation of every step will be carried out.

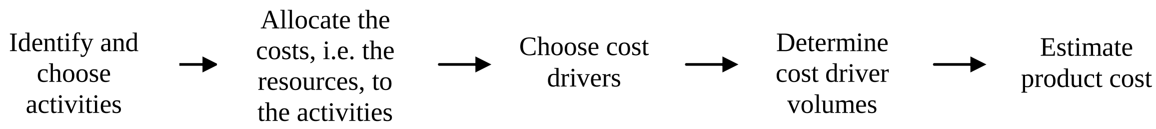


Figure 3.8: *The five steps for ABC implementation.*

Identify and choose activities deals with the task of investigating which concrete work tasks that are being carried out in the organization. A typical work procedure would be to divide the organization based on its functions, and then to perform interviews with the employees that actually work there. These persons probably have the best answers to what activities that are being carried out. Hopefully, they also possess more specific information about what would drive the costs and may even be helpful in the process of formulating appropriate cost drivers. Other work procedures may be to use direct observations, analyze organization charts and flowcharts (Ax and Ask, 1995, pp.63-64).

Subsequently, the next step would be to *allocate the costs, i.e. the resources, to the activities*. Based on some identified resources the task is to investigate what the total cost for a separate activity would be. This allocation procedure is considered to be frequently underestimated, because it is crucial that the activity costs will not get distorted. Otherwise the accuracy will be lost, even though the subsequent steps will be treated seriously (Ax and Ask, 1995, pp.64-65).

The next step is to *choose cost drivers*, which are required in order to estimate the products' consumption of activities. Here, every single activity should have a separate cost driver, i.e. activities should be merged if these have the same cost driver. This is necessary in order to reduce the complexity of the estimations. Another approach would be to merge all activities, with smaller costs, into one larger activity and then to allocate these costs with the best possible cost driver. Consequently, it is essential to find a suitable balance between accuracy and user-friendliness (Ax and Ask, 1995, pp.65-66).

Next, *the cost driver volumes* are determined; in order to be able to perform an estimation of how large activity costs that a specific product consumes. The total product cost namely constitutes the sum of the costs for all the activities that it is consumed. Additionally, as stated in the previous section (3.4.2), the cost driver volumes have to be determined properly according to one of the mentioned methods. This will then generate the unit cost of the cost driver (Ax and Ask, 1995, p.66).

Finally, it is possible to e*stimate the product cost* based on the given information. The calculations will be performed by separating the different activity levels and to collect all the activities that fall under each level. Thereafter, the cost per unit can be determined. Then the costs can be summarized for the different activities that belong to every single product (Ax and Ask, 1995, pp.71-76).

3.5.2 An eight step procedure for ABC implementation

Another proposed procedure for tracing overhead expenses to cost objects is illustrated in Figure 3.9. It is given as an eight step procedure that is particularly developed for small companies.

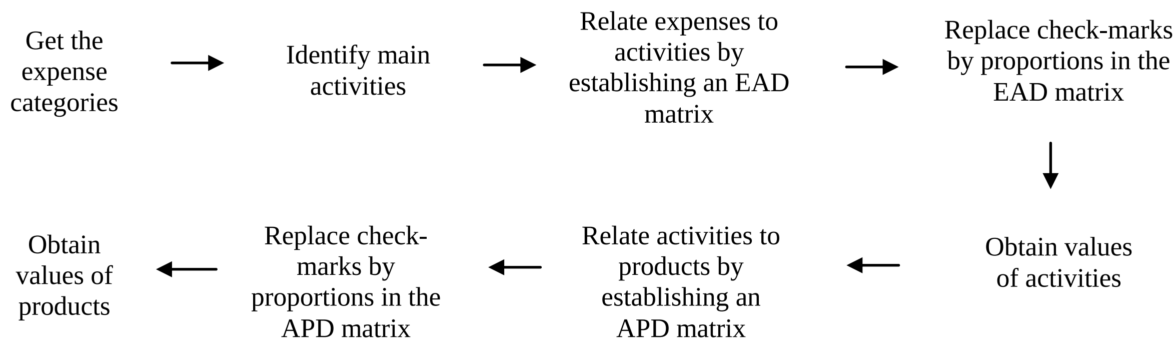


Figure 3.9: *The eight steps for ABC implementation.*

Initially, the income statement of the investigated company should be examined in order to g*et the expense categories*, and simultaneously the appropriate resource drivers can be determined. Subsequently, it is suitable to start *identify the main activities* performed at the investigated company, with the belonging cost drivers. In the next step, the now determined expense categories and main activities have to be linked together, preferably by *establishing an Expense – Activity – Dependence (EAD) matrix*, where every relation is marked out with a check-mark. The appointed *check-marks in the EAD matrix may then be replaced by proportions*, where each column must add up to one (see Figure 3.10). Based on this information, together with the value of each expense category, it is now possible to *obtain the values of the activities* as the sum of all the expenses on a given row in the EAD matrix (Roztocki et. al., 1999, pp.3-5).

Activities \ Expense category	*Administration*	*Depreciation*	*Rent and utilities*	*Office expenses*	*Transport*	*Interest*	*Product shipment*	*Business travel*	*Business insurance and legal expenses*	*Advertising*	*Entertainment*	*Miscelaneous expenses*
Customer contact	0.06		0.01	0.24				0.63		0.64	0.58	0.09
Quote preparation	0.10		0.05	0.14								0.09
Engineering work	0.10	0.70	0.12	0.08				0.14				0.09
Material purchasing	0.08		0.09	0.09		0.80						0.09
Production preparation	0.04		0.11	0.03								0.09
Material receiving and handling	0.05		0.09	0.06	0.40				0.11			0.09
Production management	0.20		0.13	0.01								0.09
Quality assurance	0.10	0.30	0.20	0.02								0.09
Product shipment	0.05		0.12	0.05	0.60		1.00		0.23			0.09
Customer payment	0.04		0.01	0.08					0.46			0.09
General management	0.18		0.07	0.20		0.20		0.23	0.20	0.36	0.42	0.09

Figure 3.10: *A fictitious EAD matrix (Roztocki et. al., 1999, p.6).*

Similarly, an *Activity – Product – Dependence (APD) matrix should be created* to mark the dependence between the performed activities and the provided products. Then the *check-marks should be replaced by proportions in the APD matrix* (see Figure 3.11). Finally, it is possible to *obtain the values of the products*, based on the previously calculated values of the activities, by summing up all the activities on a given row in the APD matrix (Roztocki et. al., 1999, pp.3-5).

Products \ Activities	*Customer contact*	*Quote preparation*	*Engineering work*	*Material purchasing*	*Production preparation*	*Material receiving and handling*	*Production management*	*Quality assurance*	*Product shipment*	*Customer payment*	*General management*
Product 1	0.00	0.00	0.20	0.14	0.21	0.12	0.34	1.00	0.32	0.21	0.33
Product 2	0.53	0.60	0.10	0.34	0.27	0.41	0.27	0.00	0.26	0.38	0.33
Product 3	0.47	0.40	0.70	0.52	0.52	0.47	0.39	0.00	0.42	0.41	0.34

Figure 3.11: *A fictitious APD matrix (Roztocki et. al., 1999, p.8).*

4 Packaging Theory

This chapter will provide the theoretical foundation needed to understand the characteristics of box packaging made from carton and corrugated cardboard. The chapter begins with a brief description of carton and corrugated cardboard as packaging materials. It then continues with a discussion of packaging design with an obvious focus on the FEFCO standard. Finally, the chapter gives an overview of the general manufacturing process of these products.

4.1 Packaging materials

Every packaging material has its unique properties (Packforsk, 2000, p.15), which consequently make them suitable for different purposes and in different situations. The decision of which packaging material to use is mainly based on; mechanical, climatic and chemical properties (Jönson and Johnsson, 2006, p.48). Two common box packaging materials are carton and corrugated cardboard, which are presented below.

4.1.1 Carton

Carton can be defined as paper that exceeds 0.3 mm in thickness (Packforsk, 2000, p.15). Consequently, it is a renewable resource and can be recycled. Carton is a packaging material with high stiffness and mechanical strength but it is also considered to have good printing properties (Jönson and Johnsson, 2006, p.49). It can favorably be combined with other packaging materials into so called laminates. These combine the properties from different materials to form new materials that are suitable for specific purposes. Two of the most common laminate materials, combined with carton, are plastic and aluminum. In such a laminate, the carton often accounts for stiffness, light protection and printing possibilities. Other laminate materials often account for functions such as moisture barrier, heat sealing, etc. (Paine, 1991, p.163). An example of a common laminate packaging is the milk carton (Packforsk, 2000, p.15).

As a result of these characteristics, carton is a very common and useful packaging material. It is important though to keep in mind that the characteristics of different carton material qualities can vary substantially. Every quality has its own characteristics and can offer the final product specific properties in terms of fiber strength, printability, runability, etc. Given the carton material quality, the grammage is also an important factor to consider. The grammage is a term that specifies the weight of a sheet with one square meter area and gives an indication of the material thickness. Given the carton material quality, certain properties of the final package can be modified by changing the grammage, e.g. robustness (Paine, 1991, p.65).

It is the combination of the carton material quality, grammage and possible laminates that together affects the final product’s properties. When utilized in corrugated cardboard boxes, it is primarily the external appearance aspects the carton liner modifies, e.g. printability, reproduction of colors, furnishing effects, physical feel, etc. (Paine, 1991, p.163).

4.1.2 Corrugated cardboard

Corrugated cardboard consists of two or more layers of paper, where at least one layer is plane and one layer is corrugated. The plane layers are called *liners* and the corrugated layers *fluting*. The simplest corrugated cardboard structure consists of two layers of paper, where one layer is wave formed and the other plane. This type of corrugated cardboard is referred to as *single face*. Several other structures exist as well and are created by adding more layers. The most common structure in box packaging is the *single wall*, which is made up by three layers of paper, where the middle layer is wave formed. Other examples of common structures are the *double wall* and *triple wall corrugated cardboard* (Jönson and Johnsson, 2006, p.54). Figure 4.1 illustrates three common structures of corrugated cardboard.

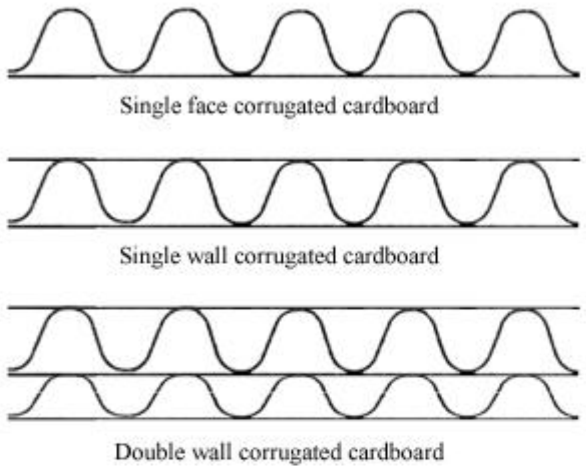


Figure 4.1: *Corrugated cardboard structures.*

In the corrugated cardboard, the plane layers account for strength and cohesiveness, whereas the fluted layers account for protection against impacts and pressure (Packforsk, 2000, pp.15-16). The rigidity of the corrugated cardboard is influenced by four factors; the height and number of flutes, their integrity and the fiber orientation of the paper used (Jönson and Johnsson, 2006, p.57). Normally, corrugated cardboard is manufactured in one of three flute heights, each designated with a letter code; B, C and E. Their flute configurations are presented in Table 4.1. There are, however, other flute configurations available on the market as well, which illustrates the possibility to adapt the material to numerous applications. Even though, corrugated cardboard boxes are most commonly used as either transport or consumer packaging (Calver, 2004, p.74; Jönson and Johnsson, 2006, p.54).

Table 4.1 *Flute configurations in corrugated cardboard (Jönson and Johnsson, 2006, p.57).*

Flute	Average flute height (mm)	Average number of flutes (per metre)
A	4.70	110
C	3.61	129
B	2.46	154
E	1.14	295

4.2 Packaging design

This section intends to briefly comment on the design of box packaging made from carton and corrugated cardboard. The concept *packaging design* is intended to describe the construction of a packaging, which also could be referred to as the blueprint of a packaging solution. The design aims to illustrate what the package looks like; both as a flat blank on a sheet but also in its final shape (see Figure 4.2). It should preferably also provide information about how the package is formed, i.e. how it is assembled, folded, glued, erected, etc (Jönson and Johnsson, 2006, pp.102-106). It should be noted that this interpretation of packaging design does not include the graphical aspects; hence these are included in the graphical design concept. Figure 4.2 illustrates a common example of a box packaging design, lying flat on a sheet to the left and in its final shape to the right.

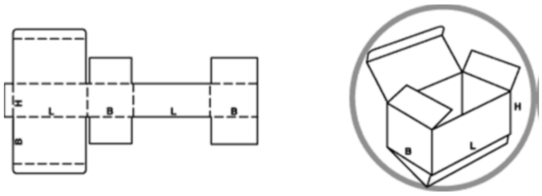


Figure 4.2: Example of a packaging design.

The packaging design process can actually have two very distinctly different faces. On one hand it can be a very creative process where a vague idea or concept of a packaging solution is converted to a realizable and manufacturable packaging design. Whereas it on the other hand could be a standardized and repetitive process with no, or very little, room for creative efforts. In the latter case, standards for packaging designs are frequently used in order to save both time and effort (Jönson and Johnsson, 2006, pp.106-112). One such standard for box packaging is the FEFCO standard, which is elaborated below (FEFCO, 2010).

4.2.1 FEFCO

There exist several different standards of packaging designs. One is the FEFCO standard, which has been developed by the European Federation of Corrugated Board Manufacturers. The organization is a respected information and competence centre in relation to the corrugated industry and publishes various publications targeting mainly customers and retailers. Amongst these publications it has published a case code catalogue with proposed standards for corrugated box packaging. This is an official system to substitute long and complicated verbal descriptions of standard packaging designs with a specifically assigned code number, used world-wide. Additionally, the system has been adopted by the International Corrugated Case Association (ICCA) (FEFCO, 2010).

According to the FEFCO structure, designs can be separated into different categories depending on certain characteristics. The designs that belong to the same category are denoted by the two first numbers in the case code. Each category has its own characteristics, which is exemplified by three common categories below. It should also be mentioned that the standard provides helpful tools when developing new packaging solutions. The design can namely be somewhat manipulated based on one of the standard styles, or simply a pure combination between two or more of these (FEFCO, 2007, p.6).

Category 02 comprises slotted-type boxes that consist of basically one piece; with a glued, stitched or taped manufacturer’s joint together with top and bottom flaps. These designs are shipped flat, ready to use and require closing using the flaps provided. The design 0206, which is illustrated in Figure 4.3, is an example of a design from this category (FEFCO, 2007, p.25).

0206

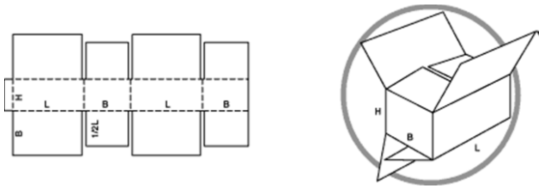


Figure 4.3: *Illustration of FEFCO design 0206 (FEFCO, 2007, p.27).*

The 0421 design belongs to the *category 04*, which is illustrated in Figure 4.4. This category typically includes folder-type boxes and trays that normally consist of only one piece of board. The bottom of the box is hinged to form two or all side walls and the cover. In some cases locking tabs, handles, display panels, etc. can be incorporated into these designs (FEFCO, 2007, p.39).

0421

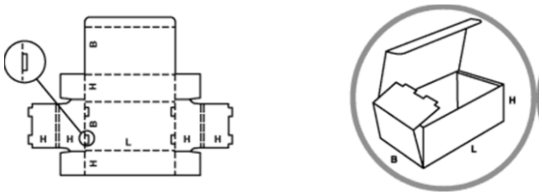


Figure 4.4: *Illustration of FEFCO design 0421 (FEFCO, 2007, p.43).*

The 0713 design, illustrated in Figure 4.5, belongs to the *category 07*. These designs typically consist of basically one piece and can have dy-glued cases. In addition, these are shipped flat and ready to use, and their main advantage is the easy set-up (FEFCO, 2007, p.80).

0713

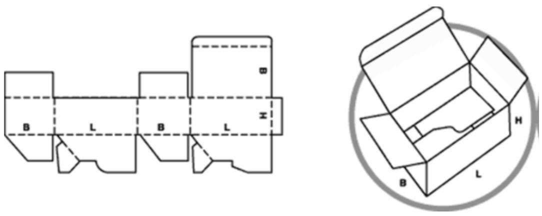


Figure 4.5: *Illustration of FEFCO design 0713 (FEFCO, 2007, p.81).*

4.2.2 Other design aspects

The packaging design is one of the most important factors to consider when choosing a box packaging solution. In the description of the FEFCO box standards above, the designs were categorized based on some common characteristics. There are, however, other aspects to consider too, which are not specific to a certain FEFCO category. Therefore, a few comments about these aspects are provided below.

An advantage with certain designs, such as the 0713, is that these can be erected automatically. This is especially favorable for customers that tend to order large quantities and already have invested in technical equipment that are able to perform such operations. This means that the filling and closing process can be easily automated by incorporating a machine. In many cases this can lead to a higher throughput and cost savings, since those activities usually are labor-intensive. It is also important to consider the closure of the packages, which can be either one or a combination of the following methods; gluing, taping, interlocking and stitching (FEFCO, 2007, p.7). If it is possible to automate the erecting activity easily or not is however related to the individual designs and not their categories.

Another aspect that is important to consider from both a functional and a manufacturing perspective is the choice of glue. Generally, two types of glue with clearly different properties exist; hotmelt and cold glue. The former is preferable to use since it sticks faster (Limgrossen, 2006a), while the latter is advantageous because it eventually gives stronger joints Limgrossen, 2006b). The number of glue strings a certain design requires is linked to the category it belongs to and it will affect the properties of the packaging. Therefore, it is favorable to be aware of this fact when deciding upon a packaging solution. The type of glue that is used can on the other hand be more or less defined by the design, but it is not linked to a specific category. Hence, this should also be taken into account.

From both a cost and an environmental perspective the consumption of material is a critical aspect to consider. The packaging design affects the material consumption in two ways. Explicit, by the amount of material that is needed to enclose the product and implicit, by the sheet utilization it can provide. The latter factor is intended to describe how large proportion of the sheet that is actually made up by packaging blanks in comparison to waste material, as illustrated in Figure 4.6. In order to increase the utilization rate, the blanks are interlaced in various patterns on the sheet (Twede and Selke, 2005, pp.361-363). However, certain designs can provide a much higher utilization rate then others due to the shape of the packaging blank. This issue is also related to the individual design rather than which category it belongs to.

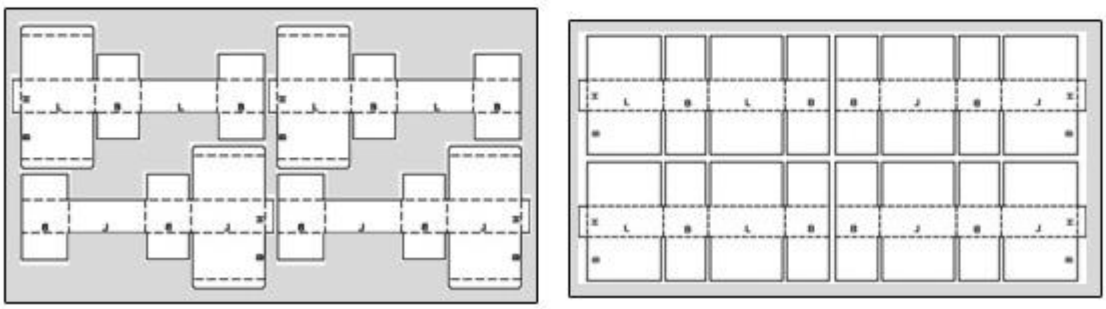


Figure 4.6: *Visualization of sheet utilization for two different designs.*

4.3 Packaging manufacturing

This section intends to give an introduction to the manufacturing of box packaging made from carton and corrugated cardboard. The number of manufacturing steps can obviously vary depending on the product characteristics and the utilized manufacturing techniques. Hence, the intention of this description is not to describe all possible manufacturing steps, but rather to provide an overall understanding of a general manufacturing process. It is also worth noting that the various manufacturing steps explained below can be more or less integrated or separated in manufacturing lines. Large-scale companies might stretch over all steps and provide a portfolio of various manufacturing techniques, while small-scale companies are rather specialized in a certain manufacturing step or can only offer a very limited number of manufacturing techniques (Corner and Paine, 2002, pp.193-195; Twede and Selke, 2005, pp.401-403).

4.3.1 Paper manufacturing

This first stage when manufacturing box packaging made from carton and corrugated cardboard includes the transformation from raw material to paper. Paper manufacturing is a continuous processing manufacturing that is characterized by having a relatively narrow product range and very high-volume demand. The high volumes justify high investments and large parts of the processes are fully automated (Hill and Hill, 2009, p.151). The process starts off with either a mechanical or chemical pulping, where paper pulp is produced, primarily from wood pulp or vegetable fiber materials. Since paper is a recyclable material, the process could also begin with processing of recycled paper in order to make new paper pulp. It then continues through a series of processes, as illustrated in Figure 4.7. The first stage is to evenly distribute the pulp into a paper web. Water also has to be removed from the paper web, which is accomplished by pressing and drying it. Finally, the paper can be given certain properties through coating, bleaching or similar, before it is being sized and winded up on rolls (Twede and Selke, 2005, pp.209-225). These stages are normally integrated in large-scale factories with high-volume manufacturing. The outcome from the paper manufacturing can later be used both as carton liners and in the manufacturing of corrugated cardboard (Advameg, 2010).

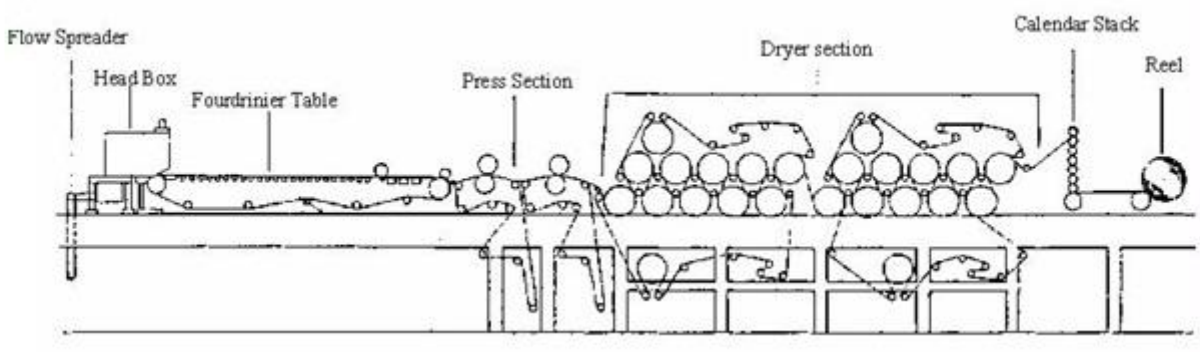


Figure 4.7: *A classic paper manufacturing machine (Twede and Selke, 2005, p.211).*

4.3.2 Corrugating

Manufacturing of corrugated cardboard is usually made in a traditional corrugator. The corrugating manufacturing principle is illustrated in Figure 4.8. The paper that will be waved is first softened with high-pressure steam, before it is formed in between large corrugating rolls. After it has been formed, it is dried through hot plates under pressure from rolls. Simultaneously, the corrugated paper is glued together with a plane paper to form a single face corrugated cardboard. This can then be sized and winded up on rolls. The procedure is the same for the various flute configurations; with the only difference being a change of corrugating roll. The principle can also be expanded to handle other structures than the single face, e.g. single wall or double wall structure. These can however not be winded up on rolls and will therefore be cut into sheets at the end of the machine, as illustrated in Figure 4.8. The paper qualities of the plane and waved layer can be the same but are often different since these provide different functions (Advameg, 2010).

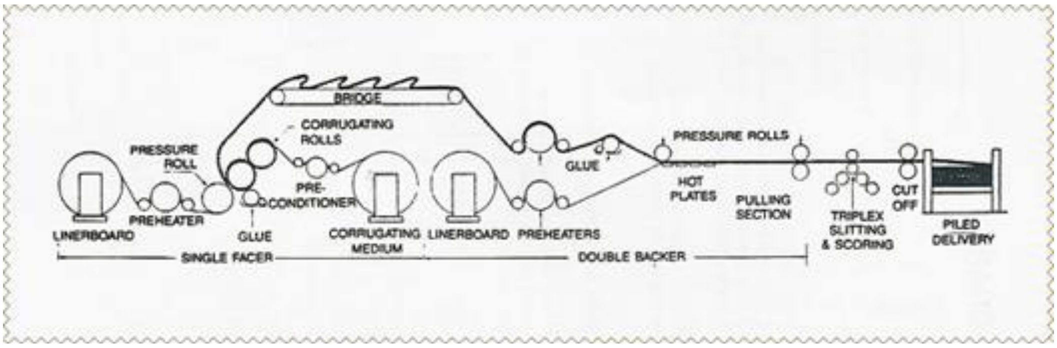


Figure 4.8: *A principle sketch of a corrugating machine (Jönson and Johnsson, 2006, p.61).*

4.3.3 Printing and lamination

The purpose of printing is to transfer graphical design from an original, e.g. digital copy, onto a printing medium, e.g. package. Printing is thus referred to as a process for reproducing text and pictures. There are several printing techniques used within the packaging industry today, including; flexography, digital printing, gravure, inkjet, screen printing, etc. The lithographic *offset printing technique* is however very common and can offer a broad range of applications (Paine, 1991, p.167).

The principle for offset printing is illustrated in Figure 4.9. As can be seen in the figure, the principle is to transfer inked images from a thin plate (on the plate cylinder) to a rubber blanket (on the offset cylinder) and then onto the printing surface. The plates are wrapped around the circumference of the plate cylinder, where the printing areas have been made fat and ink receptive. The non-printing areas are on the contrary kept wet by water and are therefore ink repellent. During one turn of the cylinder, the plate first meets a dampening roll before it meets an ink roll that transfers the ink to the ink receptive parts. After that, the plate comes in direct contact with the rubber blanket on the offset cylinder, which consequently then transfers the ink to the printing medium. The name offset derives from the fact that the plate does not actually touch the printing surface (Corner and Paine, 2002, p.184).

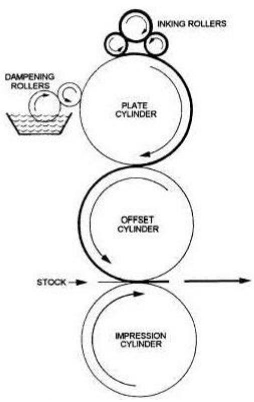


Figure 4.9: *The principle for offset printing (Jönson and Johnsson, 2006, p.67).*

Modern offset presses can be found in a wide range of sizes. From small printers used for small single-color jobs, to massive presses capable of printing millions of copies of packaging materials in full color. Normally, there are at least four rolls in a printing machine, one for each CMYK color, which is a color model used in printing and represents the four colors; cyan, magenta, yellow and key (almost exclusively black). By blending these together it becomes possible to provide a wide range of colors (Twede and Selke, 2005, p.291). A fifth roller is also often added and can be used to add a fifth color or a varnish to modify the appearance or feel of the printing surface. The offset technique provides high quality images that create the highest level of photo realistic graphics. It is therefore suitable for markets where marketing aspects are important; such as electronics, entertainment, pharmaceuticals, beverages, etc. (Jönson and Johnsson, 2006, p.66).

When using the offset printing technique for box packaging, the printed medium is a carton liner. Therefore, if the final package should be made in corrugated cardboard, it is necessary to go through a lamination process afterwards. In this process the carton liner and the single face corrugated cardboard is glued and merged together, similar to the manufacturing of corrugating cardboard described in the previous section. The combination of the lithographic offset technique and the following lamination technique is often referred to as *litho lamination*. It should then be noted that in order to gain strength and rigidity in the packaging it is important to merge the carton liner and the single face corrugated cardboard in a particular manner. The flute orientation of the corrugated cardboard should be twisted 90 degrees against the fiber orientation of the carton liner (Twede and Selke, 2005, p.361). This principle is illustrated in Figure 4.10.

Figure 4.10: *The principle for lamination.*

4.3.4 Forming, filling and closing

At this stage, sheets of single wall corrugated cardboard or carton will be transformed into filled box packages. This can be done in various ways depending on which product, package and equipment that is present. However, any line always includes the three basic stages; forming, filling and closing. In general, these steps can be combined directly into so called *complete packaging lines* or even built together through a number of conveyor systems in so called *integrated packaging lines* (Jönson and Johnsson, 2006, p.69). Yet, on the other hand, these can be separated both in time and place, and be performed by different actors. In the case of box packaging there are mainly two types of alternative packaging lines. The first is the complete packaging line, and the second is a separated packaging line where the forming is separated from the filling and closing (Jönson and Johnsson, 2006, p.72).

In a complete packaging line, box packages and products are brought in to be formed, filled and closed at a single location. This is typically the case for high-volume manufacturers of standard products where higher machine investments are justified. By postponing the forming stage from the packaging manufacturer to the filler, the need for transports can often be lowered since flat packaging blanks can be shipped at a higher utilization rate than formed box packages. The other alternative is that the box packages are pre-formed at the packaging manufacturer, shipped readymade and then filled and closed at the product manufacturer. This is typically the case where manufacturers of consumer products, e.g. electronics, spare parts, food etc., has not yet invested in a complete packaging line (Jönson and Johnsson, 2006, pp.69-72).

In the forming stage, sheets are transformed into fill ready packages, which actually include several manufacturing steps. First, the packaging blank needs to be detached from the sheet, which is accomplished in a die cutting machine. This is also where the holes and creases are made so that the package can be readily glued or stitched as required, and subsequently erected to the correct shape. Before a new sheet is cut, a tool that matches the packaging blank needs to be created. After the die cutting packaging blanks may need to be striped clean from waste material in order to proceed in the manufacturing process. The forming is then completed in a folding machine where the packaging blank is folded, glued and stitched into its final shape. The box packaging is then ready to be filled and closed (Paine, 1991, p.169).

Except from the basic steps, a packaging line often is complemented with other functions, such as; marking, weighing, labeling, etc., which also can be more or less integrated into the line (Jönson and Johnsson, 2006, p.69). These steps complete the manufacturing of box packaging made from carton and corrugated cardboard. The life cycle then continues through the remaining life cycle stages, e.g. transport, usage and recycling.

5 Empirics

This chapter begins with a thorough description of FrontPac, including their supply chain, products and organization. As a background to the developed cost estimation system, a few comments about their pricing strategy and cost structure follow. The next section presents the identified resources, activities, resource drivers, cost drivers and cost object components. Their relationships are then described and illustrated visually at the end of this chapter, which finally leads up to the allocation of resources to activities and activities to cost objects.

5.1 FrontPac AB

FrontPac AB is a manufacturing company specialized in the manufacturing of packaging and displays made from offset printed litho laminated corrugated cardboard. The company currently employs approximately 100 persons and last year's turnover was 120 MSEK (2009). The following section intends to describe the company from both an external and internal perspective. In order to illustrate the external perspective, FrontPac is placed as the focal company of their supply chain, as a way to facilitate the understanding of their business environment. To complement this picture, a detailed explanation of their products is presented as well. The description from the internal perspective is divided into two parts. The first part will briefly cover the overall organization of FrontPac. In the second part, focus will be directed towards the manufacturing and warehousing processes where the description will be more thorough and comprehensive.

5.1.1 Supply chain

The supply chain, where FrontPac is put as the focal company, is generally illustrated in Figure 5.2. As can be seen in the figure, the company is closely tied to two of the other companies in the corporate FrontPac-group; FrontWell and FrontPrint. These companies belong to FrontPac's group of first tier suppliers and provide them with two main functions; manufacturing of single face corrugated cardboard and offset printing of carton liners. These materials will then be transformed into packaging or displays in FrontPac's manufacturing process. The group of second tier suppliers constitutes the earliest actors in the supply chain. These are mainly paper manufacturers that extract raw material and turn it into various forms of paper, as described in section 4.3.1. Most of the time the second tier suppliers supply the first tier suppliers with paper material, but these can also in certain cases deliver directly to FrontPac.

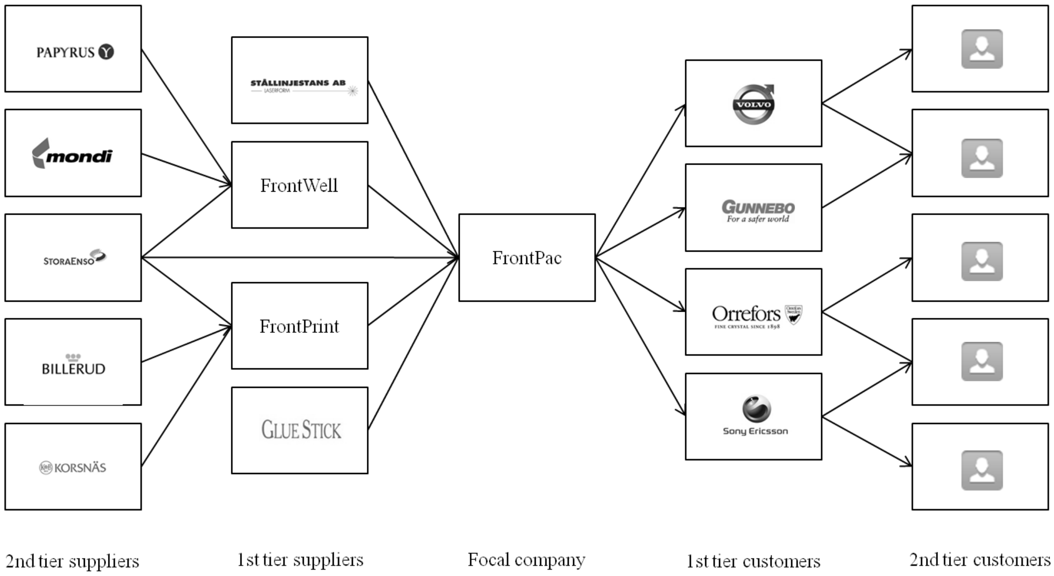


Figure 5.1: *FrontPac's supply chain.*

Since FrontPac is a make-to-order company it has a large amount of customers. Some of them put large and regular orders, while others put small and one-time orders. In between these extreme cases there is a wide range of customers with unique order patterns. Since FrontPac's products are mainly used as consumer packages with a high focus on the marketing aspects, their first tier customers are often closely related to the end customers and the consumers. This implies that they correspond to the product manufacturers, also referred to as fillers, discussed in section 4.3.4. Consequently, FrontPac's second tier customers are mainly consumers of products and packages.

5.1.2 Products

The following section intends to describe and explain FrontPac's packaging products in detail, with the purpose of facilitating the understanding of FrontPac's business, organization and processes. It also acts as a foundation to the forthcoming description of the cost objects.

The most general characteristic of FrontPac's products is the fact that these are customer specific. This implies that the products are not standardized and their specifications are not predefined. Instead, the product is defined together with the customer, based on a number of different product components. However, it should be noted that this does not necessarily make their products unique, i.e. there could be several other producers that can manufacture and sell the exact same product. The extent to which a product is possible to customize, e.g. the number of product components, can vary significantly between different companies and types of businesses. For FrontPac, the extent of product customization is very large and substantial. This implies that the product complexity can be relatively high and the amount of different products possible to manufacture is considerable. Therefore, it is very difficult, and not of any particular interest, to decide on beforehand exactly how wide the product range is, i.e. how many different products it can manufacture. Instead, the different product components and their impact on the final product will be described.

The packages constitute a much larger share of the products at FrontPac than the displays. Since the developed cost estimation system is limited to only cover packaging products, any further explanation of the displays has been left out. The company produces a wide range of packages for different purposes, but the main area of use is consumer packages, i.e. high quality primary packaging. The second most common area of use is transport packages, where focus is changed from the softer visible aspects to the more physically protective and logistical aspects. The size of the packages can range from small pastille boxes to regular sized moving boxes, depending on the size of the product it should contain. All packages are modified in size in accordance with product requirements and customer desires.

When looking somewhat further into detail of the packages, it is possible to identify the main product components and their sub-components. In order to assign a product with a cost it is necessary to identify the components, determine which activities these consume and finally the amount of activities and resources they consume. The product component chart, illustrated in Figure 5.2, provides an overview over the main product components and their sub-components, which will be elaborated below.

Figure 5.2: *Product components chart.*

Packaging design

As described in section 4.2, the packaging design is intended to describe the construction of a package, e.g. how it is folded, erected, closed, etc. Although the products are denoted as customer specific, the designs often derive from a standard box style. The primary box standard is FEFCO, but it is also complemented with other industry standards. Furthermore, FrontPac also offers totally unique packaging designs. These are not constructed based on an existing design, but rather a creative result of the in-house competence from the packaging designers and engineers.

Since the number of possible designs is very large, based on what has been expressed above, a design classification had to be made. The aim was to classify the designs based on occurrence, in order to distinguish which designs that were occurring more or less frequently. The main reason for classifying the designs is that some design specific information is required in order to gain as high accuracy as possible in the cost estimations. As an example, a sheet structure needs to be specified before estimating the cost and to provide a good sheet structure suggestion it is necessary to know the design, i.e. the form of the packaging blank. Table 5.1 illustrates the final design classification.

Table 5.1 *Packaging design classification based on occurrence.*

Class A	Class B	Class C
FEFCO 0201	FEFCO 0204	FEFCO Others
FEFCO 0203	FEFCO 0206	Industry standards
FEFCO 0427	FEFCO 0210	Unique
FEFCO 0713	FEFCO 0211	
	FEFCO 0215	
	FEFCO 0421	

The most frequently occurring packaging designs were categorized into class A. As can be seen in Table 5.1 it contains four FEFCO designs; one from each category presented in section 4.2.1. In fact, the 0713 design is definitely the most common packaging design at FrontPac. Some other packaging designs were occurring quite frequently, and were therefore assigned to class B. Similarly as for class A, it only contains FEFCO designs and includes six different styles. Finally, the rest of the designs were simply placed in class C. The designs within this class are not expected to occur frequently. These include the remaining FEFCO designs, the other industry standard designs and the unique designs.

After the design is settled the size of the package needs to be determined. For standard designs, such as the FEFCO, the size is often communicated by predefined lengths, widths and heights. Normally, these will describe the inner measures of the package in order to facilitate the transformation from product measurements to package measurements.

Packaging material

One of the most important aspects of a package is the packaging material. As has been stated already, FrontPac produces both pure carton packaging as well as litho laminated corrugated cardboard packaging. A package will therefore always consist of a carton liner, but not necessarily a single face corrugated cardboard. Necessary consumables are then also added in the manufacturing process. In comparison to the design, which should be seen as an intangible component of a package, the following components are tangible and physical to their nature.

The choice of carton liner affects the properties of the final product in various ways and is therefore an essential aspect to consider. It is mainly the two sub-components; paper quality and grammage that have the biggest impact on the final product. Just as for the carton, the single face corrugated cardboard modifies the properties of the final product. In general, carton primarily affects the printable and visible aspects of the packaging, while the corrugated cardboard rather affects the protective aspects. For the latter there are three main sub-components affecting the final product; liner paper quality, flute paper quality and flute configuration. It is the combination of these factors that gives the final package its specific properties.

Print

As has been stated previously, the choice of carton liner affects the printing quality and hence the visible and experienced quality of the package. FrontPac utilize the offset printing technique, which is appropriate to use when high quality printing is required in large quantities. When deciding the print it is therefore important to keep in mind which material that is used as printing medium.

The print has three separate product components; color, varnish and surface effects. The offset printing machine at FrontPrint has five rolls which give it a capability to print up to five colors or four colors and a varnish, in a single batch. The colors can be either CMYK, PMS (Pantone Matching System) or a combination of both. To complement the colors and give the surface another look or feel, there is a variety of varnishes that can be used. As illustrated in Figure 5.2, the varnishes can be split up into water based varnish, UV based varnish or effect varnish. There is however at last two other parameters linked to the varnish that also affects the printing cost of the final product. The first is whether the entire package should be varnished or not, which is referred to as full or partial varnishing. In the latter case only certain areas of the package will be varnished in order to make them stand out more. The second parameter is whether the varnish should be flat or clear, which can provide a different look or feel to the package. There is also the alternative to give the package a scented varnish, which gives it a desired smell.

Surface effects can also be used in order to enhance the visual impression of the package. The most common surface effects include; hologram, embossment and hot foil. The hologram is used to create an attractive and eye-catching 3D-effect on the package. The embossment creates a free form relief on the package and by adding a layer of hot foil a metallic surface can be achieved.

Extra functions
There are various extra functions that can be added to a package in order to create some added value. The extra functions are added separately and a package can have more than just one of these. These packaging components and their sub-components comprise;

- A *window*, which can be either standard rectangular or designed into a special figure.
- A *handle* that can be made out of plastic, paper or a reinforcing band.
- An *ID* attached on the package, which can be either a label or an RFID-tag.
- A *handling facilitator* that simplifies the usage of the package, e.g.
    - A *tear strip* to simplify the opening procedure.
    - A *closing tape* to close the package effectively.
    - An *inlay* to hold separate parts fixed in the package.

5.1.3 Organization

The overall organization of FrontPac is illustrated in the simplified process chart in Figure 5.3. As can be seen, the organization can be divided into eight comprehensive processes; management, sales, sales support, design, repro, planning, manufacturing and warehousing. The following section will briefly describe this organization, from customer need to delivered product. The stars indicate in which blocks cost estimations currently are performed, i.e. in the management and sales blocks.

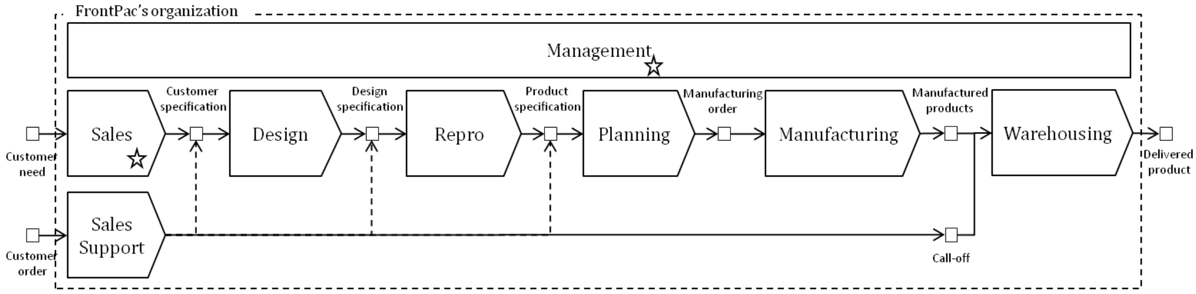


Figure 5.3: *A simplified process chart of FrontPac's organization.*

Management has an overall supporting function and serves multiple purposes. Obviously, it manages the company, which includes; strategic planning, company representation, initiating projects, etc. It also functions as an internal support to the organization, in order to facilitate and streamline the business processes. Additionally, it also includes the administration and management of all company-wide functions, such as accounting, quality, environment, etc. The star in Figure 5.3 illustrates that the cost estimation is present in the management function, which is true since certain critical orders are evaluated and priced there.

Sales is made up by the sales manager and his staff of salespersons. Their function is to establish new customer contacts and actively work to win new orders. This is illustrated in Figure 5.3, where the sales process converts the customer need into a customer specification, i.e. either a list of packaging requirements or a defined packaging solution. Sales is thus responsible for customer relationships with a clear focus on new customers. In addition, sales also manages the marketing, advertisement and representation of the company. As also indicated in the figure, the cost estimation is present in the sales block. Clearly, this is where the cost estimation system is most useful and practiced, even though it is not the salespersons themselves that perform the calculations. Instead, the cost estimation system is managed by an experienced employee with great competence and long experience of the products, company processes and cost estimation system. The estimated cost is then communicated to the salespersons and acts as a basis for their pricing decision.

Besides sales, *sales support* is in charge of customer relationships as well, but focuses rather on supporting the already existing customers. This includes order receiving from returning customers as well as managing call-off agreements and inventory control. Their responsibility is to receive, track and control orders to ensure that these are timely and correctly delivered to the customer. Depending on whether the order specifications have changed or not since the last time the customer put an order, it might be necessary to change something in the product specification. The three dotted lines in Figure 5.3 illustrates where the order can continue if any changes have to be made, otherwise the order will continue directly to the warehousing where stored products are gathered and shipped to customers.

Design can serve a few different purposes depending on the characteristics of the customer. If the customer, together with the salesperson, already has specified the desired packaging solution, including all the above mentioned packaging components, merely internal manufacturing preparations are required. The main challenge is then to optimize the sheet for manufacturing. This includes the task of deciding the most appropriate number of packages per sheet, their interlace pattern and also the size of the sheet. Otherwise, in the case where the final packaging solution has not yet been decided by the customer, the purpose is rather to suggest an appropriate design and materials that match the functional requirements set by the customer. Obviously, the result can be to use either an already existing packaging design or a uniquely developed design.

The work procedure is almost the same for *repro* as for design, even though the actual work is quite different. The purpose it fulfills is also twofold. The first alternative covers the case where the customer has an existing graphical design that it wants to use for the package. In that case, the main task is to ensure that the graphical design is compatible with the desired package design, material and printing technique. If it is not, possible adjustments and modifications have to be made before approval. In the other case, where the customer only has vague ideas, wishes or partly developed graphical designs, the task is to convert these into a good looking and well functioning graphical design. After this process, all product specifications should be ready and the order should be clearly defined. This implies that the specifications for all needed tools are possible to prepare and can be sent to external producers, if required.

Next is *planning,* where the customer order and product specification is converted into a manufacturing order. The activities included are; ordering material and required tools, controlling the raw material inventory and handle all contacts with suppliers of raw material. Furthermore, it also includes the planning and scheduling of manufacturing orders, to ensure that the finished products are available in the finished goods storage before it is time for delivery.

The last two processes are *manufacturing* and *warehousing*. The manufacturing is by far the largest block and is lead by the manufacturing manager and his staff of foremen, each responsible for their own working station. This is where the manufacturing order is realized and the raw material transformed into finished products. The warehousing is lead by the logistics manager who manages the handling and possible storing of the manufactured products. Since both of these constitute such a large and important part of FrontPac’s organization, these will be dealt with separately in the next section. These will there be broken down into further detail and examined thoroughly, as illustrated by Figure 5.4.

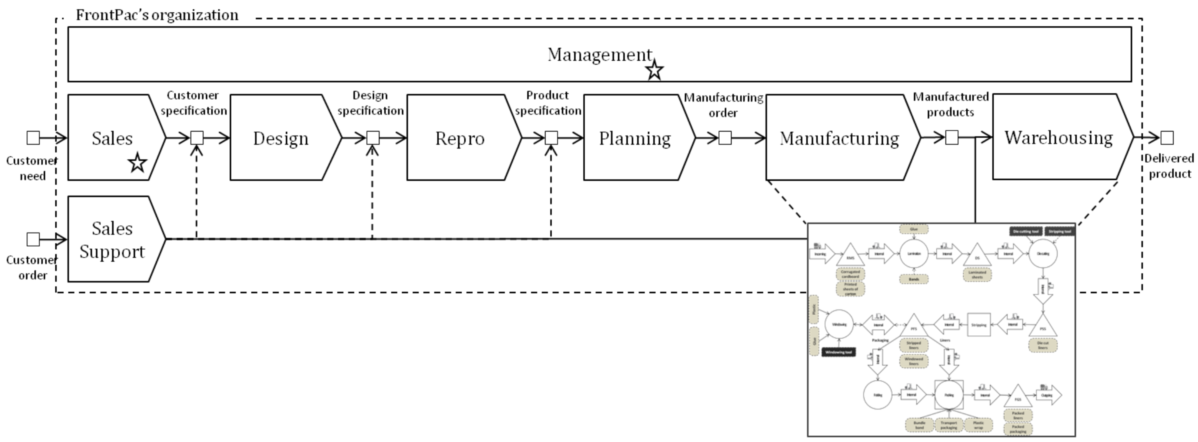


Figure 5.4: *Parts of the process chart broken down into further detail.*

5.1.4 Manufacturing and warehousing

FrontPac’s manufacturing and warehousing process is described under this headline, where the following text should be seen as a complement to the material flowchart illustrated in Figure 5.6. To facilitate the understanding of the processes a counterpart to every forthcoming heading also can be found in the flowchart. Figure 5.5 is also inserted to be helpful in the interpretation of the different flowchart symbols.

The material flowchart follows the flow of material in the manufacturing and warehousing processes, from raw material storage to finished goods storage. It is already now worth mentioning that not all products go through all steps in the processes. Some products might skip one or a few working stations, e.g. pure carton packaging does not go through the lamination operation, for obvious reasons. It is also worth mentioning that working stations and storage areas have been grouped together into seven areas in the flowchart. Since only a few activities actually have dedicated employees, these groups aim to facilitate the understanding of which working stations that share the same employees.

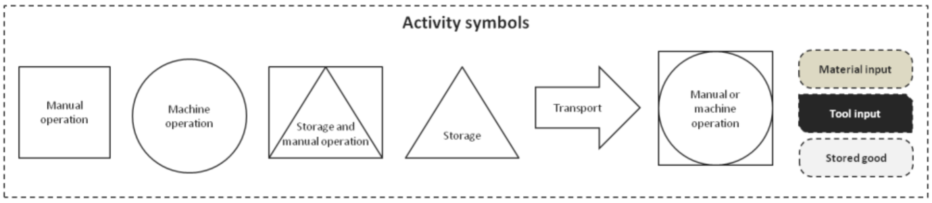


Figure 5.5: *An interpretation of the flowchart symbols.*

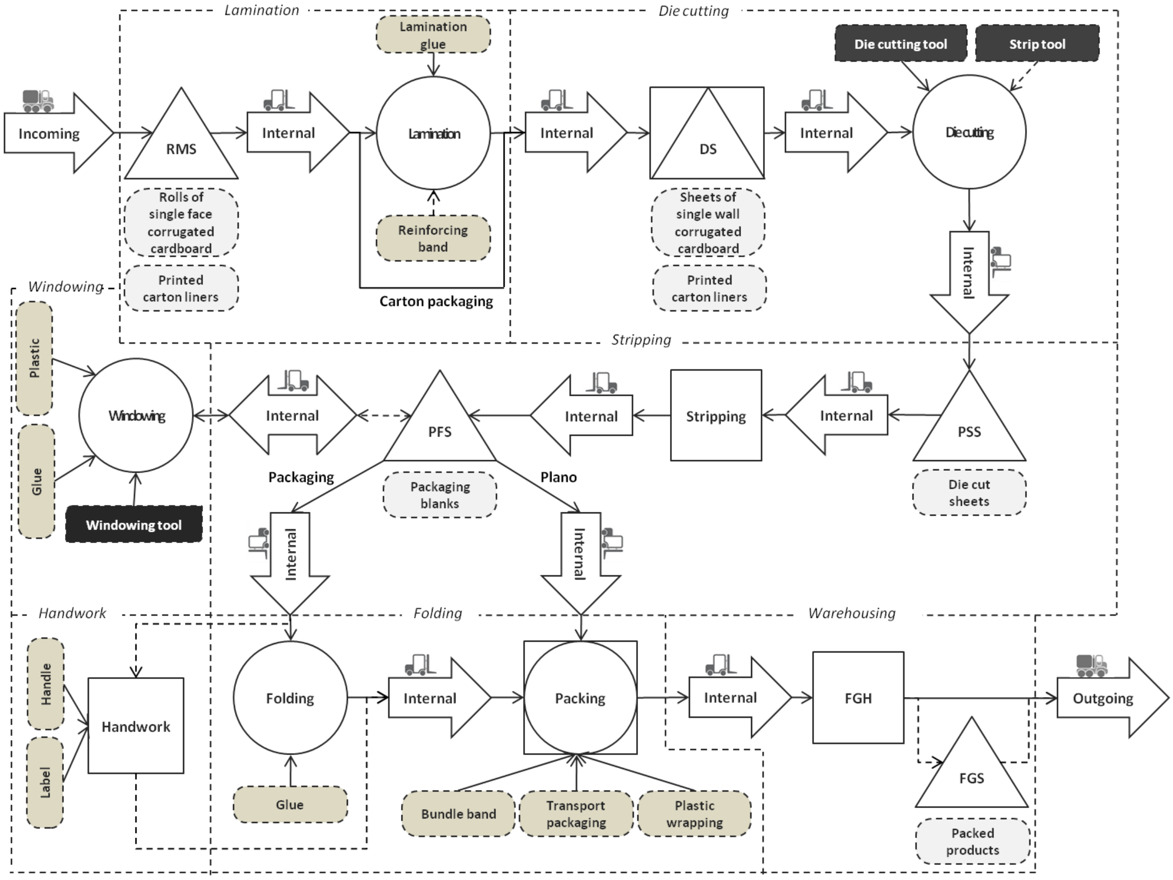


Figure 5.6: *Frontpac's material flowchart.*

External transports

The external transports define the beginning and the end of the process, as illustrated in Figure 5.6. The reason for incorporating them into the figure is both to mark out the boundaries of FrontPac's manufacturing and warehousing process, but also to illustrate the in- and outflow of material. The incoming external transports are primarily carried out by one of the other companies within the FrontPac-group, since they supply FrontPac with material. In some cases, third party logistics providers can also be used, e.g. if material is delivered directly to FrontPac from other suppliers. The outgoing external transports are managed by either customers or third party logistics providers.

Internal transports

Internal transports occur between each storage area and working station, as can be seen in the flowchart. Since all material in the process from raw material to packed products are placed on pallets, forklift trucks are used for all internal transports. Generally, the distances are very short and do not take very long time. This is one of the reasons why every working station has at least one truck driver in place who can handle the pallets that goes in and out from the working station.

Raw material storage (RMS)

In the raw material storage, rolls of single face corrugated cardboard and printed carton liners are stored. This implies that both the manufacturing of corrugated cardboard and the printing of carton liner has already been performed at FrontWell and FrontPrint respectively. The material arrives at the goods reception area, located within the storage area, where these are picked up by a forklift driver and put into an available storage place. The rolls of corrugated cardboard are stored floor stacked on the concrete floor, still on pallets, whereas the printed liners mainly are placed in pallet racks. The raw material storage area constitutes approximately ten percent of the total property area.

Lamination

After the raw material storage, material that will be turned into corrugated cardboard packaging arrives at the working station called lamination. In this operation the carton liner and the single face corrugated cardboard are merged together into single wall corrugated cardboard. In order to merge the two materials, special lamination glue is used. There are three regular lamination machines in this working station that can handle the usual range of roll widths. There is also an additional lamination machine that can handle two-sided lamination and extra wide rolls that cannot be manufactured in the other machines. Each machine is manned with one machine driver and one assistant.

Certain products have special features or extra functions, e.g. a band to reinforce a package handle. If this should be used in the final packaging, it is also added in this working station. This is accomplished by adding a small machine that attaches the band to the single face corrugated cardboard before the actual lamination operation.

Drought storage (DS)

After the lamination operation the laminated sheets need to be drought, before these proceed in the manufacturing sub-process. This takes place in the drought storage where the laminated sheets are stored in an open area with controlled air humidity. The drought time varies depending on the paper qualities of the single wall corrugated cardboard. The size of the laminated sheets can also impact the drought time. On average, a pallet will stay in the drought storage for a few days before proceeding to the next working station. For pure carton packages the printed carton liners will be moved directly from raw material storage to the drought storage where these will await the die cutting operation.

The drought storage constitutes a little less than ten percent of the total property area. The pallets are stored directly onto the concrete floor, i.e. without any pallet racks, which significantly lowers the amount of pallets the storage can hold. Some actual work is also performed in the drought storage. The laminated sheets are lying alternated with 10 sheets in every bunch, in order to prevent them from bending during the drought process. As a result, the sheets have to be turned so that all of these face the same direction, before proceeding into the die cutting operation. This is done manually by employees belonging to the die cutting station, before the pallet enters the die cutting operation. In a separate part of the drought storage, some of the die cutting tools are held for storage as well.

Die cutting

In the die cutting operation sheets of single wall corrugated cardboard and carton are die cut into so called *planos*. The holes and creases necessary for folding the packaging are made by the die cutting tool, which is built by an external manufacturer for every new product. If the volume is large enough, a strip tool can also be bought in order to decrease the set-up time in the die cutting machines. There are six different automatic die cutting machines in this working station. These can all handle most sheet sizes, but some are more appropriate than others for a certain range of sheet sizes. For extremely small quantities or especially large sized sheets, a special machine is used, which only is half-automatic. Every machine is driven by a skilled machine driver who is responsible for both setting-up and operating the machine. The employees in the drought storage also belong to this working station since they are responsible for preparing and gathering the required material.

Pre-stripping storage (PSS)

The pre-stripping storage is actually just a small area, constituting approximately five percent of the total property area, located between the die cutting station and the stripping station where the die cut sheets are put in queue for stripping. The pallets will usually stand here for less than a few hours, and these are put directly on the floor. It is the machine drivers from the die cutting station that put in pallets and the employees from the stripping station that later collect these.

Stripping

The stripping station is the first working station where the work is manual, i.e. not performed by a machine. In this operation, the die cut sheets are stripped into a pure *plano*, i.e. waste material from the die cutting operation is separated from the detached packaging blanks. The employees at the station pick up the pallets from the pre-stripping storage, strips them clean from waste material and then put them into the pre-folding storage. To their help they have forklift trucks for transports as well as a variety of mechanical and electrical tools for the stripping operation.

Pre-folding storage (PFS)

The pre-folding storage area is located between the stripping and the folding station. Depending on the product, there are several ways forward from this station. First, if the final product should have a plastic window, it is put in queue at the windowing machine and then returned when the operation is finished. Second, if the product should be delivered to the customer as a plano, it is moved to the palletizing area. Planos are mainly shrink-wrapped on pallets, but can also be packed in large fiberboard transport packages. Finally, if the product should be delivered as a folded packaging to the customer, then this is where it stays before proceeding in the process.

The pre-folding storage area occupies the smallest area of all the storages, which constitutes approximately three percent of the total property area, but holds a large amount of the die cutting tools and strip tools in a separate area. The work is performed by the employees from the stripping station.

Windowing
In the windowing operation certain packages receive a plastic window. This operation is performed in a special windowing machine. Apart from the plastic material for the window, special glue is also needed in this operation. If it is a new product, a tool has to be constructed as well. The tool is built in-house and does therefore not have to be bought from any external manufacturer. Since the windowed products constitute a relatively small percentage of all products, and will usually at a later stage proceed to the folding station, the products are transported back to the pre-folding storage after leaving the windowing station.

Folding
In the folding operation, packaging blanks are folded, glued and stitched into a desired shape, according to the design of the packaging. There are four regular machines capable of folding and gluing packages. Each machine can handle a certain range of packaging sizes and these are also more or less appropriate for different types of folding, which is determined by the packaging design. There is also one additional machine that can handle larger sized packages. Naturally, this machine operates at a lower speed than the others. Each machine is usually manned with one skilled machine driver, responsible for setting-up and operating the machine. There are also one to three packers located at the end of the machine to pack the products and perform the final quality control. The number of packers is primarily determined by the speed at which the machines operate.

Packing
The packing activity is actually physically located at different areas within the facility, depending on which manufacturing steps the products go through. Most packing work is however performed at the end of the folding machines. Here, the folded packages mainly are packed in large fiberboard boxes of various sizes. Depending on the customer requirement, the products are sometimes bunched and bundled before packed. If the finished products are not put in fiberboard transport packaging, they are shrink-wrapped before entering the warehousing sub-process. Since the shrink-wrapping is applied by a special machine, this station is denoted as semi-automatic. It should also be mentioned that the packing work is not carried out by any specifically designated employees. Usually, either the employees at the folding or stripping working station have the responsibility to pack the products properly.

Finished goods handling (FGH)
After the packing activity the manufacturing sub-process is over and responsibility is handed over to the warehousing sub-process. The packed products are picked up from their packing station and moved into the warehouse area. Depending on whether the products should be shipped directly to the customer or stored in the finished goods storage, they will be handled differently. Direct call-off orders are moved directly from the packing station to the outgoing area located within the warehouse. This is where they will await outgoing transport. Otherwise, if the products should not be shipped directly, they are put in an available storage place in the finished goods storage.

Finished goods storage (FGS)
In the finished goods storage the manufactured products are stored until shipped to the customer. All products are still located on EUR pallets, if possible. Otherwise, if the product is larger than a EUR pallet these will be stored on larger pallets. The finished goods storage is the only storage area manned with dedicated personnel. It is by far the largest storage area and constitutes approximately 40 percent of the total property area. The storage uses a combination of pallet racks and floor stacking. Before the pallets are put on the outgoing transport, the personnel prepare the pallets by gathering them in the outgoing area. This is a part of the storage area that is especially dedicated for outgoing pallets.

5.2 Pricing strategy

FrontPac's overall pricing strategy is important to understand in order to be aware of the requirements put on the cost estimation system. The pricing decision is mainly based on the estimated total manufacturing cost for the product, as illustrated in Figure 5.7, i.e. the cost for direct material, material overhead, direct labor and manufacturing overhead. The standard approach at FrontPac is then to add a percentage spread to the estimated total manufacturing cost. The percentage spread can vary, but it has to reach above a lower bound that is given by the company's goals. The lower bound is set in order to cover all costs and therefore indicates the breakeven price. In the same manner a desired percentage spread level also is specified, which gives an indication of a desired price level. This added percentage is then expected to cover the administration overhead and to generate some profit.

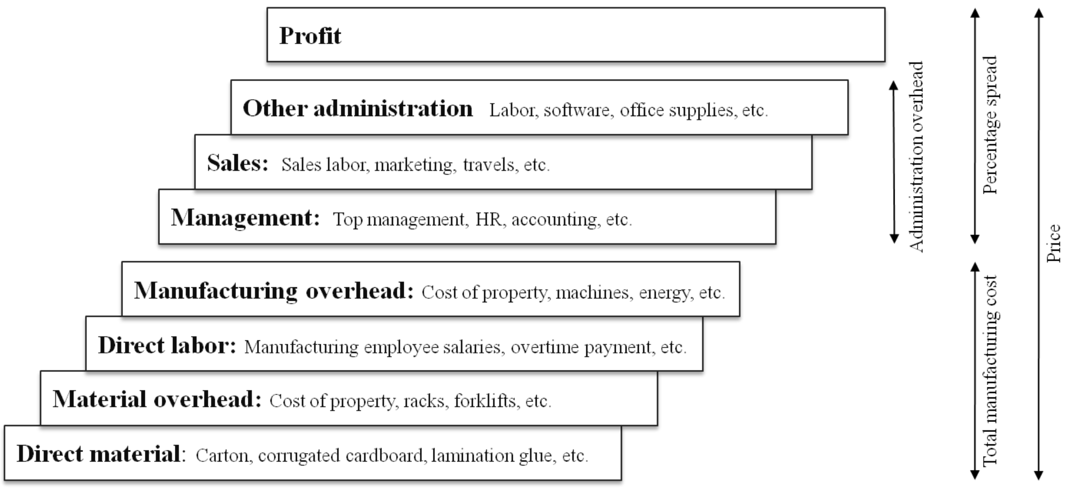


Figure 5.7: *FrontPac's cost based pricing strategy.*

The following case will exemplify the procedure explained above. Given that the estimated total manufacturing cost for an order is 150,000 SEK and the lower bound for the percentage spread is 10 percent, the breakeven price would be 165,000 SEK. If the desired percentage spread would be 25 percent, the price to strive against would be 187,500 SEK, using Equation 5.1 below. The main requirement on the cost system would therefore be to estimate the total manufacturing cost as accurately as possible.

$$Price = Total\ manufacturing\ cost * (100\% + Percentage\ spread)$$

Equation 5.1: *Price calculation procedure.*

In addition to the cost based strategy explained above it is sometimes necessary to complement the pricing decision with a competitor based strategy. This is especially the case for some of the larger regular customers. These are usually more well-informed about the current market price for the demanded product and also have the strength and power to bargain with their suppliers, in this case FrontPac. The cost is however still an essential part of the pricing decision, particularly in order to determine the breakeven price.

Furthermore, it is the product's features and characteristics that determine which pricing strategy that is appropriate to apply. When products tend to be less unique and less customer-specific, the price is increasingly regarded as the main order-winner. It will then be easy for the customers to see the general market price since many other competitors are capable of manufacturing and selling the same product. In these situations the competitor based strategy is appropriate to use. On the other hand, when products are specified according to the special needs of the customers, the market price is more difficult to establish and it will be easier and more appropriate to use the cost based pricing strategy.

5.3 Cost structure

In this section, some of the collected and processed cost data are presented. The cost structure describes the relation between two types of costs; *manufacturing* versus *administration* and *direct* versus *overhead* costs. For a manufacturing company, such as FrontPac, it is of great interest to see how large portion the total manufacturing costs constitute of the total costs. From the pricing strategy, explained in section 5.2, it can be seen that FrontPac is interested in estimating the total manufacturing costs and to cover the administration overhead with a percentage spread. This makes it even more important to know the proportion between these two types of costs.

Similarly, it is essential to know the proportion between direct and overhead costs, since this is one of the main factors that determine which cost estimation method that is the most appropriate to apply. Table 5.2 presents the relation between the manufacturing costs and the administration overhead as well as the relation between the direct costs and overhead, as a percentage of the total costs. The figures in the table are based on the costs gathered from FrontPac's income statement from the previous three years (2007 - 2009), and also contain a forecast for the current year, which is marked out with a star. The forecast is based on the costs for the first six months of that year (2010).

Table 5.2 *FrontPac's cost structure.*

	2010*	2009	2008	2007
Direct	55%	53%	56%	57%
Overhead	45%	47%	44%	43%
Manufacturing	83%	82%	85%	85%
Administration	17%	18%	15%	15%

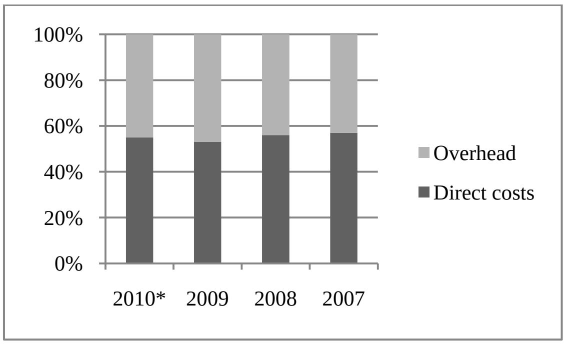


Figure 5.8: *Direct versus overhead costs.*

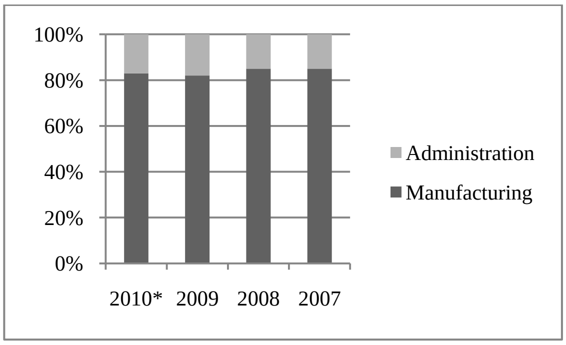


Figure 5.9: *Administration versus manufacturing cost.*

As can be seen in Figure 5.8, the proportion between the direct costs and overhead appears to be quite stable, although some small variations occur between the different years. Possibly, a slight decrease in the proportion of the direct costs is in progress. On average, the direct costs constitute 55 percent of the total costs. The relation between the manufacturing costs and the administration overhead also appears to be quite stable (see Figure 5.9). The total manufacturing costs constitute a large proportion of the total cost, approximately 84 percent. Possibly, there is also a trend towards a small decrease in the proportion of the total manufacturing costs, seen over the previous four years.

Looking a bit further into detail in the cost structure it is meaningful to split up the total cost even further. From the pricing strategy in section 5.2 seven types of costs were presented that consisted of two direct and five overhead costs as well as four manufacturing related and three administration related. When breaking down the costs into these seven categories it is possible to see their proportion of the total costs, which consequently is illustrated in Figure 5.10.

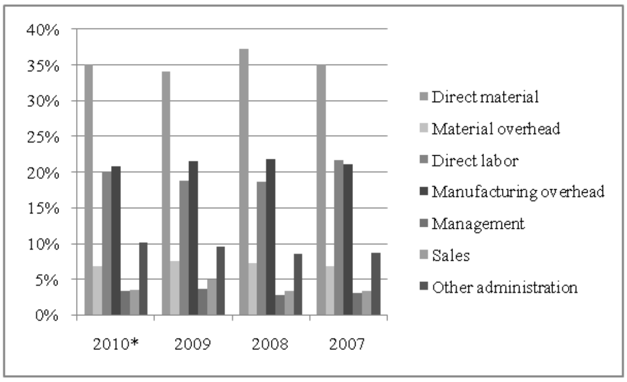


Figure 5.10: *Cost distribution per year from 2007 - 2010.*

As can be seen in Figure 5.10 the proportions show no drastic variations over the previous four years. The direct material constitutes the largest proportion of the total costs, approximately 35 percent. It should be noted that the printing cost is excluded in this percentage. Even though FrontPac receives their carton liners printed from FrontPrint, it is actually FrontPac that purchases the paper from the paper manufacturer. The printing cost is therefore included in the manufacturing overhead instead. Subsequently, manufacturing overhead is the second largest cost and except for the printing it also contains the overhead costs of FrontPac's manufacturing process. The direct labor is the third largest type of cost and together these three categories add up to over 75 percent of the total costs. The last quarter of the costs are shared between the material overhead, management, sales and the other administrative functions, as can be seen in Figure 5.11.

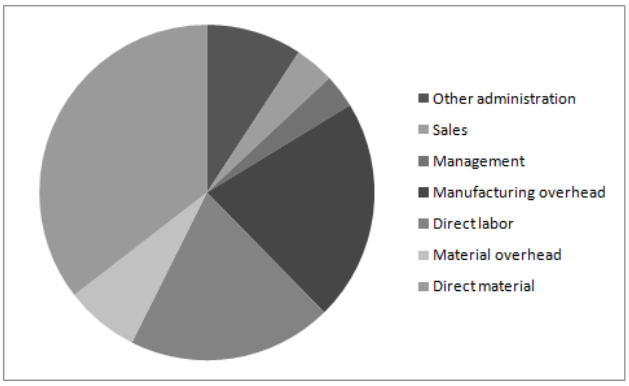


Figure 5.11: *Average cost distribution on a yearly basis.*

5.4 Identification

In this section the identified resources, resource drivers, activities, cost drivers and cost object components will be presented. The section begins with a description of the identified resources and their belonging resource drivers, which are presented in a table called *List of Resources*. After that, the identified activities are presented together with their belonging cost drivers in a similar table called *List of Activities*. Finally, the cost object, which is considered to be a customer order, is presented at the end of this section using the L*ist of Cost Object Components*.

5.4.1 Resources and resource drivers

In addition to the explanation provided in section 3.4.1, a *resource* can be seen as one, or the sum of a few belonging, expenses from the income statement. Based on the income statements from the previous four years, FrontPac's expenses have been categorized into different resources. For each resource a belonging resource driver was identified that intended to describe the consumption of that resource. The resources that shared the same resource driver where then merged and similarly split up where no common resource driver could be found. The final list of identified resources is presented in Table 5.3 together with their belonging resource drivers. This table is referred to as the *List of Resources* and also contains the determined resource volumes and resource driver volumes.

Table 5.3 *List of Resources.*

Resource	Resource volume	Resource driver	Resource driver volume
Energy	* *** 000	Power consumption (kWh)	* *** 000
Maintenance	* *** 000	Level use of resource (%)	100%
Machine depreciation	* *** 000	Machine value (SEK)	* *** 000
Manufacturing personnel	* *** 000	Time (h)	* *** 000
Extra storage area	* *** 000	Space (m^2)	* *** 000
Property	* *** 000	Space (m^2)	* *** 000
Miscellaneous	* *** 000	None	-
Administration personnel	* *** 000	Time (h)	* *** 000
Sales	* *** 000	Level use of resource (%)	100%
Accounting	* *** 000	Level use of resource (%)	100%
Business travel	* *** 000	Distance (km)	* *** 000
Office expenses	* *** 000	Employees (#)	* *** 000

Twelve resources were identified in total. Five of these are related to manufacturing and five are related to administration. The property and miscellaneous resources do not belong to any of these and are therefore marked out separately. The volumes are determined on a yearly basis and these are expressed in monetary terms, which also explains why these are masked in the table. The reason for still keeping them in the table is to point out that these are needed at a later stage, when allocating the resources to the activities. The identified resources and choice of resource drivers will be elaborated below.

The manufacturing related resources

The manufacturing related resources constitute approximately 84 percent of the total costs (see section 5.3). The *energy* resource is the same as the electrical power that machines and electrical tools consume. The amount of resources an activity consumes of this resource relates to the power consumption. Hence, this is considered to be an appropriate resource driver for the energy resource.

The consumption of the next resource, *maintenance*, is more difficult to express with a single factor. The resource contains all expenses associated with the maintenance of machines, both in terms of labor and spare parts. The consumption of this resource depends on multiple factors, such as the age and condition of the machines, machine complexity, amount of standard and special components as well as the amount of proactive and reactive maintenance, etc. For these reasons, a percentage based on these parameters has been chosen to be an appropriate resource driver.

The consumption of *machine depreciation* can more easily be traced to the activities through a single resource driver, based on available data. The consumption is subsequently based on machine value, which implies that a high value machine will bear more depreciation costs than a low value machine. The *manufacturing personnel* resource is also relatively easy to allocate with a single resource driver, where available data also exist. The amount of time, measured in man hours, an activity consumes is considered to give a sufficiently good indication of the resource consumption. At last, the *extra storage area* resource will be allocated based on the amount of extra storage space every activity requires, measured in square meters.

The administration related resources
The administration related resources constitute approximately 16 percent of the total resources. Two of the administrational resources, *sales* and *accounting*, are only consumed by one single activity respectively. Since the entire resources will be traced directly to an activity, a percentage based resource driver is sufficient to use for these resources.

Equivalently as for the manufacturing personnel, the *administration personnel* resource will be allocated to the activities based on the time each activity consumes, measured in man hours. *Business travel* includes costs for travel and accommodation, and is allocated based on the number of traveled kilometers. *Office expenses* include various stationeries and office supplies, and will consequently be allocated based on the number of administration employees in an activity.

Other resources
The second last resource is *property*, which is related to both manufacturing and administration. This is also the reason why it is not categorized into either of the two groups above. The resource includes all property related expenses such as the cost for rent, heating, lights and property related depreciations. It is allocated to the activities based on the amount of space the activity occupies, measured in square meters. At last, the *miscellaneous* resource contains the expenses that cannot be categorized differently. As a result, it is difficult to allocate the consumption of these properly to any of the activities. Since this resource is relatively small in comparison to the other resources, i.e. less than one percent of the total costs, it is quite appropriate to allocate it equally amongst all the activities.

5.4.2 Activities and cost drivers

Based on the process chart (see section 5.1.3) and the material flowchart (see section 5.1.4), the main activities at FrontPac were identified. These are divided into manufacturing, warehousing and administration in order to simplify the presentation and facilitate the understanding. In total 16 activities were identified; eight related to manufacturing, two to warehousing and similarly six to administration. Subsequently, the manufacturing related activities consist of two storage activities and six operational activities where products are refined. The activities are listed in the *List of Activities* with their identified belonging cost drivers and cost driver volumes, as can be seen in Table 5.4.

The determined cost driver volumes are masked in the table because it might be sensitive information to reveal. The reason for still keeping them in the table is to illustrate that they are needed at a later stage to allocate the costs from activities to cost objects. Similarly, space has been made for the activity volumes even though they are not a part of the identification phase.

Table 5.4 *List of Activities.*

Activity	Activity volume	Cost driver	Cost driver volume
Raw material storing	-	Goods height	* *** 000
Interim storing	-	Number of pallets	* *** 000
Lamination	-	Machine time	* *** 000
Die cutting	-	Machine time	* *** 000
Stripping	-	Activity time	* *** 000
Windowing	-	Machine time	* *** 000
Handwork	-	Activity time	* *** 000
Folding	-	Machine time	* *** 000
Finished goods handling	-	Number of pallets	* *** 000
Finished goods storing	-	Pallet months	* *** 000
Sales	-	Order quantity	* *** 000
Sales support	-	Number of call-offs	* *** 000
Design	-	Packaging design complexity	* *** 000
Repro	-	Graphical design complexity	* *** 000
Planning	-	Number of batches	* *** 000
Management	-	Order quantity	* *** 000

Manufacturing activities

In the first activity, *raw material storing*, rolls of corrugated cardboard and printed carton liners are stored. The materials are placed on EUR pallets, as illustrated in the Figures 5.12 - 5.14. The storage primarily uses floor stacking, which implies that a reasonable cost driver would be occupied storage volume. Since the diameter of the rolls is adjusted according to a EUR pallet, i.e. with a diameter of 1200 mm, these will all occupy the same base area. However, the height of the goods will vary considerably depending on the width of the roll. Hence, the height of the pallet goods and the number of pallets determine the occupied storage volume. Consequently, the total goods height is an appropriate cost driver in this storage area.

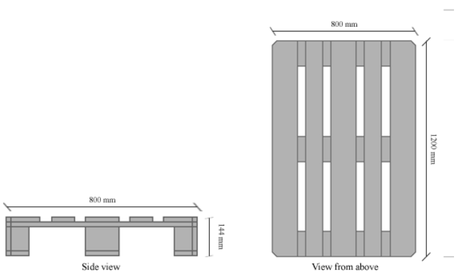


Figure 5.12: *EUR pallet with measures.*

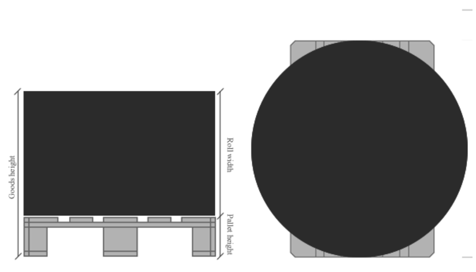


Figure 5.13: *Stored rolls of corrugated cardboard.*

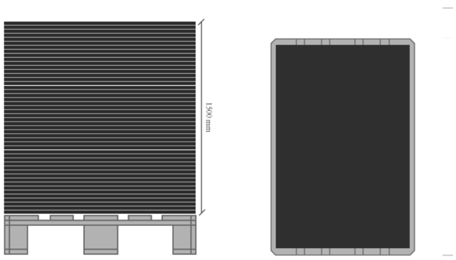


Figure 5.14: *EUR pallet stacked with sheets.*

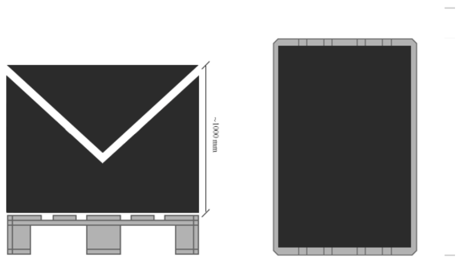


Figure 5.15: *Pallet in finished goods storage.*

The situation in the *interim storage* is slightly different from the raw material storage. The pallets hold merely stacked sheets and have a standard height of 1.5 meters according to internal requirements. Hence, the number of pallets is an appropriate cost driver for these storages. Figure 5.14 illustrates what an interim pallet looks like. Since the situation is the same for all interim storages these can be grouped into a single activity, which consequently comprises; drought storage, pre-stripping storage and pre-folding storage.

The six operational activities all share the same type of cost driver, which is the amount of time needed to perform the activity; including both set-up time and operation time. For the activities with machines; lamination, die cutting, windowing and folding, the time is expressed as *machine time*. As no machines are being used in the stripping and handwork activity, the term *activity time* is used instead when referring to the cost driver for these activities. The general procedures for determining the machine times and the activity times are expressed in Equation 5.2 and Equation 5.3 respectively.

$$Machine\ time\ (h) = Set\text{-}up\ time\ (h) + \frac{Quantity\ (units)}{Machine\ speed\ (\frac{units}{h})}$$

Equation 5.2: *Machine time calculation.*

$$Activity\ time\ (h) = \frac{Quantity\ (units)}{Activity\ speed\ (\frac{units}{h})}$$

Equation 5.3: *Activity time calculation.*

The machine times is determined by the *set-up time* required for preparing the machines and gather the material as well as the *operation time*, which is determined by the quantity divided by the machine speed. The activity time on the other hand does not require any set-up so it will only consist of the *operation time,* determined by the quantity divided by the activity speed. The procedure for determining the appropriate set-up times, machine speeds and activity speeds are explained in the activity to cost object allocation, in section 5.5.2.

Warehousing activities

The *finished goods handling* is the first of the two warehousing activities. It refers to the actual handling of the finished goods pallets. The handling of the raw material and the work-in-progress are already included in the manufacturing related activities, since it is the manufacturing employees that are responsible for gathering and preparing material as well as operating the machines. However, this is not the case for the warehousing activities. The finished goods handling activity includes the gathering of pallets from the packing station; but also to palletize the transport packaging or to shrink-wrap the packages onto a pallet. The pallets are then moved from the packing station to either the outgoing area or the finished goods storage. The cost driver is the number of pallets which determines the amount of time and labor an order consumes.

The *finished goods storing* is different compared to the interim storing in four ways. First, the finished goods pallets have a transport packaging; either a fiberboard box or a plastic shrink-wrapping. A typical finished goods pallet, with a fiberboard box as transport packaging, is illustrated in Figure 5.15. The choice of wrapping material impacts the cost and is determined by the customer. Second, the pallets have another height, 1.2 m or lower, to properly fit in the standard slot of a pallet rack. Third, the time a pallet stays in the finished goods storage cannot be simplified by a simple mean. Therefore, a factor that combines both the number of pallets and the actual time in storage is the most appropriate cost driver to use. Finally, not all pallets are actually stored in the finished goods storage. Orders that will proceed directly from manufacturing to external transports are kept in a small area for outgoing goods, located near the loading dock. As a result of this, the cost driver for finished goods storing will be to store one standard pallet of goods for one month, often referred to as a pallet month.

Administration related activities

There are six administration related activities in total. The first one, *sales*, handles new customers contacts and attempts to win new orders. The amount of time a salesperson spends on a customer depends on several different factors; but it is clearly related to the order quantity. The amount of time spent on nursing and managing a customer with large orders are significantly higher than for small orders.

Sales support manages incoming orders from already existing customers and also acts as a support for these, in various ways. The amount of activity an order consumes is primarily proportional to the number of call-offs. Every time a call-off is placed, the sales support has to enter it into the business system, control the inventory and possibly also initiate a manufacturing order.

Design is responsible for the packaging design related aspects. Hence, the amount of work a customer order consumes is determined by the design complexity. It increases as the number of components and functions, incorporated into the product, increases. Whether or not the customer has specified a desired packaging solution or not, also affects the time consumption. If a standard FEFCO design with formats is specified, merely internal manufacturing work remains to be performed. On the other hand, a unique design solution with unclear or vague requirements takes considerably longer time to develop.

The graphical design is set, modified and approved by *Repro*. The amount of time a customer order consumes of this activity is dependent on the graphical design complexity. As the factors and aspects that need to be considered increases, so does the consumed time. As an example, the amount of work will increase as the number of colors and varnishes increase. Another factor that also affects the amount of work is whether or not the graphical design is specified on beforehand; including texts, pictures, colors and effects. If not, this needs to be developed and sent for approval by the repro employees. In cases where the graphical design is decided by the customer, internal manufacturing documents and specifications still has to be produced before triggering a manufacturing order.

Planning is responsible for planning and scheduling of orders to fit in the manufacturing schedule. The amount of work is affected by many factors, but it is simply considered to be proportional to the number of manufacturing runs, so called batches. As certain orders are very large, all products are not supposed to be delivered at the same time. It is then possible to split the manufacturing order into smaller batches, in order to minimize the capital tied in storage and to optimize the manufacturing. The expense of doing this is that several batches have to be planned when required. This implies that the planners have to make additional manufacturing plans and schedules. The amount of work is therefore considered to be proportional to the number of batches.

The amount of *managerial* work an order consumes cannot easily be correlated to the characteristics of an order. The internal support provided to the other functions or the management of the company-wide functions is therefore very difficult to allocate directly to the cost objects. As a result, the management is allocated in accordance with the traditional costing approach, i.e. to relate it to the order quantity.

5.4.3 Cost object

The cost object is as previously stated, a customer order, which comprises both the physical product and the supporting services. The *List of Cost Object Components* illustrated in Table 5.5 presents the components of an order that has a considerable effect on the cost. In the table the product related components are gathered from the product description in section 5.1.1. These are then complemented with other identified customer order specific components. To simplify the presentation and facilitate the understanding merely the highest level of components are presented, e.g. the main product components. It is then possible to break these down into further detail in order to more thoroughly study how different sub-components affect the total order cost. Two similar tables are therefore attached in Appendix A where these main order components have been broken down into first level sub-components and second level sub-components.

In Table 5.5 it is also described in what way the components incur costs. The components can incur costs directly, e.g. by requiring purchasing of material or external sub-contracting work. But it can also incur costs indirectly by affecting the consumption of an activity, e.g. by affecting the machine speed in an operational activity. Clearly, some components will incur costs in both ways. These relations are marked out with crosses in the table.

Table 5.5 *List of Cost Object Components.*

Cost object components	Direct	Overhead
Design		x
Material	x	x
Print	x	x
Extra functions	x	x
Sheet		x
Warehousing		x
Transport	x	
Transport package	x	x
Customer		x
Tools	x	x
Quantity	x	x

5.5 Allocation

In this section the allocation from resources to activities and from activities to cost objects will be described. The section is divided into two parts, starting with the activities' consumption of resources and then moving on to the cost objects' consumption of activities.

5.5.1 Resource to activity allocation

First, a Resource - Activity Relation (RAR) matrix will illustrate the relations between the resources and the activities. In the matrix (see Table 5.6), relations between the resources and the activities are marked out with a cross symbol. The relations indicate that the activity in question actually consumes the related resource.

As can be seen in the matrix, the activities that were considered to be related to manufacturing also consume the resources that were labeled as manufacturing related resources. The administration related activities also logically relates to the administration related resources. The two resources, property and miscellaneous, are consumed both by the manufacturing and administrational activities, as described in section 5.4.1.

Table 5.6 *Resource - Activity Relation matrix.*

Activities / **Resources**	Energy	Maintenance	Machine depreciation	Manufacturing personnel	Extra storage area	Property	Miscellaneous	Administration personnel	Sales	Accounting	Business travel	Office expenses
Raw material storing						x	x					
Interim storing						x	x					
Lamination	x	x	x	x		x	x					
Die cutting	x	x	x	x		x	x					
Stripping	x			x		x	x					
Windowing	x	x	x	x		x	x					
Handwork	x			x		x	x					
Folding	x	x	x	x		x	x					
Finished goods handling	x	x		x			x					
Finished goods storing					x	x	x					
Sales						x	x	x	x		x	x
Sales Support						x	x	x				x
Design						x	x	x				x
Repro						x	x	x				x
Planning						x	x	x				x
Management						x	x	x		x	x	x

The RAR matrix provides the foundation for the forthcoming allocation procedure. Based on the information from the RAR matrix, it is possible to determine how much resources each activity consume. Based on the determined resource volumes, resource drivers and resource driver volumes; the crosses in the matrix can be replaced by consumption proportions, favorably measured in percent. This will then result in the respective activity volumes.

The Resource - Activity Proportion (RAP) matrix (see Table 5.7) illustrates the activities' consumption of resources, measured in percent. Apart from the fact that the crosses have been exchanged by percents, the resource volumes have also been added at the top of the matrix. Similarly, the activity volumes are shown on the right hand side of the matrix. The actual volumes have been masked, but the structure is still revealed, in order to facilitate the understanding of the structure. It can also be seen in the table that each column will add up to 100 percent, since all resources are allocated, i.e. it is a complete cost allocation approach.

Table 5.7 *Resource - Activity Proportion matrix.*

Activities / Resources	Energy	Maintenance	Machine depreciation	Manufacturing personnel	Extra storage area	Property	Miscellaneous	Administration personnel	Sales	Accounting	Business travel	Office expenses	Activity volumes
Resource volumes	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	
Raw material storing						10%	6,25%						* *** 000
Interim storing						15%	6,25%						* *** 000
Lamination	29%	33%	25%	16%		11%	6,25%						* *** 000
Die cutting	33%	50%	50%	21%		4%	6,25%						* *** 000
Stripping	1%			9%		1%	6,25%						* *** 000
Windowing	4%	2%	2%	1%		1%	6,25%						* *** 000
Handwork	2%			11%		2%	6,25%						* *** 000
Folding	25%	10%	23%	34%		11%	6,25%						* *** 000
Finished goods handling	6%	5%		8%			6,25%						* *** 000
Finished goods storing					100%	39%	6,25%						* *** 000
Sales						1%	6,25%	30%	100%		67%	24%	* *** 000
Sales Support						1%	6,25%	14%				17%	* *** 000
Design						1%	6,25%	12%				14%	* *** 000
Repro						1%	6,25%	12%				14%	* *** 000
Planning						1%	6,25%	16%				19%	* *** 000
Management						1%	6,25%	16%		100%	33%	12%	* *** 000
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

5.5.2 Activity to cost object allocation

It should first be noted that the cost object components that were identified as incurring costs directly (see section 5.4.3) will have separate cost calculations in the cost estimation system. Since these are regarded as direct, they do not consume any of the identified resources. Instead, their direct costs are calculated using various price lists, e.g. transport price list or material price list. Apart from these direct costs the overhead costs have to be covered and this is what the activity to cost object allocation aims to do.

Since the company merely deals with customer specific products it is not meaningful on beforehand to calculate and assign every possible individual customer order with a specific cost. It would be far too time-consuming since the number of possible products is extremely large, as already described in section 5.1.1. Instead, the customer orders are treated with a more general approach where a certain number of cost object components determine which activities that are consumed, and how large share of resources that are required.

The cost object components that were identified in section 5.4.3 as having a considerable effect on the cost have been gathered from the List of Cost Object Components (see Table 5.5). These have then been put against the activities in order to determine how they relate to each other. In the Activity - Cost Object Component Relation matrix (ACOCR) these relations are illustrated visually (see Table 5.8). The matrix should be interpreted as follows;

given that the component exists, does it affect the consumption of the activity? If the answer to this question is:

- Yes, given that the activity is consumed. It is marked with a cross, x.
- No It is left empty.

To clarify this principle an example is taken from the ACOCR matrix in Table 5.8. As can be seen there, the consumption of the lamination activity is not affected by the design, but it is affected by the material under the condition that the product will pass through this activity. The lamination – design box is therefore left unmarked and the lamination – carton box is marked with a cross.

Table 5.8 *Activity – Cost Object Component Relation matrix.*

Cost object components / **Activities**	Raw material storing	Interimstoring	Lamination	Die cutting	Stripping	Windowing	Handwork	Folding	Finished goods handling	Finished goods storing	Sales	Design	Repro	Sales Support	Planning	Management
Design				x	x	x	x	x				x	x		x	
Material	x	x	x	x	x	x	x	x				x	x		x	
Print				x			x	x					x			
Extra functions	x	x	x	x	x		x	x				x	x		x	
Sheet	x	x	x	x	x							x	x	x	x	
Warehousing									x	x				x	x	
Transport																
Transport package					x		x	x	x	x				x	x	
Customer	x					x		x			x	x	x	x	x	
Tools				x		x						x	x		x	
Quantity	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x

The ACOCR matrix is a structured support that is helpful in order to determine which components that affect the consumption of activities. It does however not provide any answers to which components that have a more significant impact than others. Obviously, the more components that are taken into consideration for each activity, the more accurate the actual cost can be estimated. This can also be achieved by breaking down the components in greater detail, as described in section 5.4.3. Table 5.8 only contains the highest level of components in order to facilitate the presentation and understanding. However, this procedure was undertaken for both the first and second level sub-components as well, which are illustrated in similar tables in Appendix B.

The information from these studies was useful in determining the set-up times, machine speeds and activity speeds mentioned in section 5.4.3. As described, these affected the cost drivers for the operational activities. Based on the three ACOCR matrices it was possible to determine how these factors were affected by the cost object components. Two examples are given in Table 5.9, where the machine speeds in the die cutting and folding activities are determined based on a number of influencing components. Moreover, the machine speeds in the table are fictitious. Similar tables were constructed for all six operational activities including their speeds and set-up times, which are attached in Appendix C.

Table 5.9 *Example of determined machine speeds.*

Die cutting			
Sheet size	**Material**	**Quantity**	**Machine speed**
< (1050*750)	Carton	> 2 000	3 250 sheets/h
		< 2 000	2 000 sheets/h
	F	> 2 000	3 000 sheets/h
		< 2 000	2 000 sheets/h
	E	> 2 000	2 750 sheets/h
		< 2 000	2 000 sheets/h
	B	> 2 000	2 250 sheets/h
		< 2 000	1 500 sheets/h
	C	> 2 000	2 000 sheets/h
		< 2 000	1 500 sheets/h
> (1050*750)	Carton	> 2 000	3 250 sheets/h
		< 2 000	2 000 sheets/h
	F	> 2 000	3 000 sheets/h
		< 2 000	2 000 sheets/h
	E	> 2 000	2 750 sheets/h
		< 2 000	2 000 sheets/h
	B	> 2 000	2 250 sheets/h
		< 2 000	1 500 sheets/h
	C	> 2 000	2 000 sheets/h
		< 2 000	1 500 sheets/h
> (1420*1020)	Carton	> 2 000	1 500 sheets/h
		< 2 000	750 sheets/h
	F	> 2 000	1 250 sheets/h
		< 2 000	750 sheets/h
	E	> 2 000	1 000 sheets/h
		< 2 000	750 sheets/h
	B	> 2 000	750 sheets/h
		< 2 000	500 sheets/h
	C	> 2 000	500 sheets/h
		< 2 000	500 sheets/h

Folding				
Folding	**Material**	**Quantity**	**Package size**	**Machine speed**
Automatic bottom	Carton	> 10 000	< 300	5 500 packages/h
			< 500	5 000 packages/h
			> 1 000	4 750 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	3 000 packages/h
	F/E	> 10 000	< 300	5 000 packages/h
			< 500	4 750 packages/h
			> 1 000	4 500 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	2 750 packages/h
	B/C	> 10 000	< 300	4 000 packages/h
			< 500	3 750 packages/h
			> 1 000	3 500 packages/h
		< 10 000	< 300	3 250 packages/h
			> 300	2 500 packages/h
Side glued	Carton	> 10 000	< 300	7 500 packages/h
			< 500	5 250 packages/h
			> 1 000	5 000 packages/h
		< 10 000	< 300	4 750 packages/h
			> 300	3 000 packages/h
	F/E	> 10 000	< 300	5 250 packages/h
			< 500	4 750 packages/h
			> 1 000	4 500 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	3 000 packages/h
	B/C	> 10 000	< 300	4 500 packages/h
			< 500	4 250 packages/h
			> 1 000	4 000 packages/h
		< 10 000	< 300	3 500 packages/h
			> 300	2 500 packages/h

As can be seen in Table 5.9, the *die cutting* machine speed is particularly influenced by three components; sheet size, flute configuration and batch quantity. These three determine an appropriate machine speed that combined with the batch quantity provide the operation time for the die cutting activity. The set-up time is on the other hand strongly related to the complexity of the sheet interlace pattern. If the amount of waste material in between the packaging blanks increases and the total knife length is relatively large, the set-up time definitely will increase. Whether a strip tool is used or not also affects the set-up time considerably. Since it requires very detailed knowledge and a great deal of effort to determine the complexity of the sheet interlace pattern; the number of package blanks is used as an indicator of the complexity. The cost driver for a given customer order is then given by the determined set-up time, machine speed and quantity.

The *folding* machine speed is also exemplified in Table 5.9. Just as before, the machine time is built up by a separate set-up time and an operation time. In the folding activity, packages are folded and glued into their final shape. The folding machines are probably the most challenging ones to set-up. It requires both great competence and experience before it can be performed efficiently. The main factors affecting the set-up time are the size of the package as well as the amount and types of folding and gluing. The machine speed is mainly affected by four factors; type of folding, flute configuration, quantity and package size. Depending on these components, the machine speeds will vary significantly in the folding machines.

The *lamination* machines are the easiest machines to prepare for a new job. It takes approximately 25 minutes for an average skilled machine driver to adjust and set the machine for a new manufacturing order. Given that the product should be laminated, its characteristics affect the set-up time very marginally and can therefore be neglected without any significant loss of accuracy. This implies that the machine set-up time is considered to be constant. It takes approximately another 20 minutes to gather the required material from the raw material storage, which makes the total set-up time 45 minutes long. The machine speed, and hence the operating time, is determined by three main factors; sheet width, flute configuration and quantity.

As no machines are being used for the *stripping* activity, the term *activity time* is used when referring to the cost driver for this activity. The time needed to strip a pallet is therefore equal to the operating time, i.e. there is no set-up time. The main factors affecting the activity speed are the number of packaging blanks, flute configuration and quantity.

In the *windowing* activity, a plastic film is attached to the package. Since it is a machine operation the cost driver is referred to as *machine time*. A problematic part during set-up of the windowing machine is linked to the construction of the tool. This is made in-house and it takes between 10 and 60 minutes to construct, depending on the shape of the window. Except for the tool construction it takes another one to three hours to adjust the machine properly until it becomes possible to manufacture any products. The machine speed, on the other hand, is affected by four main factors; design symmetry, flute configuration and package size as well as the quantity.

Similarly to stripping, the *handwork* activity does not require any machines, which means that the cost driver should be referred to as *activity time*. In the handwork activity, extra material can be attached to the package, such as a handle or a label. Sometimes, packages go through the handwork activity because the batch quantity is inefficiently low to manufacture in the folding machines, or the size of the package is greater or smaller than the machines can handle. The activity speed is determined by the quantity and the type of operation.

All cost drivers are now related to one or several cost object components at different levels. This implies that the identified resources have been allocated to the identified activities. How these are consumed by individual customer orders is determined by the (sub-)components of the order. This constitutes the foundation of the developed cost estimation system, where these relations and allocations should be calculated and expressed in monetary term in order to estimate the total manufacturing costs. As stated in the introduction, the administration related activities were identified and allocated respectively, but are not integrated explicitly in the developed cost estimation system in accordance to the pricing strategy. The previous and developed cost estimation system will be thoroughly described and explained in the forthcoming chapter.

6 Description of Cost Estimation Systems

In the beginning of this chapter the previous cost estimation system at FrontPac will be described thoroughly. The main focus will be directed at the existing problem areas, in order to facilitate the understanding of the developed system and the forthcoming analysis. The developed system will thereafter be presented systematically and comprehensively.

6.1 Previous cost estimation system

The description of the previous cost estimation system is broken down into three main parts in order to facilitate the comprehension. It begins with a brief description of the overall structure, providing the outline of the system. Thereafter, all the required input to the system is described followed by a presentation of the output from the system.

6.1.1 Overall structure

The previous system is an Excel worksheet that constitutes approximately two printed A4 pages, which contains both the input and the output of the system. The overall structure follows an obvious logic that is organized in a top-down approach. It is therefore appropriate for the user to start specifying information at the top of the worksheet and to continue downwards, until all the required input has been specified. The description of the system that is presented below subsequently follows the same top-down approach, which makes it easier to follow. Beneath, merely small sections of the system are visualized in association to their belonging explanations, in order to provide useful exemplifications. All sections included in the complete system are not visualized due to a discretion agreement with FrontPac.

Several cells in the system are marked with gray color to illustrate that information should be typed in manually by the user. The white cells, on the other hand, denote that calculations are performed automatically by the system, based on the available information in the other cells. The format has been chosen carefully to fit precisely on two printed A4 paper sheets. Throughout the whole system rather detailed cost information is provided as output to the user in order to make it possible to follow the calculations. Some of this information is normally not useful, although it might be preferable to perceive in certain situations in order to fully understand the final outcome. There is also a risk when too much information is provided, since it can be difficult to notice the parts that are considered to be the most important. This is a balance that has to be considered carefully when developing a system.

6.1.2 Cost estimation system input

In order to obtain a proper cost estimation output from the system, appropriate user input is required. Merely a limited number of employees are able to specify this input properly and there is merely one employee that is considered to have the authority to perform definite cost estimations. The salespersons must consequently hand over the product specification, which is agreed upon with the customer, to this employee whenever they require cost estimations. Sometimes he becomes a bottleneck in the sales process and in worse cases the customers have to wait for days until a price quotation can be provided. Additionally, it is often preferable for the salespersons to provide more than one price alternative to the customer, e.g. the price for different order quantities may be desired. Sensitivity analyses are therefore often required, but the customer would normally like to obtain the price for the initial specification prior to demanding any further price alternatives. Much non-value adding time can therefore be spent on performing these requests, due to the inappropriate information flow via the cost estimation employee, until the final product specification is set.

The user input is clarified below by being presented structurally and clearly separated into four categories. The denotations of these categories are set clearly linked to the parts in the pricing strategy, mentioned in section 5.2. These categories are; background information, direct material, direct labor & manufacturing overhead and material overhead; transport and storing. All the required input to the system is specified manually.

Background information
The first section of the system contains the general background information. Most of this information is not explicitly used in the cost estimation, but fulfills other purposes. The first row in Figure 6.1 contains the date, the sales person's ID, the name of the person responsible for the cost estimation, the identification number for the order as well as the packaging size. This information is primarily useful for constructing the possibly upcoming manufacturing order. It may also be useful when reviewing a previously performed cost estimation in order to realize who performed it, when it was performed and also which product it was performed for.

The second row of this section contains the information about the customer, the product description to report certain characteristics, customer ID and finally the order quantity. Neither is this information used explicitly in the cost estimation, apart from the order quantity. It is rather specified in order to identify the particular product and customer. However, the packaging size, customer and product description will often implicitly affect the output of the cost estimation. These may for example provide information concerning the specific packaging design that will have an impact on the manufacturing process, transport packaging, storage or similar.

It is unfortunately not suitable to perform sensitivity analyses in this system. The cost estimations at FrontPac are commonly calculated for three different order quantities to be used by the salespersons in price negotiations. When the order quantity increases, the material costs will increase somewhat proportionally, although many calculations that depend on the order quantity have to be adjusted manually, e.g. manufacturing costs, transport costs, storage costs, transport packaging costs, etc.

Date	Salesperson	Calculated by	ID-number	Package size (l x w x h)
2010-12-03	KL	SS	F012345 1'	150X100X75
Customer	Product description		Customer ID	Quantity (packages)
CUSTOMER AB	FEFCO 0713 - Windowed with inlay		12345	25 000

Figure 6.1: *The background information.*

Direct material
The direct material costs includes five cost items; carton, corrugated cardboard, consumables, possible material for extra functions and the transport packaging for the finished products. These five items are described separately below.

The cost for *carton material* is based on four input parameters; sheet size, number of carton liners, grammage and price for the specific paper quality. These have to be specified as input to the system in order to obtain the carton material cost, as can be seen in Figure 6.2. The user is thus required to specify the sheet size (length and width) in order to fill out these cells. This is an apparent issue with this system, because vast cost estimation experience and manufacturing competence is required in order to accomplish this appropriately. Normally, it is the packaging designers that perform this task when planning a manufacturing order, but when providing a price to the customer that is based on the cost estimation; these employees are not yet involved. Part of the cost estimation objective is hence to present a sheet size that is as similar as possible to the designers' final solution, applied for the eventual manufacturing order.

The total number of required carton liners is calculated based on the information about the number of packaging blanks, the order quantity and the approximate amount of carton liner spill that is required during manufacturing. Especially the expected amount of carton liner spill is difficult to determine since. it requires vast experience and understanding of the manufacturing process to be set properly. Obviously, the name of the specific paper quality and its belonging unit price should also be specified.

# of packaging blanks 2	Carton liner spill (sheets) 650	# of sheets 13 150	Paper quality KORSNÄS WHITE	Grammage 185
Sheet length (mm) 1 019	Sheet w idth (mm) 1 093	Price (SEK/kg) 15,00 kr	Weight (kg) 2 710	Carton cost (SEK) 40 643 kr

Figure 6.2: *The carton material cost calculations.*

In the next section the cost for *corrugated cardboard* is calculated, which will depend on whether the corrugated cardboard should be delivered as sheets or rolls. Corrugated cardboard sheets are most commonly used for displays and are consequently not used in the normal case. However, when used, the necessary input information is the required number of sheets (including spill sheets), sheet size, quality of corrugated cardboard quality, identification number and corresponding unit cost (cost per sheet).

If the corrugated cardboard instead is delivered on rolls, which is occurring most frequently, the amount of corrugated cardboard needed is calculated automatically, based on the specified sheet size. The user input required is the expected number of spill sheets, quality of corrugated cardboard, the corresponding unit cost (SEK per square meter) and amount of corrugated cardboard per roll. Similarly as above, the expected amount of spill is difficult to determine. Additionally, the number of rolls needed, will be calculated automatically, although the user is expected to specify the actual number of rolls that probably will be ordered, since these figures may differ. The corrugated cardboard cost is then calculated automatically.

The cost of *consumables*, e.g. lamination glue, is also calculated. The glue quality is expected to be described, but more importantly the corresponding unit cost. The amount of consumable required per square meter is also required to be specified by the user, which is rather detailed information. The required glue weight is subsequently calculated automatically and this information will then generate the consumable cost.

If any e*xtra function* is required for the packaging, its material cost is calculated by specifying the cost per item and the number of items per packaging, as can be seen in Figure 6.3. The total number of items is already specified by the order quantity which will generate the material cost for the extra function. In addition, a brief description of the extra function is also a desired input.

Extra function	Item cost (SEK)	Items per package	# of items	Extra function cost (SEK)
PLASTIC HANDLE	0,50 kr	1	25 000	12 500 kr

Figure 6.3: *The extra function cost.*

Direct labor & manufacturing overhead

The direct labor & manufacturing overhead related costs are separated into an external and an internal part. The former merely includes printing, while the latter includes lamination, die-cutting, stripping, folding and handwork.

The *external* part is simply a printing cost, which is calculated according to an on beforehand negotiated price list. The printing cost is based upon the size of the carton liner and the number of colors; but also which colors and varnish that is applied (see Figure 6.4). The type and number of colors that should be applied are described briefly, while the set-up as well as the operation cost for printing is specified by the user according to the price list.

	# of colors & varnish	Set-up cost (SEK)	Operation cost (SEK)
Print (color)	4 CMYK	3 125 kr	0,87 kr
Print (varnish)	UV Partial	1 750 kr	0,30 kr

Figure 6.4: *The external part of direct labor & manufacturing overhead.*

The *internal* part includes five activities that all are treated similarly in the cost estimation system. The user is expected to specify the machine speeds, the number of set-ups and the required set-up time. Once again, the quality of this input definitely relies on the user's experience and manufacturing competence. The actual variations in the figures are relatively large and also have a significant impact on the outcome. In order for these numbers to be set properly, almost every aspect linked to the order have to be taken into consideration. Therefore this also requires much effort from the user to perform.

On beforehand the machine costs per hour have been determined for every separate activity. It is determined to a static constant value that is used in the cost estimations for every cost object. These values were determined long ago and currently it is not possible to see what these calculations were actually based on. Neither is there a convenient way to update these values according to the present situation at FrontPac or to any future substantial organizational changes, e.g. investments in machines. However, based on these values, the required activity time is calculated automatically and subsequently multiplied with the machine costs per hour in order to obtain the total activity cost. The sum of these activity costs then generates the cost of the internal part.

Material overhead

There are also costs that are not related to either direct material or direct labor & manufacturing overhead. These are summarized under a category called material overhead, which primarily includes storing and transport. These costs are specified explicitly by the user, which means they currently have to be calculated outside the cost estimation system. The transport cost can be calculated by using negotiated price lists, but requires calculations of number of pallets, total weight and destination input, such as country and distance. The storing includes both handling costs and costs for capital tied, at all storage areas, which therefore also requires several calculations to be done by hand. Obviously, these calculations can be rather cumbersome and time-consuming to do. The cost for transport packaging are also presented in this section of the system, although it is regarded as a direct material cost and added to this type of cost later on.

6.1.3 Cost estimation system output

The cost estimation system output is structured so that the total order cost, the unit cost and the cost proportion is presented for every single cost section described above (see Figure 6.5). This part of the output occupies relatively much space and the cost information is very detailed. It is therefore somewhat difficult for the user to focus on the most interesting parts. However, these parts are subsequently summarized and consequently constitute the total manufacturing cost. These parts include the cost for direct material, the cost for direct labor & manufacturing overhead and the cost for material overhead (see Equation 6.1).

$$\text{Total manufacturing cost} = \\ (\text{Direct material cost} + \text{Direct labor} \ \& \ m\text{anufacturing overhead cost} + \text{Material overhead cost})$$

Equation 6.1: *The total manufacturing cost.*

From section 5.2, it is known that the price is set based on the total manufacturing cost. In order to cover the administration overhead and the calculated profit, a percentage spread is also used. The formula applied to determine the price can be seen in Equation 6.2:

$$\text{Price} = \text{Total manufacturing cost} * (100\% + \text{Percentage spread})$$

Equation 6.2: *Price calculation in the cost estimation system.*

Consequently, when the user determines the percentage spread, a suggested price will be provided in the system output. Both the total order price as well as the unit price is presented. Thereafter, the summarized direct material cost, internal direct labor & manufacturing overhead cost, external direct labor & manufacturing overhead cost and the material overhead cost are presented; both as their relative proportions and their total cost. These relative proportions are also presented graphically (see Figure 6.6), which enables the user to apprehend this information easier. Finally, a small field used for general comments about storing, transport and similar is placed conveniently next to this information.

Type of cost	Total cost	Unit cost	% of total cost
Transport	- kr	- kr	0,00%
Warehousing	- kr	- kr	0,00%
Carton	40 643 kr	1,63 kr	42,78%
Corrugated cardboard (sheet)	- kr	- kr	0,00%
Corrugated cardboard (roll)	7 544 kr	0,30 kr	7,94%
Consumables	3 808 kr	0,15 kr	4,01%
Extra function 1	12 500 kr	0,50 kr	13,16%
Extra function 2	- kr	- kr	0,00%
Transport packaging	500 kr	0,02 kr	0,53%
Print (color)	3 136 kr	0,13 kr	3,30%
Print (varnish)	1 754 kr	0,07 kr	1,85%
Lamination	5 972 kr	0,24 kr	6,29%
Die cutting	9 336 kr	0,37 kr	9,83%
Stripping	1 275 kr	0,05 kr	1,34%
Folding	8 340 kr	0,33 kr	8,78%
Handwork	- kr	- kr	0,00%
Storing	187 kr	0,01 kr	0,20%
Total manufacturing cost:	**94 995 kr**	3,80 kr	
Percentage spread	23 749 kr	0,95 kr	25,00%
Price:	**118 743 kr**	**4,75 kr**	

Main types of costs	%	Kronor	
Direct material	68,42%	64 995 kr	Possible comments
Internal manufacturing	26,43%	25 110 kr	
External manufacturing	5,15%	4 890 kr	
Material overhead	0,00%	- kr	

Figure 6.5: *The cost estimation system output.*

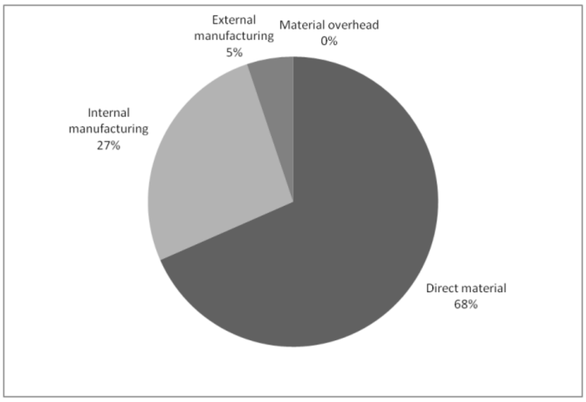


Figure 6.6: *The cost parts' proportions.*

6.2 Developed cost estimation system

The description of the developed cost estimation system initially provides a holistic view over the logical structure. Similarly to the previous system, the developed system is constructed in Excel, according to FrontPac's desire. The different worksheets included and their interrelations will therefore be explained. The description is after that broken down further into detail where the different worksheets and their purposes are described separately.

6.2.1 Overall structure

The overall structure of the worksheets in the cost estimation system can be seen in Figure 6.7. Each worksheet is marked out by a so called document symbol, where every worksheet fulfills different purposes. The system includes a *user interface*, which is the only worksheet the user actually is in contact with. A couple of necessary supporting worksheets have subsequently been structured. The overall structure of the system can be separated into four categories based on the information flow between the user interface and the main supporting worksheets. All the worksheets will be further clarified beneath by describing these four different categories. The purpose with the supporting worksheets is to reduce the information on every worksheet and to simultaneously make it less difficult to follow the intended logic. Some worksheets received an asterisk, denoting that these sporadically require updates. These are either price lists or activity costs, where the latter depend on the current manning and machine situation. One worksheet primarily performs the calculations to generate a sheet suggestion. Another three worksheets referred to as direct material, direct labor & manufacturing overhead and material overhead; determine all the different cost parts that add up to the total manufacturing cost for the order. These four are also the main supporting worksheets. In order for this principle to function systematically, one supporting worksheet keeps the activity costs, while three other worksheets referred to as machine speeds, printing prices and material prices; keep machine speeds and price lists.

In the forthcoming description, merely the summarized information flow between the user interface and the supporting worksheets is visualized. The details in these information flows are attached completely in Appendix D. For the cost estimation system, merely the user interface will be visualized, divided into two strict sections. One section visualizes all the input information and the other one all the output.

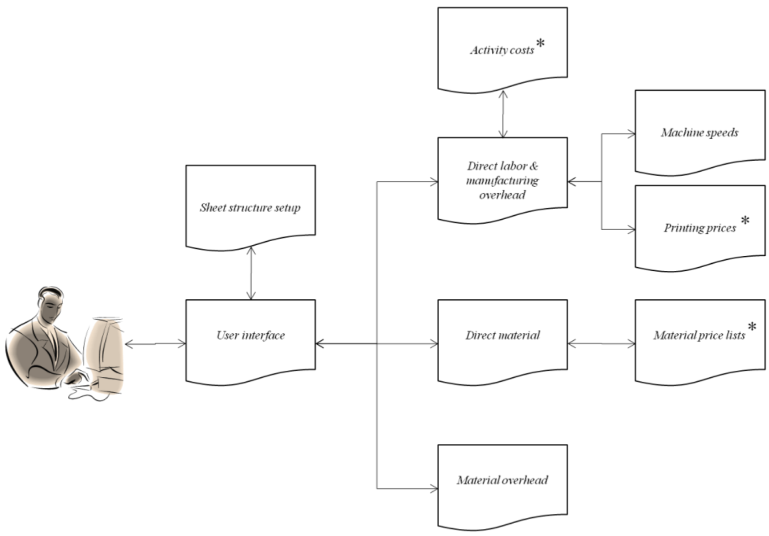


Figure 6.7: O*verall structure of the developed cost estimation system.*

It should be noted that all the prerequisites for allocating the administrational resources via activities on to the cost objects have been prepared in previous chapters. The resources and activities with their belonging drivers and volumes are thus identified and determined also for the administration. However, as it have not been of any current interest for FrontPac to incorporate these explicitly into the system, a percentage spread will still be added to the manufacturing cost in order to cover the administrational overhead. This approach is in accordance with their current cost based pricing strategy.

6.2.2 User interface

The user interface is a worksheet where the user provides the system with necessary input, either by typing it in manually or making appropriate selections from dropdown menus. As a result, the user will obtain the desired cost information for price negotiations with the customer, such as a total order cost, a unit cost as well as an appropriate graphical visualization of the cost proportions. The required input is strictly limited to only include information concerning the order and product components. This will then make it possible to use the model without any detailed experience of the company processes or any vast cost estimation competence. The complete user interface will be visualized below, where the required user input and the obtained output is strictly separated.

Structure and interface

The user interface is specifically adapted to fit well in size, both digitally but also as printed text in A4-format. Specific requirements from the future users have contributed to the structure of the interface and cells have also been marked with colors in order to display different user input alternatives. Necessary supporting information for the user has appropriately been placed on the right hand side in order to exclude it from the printed pages. The graphical interface of the system has also been developed carefully in order to be satisfying for the users in several aspects, e.g. to be user-friendly, presentable and to enable that necessary information can be found easily.

Displayed information

Merely the required information to perform the cost estimations appropriately is displayed on the user interface. The intention is to make it dense, but yet simple to use and survey. The required information implies that it is considered to be crucial in order to specify the particular order cost. As mentioned previously in section 3.2.2, a consideration between structural and human capital is a necessity. This has therefore been taken into account during the development of the system, based on the future users' requirements and the desired accuracy of the cost estimations. The required input has thus been limited as much as possible in order to reach sufficient cost estimation accuracy. The user interface input is visualized in Figure 6.8 where there evidently are many similarities with the previous system.

User input

The input required for the user interface is structured in a top-down approach similar to the previous system. It can be divided into several separate sections that each contains at least one input cell. The required input sections thus treats information about the background, product, sheet, print, material, extra function, manufacturing, warehousing and transport. The cost estimations subsequently generate an output based on this information. The forthcoming illustrations of the worksheet information flows are then treated with this level of detail.

The *background information* section is similar to the previous system where the date, the salesperson, the person responsible for the cost estimation, the order ID number and the customer has to be input. Subsequently the *product information* input should be specified, which includes; order quantity, packaging design, length, width and height (of the packaging). The next section treats *sheet information*, where a sheet first is suggested based on the specified product information, whereby the user is expected to specify the final sheet choice. Some *print information* is then required, which includes; number of print variants, number of colors, type of color and type of varnish. Subsequently, *material information* such as; carton quality, grammage, window size, flute configuration and cardboard quality is provided by the user. A separate section is also dedicated for *extra function information* which includes two similar rows that each requires a brief extra function description, number of items per unit, unit cost and handwork speed. The final input section treat three information parts; *manufacturing* with the number of batches, *warehousing* with the number of months and number of call-offs and lastly *transport* with the destination country and distance.

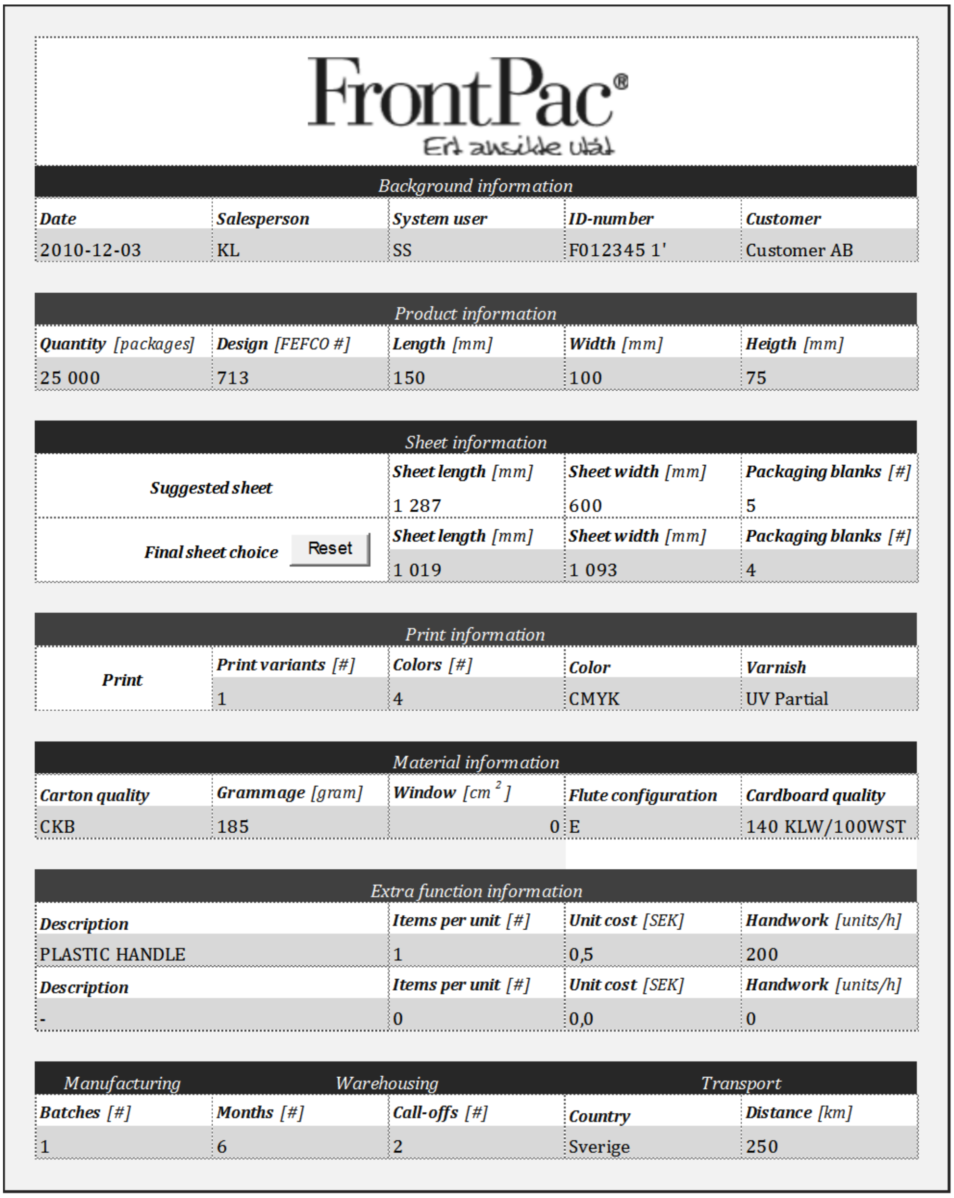


Figure 6.8: *The user interface input.*

Output
For the output the previous system was the main inspiration in order to ensure that the desired information was visualized. Although, as mentioned previously, the information was condensed in order to include merely the most essential information for the user. As can be seen in Figure 6.9, the system output generates the total manufacturing cost. This is built up by the five cost parts; direct material, print, manufacturing, storing and transport. A suggested price is then calculated by adding a constant percentage overhead and a user specified profit margin to the total manufacturing cost. These two parts consequently constitutes the percentage spread that was used in the previous system. A graphical visualization of the cost proportions, between the different cost parts, is also provided.

Cost information

Type of cost	*Cost*	*Unit cost*	*% of total cost*
1. Direct material	54 283 kr	2,17 kr	45%
2. Print	8 596 kr	0,34 kr	7%
3. Manufacturing	46 364 kr	1,85 kr	38%
4. Storing	10 489 kr	0,42 kr	9%
5. Transport	1 553 kr	0,06 kr	1%
Total manufacturing cost	**121 284 kr**	**4,85 kr**	
Administration overhead	15%	15%	
Profit margin	10%	10%	
Price	**151 605 kr**	**6,06 kr**	
Estimated profit	**12 128 kr**	**0,49 kr**	
Color and varnish plates	6 950 kr		
Tools	7 800 kr		
Total cost	**178 484 kr**		

Cost proportions

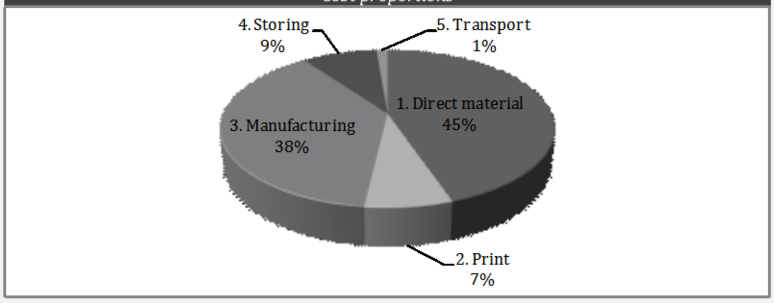


Figure 6.9: *The user interface output.*

6.2.3 Sheet structure setup

The *sheet structure setup* worksheet is not in itself crucial for performing cost estimations. It can be seen as a powerful extra function to the system. It was therefore appropriate to dedicate a separate worksheet for this function. Its purpose is to generate a sophisticated sheet suggestion for the user, based on some design specific information. The function with this worksheet is though required to enable the salespersons to perform cost estimations independently. Based on the product information input, the required sheet information becomes the output (see Figure 6.10 and Figure 6.8). It should be noted that the sheet size decision merely affects internal manufacturing conditions. It is therefore not specified by the customer. The sheet structure choice actually requires a deep understanding of the investigated packaging designs and of the manufacturing process in order to be capable of proposing an appropriate sheet size. Normally, this is performed by the experienced designers as they determine appropriate sheet sizes for manufacturing orders. The final sheet decision therefore has to be set by the user, who has to determine whether there is a more appropriate sheet size than the one suggested. Before making this decision, it can be preferable to consult the designers, since they may recommend another sheet size. Otherwise the suggestion preferably can be chosen.

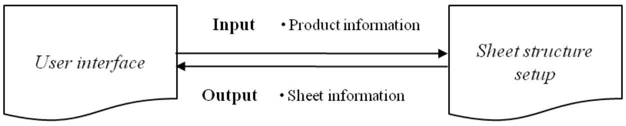


Figure 6.10: *Worksheet information flow for sheet structure setup.*

An explanation of the logic in the sheet structure setup operation is now performed in order to facilitate the understanding. The logic is also illustrated in Figure 6.12. First, the interlacing type is established, which is specified by the particular packaging design. Each design either has no interlacing, one-sided interlacing or two-sided interlacing. For one-sided interlacing every second unit is interlaced, whereas every unit is interlaced for two-sided interlacing. The interlacing type namely affects how the packaging blanks are placed on a sheet. For the established interlacing type, two sheet suggestions are provided, since the packaging can be twisted 90 degrees. This principle is illustrated in Figure 6.11, which besides is an example of two-sided interlacing. The interlacing type will consequently affect the sheet size. However, as also can be seen, the forthcoming points of decision for the sheet structure setup will be equal for all the interlacing types.

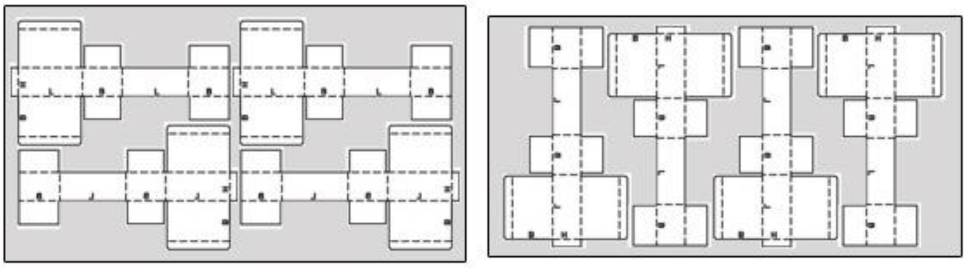


Figure 6.11: *Two sheet suggestions for a two-sided interlacing packaging design.*

Second, it is stated whether it is considered to be a high or low order quantity. There is namely a specifically defined limit separating these two categories, since it often is justifiable to strive against having a larger sheet size for higher quantities. The order quantity hence determines the maximum sheet size that is accepted for that order. After that, the sheet structure setup tries to maximize the number of packaging blanks, for this specified maximum sheet size. The main reason for this is that the cost for the die-cut tool increases somewhat proportionally to the total knife length. Hence, larger sheets incur more expensive die-cut tool costs, but also longer set-up times in the die-cutting working station.

Third, if the order quantity is high, the next point of decision is whether the number of packaging blanks is equal or different for the two suggestions. In the case that these are different, the suggestion with the most packaging blanks is chosen. Otherwise, these are equal and thus another point of decision is reached, namely which sheet widths the suggestions provide. Consequently, the one with the shortest sheet width is chosen, since this is the most favorable suggestion for the lamination operation. Similarly, if the order quantity is low, the suggestion with the highest sheet utilization is chosen, i.e. with the least amount of waste material.

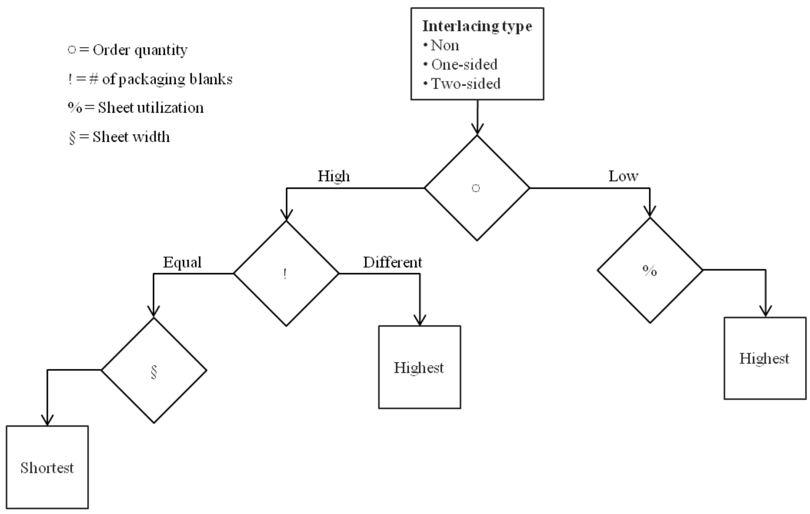


Figure 6.12: *Sheet structure setup logic.*

6.2.4 Direct material

The *direct material* worksheet requires material and sheet information as input to generate the direct material cost as output to the user interface. Hence, all material cost calculations are gathered and performed in separate sections within this worksheet. In order to enable easy and structured updates of the necessary material price lists, these were all gathered in a separate supporting worksheet called *material price list*. The purpose with the this worksheet is primarily to return the unit price for specific qualities of carton and corrugated cardboard, needed for the calculations in the direct material worksheet. The structure of the information flow between these worksheets is illustrated in Figure 6.13.

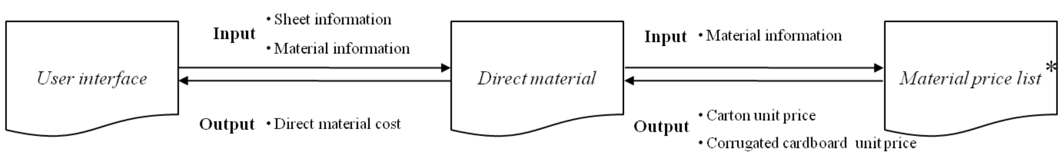


Figure 6.13: *Worksheet information flow for direct material.*

6.2.5 Direct labor & manufacturing overhead

In the *direct labor & manufacturing overhead* worksheet the costs for all the manufacturing related activities are calculated in order to generate a print cost, a manufacturing cost as well as a tool and a varnish plate cost. These are calculated based on some of the information specified in the user interface, as can be seen in Figure 6.14. These are sheet, material, print and manufacturing information.

Additionally, the direct labor & manufacturing overhead worksheet obtains some information from three other supporting worksheets. The *printing price list* has conveniently been put in a separate supporting worksheet, since it merely is a price list that requires sporadic updates. It generates the set-up cost and the operation cost for printing, but also the cost for color plate and varnish plate. This worksheet requires sheet and print information as input.

The *machine speeds* have been placed in a separate worksheet that generates the desired machine speeds. The input required to this worksheet is material, sheet and product information. Depending on some parameters that are considered to affect the machine speeds, appropriate speeds have been set as discrete values for every operational activity, as described in section 5.5.2. For example, in lamination, a certain machine speed is set based on the flute configuration, order quantity and sheet width. It was convenient to put this information in a separate worksheet because it required a large amount of space. Also, if any new machine investments are undertaken in the future, it may be necessary to simultaneously adjust the speeds or the principal structure of the logic.

The purpose with the last supporting worksheet, *activity costs*, is to calculate a unit cost for all the activities that are not connected to the administrational resources. It was appropriate to gather this information in a separate worksheet for several reasons, but mainly in order to facilitate necessary future updates. The worksheet has gathered all information needed to establish the activity costs, which also explains why no input is needed. It also contains standardized procedures for updating the allocation of resources to activities, to facilitate updates and analyzes.

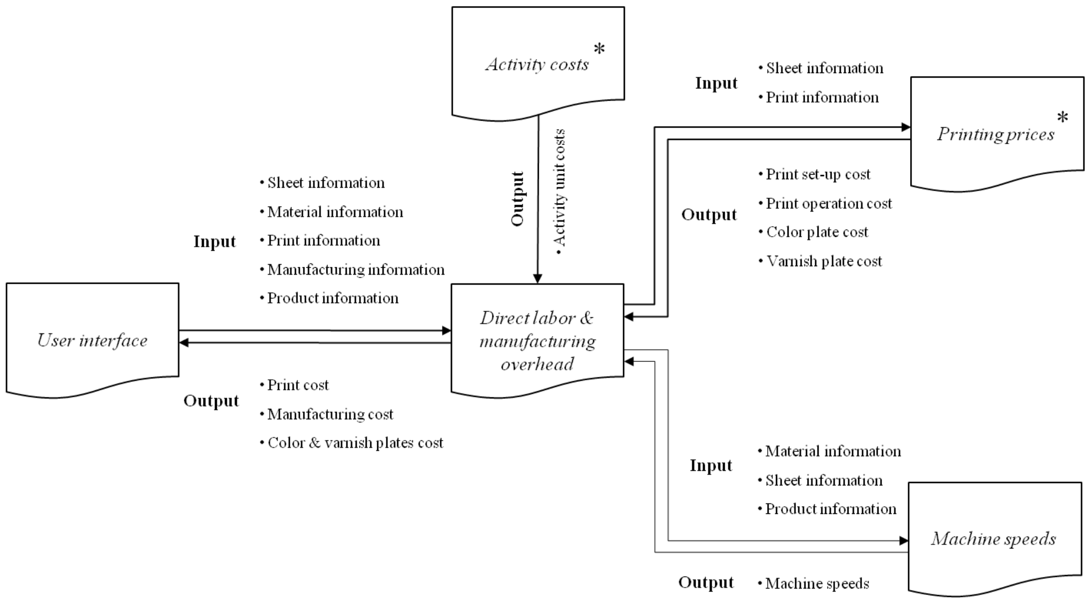


Figure 6.14: *Worksheet information flow for direct labor & manufacturing overhead.*

6.2.6 Material overhead

A separate worksheet was dedicated for calculations of the remaining activities that did not belong to direct material or direct labor & manufacturing overhead, which is called the *material overhead*. The purpose of this worksheet is mainly to calculate the costs of all the activities that belong to the group of material overhead; raw material storing, interim storing, finished goods handling and finished goods storing. But also to calculate some of the other direct costs, such as transport and tool costs. It was appropriate to keep all this information in one worksheet, since it does not necessarily require any updates and neither are these the main parts of the total order cost. The generated output from the worksheet is the costs for storing, transport and tools (see Figure 6.15 and Figure 6.8) and in order to produce this output the required input is information concerning; material, sheet, warehousing and transport.

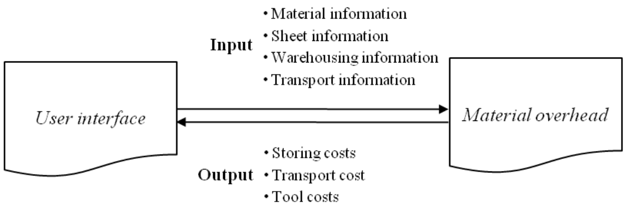


Figure 6.15: *Worksheet information flow for material overhead.*

7 System Results

In this chapter, the results from the proposed solution to the problematization, stated in the introduction, will be presented. It will begin with the validation results for the developed cost estimation system. Thereafter, the results connected to the four problem areas that were stated in the purpose will be presented. These include; number of possible users, time to price, sensitivity analysis and dynamic aspects.

7.1 System validation

Before commenting on the positive side effects of the developed cost estimation system, it is appropriate to ensure that it provides valid and correct output. In order to validate the system, 50 cases have been studied, where the identical customer order has been calculated for both systems. These cases were randomly selected from the time period September to November 2010 and are therefore considered to be a representative selection of typical customer orders.

The results from the validation have been visualized in a diagram (see Figure 7.1). In the diagram the total order cost for the developed system has been plotted against the total cost for the previous system. Two versions of the developed cost estimation system have been tested in order to simulate two frequently occurring situations; approximate price quotations and definite price quotations. The approximate price quotation represents a situation early in the sales process where the customer whishes to obtain approximate price quotations for preliminary product specifications. This information then acts as a base for further discussions and modifications with the customer. The definite price quotation represents the final price offer, where more effort is put on actually estimating the cost as accurately as possible, according to the final product specification. To simulate these situations, the former situation applies the suggested sheet information and manufacturing parameters that is suggested by the developed cost estimation system; while the latter situation applies the determined sheet information and manufacturing parameters used in the previous model that is determined by the cost estimation employee.

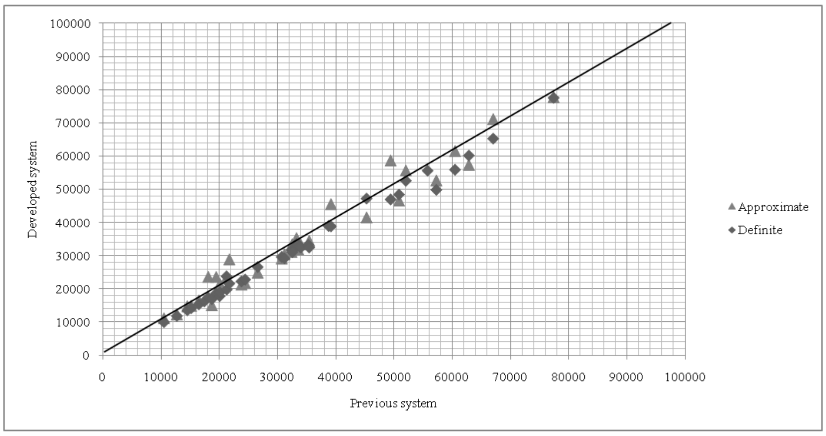


Figure 7.1: *Developed system output plotted against previous system output.*

As can be seen in Figure 7.1, the developed cost estimation system appears to provide definite price quotations that are relatively close to the results obtained from the previous system. For approximate price quotations the developed system costs deviate more from the costs of the previous system. Furthermore, the developed system appears to systematically underestimate the total cost in relation to the cost that is provided by the previous system. This is also confirmed in the statistical analysis of the validation data, as can be seen in Table 7.1.

Table 7.1 *Statistical validation results.*

Cost estimation system	R^2	Mean	Standard deviation
Developed: Approximate	99,18%	-0,14%	8,15%
Developed: Definite	99,77%	-4,21%	5,22%

As can be seen in Table 7.1, the developed system is actually systematically underestimating the cost in both situations, since both means are negative. It is also possible to notice that the mean for the approximate estimations are actually closer to the corresponding result for the previous system, compared to the definite estimations. This will be analyzed and explained in the discussion, section 9.3. The coefficient of determination (R^2) is closer to 100 percent for the definite estimations than for the approximate, which also is apparent from the standard deviation results. The approximate estimations obviously had larger standard deviations compared to the definite estimations.

7.2 Number of possible users

As stated in the introduction, the first problem area with the previous cost estimation system was concerned with the number of possible users. The main drawback with the previous system was that only a few experienced and skilled employees were actually able to perform cost estimations. Obviously, this kind of dependency is never advantageous, neither for the concerned employees, nor the company.

The developed system increases the number of authorized salespersons that can perform cost estimations from today's 20 percent up to 100 percent. Additionally, since the requirements on the users has decreased significantly, both management and sales support can use it and gain new advantages as well, e.g. sales support can improve their customer service with the use of cost estimations and management can utilize it in order to perform profitability analyses, evaluate critical orders and analyze organizational changes. In total, this results in a significant increase of the number of possible users from just over 10 percent to almost 55 percent of the administrational employees. The difference between the systems in the number of possible users is illustrated in Figure 7.2.

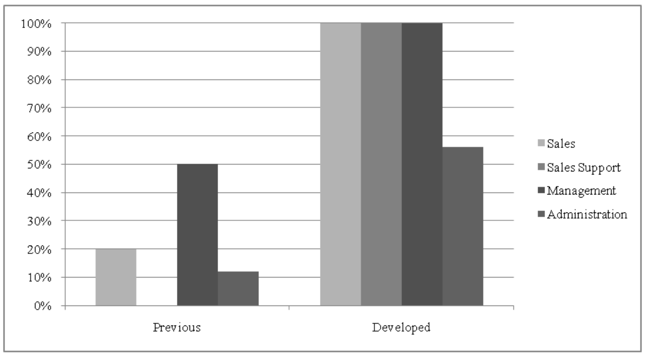


Figure 7.2: *Number of possible users as a percentage of employees per function.*

7.3 Time to price

The second problem area is concerned with the *time to price*, i.e. the time elapsed from that a price is inquired by a customer until a price quotation can be communicated by a salesperson. The disadvantage with the previous cost estimation system was that the salespersons could not by themselves estimate the cost and hence determine a price for a specific customer order. The implication was that the product specifications had to go through the cost estimation employee before a price quotation could be communicated to the customer. The cost estimation employee subsequently had to provide the salespersons with an estimated cost which would be used as a decision basis for the price quotation. This is illustrated in the sales process in Figure 7.3.

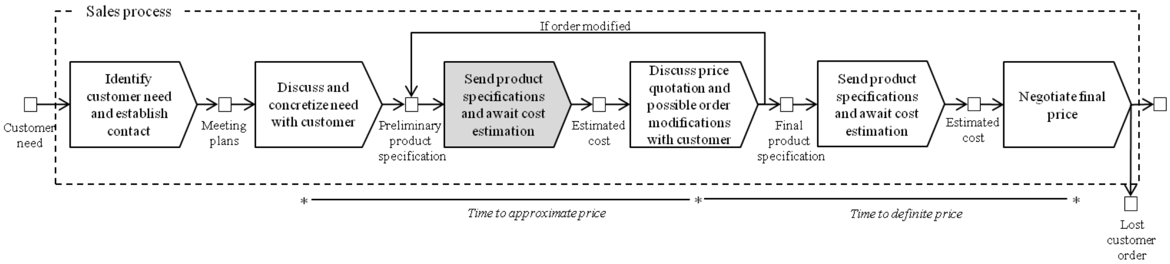


Figure 7.3: *Improvement in sales process.*

As can be seen in Figure 7.3 the sales process consists of six comprehensive activities. Four of these are carried out explicitly by salespersons, but one reoccurring activity is dependent on input from the cost estimation employee. This is the activity called *Send product specifications and await cost estimation*. The first time it appears is in the iterative procedure where the current order is discussed, modified and defined by the customer together with the salesperson. The problem is that this creates an unnatural stop in the discussion since approximate price quotations are needed for further discussions and modifications. The second time it appears is after the iterative procedure where the final product is specified and its specifications are clearly defined. This time the input from the cost estimation employee is used as a base for the final price negotiation.

As a result of the sales process, there are two different time to price situations that are interesting to investigate. The first is concerned with the time to approximate price and the second is concerned with the time to definite price, which was discussed in section 7.1. These are also visualized in Figure 7.3. With the developed system it is possible to reduce the time to approximate price significantly by streamlining the process. The developed system eliminates the need for the activity called *Send product specifications and await cost estimations* as it occurs in the iterative procedure. This implies that the actual time between approximate price inquiry and response will decrease. As a side effect, this also implies that fewer persons are involved in the sub-process of approximate price quotations. However, for definite price quotations an experienced and skill-full cost estimation employee still has to review the cost estimation. This means that the time to definite price will not decrease.

7.4 Sensitivity analysis

The third problem area was concerned with the possibility to perform sensitivity analyses easily. The previous cost estimation system did not provide much support in making sensitivity analyses since the user had to perform most calculations manually, e.g. only the material costs were affected by specifying a new sheet size and the manufacturing effects had to be established by the user. The developed system provides possibilities to change single parameters and to investigate how these changes affect the total cost and the unit cost, without any further modifications.

The main parameters that can be changed in order to analyze the cost effects can be divided into internal and external parameters. The internal parameters are company specific parameters and are not determined by the customer. These include sheet information and manufacturing information including; number and size of batches, set-up times and machine speeds. These are possible to change in order to see how the different types of costs, as well as the total cost are affected. The external parameters are determined by the customer together with the salespersons. These include the following; design (including package size), order quantity, material (both carton and corrugated cardboard), print (both color and varnish), warehousing and transport. These are possible to modify in order to see how the cost, and thus the price, changes.

Furthermore, the developed system offers objective and unbiased cost estimations in comparison to the previous system. It is considered to be more objective since the room for personal opinions and modifications has been considerably limited. The developed system only requires input such as order components, which are less likely to be subjective than e.g. production parameters. This also implies that the developed system makes it is easier to review an original cost estimation and make the necessary modification in order to provide the customer with an updated price. This was not possible with the previous system.

7.5 Dynamic aspects

The last identified problem area with the previous system was the lack of dynamic in the resource to activity allocation. One of its largest disadvantages was that it provided no means of modifications in accordance to organizational changes. To exemplify; if new machine investments were made or the activity manning changed from one shift to double shift, it did not affect the cost estimations unless someone calculated and updated the new activity costs manually. However, the developed system provides helpful tools in performing these calculations and also automatically updates the model when these are performed. An entire worksheet has been dedicated for this purpose and it provides the authorized user to easily update the system according to any substantial organizational changes, such as those mentioned above.

8 Suggested Procedure for ABC Implementation

The intention with this chapter is to present the suggested procedure for ABC implementation in make-to-order companies. The procedure is based on a single case study performed at the packaging manufacturer FrontPac and previous ABC implementation research. The aim is to provide practical guidelines that preferably can be used during ABC implementation projects.

8.1 Overall structure

Part of the purpose of this thesis was to suggest a procedure for ABC implementation in make-to-order companies, which consequently will be presented in this chapter. It is based on both previous research concerning ABC implementation and the gained experiences from the single case study performed at FrontPac. The implementation procedure comprises the actual project start-up, the identification and allocation of the ABC concepts that are required to develop the cost estimation system, the company integration of the system and the termination of the project. In Appendix E, several different templates of matrices and tables that are appropriate to use during the implementation procedure have been placed. These are left blank in order to be an inspiration, or even printed and used, in other ABC implementation projects.

The implementation procedure is divided into five clearly separated phases; each with specific milestones. These include the critical success factors (CSF) and the expected deliverables (see Table 8.1). Every phase then contains a number of stages to be achieved, in order to accomplish the milestone deliverables. However, the sequence between the stages is generally not as strict as for the phases, although this varies between the specific phases. The phases namely have clear milestones, compared to the stages. Normally, independent of the phase, some stages may be performed in parallel while the sequence is more specified. The details in the implementation procedure are clarified below.

Table 8.1: *Procedure for ABC implementation in make-to-order companies.*

	Phase	Stage	Description
0	Initiation	Establish objective Establish scope Plan project	Determine the purpose of the project Determine the depth and the delimitations of the project Establish time schedule, budget and project team
	Milestone	Deliverable CSF	Project specification Top management support & project management experience
1	Identification	Identify resources Identify activities Identify cost object components Identify resource drivers Identify cost drivers Determine resource and driver volumes Determine cost driver volumes	Identify and categorize expenses into resources Identify the main activities in the company Identify the different cost object components Identify the belonging resource drivers Identify the belonging cost drivers Determine the volumes of the resource and the resource driver Determine the cost driver volumes
	Milestone	Deliverable CSF	List of Resources, List of Activities & List of Cost Object Components Easy access to cost data
2	Allocation	Find resource - activity relations Estimate resource - activity proportions Find activity - cost object component relations Develop cost estimation system Validate cost estimation system	Identify and mark out relations in the RAR matrix Determine and mark out the activities percental consumption in the RAP matrix Identify and mark out relations in the ACOCR matrix Create a CE table or a CE model to facilitate cost estimations Validate the model output against appropriate data
	Milestone	Deliverable CSF	RAR, RAP and ACOCR matrices & cost estimation system Deep understanding of the entire company Modeling experience, if needed.
3	Integration	Document results Communicate changes Educate future users Distribute cost estimation system and user manual	Write a user manual and document other necessary information Forward changes to all concerned employees Train and instruct future users in the developed cost estimation system Make the cost estimation system and user manual available
	Milestone	Deliverable CSF	User manual and competent users Committed recipients & pedagogical instructors
4	Completion	Evaluate project Reflect upon project Terminate project	Evaluate the results and the process of the project Discuss and evaluate possible future projects and lessons learnt Terminate the project and resolve project team
	Milestone	Deliverable CSF	Successfully implemented cost estimation system Understanding of time and effort needed Cross-functional and cross-disciplinary competencies

8.2 Initiation

The stages within the first phase, *initiation*, denote general project start-up tasks. It includes a decision concerning what is going to be performed during the implementation, who is going to perform it and how to perform it. This phase has therefore received the number zero. The deliverable in this phase is a project specification. This should contain the basic information stated during this initiation phase, such as objectives, scope and an overall project plan. These parts are clarified further beneath. The project specification document should then favorably be a support during the actual project work, in order to ensure that the originally intended direction is kept. Top management support is the main CSF in this phase, because if the initial direction is misleading, or there is an obvious lack of time, money or resources; the end result will probably become quite inadequate. Furthermore, a lack of project management experience may also cause problems. The experience is usually required in order to realize where critical challenges may occur during a project, since the required effort over time may otherwise be underestimated. Other problems that may occur during the project, as a result of unsuccessful project management, are concerned with the lack of clear responsibilities with unclear roles and work tasks together with the risk for sub-optimizations.

8.2.1 Establish objective

Initially the objectives have to be established properly through close communication with the persons that ordered and initiated the project, together with the stakeholders. The objectives have to be considered carefully and be clearly specified on paper, in order to be able to communicate these appropriately to all concerned employees and stakeholders. These should preferably be expressed in quantifiable terms to enable measurements that can confirm the expected improvements. Some examples of possible objectives can be seen in Table 8.2.

Table 8.2: *Possible project objectives.*

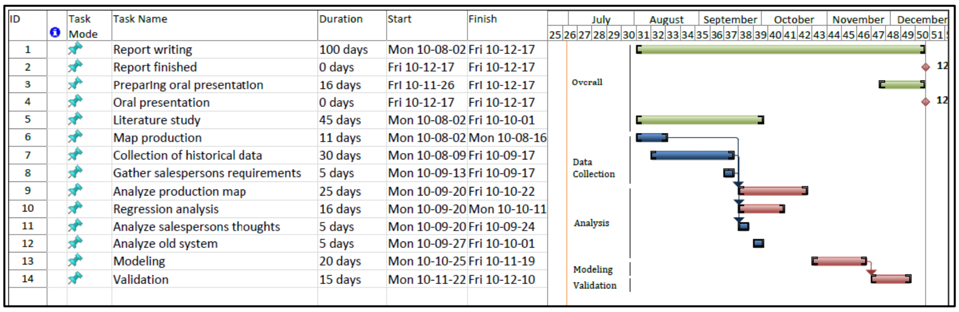
Objectives
Reduce required time to price with five hours.
Enable accurate sensitivity analyses two times faster.
Enable everyone at sales support to provide price informations.

8.2.2 Establish scope

Similarly, the scope of the project, together with the appropriate delimitations, has to be determined. The intended depth and level of detail of the project should be clearly specified. This should be performed in connection to the establishment of the objectives, also in communication with the project recipients. The scope namely sets the frame for the time, money and resources required in order to complete the objectives, successfully. These are normally very situation specific and it is thus difficult to state any general suggestions. By giving it some consideration these should become clear for the specific situation.

8.2.3 Plan project

The project should have a clear overall plan, which e.g. may include a time schedule visualized as a GANTT chart (see Figure 8.1), a budget over the project and a project organization chart (see Figure 8.2). The time schedule can be a very helpful support during the entire project in order to ensure that the time frame is kept. In many cases it is suitable to illustrate the overall project organization, in order for the project members and stakeholders to clearly see the different responsibility areas. A cross-functional competence is usually required to gain holistic insights of the company and this requirement is more critical when the company is larger and more complex. This also implies that the need for a project organization chart increases, since the persons involved with the project may be unfamiliar with each other. It may also be appropriate to perform a stakeholder mapping (see Figure 8.3), in order to realize which persons that are interested in the project and what influence they might have. This project planning stage may in fact be crucial for most projects, because the recipients normally do not determine whether the project should be conducted until a pleasing project plan has been presented.



ID	Task Mode	Task Name	Duration	Start	Finish
1		Report writing	100 days	Mon 10-08-02	Fri 10-12-17
2		Report finished	0 days	Fri 10-12-17	Fri 10-12-17
3		Preparing oral presentation	16 days	Fri 10-11-26	Fri 10-12-17
4		Oral presentation	0 days	Fri 10-12-17	Fri 10-12-17
5		Literature study	45 days	Mon 10-08-02	Fri 10-10-01
6		Map production	11 days	Mon 10-08-02	Mon 10-08-16
7		Collection of historical data	30 days	Mon 10-08-09	Fri 10-09-17
8		Gather salespersons requirements	5 days	Mon 10-09-13	Fri 10-09-17
9		Analyze production map	25 days	Mon 10-09-20	Fri 10-10-22
10		Regression analysis	16 days	Mon 10-09-20	Mon 10-10-11
11		Analyze salespersons thoughts	5 days	Mon 10-09-20	Fri 10-09-24
12		Analyze old system	5 days	Mon 10-09-27	Fri 10-10-01
13		Modeling	20 days	Mon 10-10-25	Fri 10-11-19
14		Validation	15 days	Mon 10-11-22	Fri 10-12-10

Figure 8.1: *GANTT chart.*

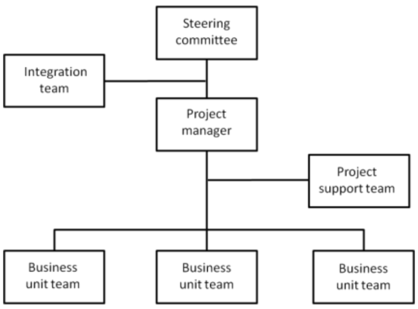


Figure 8.2: *Project organization chart.*

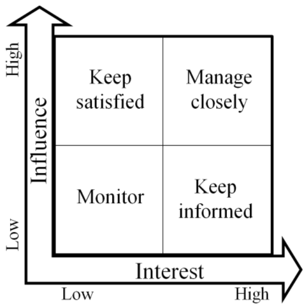


Figure 8.3: *Stakeholder mapping matrix.*

8.3 Identification

In the *identification* phase the actual ABC implementation begins by collecting appropriate cost estimation information, which becomes the foundation to the subsequent allocation procedure. The identification of resources and activities are treated similarly, i.e. these contain equivalent stages, but these are not necessarily strictly separated in time. It is certainly more adequate to perform some of these stages more in parallel, due to their close relations; although it is difficult to suggest a general approach. Hence, this has to be given by the certain situation at hand. The CSF in this phase is easy access to cost data; comprising and detailed enough to generate satisfying deliverables. In this phase there are three deliverables; List of Resources, List of Activities and List of Cost Object Components.

8.3.1 Identify resources

To begin with, all the existing expenses at the company have to be identified. These may preferably be identified from the income statement, which often contains all the information needed. Otherwise any complementary information can be obtained from accounting. It is also appropriate to gather the expenses into different expense categories due to their similarities, e.g. printers and computers may be gathered under office expenses. These expense categories are henceforth referred to as resources. Consequently, these can be collected in the List of Resources, which will be completed in a subsequent stage. The list will probably be rather extensive to begin with, although it most likely can be shortened in a subsequent stage.

8.3.2 Identify activities

In this stage, all the main activities performed within the company have to be identified. The activities are clearly linked to actions that occur at the company. For example, in a manufacturing company the different working stations normally can be seen as different activities, which are performed in order to deliver the final outcome to the customer. It is suitable to use process maps, flowcharts (see Figure 8.4) and similar, in order to become fully aware of what actually is being performed, especially from an overall perspective. Some of these documents may have been constructed formerly at the company and may therefore be used once again. Otherwise it may be more suitable to construct new ones. This stage actually requires much time in order for the project members to become fully aware of the current situation at the company. However, these gathered insights will be incredibly helpful further on. The activities can be collected in a List of Activities, which will be completed in a subsequent stage.

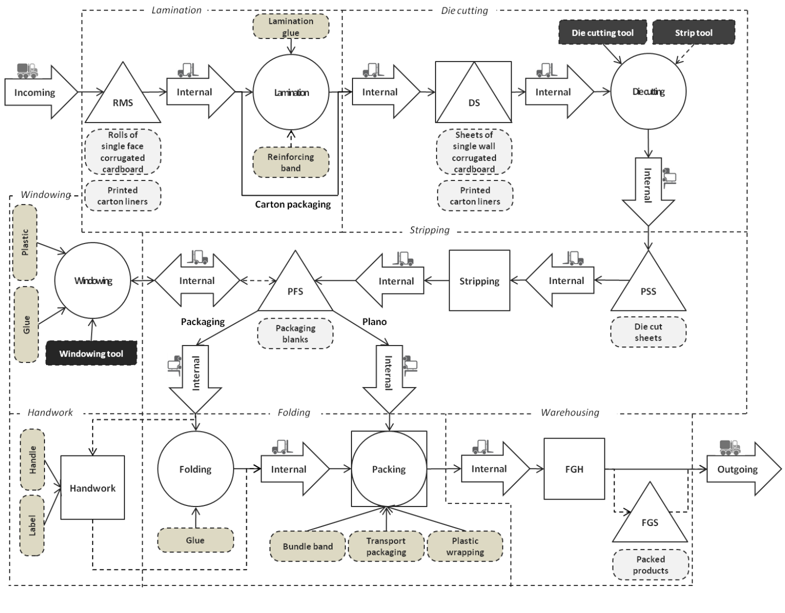


Figure 8.4: *Material flowchart.*

8.3.3 Identify cost object components

Initially the actual cost object, e.g. a product or an order, has to be recognized. All the concerned cost object components within the company should then preferably be identified, in order to enable the identification of the cost drivers and to perform the cost allocation. By creating a List of Cost Object Components, as can be seen in Table 8.3, it becomes easier to get an overview of these. This is helpful when allocating the costs in the next step. It is preferable to mark out in the table if the components directly incur costs, indirectly incur costs by affecting the consumption of activities or both. Otherwise this information has to be taken directly from the mind every single time the allocation to the cost object should be determined, which is clearly undesirable. An empty template for the List of Cost Object Components can be found in Appendix E.

Table 8.3: *List of Cost Object Components.*

Cost object components	Direct	Overhead
Component 1		x
Component 2	x	x
Component 3	x	x
Component 4	x	x
Component 5		x
Component 6		x
Component 7	x	
Component 8	x	x
Component 9		x
Component 10	x	x

8.3.4 Identify resource drivers

In this stage the resource drivers subsequently have to be identified. These have to be possible to express in quantifiable units, e.g. in square meters or hours, in order to enable the allocation of the resources to the activities. By realizing what actually drives the costs, it becomes possible to merge resources that are considered to have an equivalent resource driver. If no uniform resource driver can be found, the expenses within the resource have to be separated until it is found. The important iterative procedure required to set the final resources and drivers has to be clearly emphasized. This will namely help keep the number of resources to a minimum, which is favorable in order to avoid all too complex structures. Hence, if two resources are considered to have the same driver, these consequently should be merged. As a result, it starts off with a large number of expenses and ends up with a decent List of Resources that is clearly reviewable. These drivers can subsequently be added to the List of Resources.

8.3.5 Identify cost drivers

Similarly as in the previous stage, the cost drivers have to be identified for all the activities that were listed previously. These equivalently have to be possible to express in quantifiable units. The List of Cost Object Components can be helpful when trying to understand what actually drives the cost. When two activities are considered to have an equivalent cost driver, the activities can preferably be merged, in order to make the List of Activities denser. If no uniform cost driver can be found, the activity has to be split into several activities until a uniform cost driver is found. The iterative procedure required for setting the final List of Activities should also be emphasized. The identified cost drivers are consequently added to the List of Activities.

8.3.6 Determine resource and driver volumes

The remaining resource related stage deals with the determination of the resource and driver volumes. These are important to set carefully in order to avoid under- or overestimation of the total costs within the company. This information can be collected by using actual data, i.e. by analyzing the actual and planned operational volume within the company according to one of the available methods mentioned in section 3.4.2. Otherwise the volumes can be determined by performing measurements of the operational volume or, if no other option remains, making educated guesses. A complete List of Resources should finally be presented as illustrated in Table 8.4 and an empty template of such a list can be found in Appendix E.

Table 8.4: *List of Resources.*

Resource	Resource volume	Resource driver	Resource driver volume
Resource 1	* *** 000	Resource driver 1	* *** 000
Resource 2	* *** 000	Resource driver 2	* *** 000
Resource 3	* *** 000	Resource driver 3	* *** 000
Resource 4	* *** 000	Resource driver 4	* *** 000
Resource 5	* *** 000	Resource driver 5	* *** 000
Resource 6	* *** 000	Resource driver 6	* *** 000
Resource 7	* *** 000	Resource driver 7	* *** 000
Resource 8	* *** 000	Resource driver 8	* *** 000

8.3.7 Determine cost driver volumes

The cost driver volumes are determined equivalently as the resource and driver volumes, which also are important to set carefully. Actual data, measures or educated guesses have to be applied also in this stage. The List of Activities can be completed in this stage, as can be seen in Table 8.5. An empty template of such a list can be found in Appendix E.

Table 8.5: *List of Activities.*

Activity	Activity volume	Cost driver	Cost driver volume
Activity 1	-	Cost driver 1	* *** 000
Activity 2	-	Cost driver 2	* *** 000
Activity 3	-	Cost driver 3	* *** 000
Activity 4	-	Cost driver 4	* *** 000
Activity 5	-	Cost driver 5	* *** 000
Activity 6	-	Cost driver 6	* *** 000
Activity 7	-	Cost driver 7	* *** 000
Activity 8	-	Cost driver 8	* *** 000

In conclusion, the iterative procedures within this phase are crucial to the end result, despite actual cost data accessibility and quality. Neither should the importance of providing appropriate denotations for the resources, activities and their drivers, be neglected, in order to avoid any eventual confusion. The deliverables in this phase should definitely be set as a final edition, i.e. sufficient iterations should have been performed to ensure that no further adjustments are required during the implementation. These deliverables will namely affect the rest of the work being performed, which makes it cumbersome to adjust anything within this phase afterwards.

8.4 Allocation

The stages performed in the previous phase fulfill an important purpose for the performance of the ones included in this phase, referred to as *allocation*. Based on the lists that were developed in the previous phase, appropriate relations between the elements within these lists now should be found. The stages within this phase can preferably be performed more in sequence compared to the ones in the previous phase. The final deliverable is to develop a cost estimation system, particularly suitable for the specific company. The main CSF in this phase is to have an understanding of the entire company that is deep enough to achieve the deliverable appropriately. Another CSF that appears if a more advanced system should be developed is modeling experience.

8.4.1 Find resource – activity relations

All the resources and activities that were specified as deliverables in the previous phase should in the first stage be gathered into a RAR (Resource - Activity Relation) matrix. The resources should be placed on the columns and the activities on the rows. The procedure is then to determine which activities that consume which resources and to mark out these relations in the matrix. If an activity consumes a resource it is appropriate to mark the corresponding cell, as can be seen in Table 8.6. An empty template to the RAR matrix can be found in Appendix E. The entire matrix should preferably be finished before proceeding onto the next stage, since there is a clear connection between these stages.

Table 8.6: *RAR matrix.*

Activities / **Resources**	Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6	Resource 7	Resource 8
Activity 1		x		x			x	
Activity 2			x			x		x
Activity 3	x	x	x	x			x	
Activity 4	x	x		x	x			x
Activity 5	x		x	x		x		
Activity 6	x		x	x	x			x
Activity 7	x		x	x				x
Activity 8	x	x		x			x	

8.4.2 Estimate resource – activity proportions

In the second stage, the symbols in the developed RAR matrix should be replaced by estimated proportions, i.e. the activities' percental resource consumption. It can be performed by using actual data, educated guesses or systematic appraisal, i.e. by performing a logical reasoning based on the actual information about the resources and the activities. The result is subsequently called a RAP (Resource – Activity Proportion) matrix. The proportions in every column must then add up to one, denoting that the whole resource have been allocated between all of the concerned activities. It can be seen in Table 8.7 that based on the specified resource volumes these proportions will generate the sought activity volumes. An empty template of the RAP matrix can be found in Appendix E.

Table 8.7: *RAP matrix.*

Activities	Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Resource 6	Resource 7	Resource 8	Activity volumes
Resource volumes	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	* *** 000	
Activity 1		20%		30%			10%		* *** 000
Activity 2			10%			30%		15%	* *** 000
Activity 3	30%	20%	25%	5%			50%		* *** 000
Activity 4	20%	50%		15%	40%			30%	* *** 000
Activity 5	5%		40%	20%		70%			* *** 000
Activity 6	10%		20%	5%	60%			50%	* *** 000
Activity 7	10%		5%	10%				5%	* *** 000
Activity 8	25%	10%		15%			40%		* *** 000
	100%	100%	100%	100%	100%	100%	100%	100%	

8.4.3 Find activity – cost object component relations

Similarly, the relation between the activities and the cost object components should be determined by creating an ACOCR (Activity - Cost Object Component Relation) matrix. The activities are put on the columns and all the cost object components on the rows (see Table 8.8). The symbols are marked out based on the following question; given that the component exists, does it affect the consumption of the activity? Then the ‘x’ denotes that it does if the activity is consumed and the blank that it never does. This matrix is a support that will facilitate the task performed in the subsequent stage. The need for this matrix is greater when the company structure is more complex, with a large amount of cost object components. It will simply be too much information to keep in mind in those cases. Depending of the scope of the project it may be required to present a further level of detail of the cost object components. Merely the highest level of detail is illustrated here and an empty ACOCR matrix template can be found in Appendix E.

Table 8.8: *ACOCR matrix.*

Cost object components / Activities	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8
Component 1				x	x	x		x
Component 2	x		x	x	x	x		
Component 3		x		x			x	x
Component 4	x			x				
Component 5	x		x	x			x	
Component 6		x				x		x
Component 7					x			
Component 8		x			x		x	
Component 9			x					x
Component 10					x		x	x

8.4.4 Develop cost estimation system

When a company provides make-to-order products it becomes time-consuming and complicated to allocate the costs to the products before the product has been clearly specified. Hence, a different approach is desired, which becomes evident in this particular stage. A cost estimation system should thus be developed instead, which may have many different appearances. Based on the scope of the project it should be clear how advanced system that is desired. The cost estimation system can however be resembled either as a table or a model. In a CE (Cost Estimation) table the user has to determine how much a cost object consumes of an activity, manually and explicitly. As can be seen in Table 8.9 the user is required to determine the consumption of the different activities, which is marked with grey color. The activity costs are calculated by multiplying the consumption with the unit cost. The sum of all the activity costs then generates the cost of the cost object. A CE table consequently puts more requirements on the user's competence and experience. It will however at least help standardize the necessary calculations in a prepared template.

Table 8.9: *CE table.*

Activity	Activity 1	Activity 2	Activity 3	**Total**
Unit cost	1000 SEK / h	500 SEK / pallet	2000 SEK / month	
Consumption	1 h	2 pallets	1 month	
Activity cost	1000 SEK	1000 SEK	2000 SEK	**4000 SEK**

It is referred to as a CE (Cost Estimation) model when the consumption of activities can be calculated merely based on the user input information about the cost object components. An example of a CE model can be found in the description of cost estimation systems, section 6.2. The model complexity will then increase with the accuracy requirement. The crucial decision to consider is the choice of standardization against the effort needed in order to build an advanced model. Modeling experience hence becomes a more critical CSF the more advanced model that is to be developed. Obviously, the actual purpose of the system clearly has to be understood before entering this stage, in order to gather appropriate persons for the project team that can provide the desired competence. The step procedure seen in Table 8.10 may preferably be applied in order to develop the CE model.

Table 8.10: *Step procedure to develop the CE model.*

Step	Description
Requirement engineering	Gather wishes, requirements, etc. on the model.
Skeleton building	Construct the overall structure and fundamental parts of the model.
Draft development	Develop a draft based on the skeleton by constructing the supporting subfunctions.
Model expansion	Expand the model by taking more aspects into consideration.

8.4.5 Validate cost estimation system

Before completing this phase, the project team thoroughly has to investigate the validity and function of the cost estimation system. Initially, validation data that can be used to compare and analyze the results from the system have to be collected. It is subsequently also necessary to neglect data that appears to be unrepresentative in order to ensure that the validation becomes accurate. Statistical tools for data analysis should preferably be applied when validating the results (see Figure 8.5). Spreadsheets can preferably be used for the examination, where e.g. standard deviation, variance, coefficient of determination (R^2) and analysis of residuals can be determined for the data in order to express the validity quantitatively. It is otherwise difficult to draw any conclusions from the validation. In addition, it is appropriate to perform tests on possible future users in order to receive useful comments concerning the system. This will namely enable the desired system modifications to be performed. This task is very iterative to its nature where small adjustments are being tested carefully until the system performance is satisfying. The effort required for the validation should therefore not be underestimated, because once it has been set and integrated into the company, the workload for making adjustments rapidly increases.

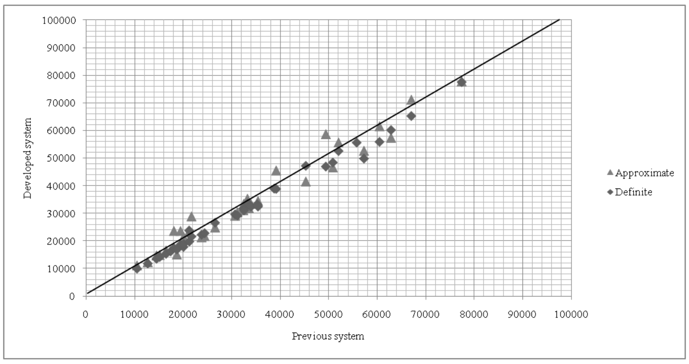


Figure 8.5: *Statistical validation of cost estimation system.*

8.5 Integration

In the two previous phases, all the actual cost estimation preparations have been performed. The challenge in this phase, referred to as *integration*, is to ensure that the future users actually learn how to use the cost estimation system. Consequently, the deliverables are a user manual and competent users for performing cost estimations. The developed system will not fulfill its full potential if this phase eventually becomes unsuccessful. In order for it to become successful, committed recipients and pedagogical instructors are required, and these are therefore the CSFs.

8.5.1 Document results

In the first stage, gained insights and generated information during the project have to be gathered appropriately in documents, which should become available within the company for future needs. In particular all documentations of the final deliverables for the previous phases should be performed, but also the relevant supporting information used to finalize the deliverables. By doing this, it becomes possible to return and in detail find out how the deliverables were set, if future adjustments will be necessary to perform. Furthermore, most of this information should be used to create a user manual for the system, before entering the subsequent stage. The need for a user manual is greater for a larger and more complex company, together with the complexity of the system.

8.5.2 Communicate changes

The changes and the new conditions for the cost estimations then have to be communicated appropriately to all the concerned employees. The goal is to prepare them for the upcoming stages and to create an understanding among all of them at once. This stage is simply an important facilitator for the subsequent ones.

8.5.3 Educate future users

Thereafter, merely the future users are selected from the concerned employees to be educated in the developed system. It is appropriate to gather many persons simultaneously to provide a pedagogical presentation about the new cost estimation conditions, in order to streamline the task. Then it should be possible for the concerned persons to test the system together with the instructors in workshops, in order to achieve an efficient education process and to finally entitle them as actual users.

8.5.4 Distribute cost estimation system and user manual

The educated users are now prepared to receive the system together with a user manual. The users undoubtedly have to become even more acquainted to the system by actually using it in the daily work tasks, with the user manual as a support. It is common that persons learn the most by actually sitting down individually and peacefully, using and testing the system.

In fact, the stages within this phase can be performed in many different ways and these have to be set based on the specific company circumstances. It is important though to bear in mind the CSF referred to as committed recipients and pedagogical instructors. The significant effort needed to achieve this properly, depends on the peoples' attitudes for changes. A greater effort is required the more unwilling the attitude is, in order to fulfill the deliverable called competent users.

8.6 Completion

The final phase, *completion*, does not have to be as time consuming as the previous phases. However, the importance of the included stages should definitely not be neglected. The deliverable and CSF of this phase is more or less equal to those covering the entire project.

Hence, a successfully implemented cost estimation system should be the deliverable and the CSFs are to understand the actual time and effort needed in order to accomplish the deliverable appropriately; but also the actual need for cross-functional and cross-disciplinary competencies within the project team. The former CSF is more critical the larger and complex the company is, in order to truly understand the whole business, flawlessly.

8.6.1 Evaluate project

A careful evaluation of the project's results, e.g. objectives, time frame, budget; but also the work process, should be performed in the first stage. It is preferable that the whole project team sit down together and collect all the opinions at once, but probably also that the one responsible for the project will gather written anonymous comments in order to pick up the more delicate issues.

8.6.2 Reflect upon project

The next stage should preferably be performed simultaneously as the previous one, when everyone from the project team is actually gathered. The general reflections should subsequently be commented on, i.e. to discuss what future projects that suitably may be staged and the lessons learnt along the way. It also includes comments concerning what probably should have been performed differently.

8.6.3 Terminate project

Finally, the project can be terminated and the project team resolved. It could simply be a formal ending of the meeting that was mentioned in the previous stages.

To conclude, the implementation procedure is visualized in Figure 8.6, in a summarized version. The stages are described by their key words in order to facilitate the focus on the overall aspects of the procedure.

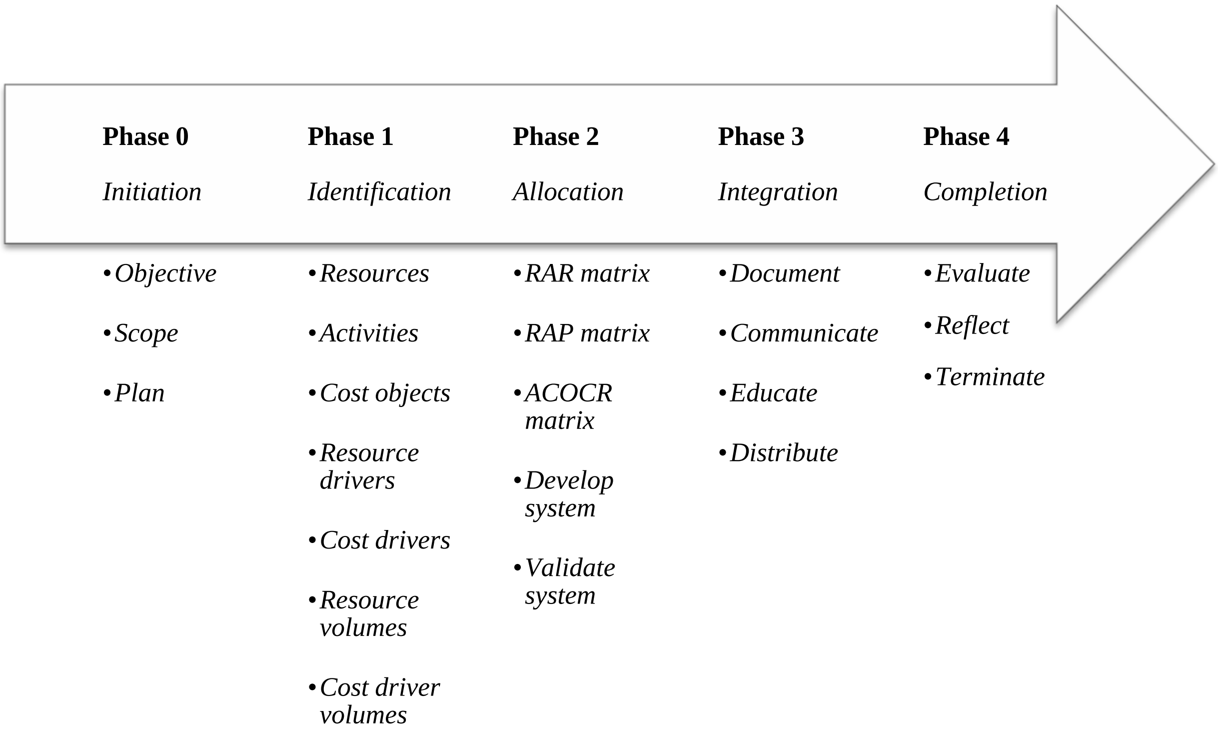


Figure 8.6: *The procedure for ABC implementation in make-to-order companies.*

9 Discussion

In this chapter the choice of cost estimation method, which is the basis for the empirics, is justified according to the frame of reference. The discussion then continues with a principle comparison between the previous and the developed cost estimation system, followed by the results for the developed system. Finally, the suggested procedure for ABC implementation will be discussed.

9.1 Cost estimation method

This section first argues for the choice of ABC as the cost estimation method to be applied at FrontPac. The specific ABC solution chosen, due to the fact that FrontPac is a make-to-order company, will also be justified.

9.1.1 Choice of cost estimation method

In this section the choice of cost estimation method will be justified based upon the theoretical studies and the empiric findings, as mentioned in chapter 3 and 5. First, the arguments for choosing complete cost allocation are presented by analyzing FrontPac's pricing strategy. Second, the cost structure will be commented as an explanation for choosing ABC. Finally, the operational volume choice, which is required for ABC, is discussed.

Cost allocation approach

From the previously mentioned theoretical aspects about cost estimations, it might be justifiable to question why the complete cost allocation approach was chosen in this thesis. Based upon the pricing strategy that FrontPac currently applies, this can be justified. A combination of at least two of the pricing strategies that were mentioned in section 3.1 are applied, i.e. a combined strategy based on both costs and competitors, but to a certain extent also customers. As the estimated cost is supposed to act as a foundation for pricing decisions, it becomes obvious that a complete cost allocation necessarily has to be applied in order to ensure that all the costs in the company will be allocated to the cost objects.

Cost allocation method

The two most common methods for complete cost allocation are subsequently traditional costing and ABC. The fundamental difference is linked to the allocation of overhead costs. The investigated company's cost structure will therefore determine which method that is most suitable. As stated in section 3.3.2, when the amount of overhead costs constitutes a large proportion of the total cost, ABC is the preferred method to use. The traditional costing method namely allocates the overhead costs very poorly. As presented in section 5.2.1, the overhead costs constitute approximately 45 percent at FrontPac, which should be seen as a large proportion. ABC is therefore the most preferable cost estimation method to apply.

Operational volume

Another choice also appears for ABC, namely the aspects about the operational volume. Once again, the actual purpose of the cost estimation reveals which choice that is the most preferable to apply. For pricing decisions, the normal year method is suitable to apply, because all the costs will be covered in the cost estimations and the figures from several prior years will be taken into account. Hence, it typically provides a solid foundation for pricing decisions. The alternative would be to use the practical maximum capacity. This may have been a suitable method to use, especially if FrontPac would have been interested to use the information, which is possible to obtain, for performing continuous improvements. At the moment, FrontPac does not consider it to be worthwhile to spend time on such activities, whereby the advantages subsequently would not have been utilized properly. It would consequently have become more complicated to determine the operational volumes for the cost estimations, without any particular benefits. From section 5.3 about FrontPac's cost structure it was visualized that the deviations over the most recent years merely have been marginal. This subsequently facilitates the determination of the operational volume. For these reasons the normal year method was chosen.

9.1.2 ABC in make-to-order companies

The specific ABC solution that is applied due to the fact that FrontPac provides make-to-order products will be clarified in this section. In fact, the particular difference mainly occurs in the activity to cost object allocation. When allocating activities to cost objects it becomes apparent that two strictly different situations may occur. Either there are a limited number of products provided or there is not. The former situation is frequently described in literature whereas the allocation task becomes similar to the one performed from resources to activities, while the latter situation is more difficult to solve.

Another solution is obviously required when a limited number of products do not exist. This has been clearly emphasized in this thesis and a suggested solution has been proposed in chapter 8. Although the number of products provided is not limited, the number of provided cost object components is actually limited. The fact that there are a limited number of provided components has therefore been the fundamental insight that has been applied to solve the activity to cost object allocation. Cost objects can namely be seen as a combination of several cost object components. By realizing the different components' influence on the activity consumption, it becomes possible to perform cost estimations. As long as it is known which components that are linked to a specific cost object and which costs that are direct. By constructing an ACOCR matrix, as mentioned in section 5.5.2, the complexity of this issue is reduced, since it can be a support when allocating the activities to the cost objects. It should however be stressed that this allocation does not become simple as a result of this; it rather becomes less difficult.

9.2 Cost estimation systems

There is a clear difference between the previous and the developed cost estimation system, which is discussed in this section. The focus is put on understanding the underlying factors affecting the final choice of cost estimation system. The discussion is thus performed on a more general level, but with the solution applied at FrontPac as an obvious base.

It is the purpose of the cost estimation system in a specific situation that determines which system properties that are most suitable to prioritize (see Table 9.1), e.g. time to price or construction. The purpose of the system is given by the overall situation for the actual company, i.e. market, customers, products, employees, etc. It is therefore difficult to rapidly conclude what kind of system that should be chosen; this requires careful considerations. This is due to the fact that it affects the company to a large extent, but also that it may be difficult and expensive to change once it has been chosen. By identifying the most crucial properties for the company's situation it becomes apparent whether it is appropriate to aim towards developing a system that is more or less standardized. It may similarly be expressed as developing a system that relies mostly on structural or human capital, as mentioned in section 3.2.2. The advantages with more standardized systems for certain properties, compared to less standardized, are illustrated in Table 9.1. This table can consequently be helpful when choosing the degree of standardization, although it is not claimed to be a complete list that is applicable for all companies. This is rather constructed based upon the most important properties in FrontPac's situation and consequently a similar list would be necessary to create for another company.

Table 9.1: *Properties affecting the degree of cost estimation system standardization.*

Properties	More standardized	Less standardized
Time to price	Short	Long
Product range	Low	High
Competence	Low	High
Possible users	Many	Few
Construction	Difficult	Simple
Possible accuracy	Low	High
Sensitivity analyses	Simple	Difficult

Before developing the cost estimation system for FrontPac, their situation was considered carefully in order to fully understand what properties of the system that was desired. Based upon the problem areas stated in section 1.3, it is possible to understand what solution that would be the most suitable. The problem areas are that the time to price is too long, it relies too much on competence which merely enables few possible users, it is time-consuming to perform sensitivity analyses and the machine costs are static. As can be seen in Table 9.1 most of these problem areas clearly occur due to the fact that FrontPac previously had an excessively non-standardized system that relied too much on human capital. The conclusion thus became that it was appropriate to aim towards a more standardized system with more focus on structural capital, which also is illustrated in Figure 9.1. It should however be noted that the properties in the figure not are weighted, which evidently has to be performed in order to conclude what degree of standardization that is most suitable to aim for.

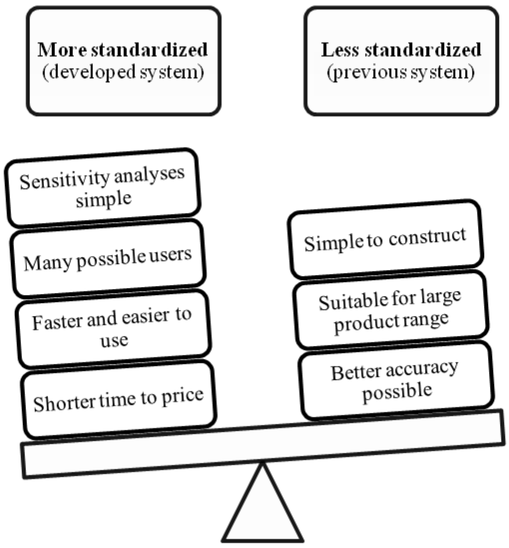


Figure 9.1: *Properties affecting the degree of cost estimation system standardization.*

The main natural drawbacks with developing a more standardized system are though linked to the properties referred to as construction, product range and accuracy (see table 9.1). The construction issue is solved by consulting external support. Otherwise some other employee at FrontPac probably would have been able to manage this task. The accuracy was not considered to be the main issue at FrontPac, because there are natural uncertainties in the cost estimations within this industry, mainly due to the large overhead cost proportion. The fact that the pricing not merely is based upon the estimated cost certainly matters as well, since customer and competitor based pricing strategies also are taken into consideration. In fact, it was the wide product range that was the main issue and challenge with constructing a more standardized system. This caused some delimitations to be stated for the system development, e.g. not all products were taken into consideration explicitly. However, it was solved by considering the most frequently occurring products more explicitly. The remainder were also included, but consequently merely considered implicitly. In total, in FrontPac's case it was rather obvious that many advantages would be achieved by developing a more standardized system.

9.3 System results

In this section the validation results from chapter 7 will be discussed first. The discussion then continues with the improvements with the developed system, which were also presented in chapter 7. These were based on the identified problem areas with the previous system.

9.3.1 System validation

As mentioned previously in section 7.1, the salespersons are merely able to perform approximate cost estimations. In these cases, the sheet suggestion and the manufacturing parameters that the system provides are used. These kinds of cost estimations may be sufficient in price negotiations with less strategic customers or at least for providing an initial approximate price for a preliminary product and order specification. In order for a cost estimation to become definite, the cost estimation employee has to ensure that all important aspects are taken into consideration and to specify the critical parameters, e.g. the sheet information and manufacturing parameters. It is namely incredibly difficult to enable a standardized system to take all aspects into consideration. Consequently, the cost estimation employee's competence may be utilized more appropriately when focus instead is put on merely setting the critical parameters, rather than specifying the most basic information for the system as well. The definite cost estimations may therefore be particularly necessary for price negotiations with more strategic customers, but also as soon as the final price has to be communicated to a customer.

It is intuitively clear, and was statistically proven, that the standard deviations in total cost for the developed system compared to the previous system are larger when having a suggested sheet compared to a specified sheet. The definite cost estimations are therefore more reliable than the approximate. This is simply a precondition for distinguishing between approximate and definite, i.e. the definite cost estimation should obviously generate a more accurate total cost than the approximate. This fact was consequently confirmed by this result. The difference was though not that vast, eight instead of five percent, which indicates that the approximate cost estimations provide fairly accurate total costs. The coefficient of determination in addition provided a corresponding result that agreed with this conclusion.

Furthermore, the developed system generally provides slightly lower total costs compared to the previous system. This is mainly due to the fact that lower machine costs have been determined for the developed system, which reduces the manufacturing cost. However, it should be stressed that the desired objective was not to develop a system that would generate results with as small deviations as possible from the corresponding results for the previous system. This was clearly expressed by FrontPac. The deviations can therefore not be used to conclude which actual cost estimation accuracy the developed system provides. In the forthcoming sections it is instead discussed whether the identified problem areas are improved.

However, the surprising result that the mean values for approximate cost estimations are closer to the previous system compared to the definite, clearly has to be explained. It should namely be interpreted such as the approximate cost estimations provide slightly higher total costs compared to the definite. This is primarily due to the fact that the most optimal sheet size, from a total cost perspective, may not always be chosen for approximate cost estimations, since the suggestion provided by the system is used. Consequently, slightly higher mean values of the total cost are expected in these cases. According to the explanation provided in the previous paragraph concerning the negative mean values, it becomes apparent why the mean values for approximate cost estimations are closer to the previous system compared to the definite. It is namely not all too interesting to compare the results from the developed system with the previous system.

9.3.2 Number of possible users

The number of input parameters in the developed system has been kept as low as possible in order to reduce the complexity and to make it easy and fast to use. The type of required input parameters for approximate cost estimations has also been restricted to merely include customer order components. This implies that any employee with sufficient knowledge about FrontPac's products and customer orders will be able to perform approximate cost estimations. It has therefore caused a significant increase in the number of possible and competent users of the system. However, it has to be noted that the same competence as with the previous system still is required in order to perform definite cost estimations.

Additionally, it should be mentioned that in order to increase the amount of actual users it is necessary to instruct and educate the possible users. With the developed system less education is required to create equivalently competent users, due to the reduced knowledge requirements and more user-friendly interface. For a new employee with no previous experience or knowledge of this industry, a few days of education is expected to be required before being comfortable and properly skilled in using the developed system. This should be compared to the previous system where several months or years were required before it would be possible to be used as fast and accurately as the developed system. The reason is mainly that it was not possible to perform approximate cost estimation as easily with the previous system. The available choices were thus merely to perform definite cost estimations or none.

9.3.3 Time to price

The time to price is an especially important order winner in many make-to-order industries and specifically in the consumer packaging industry. The sales process is therefore more streamlined with the developed system, since non-value adding information flows are avoided. The salespersons can namely perform approximate cost estimations individually and communicate price quotations without any dependence on other employees. Significant reductions in time to price are hence possible and expected to be achieved for approximate cost estimations. Moreover, the cost estimation employee also has other responsibility areas and thus cannot always perform the requested cost estimations directly. There is though no time reduction in time to price for definite cost estimations. The reason is that this still has to be performed by a skilled cost estimation employee who ensures that all important aspects concerning the product and order are taken into consideration. However, in order to measure the actual time reduction for the sales process, both systems have to be integrated and used within the company. Since the integration and actual use of the developed system was a delimitation of this thesis, these measurements were not possible to perform.

In addition, the introduction of approximate cost estimations may also solve some internal communication issues that frequently occur and tend to cause irritations. The accuracy in the information is namely expected to be reduced the more employees that are involved in the sales process. There is also an obvious risk that some information might be forgotten, which hence would affect the cost estimations negatively. This therefore implies that the input to the system, at least from this perspective, becomes more reliable.

9.3.4 Sensitivity analysis

With the developed system it is not particularly difficult to perform sensitivity analyses, since it can be performed by simply changing one single internal or external parameter. This is a vast improvement compared to the previous system, where a change in one parameter often tended to require a manual change of several other parameters as well. This is obviously a huge benefit that may provide increased service quality to customers.

Sensitivity analyses of internal parameters can consequently favorably be used internally, both in the planning and design sub-processes, in order to raise the awareness of how to design and manufacture as economically as possible. This can be particularly helpful when introducing new and less skilled employees to their new positions within the company.

Sensitivity analyses of external parameters can on the other hand be evidently valuable for the sales process. The possibility to provide fast price quotations based on the customers choices is, as previously stated, an undisputed order winner in FrontPac's industry. To exemplify this, customers often are interested in knowing what price discounts certain quantity raises can generate or how the price is affected by decreasing the months of warehousing and increasing the number of call-offs. Consequently, this aspect is considered to lower the time to price, which was expressed in the previous section, even further. This is also why the value of the developed system stretches beyond merely the sales sub-process. These types of questions arise in the sales support and management sub-processes as well, which implies that they clearly also can benefit from the developed system.

The objectiveness of the total cost that is obtained from the developed system should not be underestimated. The risk of performing too optimistic or too pessimistic cost estimations, which has been an issue with the previous system, is therefore significantly lowered. Additionally, this enables more than one employee to be involved in the cost estimation, but also that the information from previously performed cost estimations can be reviewed and understood by other employees. In fact, even though the estimation initially was calculated by another employee it becomes possible for an independent employee to perform careful sensitivity analyses. This is especially advantageous when returning customers put new orders that merely include small modifications.

9.3.5 Dynamic aspects

With the developed system the machine costs can be altered dynamically by an authorized employee as the organization changes. These will therefore no longer be static, as with the previous system. It is simultaneously much easier to notice how the previous machine costs were set, which facilitates the determination of the updated machine costs.

In addition to the system always being updated and valid, this also provides another dimension to the sensitivity analyses. Not only is it now possible to change the order and product specific parameters to notice how the cost is affected, but it is also possible to see how organizational changes can affect the costs of single products. The developed system is thus a powerful tool that provides advantages and possibilities that stretches beyond sales and sales support, to also include management.

9.4 Procedures for ABC implementation

One part of the purpose with this thesis was to suggest an appropriate generic procedure for ABC implementation in make-to-order companies; especially for companies that experience similar situations as FrontPac. The two implementation procedures mentioned in section 3.5 will therefore be discussed based on the obtained case study experience. Finally, the explanation of, and background to, the suggested implementation procedure is clarified.

9.4.1 The five step procedure for ABC implementation

The five step procedure described in section 3.5.1 is expressed very generically, as it focuses on providing an overall perspective. It therefore covers a great part of the possible actual implementation procedures that may be applied in specific situations. Consequently it follows a logical overall structure, although the steps are expressed too vaguely to be used as a practical guideline during an actual implementation of ABC. Additionally, it is crucial to stress that the different steps are far too strictly separated. Instead, it is important to illustrate that there is an iterative nature between the steps. It is difficult to reach a satisfying result if the iterative procedure is neglected, especially if the implementation task is performed in a larger and thus more complex company. It is also crucial to stress that ABC implementation requires much effort compared to other cost estimation methods, in order to become the superior alternative.

Furthermore, the implementation procedure anticipates that the resources and their different costs already are given on beforehand. In fact, these are normally quite cumbersome to determine and should hence not be neglected. Similarly as for activities; resources, resource drivers and their belonging volumes have to be determined, in order to enable the resources to be allocated to the activities properly. As mentioned previously, this task is often underestimated, because all the focus is put on the challenge of allocating the activities. The accuracy will namely be lost if this preparatory work with the resources is performed too approximately. Consequently it will not matter, to the same extent, how accurately the forthcoming steps are being performed. The required effort in the initial steps with the resources has definitely been experienced throughout this thesis, where this part required almost as much time as the determination of the performed activities. This aspect should therefore be emphasized clearly.

9.4.2 The eight step procedure for ABC implementation

The eight step procedure for ABC implementation described in section 3.5.2 has been developed especially for small companies. The objective was to help small companies switch from traditional costing to ABC, by keeping the investments on reduced levels. The description is therefore more practical to its nature in this case. It is easy to follow the systematic reasoning throughout the description, given that the reader is somewhat acquainted to the ABC concept. It consequently provides a complementary perspective to other more theoretical literature about ABC, such as the procedure discussed in the previous section.

The most important experience from this procedure is the presentation of the EAD and APD matrices, where much information is collected conveniently. In addition, the actual allocation procedure that was presented, very much inspired the eventually suggested procedure. There is though a lack of description for the situation when companies are providing more customer specific products. In these cases the APD matrix is not meaningful to construct before the customer orders are received or the product has been defined, because it would be far too time-consuming. The implementation procedure will hence be different in these situations. This is consequently described more in detail for the suggested implementation procedure. Furthermore, in the procedure there is also a lack of project focus with clear initiation, integration and completion tasks together with a similar neglecting of the theoretical background about ABC as mentioned in the previous section.

9.4.3 Suggested five phase procedure for ABC implementation

Based upon the experienced and stated drawbacks with the two implementation procedures that were discussed above, a new modified procedure for ABC implementation is suggested. The overall structures of these procedures have influenced the suggested procedure. Some experiences from the conducted ABC implementation have also truly affected the outcome. The intention was namely to create a suggestion that would have been helpful to have when initiating this thesis. Four main parts of such adjustments have thus been identified, which are presented separately below.

Make-to-order companies require cost estimation systems

In make-to-order companies that offer very customer specific products, the number of different products can be infinitely large. It is therefore not meaningful to estimate the cost for every individual cost object on beforehand, since it would be far too time-consuming. This issue was experienced at FrontPac and therefore another solution for performing the activity to cost object allocation is required. The suggested procedure was presented in chapter 8 and includes the identification of the cost object components, finding the relations between activities and cost object components, developing a cost estimation system and to validate this system. This solution is considered to be appropriate to apply since the cost estimation task thus is prepared in advance. This enables the cost estimations to be performed rapidly and in a standardized manner, as soon as the customer order has been received or the product has been defined. The choice is although to decide how advanced the system should be in order to generate satisfying cost estimations, in terms of accuracy and user-friendliness.

Emphasized focuses on resources, drivers and volumes

In ABC implementation literature, the main focus is directed towards the activities and the activity to cost object allocation. The experience from this case study reveals that more focus has to be put on the parts concerning resource identification and allocation. When the resource related tasks are performed unreliably this will have a considerable impact on the final cost estimation outcome, no matter how accurately the activities are identified and allocated. The implementation may probably also be delayed when such issues suddenly occur. In addition, the merging of resources and activities should be very evident if the resource drivers and cost drivers have been determined appropriately. This is important to perform carefully in order to ensure that the allocations can be achieved properly. The necessary iterative procedure of this task has therefore evidently been emphasized, in order to enable that the most suitable solution is followed. Additionally, the volume determination of the resource, resource driver and cost driver should be performed carefully, in order to ensure that the cost objects eventually will be burdened with the most correct costs. This part is also emphasized more explicitly in the suggested implementation procedure to ensure that the project members will not underestimate the importance of these tasks.

Project form with clear milestones including critical success factors and deliverables

When it has been decided that ABC should be implemented, it is crucial to be aware of the effort required in order to achieve the objectives successfully. The work should preferably be structured as a project that involves members from cross-functional parts of the company. It is therefore appropriate to have a clear practical project structure to follow throughout the implementation procedure. This has thus been clearly emphasized in the suggested implementation procedure. Important milestones, including CSFs and deliverables, that primarily the project manager have to bear in mind, has been emphasized as well. This can subsequently be helpful throughout the whole project, particularly for persons that are unfamiliar with ABC implementations.

Focus on providing practical guidelines with useful tools

As a complement to the project structure, the focus has been put on providing practical guidelines and useful tools, which can be applied during the ABC implementation. These can be incredibly helpful for the project members if they are unaware of which alternatives that are possible to apply. Templates of relevant tables and matrices can also be found in appendix, which can be a further help when structuring the obtained data and information. The overall implementation procedure was also visualized in two versions as a help for understanding the overall structure of the project. One version is more extensive and the other one denser, where both suitably can be printed and visualized as a help for the project members.

10 Conclusions

The conclusions of this thesis will be stated in this chapter based on the previously performed discussion. The conclusions concerning the cost estimation systems, as well as the suggested procedure for ABC implementation in make-to-order companies, will be provided.

10.1 Cost estimation systems

The differences between the previous and the developed cost estimation system has been presented and discussed throughout the previous chapters. Generally, it can be concluded that the system at FrontPac was transformed from being rather non-standardized and relying heavily on human capital to become more standardized and to rely more on structural capital. As a result, the following advantages with the developed cost estimation system have been proven:

… an increased number of employees are able to perform cost estimations as it has become less dependent on user's experience and competence.

… the salespersons can now provide an approximate price quotation to the customers by themselves, which significantly reduces the time to approximate price.

… the salespersons can simultaneously perform sensitivity analyses themselves according to the customers' requirements.

… the machine costs are more dynamic, which implies that these can more easily be updated in accordance to organizational changes.

The developed cost estimation system is already an improvement for FrontPac, although more aspects can favorably be added into the system, e.g. some of the stated delimitations in this thesis can be relaxed. The conditions for FrontPac may also change in the future, whereby it may become necessary to modify the cost estimation system. The integration phase of the implementation procedure was one of the stated delimitations. The integration of the system has therefore not been entirely completed, although it has been initiated during the thesis. The responsibility for this phase has thus been transferred to a specific employee at FrontPac who will ensure that the developed cost estimation system eventually will replace the previous. Linked to the integration, the credibility of the cost estimation system also has to be improved further. This will be performed by using it in the daily business for some time. Any eventual necessary adjustments can consequently be identified and solved properly in this manner.

Generally, the development of a cost estimation system has to be customized according to the specific situation at hand, i.e. it is difficult to suggest a general development approach for other companies. There are though certain properties that typically need to be considered when deciding upon the cost estimation system's performance. By taking these properties into consideration it becomes easier to realize which degree of standardization in the cost estimation system that is appropriate to strive against.

10.2 Procedure for ABC implementation

The suggested procedure for ABC implementation in make-to-order companies have also been presented and discussed throughout the thesis. To conclude some important differences between general ABC implementation literature and the suggested procedure, it should be highlighted that:

- … make-to-order companies require a cost estimation system to enable activity to cost object allocation to be performed.

- … the focus on resources, drivers and volumes have inevitably been emphasized.

- … the suggested procedure has been structured in project form with clear phases and milestones, including deliverables and critical success factors.

- … practical guidelines and tools are provided that may be useful in ABC implementation projects.

The suggested procedure for ABC implementation has been especially developed for make-to-order companies. This choice was simply made based on the situation at hand, since part of the purpose with this thesis was to develop a cost estimation system for FrontPac. It can however be adjusted for other types of companies as well, e.g. make-to-stock companies. There are namely many similarities, which imply that merely small modifications of the suggested procedure are required in order to widen its practical use.

It would also be of interest to test the suggested procedure in other similar case studies and ABC implementation projects, in order to increase the credibility. Otherwise it is difficult to state with certainty that it can be applied in all general ABC implementation projects for make-to-order companies. At the moment it is merely certain that it suited the ABC implementation project that was performed at FrontPac in this thesis.

As stated in the theory, it is becoming more common that companies provide customized products due to customers' increasing requirements. This kind of procedure for ABC implementation should thus be of an increasing interest for these companies. Not least since it will enable the projects to be completed rapidly and smoothly.

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Appendix A – List of Cost Object Components

In this appendix the three Lists of Cost Object Components are attached. The first list was presented previously in section 5.4.3 and the two following lists are derived from this list. In the respective lists the components have been broken down one level and related to a direct, overhead or combined cost effect.

Table A.1 *List of Cost Object Components.*

Cost object components	Direct	Overhead
Design		x
Material	x	x
Print	x	x
Extra functions	x	x
Sheet		x
Warehousing		x
Transport	x	
Transport package	x	x
Customer		x
Tools	x	x
Quantity	x	x

Table A.2 *List of Cost Object Components: first level sub-components.*

Cost object component	**Cost object sub-components**	**Direct**	**Overhead**
Design	Standard design		x
Design	Unique design		x
Material	Carton liner	x	x
Material	Corrugated cardboard	x	x
Material	Consumables	x	
Print	Color	x	x
Print	Varnish	x	x
Print	Surface effects	x	x
Extra functions	Window	x	x
Extra functions	Handle	x	x
Extra functions	Identification	x	x
Extra functions	Handling facilitators	x	x
Sheet	Sheet size		x
Sheet	Number of blanks		x
Warehousing	Number of finished goods pallets		x
Warehousing	Number of months		x
Warehousing	Number of call-offs		x
Transport	Country	x	
Transport	Distance	x	
Transport	Weight	x	
Transport package	Type of transport package	x	x
Transport package	Number of transport packages	x	x
Customer	Importance		x
Customer	Quality requirements		x
Tools	Die cutting tool	x	
Tools	Strip tool	x	x
Tools	Window tool		x
Quantity	Order quantity	x	x
Quantity	Batch quantity		x

Table A.2 *List of Cost Object Components: second level sub-components.*

Cost object component	Level 1 sub-components	Level 2 sub-components	Direct	Overhead
Design	Standard design	Standard # (e.g. FEFCO 0713)		x
Design	Standard design	Package size		x
Design	Unique design	Unique design		x
Material	Carton liner	Paper quality	x	x
Material	Carton liner	Grammage	x	x
Material	Corrugated cardboard	Liner paper quality	x	x
Material	Corrugated cardboard	Flute paper quality	x	x
Material	Corrugated cardboard	Flute configuration	x	x
Material	Consumables	Type of lamination glue	x	
Material	Consumables	Type of folding glue	x	
Material	Consumables	Type of window glue	x	
Print	Color	Type of color	x	x
Print	Color	Number of colors	x	x
Print	Varnish	Type of varnish	x	
Print	Varnish	Glossiness	x	
Print	Varnish	Amount	x	x
Print	Surface effects	Type of effect	x	x
Print	Surface effects	Amount	x	
Extra functions	Window	Shape of window		x
Extra functions	Window	Size of window	x	x
Extra functions	Window	Type of plastic	x	
Extra functions	Handle	Type of handle	x	x
Extra functions	Handle	Type of material	x	
Extra functions	Identification	Type of label	x	x
Extra functions	Identification	Type of RFID-tag	x	x
Extra functions	Handling facilitators	Type of inlay		x
Extra functions	Handling facilitators	Type of tear strip		x
Extra functions	Handling facilitators	Type of closing tape	x	x
Sheet	Sheet size	Sheet width		x
Sheet	Sheet size	Sheet length		x
Sheet	Number of blanks	Number of blanks		x
Warehousing	Number of pallets	Number of pallets		x
Warehousing	Number of months	Number of months		x
Warehousing	Number of call-offs	Number of call-offs		x
Transport	Country	Country	x	
Transport	Distance	Distance	x	
Transport	Weight	Number of pallets	x	
Transport	Weight	Pallet weight	x	
Transport package	Type of transport package	Type of transport package	x	x
Transport package	Number of transport packages	Number of transport packages	x	x
Customer	Importance	Importance		x
Customer	Quality requirements	Quality requirements		x
Tools	Die cutting tool	Number of knife meters	x	
Tools	Strip tool	Number of knife meters	x	x
Tools	Window tool	Shape of window		x
Tools	Window tool	Size of window		x
Tools	Window tool	Material	x	
Quantity	Order quantity	Number of packages	x	x
Quantity	Order quantity	Number of sheets	x	x
Quantity	Batch quantity	Number of packages		x
Quantity	Batch quantity	Number of sheets		x

Appendix B – ACOCR Matrices

In this appendix, the three ACOCR matrices corresponding to the three Lists of Cost Object Components in Appendix A, are attached. The first matrix was presented previously in section 5.5.3 and the two following lists are derived from this matrix. In the respective matrices the components have been broken down one level and related to the activities to further investigate how the different sub-components affect the cost drivers.

Table B.1 *ACOCR matrix.*

Cost object components / Activities	Raw material storing	Interimstoring	Lamination	Die cutting	Stripping	Windowing	Handwork	Folding	Finished goods handling	Finished goods storing	Sales	Design	Repro	Sales Support	Planning	Management
Design				x	x	x	x	x				x	x		x	
Material	x	x	x	x	x	x	x	x				x	x		x	
Print				x			x	x					x			
Extra functions	x	x	x	x	x		x	x				x	x		x	
Sheet	x	x	x	x	x							x	x	x	x	
Warehousing									x	x				x	x	
Transport																
Transport package					x		x	x	x	x				x	x	
Customer	x					x		x			x	x	x	x	x	
Tools				x		x						x	x		x	
Quantity	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x

Table B.2 *ACOCR matrix: first level sub-components.*

Cost object component	Cost object sub-components **Activities**	Raw material storing	Interimstoring	Lamination	Die cutting	Stripping	Windowing	Handwork	Folding	Finished goods handling	Finished goods storing	Sales	Design	Repro	Sales Support	Planning	Management
Design	Standard design				x	x	x	x	x				x	x		x	
Design	Unique design				x	x	x	x	x				x	x		x	
Material	Carton liner	x	x	x	x	x	x	x	x				x	x		x	
Material	Corrugated cardboard	x	x	x	x	x	x	x	x				x	x		x	
Material	Consumables																
Print	Color				x			x	x					x		x	
Print	Varnish													x		x	
Print	Surface effects													x		x	
Extra functions	Window	x	x				x						x			x	
Extra functions	Handle	x	x	x				x	x				x			x	
Extra functions	Identification	x	x					x	x					x		x	
Extra functions	Handling facilitators	x	x		x			x	x				x	x		x	
Sheet	Sheet size			x	x	x							x			x	
Sheet	Number of blanks				x	x							x	x		x	
Warehousing	Number of finished goods pallets									x	x				x	x	
Warehousing	Number of months										x				x	x	
Warehousing	Number of call-offs									x	x				x	x	
Transport	Country																
Transport	Distance																
Transport	Weight																
Transport package	Type of tramsport package					x		x	x	x					x	x	
Transport package	Number of transport packages					x		x	x	x					x	x	
Customer	Importance	x										x			x	x	
Customer	Quality requirements						x	x	x							x	
Tools	Die cutting tool																
Tools	Strip tool				x	x										x	
Tools	Window tool	x	x				x						x	x		x	
Quantity	Order quantity	x	x							x	x	x			x	x	x
Quantity	Batch quantity			x	x	x	x	x	x				x		x	x	

Table B.3 *ACOCR matrix: second level sub-components.*

Cost object component	Level 1 sub-components	Level 2 sub-components Activities	Raw material storing	Interimstoring	Lamination	Die cutting	Stripping	Windowing	Handwork	Folding	Finished goods handling	Finished goods storing	Sales	Design	Repro	Sales Support	Planning	Management
Design	Standard design	Standard # (e.g. FEFCO 0713)				x	x	x	x	x				x	x		x	
Design	Standard design	Package size						x	x	x				x	x		x	
Design	Unique design	Unique design				x	x	x	x	x				x	x		x	
Material	Carton liner	Paper quality	x	x	x	x	x	x	x	x				x	x		x	
Material	Carton liner	Grammage	x	x	x	x	x	x	x	x				x			x	
Material	Corrugated cardboard	Liner paper quality				x	x		x	x					x		x	
Material	Corrugated cardboard	Flute paper quality			x	x	x		x	x							x	
Material	Corrugated cardboard	Flute configuration	x	x	x	x	x	x	x	x				x			x	
Material	Consumables	Type of lamination glue																
Material	Consumables	Type of folding glue																
Material	Consumables	Type of window glue																
Print	Color	Type of color								x					x		x	
Print	Color	Number of colors				x			x	x					x		x	
Print	Varnish	Type of varnish																
Print	Varnish	Glossiness																
Print	Varnish	Amount													x		x	
Print	Surface effects	Type of effect													x		x	
Print	Surface effects	Amount																
Extra functions	Window	Shape of window						x						x			x	
Extra functions	Window	Size of window	x	x				x						x			x	
Extra functions	Window	Type of plastic																
Extra functions	Handle	Type of handle	x	x	x				x	x				x			x	
Extra functions	Handle	Type of material																
Extra functions	Identification	Type of label	x	x					x	x					x		x	
Extra functions	Identification	Type of RFID-tag	x	x					x	x					x		x	
Extra functions	Handling facilitators	Type of inlay	x	x										x	x		x	
Extra functions	Handling facilitators	Type of tear strip				x								x	x		x	
Extra functions	Handling facilitators	Type of closing tape	x	x					x	x				x	x		x	
Sheet	Sheet size	Sheet width			x	x	x							x			x	
Sheet	Sheet size	Sheet length				x	x							x			x	
Sheet	Number of blanks	Number of blanks				x	x							x	x		x	
Warehousing	Number of pallets	Number of pallets									x	x				x	x	
Warehousing	Number of months	Number of months										x				x	x	
Warehousing	Number of call-offs	Number of call-offs									x	x				x	x	
Transport	Country	Country																
Transport	Distance	Distance																
Transport	Weight	Number of pallets																
Transport	Weight	Pallet weight																
Transport package	Type of transport package	Type of transport package					x		x	x	x					x	x	
Transport package	Number of transport packages	Number of transport packages					x		x	x	x					x	x	
Customer	Importance	Importance	x										x			x	x	
Customer	Quality requirements	Quality requirements						x	x	x							x	
Tools	Die cutting tool	Number of knife meters																
Tools	Strip tool	Number of knife meters				x	x										x	
Tools	Window tool	Shape of window						x						x	x		x	
Tools	Window tool	Size of window	x	x				x						x	x		x	
Tools	Window tool	Material																
Quantity	Order quantity	Number of packages									x	x	x			x	x	x
Quantity	Order quantity	Number of sheets	x	x													x	
Quantity	Batch quantity	Number of packages						x	x	x				x		x	x	
Quantity	Batch quantity	Number of sheets			x	x	x							x			x	

Appendix C – Machine Speeds & Set-up Times

In this appendix the principle structure of how the machine speeds and set-up times were determined is presented. The influencing factors are gathered from the ACOCR matrices described in Appendix B. The actual machine speeds and set-up times are fictitious since these information could be sensitive to reveal.

Table C.1 *Die cutting and folding machine speeds and set-up times.*

Die cutting			
Sheet size	**Material**	**Quantity**	**Machine speed**
< (1050*750)	Carton	> 2 000	3 250 sheets/h
		< 2 000	2 000 sheets/h
	F	> 2 000	3 000 sheets/h
		< 2 000	2 000 sheets/h
	E	> 2 000	2 750 sheets/h
		< 2 000	2 000 sheets/h
	B	> 2 000	2 250 sheets/h
		< 2 000	1 500 sheets/h
	C	> 2 000	2 000 sheets/h
		< 2 000	1 500 sheets/h
> (1050*750)	Carton	> 2 000	3 250 sheets/h
		< 2 000	2 000 sheets/h
	F	> 2 000	3 000 sheets/h
		< 2 000	2 000 sheets/h
	E	> 2 000	2 750 sheets/h
		< 2 000	2 000 sheets/h
	B	> 2 000	2 250 sheets/h
		< 2 000	1 500 sheets/h
	C	> 2 000	2 000 sheets/h
		< 2 000	1 500 sheets/h
> (1420*1020)	Carton	> 2 000	1 500 sheets/h
		< 2 000	750 sheets/h
	F	> 2 000	1 250 sheets/h
		< 2 000	750 sheets/h
	E	> 2 000	1 000 sheets/h
		< 2 000	750 sheets/h
	B	> 2 000	750 sheets/h
		< 2 000	500 sheets/h
	C	> 2 000	500 sheets/h
		< 2 000	500 sheets/h

Folding				
Folding	**Material**	**Quantity**	**Package size**	**Machine speed**
Automatic bottom	Carton	> 10 000	< 300	5 500 packages/h
			< 500	5 000 packages/h
			> 1 000	4 750 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	3 000 packages/h
	F/E	> 10 000	< 300	5 000 packages/h
			< 500	4 750 packages/h
			> 1 000	4 500 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	2 750 packages/h
	B/C	> 10 000	< 300	4 000 packages/h
			< 500	3 750 packages/h
			> 1 000	3 500 packages/h
		< 10 000	< 300	3 250 packages/h
			> 300	2 500 packages/h
Side glued	Carton	> 10 000	< 300	7 500 packages/h
			< 500	5 250 packages/h
			> 1 000	5 000 packages/h
		< 10 000	< 300	4 750 packages/h
			> 300	3 000 packages/h
	F/E	> 10 000	< 300	5 250 packages/h
			< 500	4 750 packages/h
			> 1 000	4 500 packages/h
		< 10 000	< 300	4 000 packages/h
			> 300	3 000 packages/h
	B/C	> 10 000	< 300	4 500 packages/h
			< 500	4 250 packages/h
			> 1 000	4 000 packages/h
		< 10 000	< 300	3 500 packages/h
			> 300	2 500 packages/h

Die cutting	
# of blanks	**Set-up time**
1	1,0 h
2-5	1,5 h
6-8	2,0 h
>=9	2,5 h

Folding		
Folding	**Package size**	**Set-up time**
AB.	< 350	2,0 h
	>= 350	1,5 h
SG.	< 350	1,0 h
	>= 350	1,0 h

Table C.2 *Lamination and windowing machine speeds.*

Lamination				Windowing				
Flute	**Quantity**	**Width**	**Machine speed**	**Symmetry**	**Material**	**Quantity**	**Packaging size**	**Machine speed**
F	> 2 000	< 1 000	3 750 sheets/h	Asymmetric	Carton	> 10 000	< 300	2 750 packages/h
		< 1 300	3 250 sheets/h				> 300	2 400 packages/h
		> 1 300	2 750 sheets/h			< 10 000	< 300	2 000 packages/h
	< 2 000	< 1 000	2 000 sheets/h				> 300	1 500 packages/h
		< 1 300	2 000 sheets/h		F/E	> 10 000	< 300	2 500 packages/h
		> 1 300	2 000 sheets/h				> 300	2 250 packages/h
E	> 2 000	< 1 000	3 500 sheets/h			< 10 000	< 300	2 000 packages/h
		< 1 300	3 000 sheets/h				> 300	1 400 packages/h
		> 1 300	2 500 sheets/h		B/C	> 10 000	< 300	2 000 packages/h
	< 2 000	< 1 000	2 000 sheets/h				> 300	1 800 packages/h
		< 1 300	2 000 sheets/h			< 10 000	< 300	1 500 packages/h
		> 1 300	2 000 sheets/h				> 300	1 250 packages/h
B	> 2 000	< 1 000	3 000 sheets/h	Symmetric	Carton	> 10 000	< 300	3 750 packages/h
		< 1 300	2 500 sheets/h				> 300	2 500 packages/h
		> 1 300	2 000 sheets/h			< 10 000	< 300	2 400 packages/h
	< 2 000	< 1 000	1 500 sheets/h				> 300	1 500 packages/h
		< 1 300	1 500 sheets/h		F/E	> 10 000	< 300	2 600 packages/h
		> 1 300	1 500 sheets/h				> 300	2 300 packages/h
C	> 2 000	< 1 000	2 250 sheets/h			< 10 000	< 300	2 000 packages/h
		< 1 300	1 750 sheets/h				> 300	1 500 packages/h
		> 1 300	1 500 sheets/h		B/C	> 10 000	< 300	2 250 packages/h
	< 2 000	< 1 000	1 250 sheets/h				> 300	2 000 packages/h
		< 1 300	1 250 sheets/h			< 10 000	< 300	1 750 packages/h
		> 1 300	1 250 sheets/h				> 300	1 250 packages/h

Table C.3 *Stripping activity speeds and windowing set-up times.*

Stripping			
Material	**Quantity**	**Blanks**	**Machine speed**
Carton	>2000	<4	3 250 sheets/h
		>=4	2 250 sheets/h
	<2000	All	1 500 sheets/h
F	>2000	<4	3 000 sheets/h
		>=4	2 250 sheets/h
	<2000	All	1 500 sheets/h
E	>2000	<4	2 750 sheets/h
		>=4	2 000 sheets/h
	<2000	All	1 500 sheets/h
B/C	>2000	All	2 000 sheets/h
	<2000	All	1 000 sheets/h

Windowing		
Symmetry	**Package size**	**Set-up time**
Asymmetric	< 350	3,0 h
	>= 350	2,5 h
Symmetric	< 350	2,0 h
	>= 350	1,5 h

Appendix D – Worksheet Information Flows

In this appendix the worksheet information flows described generally in chapter 6 are attached. The information has been broken down one level in detail from the section level to individual cell level from the user interface.

Table D.1 *Sheet structure setup.*

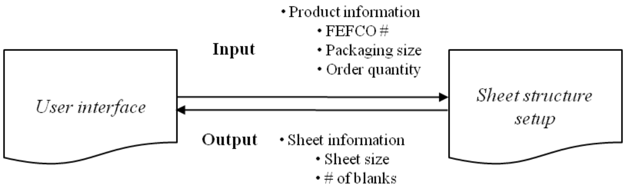


Table D.2 *Direct material.*

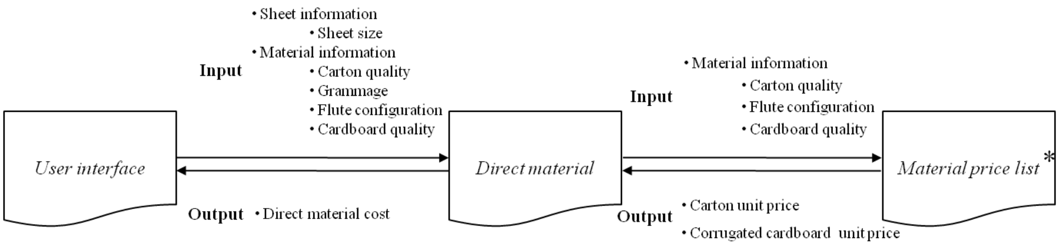


Table D.3 *Direct labor & manufacturing overhead.*

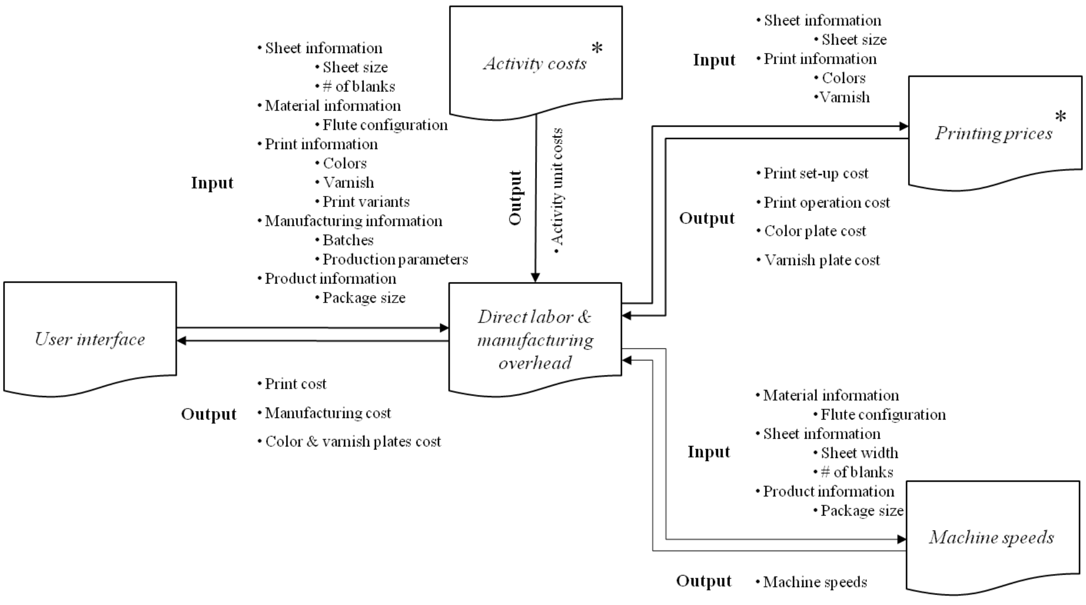
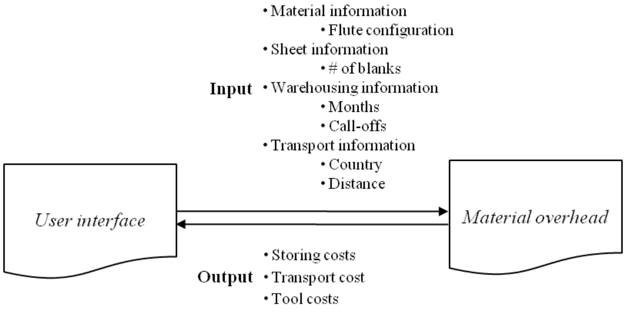


Table D.4 *Material overhead.*



Appendix E – ABC Implementation Templates

Empty templates from the suggested ABC implementation procedure are attached here for facilitating purposes. They can be used to gather and present cost data in appropriate ways to simplify the identification and allocation phases.

Table E.1 *List of Resources.*

Resource	Resource volume	Resource driver	Resource driver volume

Table E.2 *List of Activities.*

Activity	Activity volume	Cost driver	Cost driver volume

Table E.3 *List of Cost Object Components.*

Cost object components	Direct	Overhead

Table E.4 *RAR matrix.*

Activities / Resources															

Table E.5 *RAP matrix.*

Resource volumes																
Resources																
Activities																Activity volumes

Table E.6 *ACOCR matrix.*

Cost object components / Activities															