LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
LUT School of Engineering and Science
Master´s Degree Programme in Industrial Engineering

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Profitability potential of high value added cellulosic raw materials in China

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Table of Contents

ABSTRACT

Author: Sampo Järvinen **Title:** Profitability potential of high value added cellulosic raw materials in China
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Master's thesis. Lappeenranta University of Technology, LUT School of Business and Management 80 pages, 28 figures, 16 tables, 18 equations and 3 appendices Examiner: Professor Timo Kärri Supervisors: Dr. Matti Ristolainen, UPM Pulp Business, Research and Innovation Dr. Harri Kosonen, UPM Pulp Business, Research and Innovation
Keywords: Traditional costing, activity-based costing, time driven activity-based costing, target costing, target pricing, supply chain management, supply chain innovation, financial modelling, product development, fluff pulp

The objective of this Master's thesis is to determine what would be the target cost and target price for several new kinds of fluff pulps developed and produced if innovated based on the market conditions in China. The aim is to find the most value creating, profitable and feasible innovation focus areas on new fibre development for fluff pulp and ultimately steer the research and development actions.

This study has been executed using decision-making methodological strategy research methodology combined with Balanced approach research method. The research is an innovative and practice oriented case study, consisting of the development of a financial simulation model. The study includes informal interview with supply chain management professionals in China and participant observations such as manufacturing site visitations. Theoretical part of the thesis is based on literature review.

In this thesis, three models were created, a cost model, financial model and cash flow model. In the cost model three alternative costing methods were used and compared: traditional costing, activity-based costing and time driven activity-based costing. In the financial model financial metrics between status quo and alternative operating setting were compared. In the cash flow model, target costing was implemented to quantify what brings most value to the customer and what would be the new price for different fluff pulp development areas.

Based on the results, pulp value chain's R&D sector should focus on helping customer increase selling price. In addition, latex binder addition, fixed costs and web's basis weight show clear improvement potential. Hammermill energy consumption and drying energy which were assumed to play an important role, did not in the end show as big of an impact as the ones previously listed. These results can be generalised to be valid not only in China but also in globally by keeping in mind there might be slight variations in different cost group's significances.

TIIVISTELMÄ

Tekijä: Sampo Järvinen

Työn nimi: Korkean lisäarvon sellumateriaalien kannattavuuspotenttiaali Kiinassa

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Hakusanat: Perinteinen kustannuslaskenta, toimintoperusteinen kustannuslaskenta, aikaohjattu toimintoperusteinen kustannuslaskenta, tavoite kustannus, tavoite hinta, toimitusketjun johtaminen, taloudellinen mallintaminen, tuotekehitys, fluff-sellu

Tämän diplomityön tavoitteena on määrittää tavoitekustannus ja –hinta erityyppisille uusille fluffi sellulaaduille Kiinan markkinoille. Tavoitteena on löytää eniten asiakkaille arvoa luovat, tuottoisat ja toteutettavissa olevat fluffikuitujen innovaatioalueet ja lopulta ohjata tutkimus- ja kehitystoimia näitä kohti.

Tämä tutkimus on toteutettu päätöksentekomenetelmästrategian tutkimusmetodologialla yhdistettynä tasapainotetun lähestymistavan tutkimusmenetelmään. Tutkimus on innovatiivis-käytännänläheinen tapaustutkimus sisältäen taloudellisen simulaatiomallin. Työssä on hyödynnetty haastatteluja johtavien kiinalaisten toimitusketjun johtamisen ammattilaisien kanssa sekä havainnointia tuotantolaitoksilla. Teoreettinen osuus työstä perustuu kirjallisuuskatsaukseen.

Työssä luotiin kolme eri mallia: kustannuslaskenta-, tilinpäätös- ja kassavirtamalli. Kustannuslaskentamallissa sovellettiin kolmea eri kustannuslaskentamenetelmää: perinteistä, toimintoperusteista ja aikaohjattua toimintoperusteista kustannuslaskentaa (engl. time-driven activity based costing). Tilinpäätösmallissa status quo ja simuloidun tuotannon väliä vertailtiin taloudellisilla mittareilla. Kassavirtamallissa, tavoite kustannus-metodia –metodia sovellettiin kvantifioimaan mikä luo asiakkaalle eniten arvoa ja mikä voisi olla uuden fluffikuidun myyntihinta eri kehitysalueilla.

Tulosten perusteella selluarvoketjun tutkimus-ja kehitysyksikön tulisi keskittyä asiakkaan tuotteen myyntihinnan korottamiskeinoihin. Lisäksi, lateksisideaineen vähennys, kiinteiden kustannusten lasku ja neliöpainon pienentäminen ovat potentiaalisia kehityskohteita. Vasaramyllyn energiakulutuksen ja kuivausenergian pienentäminen eivät olleet yhtä merkittäviä kuin tutkimuksen alussa oli ajateltu. Tulokset voidaan yleistää pitävän paikkansa Kiinan lisäksi myös globaalisti ottamalla huomioon pienet vaihtelut kustannusrakenteessa eri maiden välillä.

Acknowledgements

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TABLE OF FIGURES AND TABLES

Figures

Tables

Equations

ABBREVIATIONS

ABC – Activity based costing
ADt – Air-dried ton
CPA – Consumer profitability analysis
EBIT – Earnings before interest and taxes
EBITDA – Earnings before interest, taxes, depreciation and amortization
ETLA – Research Institute of Finnish Economy
EVA – Economic value added
FMCG – Fast-moving consumer goods
GAAP – Generally accepted accounting principles
GDP – Gross domestic product
GNP – Gross national product
IRR – Internal rate of return
LCC – Life cycle cost
MIRR – Modified internal rate of return
NOPAT – Net operating profit after taxes
NPV – Net present value
ROA – Return on assets
ROCE – Return on capital employed
ROS – Return on sales
SCM – Supply chain management
SCCM – Supply chain cost management
TDABC – Time driven activity-based costing
WACC – Weighted average cost of capital
WC – Working capital

1 Introduction

1.1 Background and motivation for the research

Recent study conducted by The Research Institute of Finnish Economy (ETLA) shows that ten most significant companies in Finland calculated by economic value added contribute 7.6 % of Finland's GDP. The productivity and the growth rates in these companies have substantially outperformed the computational average. In addition, these companies generate notable multiplicative effects to the economy. UPM-Kymmene Oyj, the company for which this thesis is made is, according to the report the most significant company for the Finnish economy in terms of the GPD, generating all together 4084 million euros (1507 by themselves in Finland and 2577 by multiplicative effects) when the whole value chain is considered. This rises UPM's share of the GDP to 2.0 %. (Ali-Yrkkö, et al., 2016)

The top companies, UPM-Kymmene included are intertwined with other companies through their value chains. The positive development of one company ripples on through its value chain, and the effects are spread to other companies. This makes it clear that during the decision-making processes on research and development activities, the whole value chain cost reduction potential, value addition and overall profitability needs to be taken into account. This is true in existing markets but also in new market exploration. In order to create a true impact in the value chain by research and development actions, a true understanding of the value chain is needed. Only the value creating activities makes sure the feasibility. One of the evaluation method is financial benefit.

While the concept of supply chain focuses on operations and logistics, in other words material flows (Tan, 2001), the term "value chain" extends the focus also to information and cash flows. Information and cash flows have been considered as part of the supply chain as well in previous literature (Hofmann & Kotzab, 2010), but played a smaller role compared to logistics. To emphasize the importance of additional value creation and customer orientation in innovation departments' key objectives, in this research the term value chain is selected instead of supply chain. Furthermore, in this research, value chain management cuts across several disciplines such as operations management, strategic management and product innovation management, so the use of (financial) value chain is well-justified.

World market pulp demand in 2015 was 63.6 million tonnes, which is 38 % of total wood pulp consumption. From this, fluff pulp accounts about 10 % and is expected to grow at a rate of 2.7 % a year. Produced using typically coarse, long-fibre softwoods, fluff pulp historically has been a specialty pulp grade with higher prices and margins than the more common papermaking pulp grades. It is one of the most sustainable raw materials on earth for hygiene and nonwoven products, based on tree species grown with no or little irrigation, no pesticides on land with no value for food production.

Breaking down the fluff pulp consumption into regions, we can see that Asia is already the biggest market with a share of almost 40 % of the world's total fluff pulp consumption (**Figure 1**). From Asia's figure China accounts roughly 30 %. China by itself accounts for 12 % of the global fluff pulp consumption and keeps on growing the second fastest after India. Saying that, China is and will be a major market for fluff pulp and in the future.

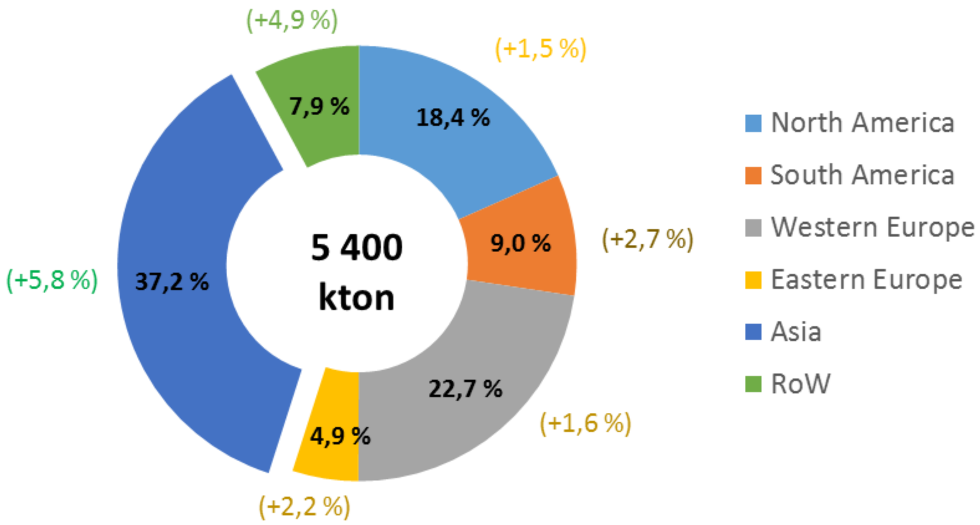


Figure 1. Fluff pulp consumption (inner circle) and their growth rates (inside brackets) (RISI, 2016)

From the Asia's fluff pulp consumption 7.3 % of the sales is nonwovens, which is interesting market because generally speaking Scandinavian softwood could be the most suitable to the nonwoven end-uses. In these applications runnability, good formation, low binder consumption, low shredding energy, even web, opacity and surface smoothness are valued.

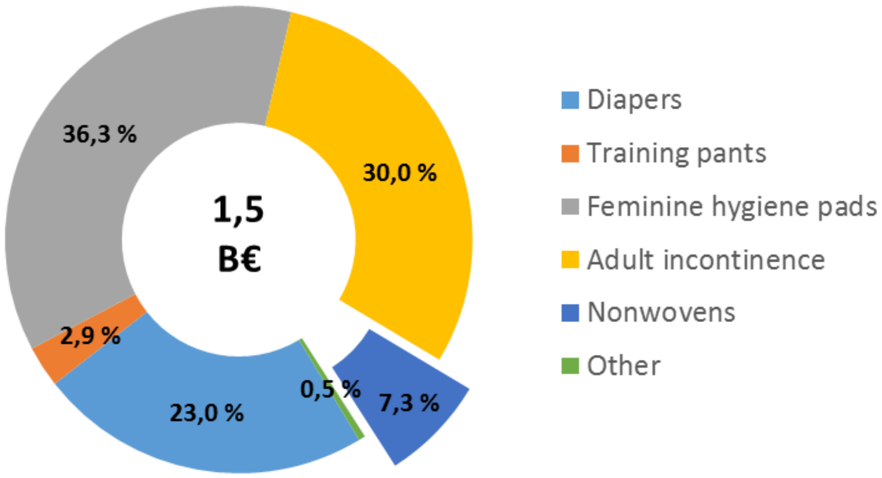


Figure 2. Fluff pulp end use application areas by end-use, 2015 (Smithers and Pira, 2015a)

However, the Scandinavian fluff pulp's advantages should be brought out clearer and further increase its competitiveness by focused R&D actions as its market share is currently only 5.2 % of the total fluff pulp's fibre consumption (**Figure 3**).

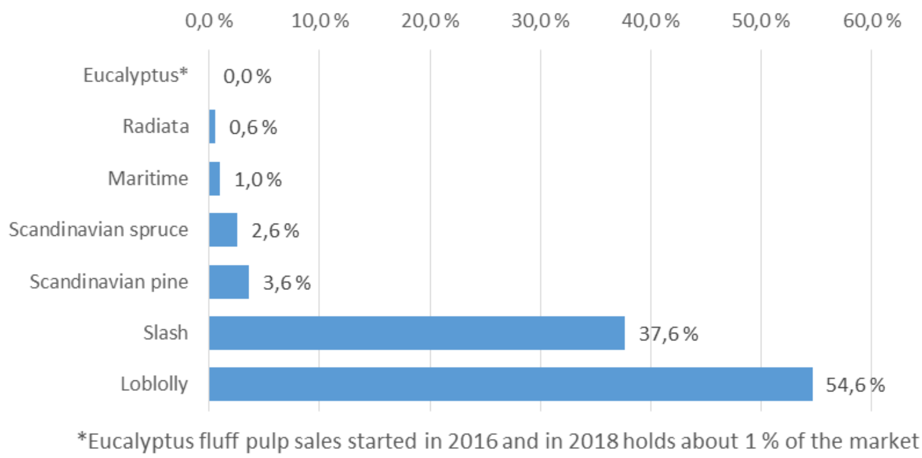


Figure 3. Global fluff pulp consumption by raw material (Smithers and Pira, 2015a)

The competitive landscape for fluff pulp is dominated by large pulp and paper companies located in North America (**Figure 4**). Currently, only 7.0 % of the production is in Western Europe. This is mainly due to the presence of the most optimal wood species for fluff pulp being located there such as Northern America Southern pine, Loblolly and Slash. The four largest fluff pulp producers account for about 80 % of all fluff pulp production in 2015. However, this might change because optimal fibre in the future might be Scandinavian pine and/or spruce due to its characteristics and various treatment alternatives it has that allows fibre modifications.

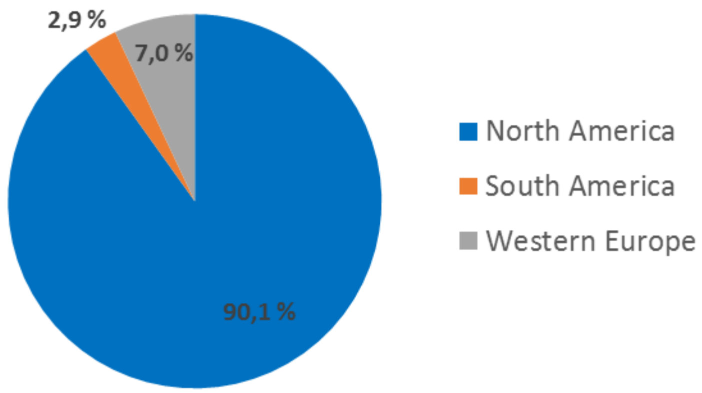


Figure 4. Fluff pulp production rates by region in 2015 (Smithers and Pira, 2015a)

As can be seen in the Figure 5 nonwovens pose not only a market potential but also a huge environmental benefit in terms of replacing fossil-based synthetic materials, which account currently 82.6 % of the total raw material consumption. Wood pulp, which is mainly fluff pulp, accounts only 6.9 %. For example, wet wipes are one of the several major microplastics sources and the biggest reason for costly sewer systems fatbergs. This could be solved by using wood pulp as a raw material for them instead of non-biodegradable synthetic materials. This can be done by strengthening the properties and the overall value chain's cost competitiveness.

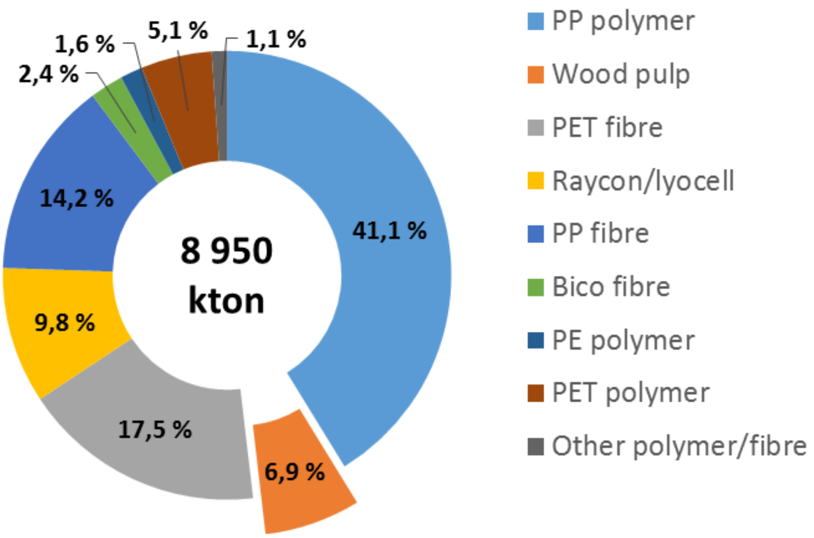


Figure 5. Raw materials typically used in nonwovens (Smithers and Pira, 2015b)

1.1 Research questions and objectives

The objective is to determine what would be the target cost and target price for several new kinds of fluff pulp developed and produced if innovated based on the market conditions in China. Research aim is to find the most profitable and feasible innovation focus areas on new fibre development for fluff pulp. The value should be monetarised both for the fluff pulp producer but also for the customer that would ultimately steer the research and development actions. Therefore, the research questions can be divided into one main research question that has three sub-questions.

Main research question:

- How Cost Management methods and financial modelling can be utilized to support R&D function in novel fibre development for a customer in fluff pulp value chain?

The main research question can be divided into three sub-questions:

- Which of the Cost Management methods is most applicable for creating a model that quantifies the current cost structure of a customer in Mainland China? How the cost results differ between different approaches?
- In which way the model needs to be developed to obtain increased customers' value of new pulp grade and new fibre properties? What matters to the most for a customer and what is the best financial measure to demonstrate the benefits?
- What is the new selling price and allowable additional costs of a potential new type of fibre sold to a customer in Mainland China?

1.2 Research methods, framework and limitations

The research paradigms in industrial management can be divided into five categories: formal conceptual research strategy, nomothetic strategy, action-oriented strategy, constructive strategy and decision-making methodological strategy (Olkkonen, 1993). Usefulness of these paradigms can be estimated by comparing their ability to produce suitable results for the research problem at hand. The formal conceptual strategy is used for theory building as definitions exist at the abstract level and do not contain measurable attributes (Wacker, 2004). Nomothetic strategy is a quantitative approach where the aim is to make objective observation of the test subjects and to create general symmetrical rules (Chelpa, 2005). In the action-oriented strategy, the researcher is an active observer in the research case and makes conclusions and future recommendations according to the experience analysis. Constructive strategy focuses on problem-solving by innovating and developing completely new models or mathematical programmes for specific cases in organisations (Kasanen, et al., 1993). The fifth research approach, the decision-making strategy, produces solutions for explicit problems on a more general level.

From the five paradigms, both the constructive strategy and decision-making methodological strategy would be suitable for this research; however, the latter is the most suitable and chosen as it delivers practical information for decision-makers and works well on cost modelling methods that have already been proved to work well. In this case, forestry sector and particularly in pulp and paper industry, activity-based costing is already in use and proved to work equally well or better as traditional costing (Fogelholm, 1993; Korpunen, 2015). In the decision-making methodology, the problem is firstly specified, then reconstructed into mathematical form and next tested with case studies (Olkkonen, 1993). In the final step, the mathematical forms and case study results are evaluated and further suggestions for developing the decision-making tool are made. This approach is strongly quantitative. However, decision-making methodology is often considered to require access to a large amount of data from management information systems, which is typically not possible or the data is inconsistent, incomplete, in accurate or missing.

In addition, when choosing a research strategy, there are always trade-offs in control, realism and generalizability. According to (Golicic, et al., 2005), Quantitative research methods (deductive) optimize control and generalizability (external validity), while qualitative research methods (inductive) maximizes realism (internal validity). It is agreed that supply chain management researchers are biased in to the positivist paradigm and therefore past researches that are considered to be valid are mostly quantitative ones. However, business environment in which supply chain cost management and companies' research and development stands are becoming increasingly complex and less compliant to using just one type of research approach. Therefore, Golicic *et al.* (2005) recommends researchers to use balanced approach where qualitative methods are included "in order to accurately describe, truly understand and begin to explain contemporary businesses' phenomena". This means qualitative and quantitative research approaches are not substitutes, rather they observe different aspects (McCracken, 1988). Qualitative research methods are used for example by bringing in an actual case study of a customer's operations. In practice in this research this means a financial model with what the operations can be simulated by basic parameters. Golicic *et al.* (2005) describes the importance of this step by stating "research studies need to utilize qualitative methods in addition to quantitative methods" to gain relevance in supply chain academics research.

Combining decision-making methodological and balanced research method is well justified as against of general apprehension the utilization rate of qualitative methods has been low in the past (**Table 1**). Especially in North American journals primarily normative (theoretical models and literature reviews) and quantitative (simulation/modelling and surveys) researches can be found. Halldorsson & Larsson (2004) examined supply chain management articles from 1997 through 2004 in Journal Of Business Logistics (JBL), International Journal of Physical Distribution and Logistics Management (IJPDLM) and the International Journal of Logistics Management (IJLM) and found out that only 8 out of 71 employed qualitative methods. This has been extended to German journals and affirmed the same phenomena and that only 7% of the articles were based on case studies. The research was categorised to consist also qualitative research methods if, for example brief interviews were held prior to survey but the whole methodologies were not described and still qualitative research had low incidence. It should be kept in mind that research in Europe relies more on qualitative methods than in North America (Golicic, et al., 2005, p. 18) but still the situation is rarely much better in most European Universities. These findings clearly indicate that logistics is dominated by quantitative research and that more qualitative research is needed and therefore Balanced Research Method is applied (**Figure 6**).

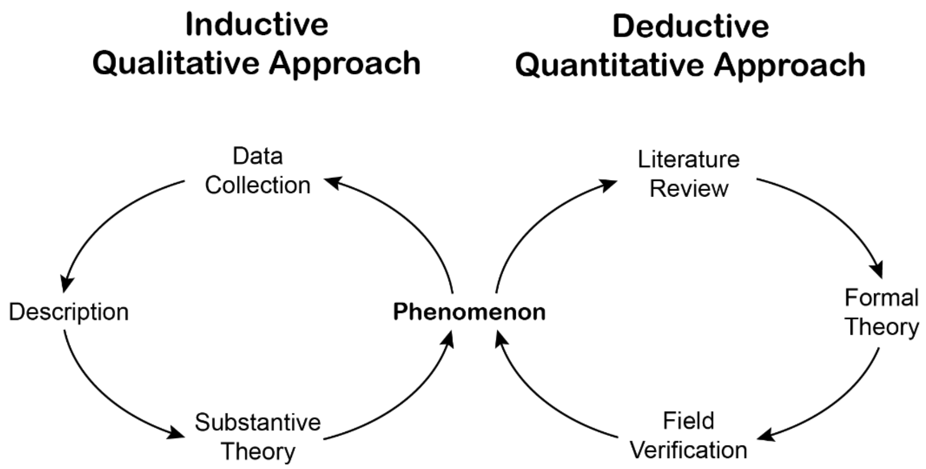


Figure 6. The Balanced Approach Model (adapted from (Golicic, et al., 2005) & (Woodruff , 2003)

Balanced Approach research method is introduced to this research to bring more qualitative approach to the quantitative theory-based modelling. The Balanced Approach Model is usually taken in the use if the business phenomenon of interest is quite new, dynamic and complex but also if relevant variables are not easily identified and the context of the study makes extant theories unavailable. In addition, quantitative approach by itself is not enough to describe the overall phenomenon behind profitability and customer demands due to the problem's multiplicity. For these reasons, the research also needs a qualitative approach in order to build a clearer picture and ensure validity. This extends this study from theoretical model creation to the practice in company level and closer to managerial decision making. With the quantitative approach we can accurately measure product innovation impact with the model by first qualitatively identifying and understanding relevant variables and gathered their detailed values.

Qualitative research questions often start with "how" or "what" pointing the researcher's target to clarify the process. Golicic *et al.* (2005) have given an example of a qualitative research question: "What is the nature of change in a customer's desired value?" Research questions that strive for explaining relationships among variables are ideal for quantitative approach and these research question might start by asking "why" or "to what extent". The approach is good in evaluating a direction or strength of relationships. In other words, quantitative approach generates the "big picture" and to develop a general explanation (Golicic, et al., 2005) whereas qualitative approach gives validation, depth and precision.

The model is called balanced because the research program tackles the issue by taking back and forth between qualitative and quantitative approaches as shown in Figure 6**Error! Reference source not found.**. At the beginning an inductive approach is taken to understand and generate substantive theory about the phenomena and afterwards a deductive approach is used for developing and testing the theory. This is done in a circle incrementally forming a better understanding of the issue and ensuring generalization but on the same time validity in a new research context of value chains in Mainland China and thereby consistently contribute to the body of supply chain management knowledge from a research and development perspective.

Table 1. Preferred Research Methods in Supply Chain Management (adapted from (Halldorsson & Larsson, 2004)

Method	Utilization rate
Survey	54,3%
Interview	13,8%
Case Study	3,2 %
Archival/Secondary Data	9,6%
Simulation/Modelling	19,2%
Focus Groups	n/a
Experiment	n/a

Utilizing both, decision-making methodological strategy and balanced approach model from industrial engineering and management research methods that Olkkonen (1993) has presented, the research method is actually approaching Design Science methodology (also known as constructive research) as seen in the **Figure 7**. Therefore, it the research approach can be described as a category of research methods instead of one single research framework.

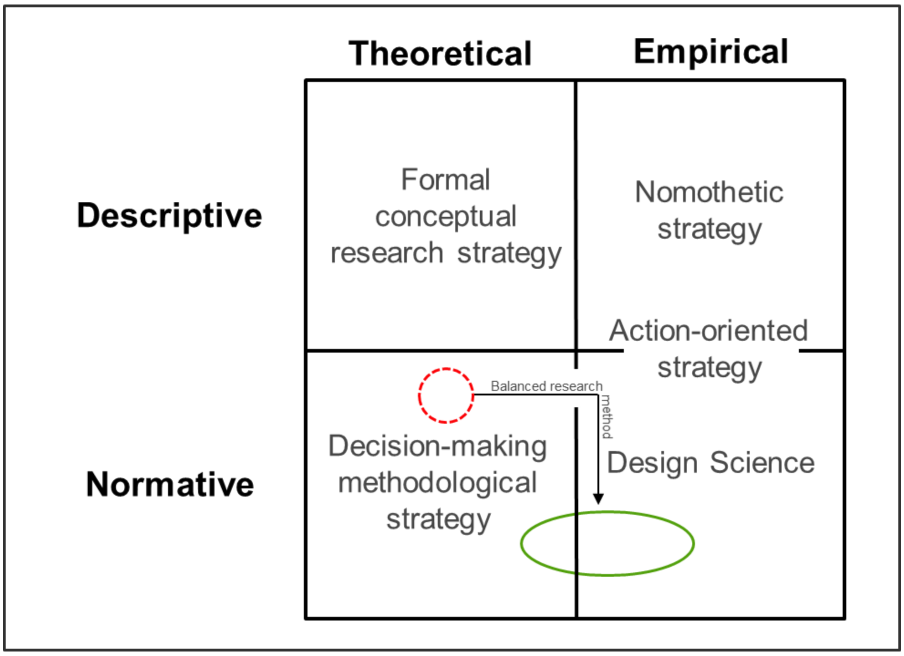


Figure 7. Research Design in relation to other business and management research methods. Red dot circle represents the research methodology's position without the Balanced Research method and green oval shape the final research paradigm with an implementation of the Balanced Research method.

This research is an innovative and practice oriented case study, as described by Dul and Kan (2008, p. 217), consisting of the development of a mathematical model methods, which in this study means an excel simulation model. The study will include informal interview with supply chain management professionals in China and participant observations such as manufacturing site visitations. Theoretical part of the thesis is based on literature review.

This thesis is limited to studying certain value chains in East and Southeast Asia, particularly in China. In addition, the scope of this research is limited to modelling costs in the value chain level, within this a special target is to highlight costs that product innovation department can have an impact on when designing a new kind of product. To put this into a framework, the Product-Relationship-matrix proposed by Seuring (2002, p. 18) is the most applicable (**Figure 8**). In the figure this study will focus on sectors II (Product design in the supply chain), and IV (Process optimization in the supply chain) in the matrix in which the research and development function can have the most impact on. Those two sectors form the value chain perspective and functions as a base for the financial value chain which is then modelled. The sectors I and III would cover the logistics of the product are outside of the research scope.

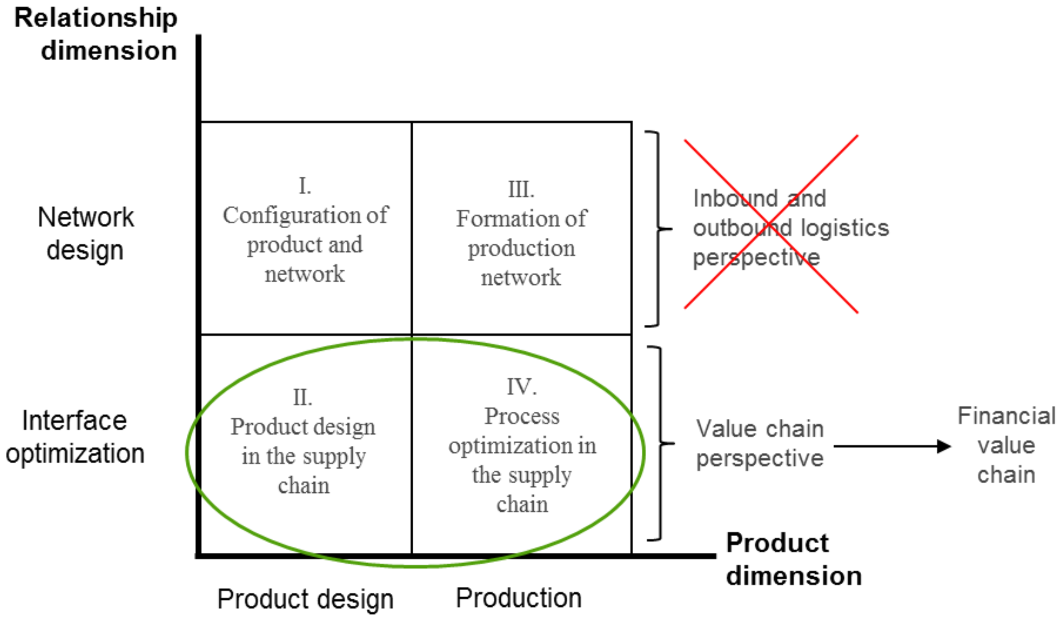


Figure 8. Research focus in the Product-Relationship-Matrix of Supply Chain Management, adapted from Seuring (2002, p. 18). The green circle represents this study's scope. The Logistics part of Supply Chain Management is outside of this study's scope.

1.3 Structure of the study

An overview of the thesis' structure is presented below in the **Table 2**. This thesis is comprised of a theoretical part and empirical section. Theoretical part of the thesis is based on literature review and covered in Chapters 2 and 3. Chapter 2 describes the fundamentals of cost management and supply management and how they have over years developed into supply chain cost management. In addition, it covers the product design and innovation perspective of the supply chain cost management, which finally comes down to highlighting the importance of target costing. Chapter 3 gets deep down to various cost management methods in the value chain and to their comparison. The comparison is also done geographically aiming to find the optimal cost management methods for the practical case study in Mainland China. As it turns out, between Western and Chinese scholars same methods are known and used. However, in practice in operational level at companies they are not typically used. The more outside from major cities and the further from costal area towards the inland you go to the less typical the latest cost management methods are in the customers' operations.

The scope of the thesis is reviewed in the empirical experimentation and validation will be executed in Chapters 5 and 6. Chapter 5 focuses on building a model for determining the current cost structure of one fluff pulp customer that uses airlaid process in production of several types of nonwovens. Advantages and disadvantages of using different fluff pulps are researched. Chapter 6 continues from that and extends it to a financial model that result in obtaining financial metrics. Sensitivity analysis is used to identify the most important parameters. The outcomes are qualitative and quantitative. Firstly, the model tells which new fibre properties are the most valuable for customer but also secondly, what would be the new potential fluff pulp's selling price based on its characteristics. Ultimately, this sets target costs for fibre development and manufacturing to the research and development function.

Table 2. Structure of the study

Chapter	Section	Objective
I		Introduction and background
II	Theoretical part	Literature review
III		
IV	Empirical selection	Development of the cost model & results
V		Development of the financial model & results
VI		Innovation potential and value creation
VII		Discussion and conclusion

2 Supply chain management

The scholars and practitioners have struggled with the definition for supply chain management from the early stages of the field's evolution. From logistics before 1950s it has also been variously referred as distribution, physical distribution, logistics, business logistics, integrated logistics, materials management, value chains and rhocrematics which is a Greek term referring to the management of material flows. The logistics as a field has a strong military history when it had to do with procurement, maintenance and transportation of different military facilities, material and personnel. The firms back in then were interested in getting right goods to right place at the right time and hardly no research was done on trading one cost for another. Other areas were thought to be more important. Hence, there was not even opportunity to learn broader concepts of logistics or beyond.

The concept of logistics and the field that eventually has shaped into supply chain management developed from the marketing field. Lalonde and Dawson (1969) traced the early history of logistics and note that Arch Shaw in 1912 saw the two sides of marketing where one deals with demand creation (promotion) and the other with physical supply. First the distribution seemed to be part of the marketing mix and was defined more in terms of transaction channel activities than physical distribution ones. Companies still in 1950s and early 1960s paid a great deal more attention to buying and selling than to physical distribution.

The kick off for laying foundations for physical distribution was made by Lewis *et al.* (1956) in a study for the airline industry. The airline industry was thinking how it could better compete in hauling flight even when their costs were significantly higher than other forms of transportation. The study found out that it is necessary to view shipping from a total cost perspective and not from just a transportation cost one. Although airfreight cost was typically higher, airfreight's faster and more reliable service led to lower inventory costs on both ends of the shipment. This lead to the total cost concept in logistics, which began to take off in the 1960s. The focus was on firms' outbound logistics and little attention was given to inbound material movements.

In 1964, the scope of physical distribution was expanded (Heskett *et al.*, 1964) to include physical supply and was called business logistics. Using a descriptive name of business logistics was not only an attempt to distinguish the name from military logistics but to focus on logistics activities that took place within the business firm.

In the 1060s and 1970s the study and practice of physical distribution and logistics emerged spurring by the recognition of high logistics costs and therefore got managerial attention. It was estimated that on a national level logistics costs in the USA accounted for 15 % of the gross national product (Heskett *et al.*, 1973). Similarly, in UK, they were 16 % of sales (Murphy, 1972), in Japan 26.5 % of sales (Kobayashi, 1973), in Australia 14.1 % of sales (Stephenson, 1975), and as of 1991 in China they were 24 % of GDP. Physical distribution with its outbound orientation was first to be laid focus on, since it represents about two thirds of logistics costs. Subsequently, business logistics, including inbound movement followed soon after that.

Heskett *et al.* (1973, p. 25) recognized that logistics takes place throughout the supply channel, from producer to end consumer. Heskett *et al.* (1973) also suggested that there needs to be coordination of the product flows throughout the entire channel, which is probably the first implication of what SCM is described now. The early definitions already suggested a broad scope for the physical distribution and logistics but still the focus was on coordinating among the activities within the logistics function and giving little emphasis on coordinating among the other functions within the firm, not to mention with the external channel member. The reason for this is most likely technical limitations of information systems at the time. Coordination between business functions was to become a major theme in later years starting from late 1970s and early 1980s. This can be seen from the interfunctional and interorganizational coordinative functions in **Figure 9**: Strategic planning, information services, marketing/sales and Finance.

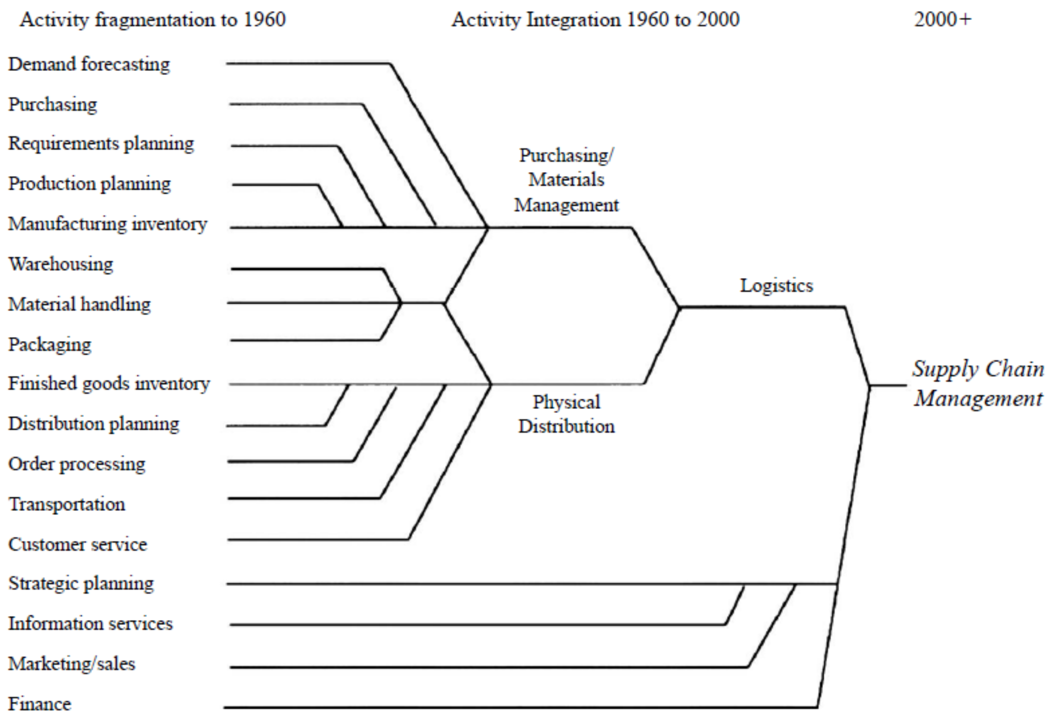


Figure 9. Evolution of supply chain management from 1960 to 2000 and beyond (Ronald , 2007, p. 338)

The Council of Supply Chain Management Professionals (CSCMP), which is the organisation of supply chain practitioners, researchers and academics, has defined SCM as:

> "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies."

Whereas, CSCMP defines logistics to be just one part of SCM:

> "Logistics management is that part of SCM that plans, implements, and controls the efficient forward and reverse flow and storage of goods, services, and related information between the point of origin and point of consumption in order to meet customer requirements."

Therefore, nowadays SCM is viewed as managing product flows across multiple companies and logistics is considered as managing the product flow activities just inside one company. Seeing it in a big picture, a contemporary view of SCM is to think of it as managing a set of processes, where a process is a group of activities in functions throughout the entire supply channel relevant to achieving a defined objective, which is typically a customer need, whole product or service to the end customer. Saying that, the contemporary view is that SCM is a new frontier for demand generation – an effective competition tool. **Figure 10** presents how SCM can be used as a tool for reaching business competitiveness. On the same time, it illustrates the divergence of SCM and supply chain cost management (SCCM). SCCM is a subcategory of SCM and serves as a tool to reach SCM objectives. Theory of SCCM is covered in Chapter 3 but first it is described how to combine SCM and SCCM.

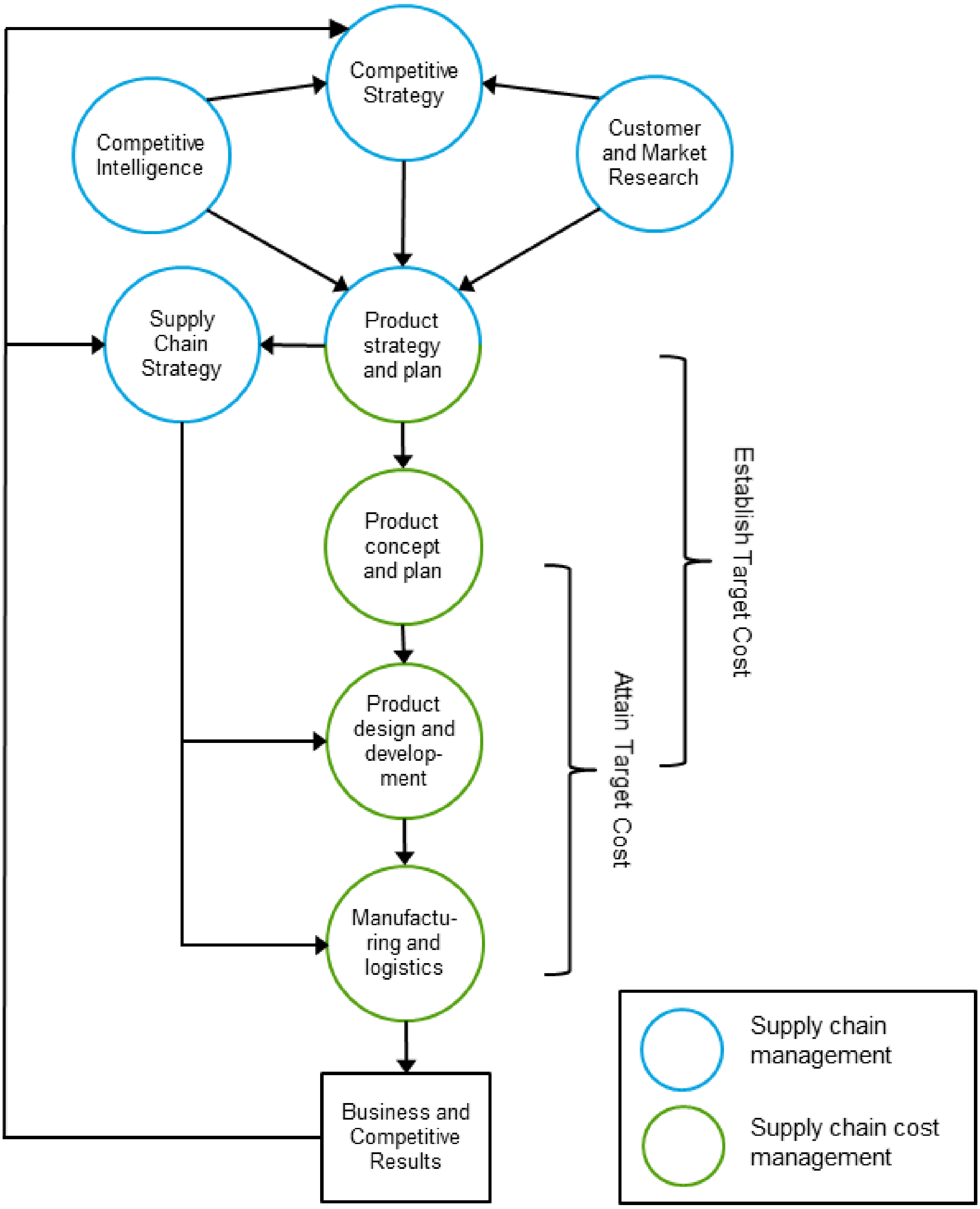


Figure 10. The divergence and connection point of supply chain management and supply chain cost management (adapted from (Ansari, et al., 1997; Archie & Wilbur, 2000, p. 214)

When looking at a typical product life-cycle of a nonwoven or absorbent product over the years it becomes clear that the trend is for reduced lifetime and increased differentiation in the downstream. A product's lifetime is an attribute of new product introduction rates and intervals between new product generations. This has been especially true in electronics but nowadays also in fast moving consumer goods (FMCG), causing the product design and development phase to become more pronounced when overall production costs are examined. For the pulp industry the production development cost has been low in relation to many other industries where product development itself can incur significant costs; from 3 % to even 25 % and average being 9 % of total costs. However, its activities can significantly impact on production costs of pulp and the whole end-product along the value chain. A big portion of the costs can be influenced in the production development phase. By this, the feasibility of a development action depends on gained benefits in the value chain. This is where the whole supply chain perspective rises its importance affecting heavily to operational and configurational efficiency. Not only the existing pulp value chains are known to have price sensitive markets but also the potentially substitutable synthetic raw materials are known to be price competitive.

The competitive landscape reflects to the whole product design process by the fact that the whole chain needs to be optimized, when creating a new product. For effective supply chain management to occur, firms must adopt a new managerial approach (Balsmeier & Voisin, 1996) meaning that in contrast to anterior optimization which happened on local objectives, companies should take a broader perspective in supply chain management. New cost management systems need to be more focused on maximizing customer satisfaction over minimizing local costs. In traditional approach decisions are made without regard to their effect on other components of the chain resulting in inability to fulfil company-wide objectives, conflicts between functional areas and at the end of the day failure in meeting customer satisfaction. For example, Ellram (1991) points out that the goal of supply chain management should be to improve customer satisfaction at reduced overall costs not just local costs.

The starting point for the supply chain management is presented in the **Table 3**, which describes the typical cost structure of a 600 kt/a softwood chemical pulp mill cost structure. For fluff pulp the chemical costs are a bit higher than for normal chemical pulp because of the chemical debonders added during production to make it easier (lower energy) to defiberize the fluff pulp in the hammermill prior to use. The total cost is around 475-550 €/ton including delivery (Diesen, 2007).

Table 3. Typical cost structure of a 600 kt/a softwood chemical pulp mill at full production (Diesen, 2007)

1. Variable Costs	%
Wood	31.0
Chemicals	7.9
Energy	0.7
Operating Material & Services	10.7
Total Variable Costs	50.3
2. Fixed Costs	
Maintenance Materials	5.2
Personnel & Administration	3.3
Others	5
Total Fixed Costs	13.5
3. Capital Costs	36.2
Total Costs	**100**

The next step for analysing the supply channel's total costs would be to know the buyer's costs. By this performing a cost-benefit analysis in the value chain as presented in the **Figure 11** we would know in which research and development actions to focus on if maximized benefits are sought. For example, if the research and development function were able to modify the fluff pulp in a way that it would reduce the latex binder consumption on fluff pulp buyer's side, what would be the overall monetary benefits in the value chain? Derivate of the value chain cost curve would show the optimal situation.

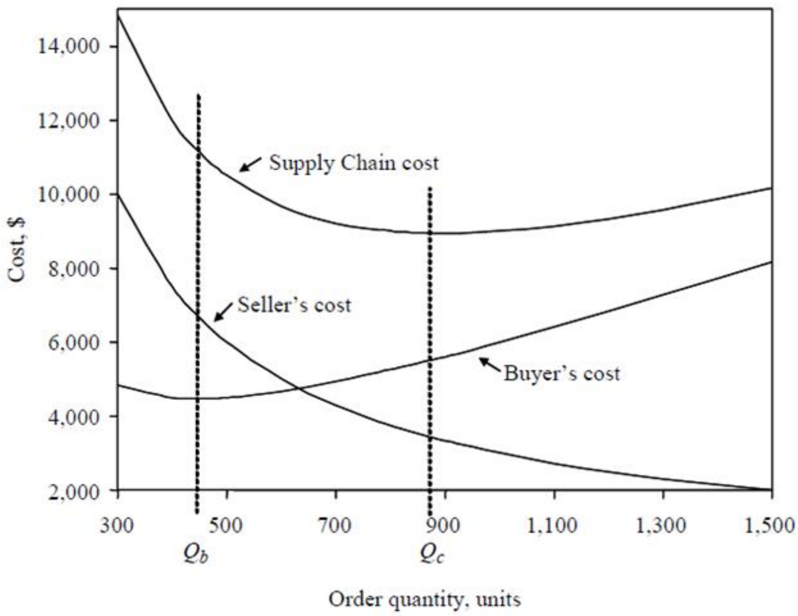


Figure 11. Illustrative total cost in the supply channel

2.1 Supply chain management meets cost management

There are various ways companies and researchers have approached cost management in supply chains. Researchers and practitioners started with traditional cost management and moved into activity-based management (ABM), including mostly activity-based costing but also in some cases time-driven activity-based costing. Recently the focus has switched towards target costing (Smith & Lockamy, 2000) and its combinations with other methods, mostly with ABC. The main criticism levelled against traditional cost management system is that it often solely focuses on reducing costs in many different unconnected local levels. Some firms have attempted to mitigate this problem by using activity-based management instead. However, it does not remove the problem that it fails to address the issue of how the whole supply channel could be utilized to reduce costs or increase customer satisfaction.

Companies utilize financial data from their cost management systems to plan and control the operations of their supply chains. Over the time, they can deepen this knowledge by establishing the costs of products and services and their alternatives that are moving through the supply chains (Jonson, 1994, p. 18). Unlike in the optimal supply chain (**Figure 12)** where the information flow of demands and design information goes from the downstream to upstream, the information does not convey to other participants of the supply channel in the traditional approaches. Due to these facts, researchers and companies have slowly moved over to target costing, which is considered as a better choice for supply chain (cost) management. In target costing, costs are perceived as a result, whereas customer requirements are seen as binding competitive constraints (Smith & Lockamy, 2000). The result is a method where supply chain incurs costs that are necessary to satisfy customers' expectations for functionality and price, resulting in more competitive products as seen in Figure 10. The Chapter 3 discusses all the cost management systems, their popularity in China and the benefits and drawbacks of using them.

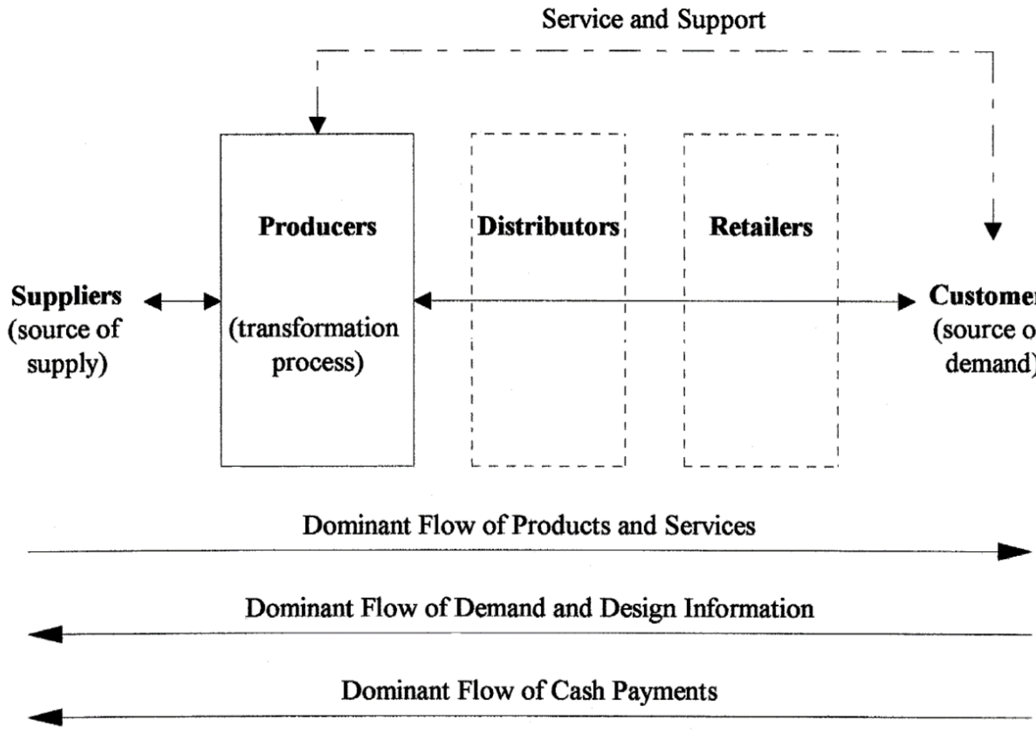


Figure 12. Supply chain material flow in an optimal case (Adapted from APIC/CPIM (1997) & (Wilbur & Lockamy, 2001)

2.2 Product design and innovation perspective in supply chain management

Supply chain management covers strategic, tactical and operational elements that provide companies a wide span of different possibilities to maintain competitiveness. Research and development is an important part of this. Recently supply chain management development initiatives have been categorised mainly into two categories: logistics innovation (LI) and supply chain innovation (SCI) (Munksgaard, et al., 2014, p. 50). Putting the two into the product-relationship-matrix of supply chain management (Figure 8) the logistic innovation's research focus positions itself to the upper left and right corner. This is where network design, distribution and logistics is covered. As an example of logistics innovation development initiative could be for example logistics technologies (e.g. digital solutions such as: EDI, ERP, RFID) and logistics programs (single or multi-level vendor-managed inventory (VMI), scan-based trading cross-docking, *etc*.), which focuses on the network and its material flow. Meanwhile, the supply chain innovation is more to do with the supply channel its offerings to customer, of which this study is focused on. Supply chain innovation is a concept that has been increasingly invoked in academic circles well as in practice in recent years.

Based on literature review on SCI Arlbjørn *et al.* (2011, p. 9) put a following definition of SCI: “Supply chain innovation is a change (incremental or radical) within a supply chain network, supply chain technology, or supply chain process (or a combination of these) that can take place in a company function, within a company, in an industry or in a supply chain in order to enhance new value creation for the stakeholder.” In addition, Arlbjørn *et al.* (2011) introduces three elements of SCI, namely supply chain business process, supply chain technology and supply chain network structure or compositions of these. The development of SCM is achieved through supply chain innovation and logistic innovation.

The emphasis in SCI has recently drawn into value, some researchers referring it as value-based supply chain management making the supply chain cost management more market oriented and value driven. Since the supply chain management is achieved through supply chain cost management and supply chain innovation, value creation and its measurement help to meet strategic objectives through research and development department.

As addressed by Hofmann (2010), the key factors for successful differentiation and competitiveness are proactive management within the supply chain, efforts strongly related to supply chain innovation. Since the supply chain management is achieved through supply chain cost management and supply chain innovation, value creation and its measurement help to meet strategic objectives through research and development department. According to Munksgaard *et al.* (2014, p. 51) value created from supply chain innovation is primarily cost driven. Slater (1997) envisions value to be the difference between benefits derived and sacrifices and/or costs incurred. According to Porter (1985, p. 38), value is “the amount buyers are willing to pay for what a firm provides them.” This claim is backed by various researchers and stated that value is conceptualized and measured using monetary terms. However, some researchers (Slater, 1997; Willson & Jantrania, 1998; Amit & Zott, 2001) have stated that value could also include things like competence, effectiveness, differentiation and social rewards, which are non-monetary aspects. Given this, value could be envisioned more broadly as the difference between benefits derived and sacrifices and/or costs incurred (Slater, 1997). These benefits (read: value addition) might extent even to creation of new markets (Munksgaard, et al., 2014, p. 53). Therefore, sources of value do not exist within a firm’s boundary alone, contrary, to create superior value, organizations are strived to understand their entire value chain extensively.

2.3 Target costing in supply chain management

Cost efficiency and partly success for firms depends on their ability to balance a stream and process changes with meeting customer demands, improving cost, delivery, service and product quality and delivery flexibility. In other words, the success depends on how a firm performs Figure 10's supply chain management activities. This happens across different organisational functions, companies and national borders. Managing these effectively requires. In order this to happen effectively Balsmeier and Voisin (1996) started the swift from traditional operating method to a new managerial approach. Increasing competition is forcing companies to go away from managing each segment as an independent entity and concentrating on achieving local objects. Today's value chains are taking into account their effect on the down or upstream value chain and looking the costs structure as a whole. Therefore, the success of value chains depends on how by coordination the network of firms are able to fulfil the end-customer needs better than other competitive value chains. Not anymore just companies but also value chains are competing.

A primary reason for the failure of traditional approach was its dependence a cost management system that is focused on minimizing local costs over maximizing customer satisfaction (Archie & Wilbur, 2000, p. 210). This method works against of SCM's ultimate goal of increase customer satisfaction of which only one way is the minimization of costs among several other ways. Saying this, solely using traditional approach and ABM the SCM would fail to utilize other ways than cost minimization to increase customer satisfaction. Target costing focuses less on costs than on customer requirement. Customer requirements are seen as competitive constrains of which have to be first met and subsequently met as cost effective as possible. Instead of cost minimization, the cost rationalization as a function of customer satisfaction is sought.

Cost estimation and reduction have always been a great concern in a product design cycle (Romero Rojo *et al.* 2009). In recent years, research aim has been focused on two aspects in product development improvement: how to shorten the product development and how to reduce the product development cost. This is due to contemporary global manufacturing environments that require agility, yet applying the state-of-the-art technology to respond to various customer requirements, needs, and wants. Typically, costs considered under product development costs are the sum of the costs in product design, production and logistics. Overhead costs are usually taken into account, in practice with an estimation by multiplying the product development cost by a constant variable. The product design cost normally determines the achieved market share, profitability and return on investment that is why accurately estimated costs play vital part while influencing to the selection of a mix of production development processes which can completely meet customer requirements with a lowest sum of costs. Accurate estimation and optimal controlling the cost of product design is crucial to shorten product development cycle and reduce its cost.

3 Supply chain cost management methods

Supply chain cost management has divided to its own sub-research category from supply chain management and gotten influence from cost management (also referred as management or managerial accounting). In fact, cost reduction has been among the most cited objectives in supply chain management research over the recent years. Both supply chain management and cost management are platforms for a wide variety of methods, concepts and instruments. Therefore, looking at the intersection of those two, which is called supply chain cost management, does not lead to a single, clear concept. Therefore, it is important to clarify what is supply chain cost management and how it has evolved in the presence of cost management and its methods. It is noteworthy that still many researchers categorise cost management activities in supply chain straight under supply chain management, not under its specific field of supply chain cost management. Some even put it under strategic management accounting or cost/managerial accounting.

In the past, researcher used developed instruments that were evolved from management accounting to treat intercompany historical data. However, this was insufficient, and the focus has shifted on more real time evaluation methods. Instead of only arranging past data, according to Dellmann & Franz (1993) "the present cost data within the value chain must be assessed, planned, controlled and evaluated". The need for real time and future oriented decision-making lead to development of concepts further than management accounting, for example concepts like generally most recognised target costing, activity-based costing and life-cycle costing. On the same time, the broadness of supply chain cost management has moved from intercompany perspective towards more integrated supply chain operation where development areas are looked from supply channel perspective. The force for this change has been an increasingly intense competition of profits. For cost allocation, this has meant that it has had to undergone changes to better meet managers' needs of aiming higher competitiveness. What this has mean in practice is for example more value-based activities and decision-making. As Gupta & Gunasekran (2005) states the role of managerial accounting in a new enterprise environment: "One of the critical roles of managerial accounting is to identify and eliminate . . . non-value adding activities throughout the value-chain." Successful fusion and management of accounting and decision-making is a major competitive edge in the 21st century (Drucker, 1992) .

Currently, most of the cost systems are based on traditional operating principles and concepts (Jonson and Kaplan, 1987, p. 12) and the transition out from these has been rather slow. However, activity-based management has gained popularity and is expected to do so even more. In **Table 4** the evolution of cost measures is presented. It should be noted that the scholars are always the first movers and for practitioners it typically takes more time to implement a new way of operating. In addition, there is variation geographically as well. The next sections of the research discuss some of these systems more detailed, their popularity in China and the benefits and drawbacks of using them.

Table 4. Evolution of cost measures, adapted partially from Ferrer (1995); Gupta & Gunasekran (2005)

Period	Approach	Model
Pre-industrial and early period	Average cost	Total cost/total output Selling price = cost plus
Until 1940s	Total manufacturing cost focus	Direct material, direct labour, manufacturing overhead, other administrative costs. Selling price = cost plus (This model based on full/absorption costing and used for reporting costs under GAAP).
1940s-1980s	Direct costing, fixed *vs.* variable	Direct costs, variable manufacturing and other overheads, fixed costs. Selling price = cost plus
1940s-	Opportunity costing	Focuses on the missed opportunity costs for managerial decision-making.
1940s-	Transfer pricing	Focuses on transfer of goods and services within the organization for cost allocation purposes.
1980s-	Activity-based costing	Direct costs, activity based driven costs, fixed costs. Selling price = cost plus
1990s-	Market driven	Target cost = market selling price = desired profit. Costs have to remain within the target.
1990s	Product life cycle	Life cycle costing. Cost has a long-term horizon and includes all costs from inception to its end. Selling price = cost plus
1990s	Just in time	Throughput costing. Some inventory accounts are merged. Selling price = cost plus.
2000 onwards	Value-based costing	A blend of market driven and life cycle approach but is focused on highlighting the value creation.

In today's fierce global competition, supply chain management (SCM) is an important tool for managers to improve productivity, profitability and the performance of their operations. However, to do so supply chain management and especially value chain management need more accurate cost information about the activities and processes within the organization. According to value chain theory, value chain can create value and consume resources. The key element is to eliminate the non-value-added assignments and costs sources, resulting in the optimization, changes and reorganization of value chain to reduce costs. Throughout systematic and comprehensive analysis, it enables value adding activities and non-value adding activities to be distinguished. In the process not only the local point's interest fulfilment is taken into account, but also the overall value chain's benefit. This is especially important in design stage in the current markets but also in new market exploration when analysing the potential new market and specifying the competitive advantage possibilities over existing players. The idea behind this optimization is that we are able to create a simulation model based on a determined cost method. The model could easily determine profitability of the concept product of which properties are defined to meet certain consumer segment needs and thus create winner value chains.

3.1 Traditional costing

Traditional costing method, which refers to total manufacturing cost and direct cost (used from the early industrial period to 1980s), evolved from the average cost method. Whereas in the average cost method, total cost is divided by the total output, in total manufacturing cost the total cost is broken down into direct (material and labour) costs and indirect (manufacturing and overhead) costs. The indirect costs are estimated by averaged over single or multiple cost pools. Based on a cost driver, which can be for example, direct labour, material, or labour or machine hours, are used to determine individual product cost. The traditional costing and accounting system was designed to capture the operational costs by using the Generally Accepted Accounting Principles (GAAP). These calculations were used in the basis for financial statements referred as financial accounting. The traditional costing method suited well for the needs of the times as early as 1850s. These management control systems provided much needed coordination, control and discipline for large enterprises that time. However, in the new enterprise environment in 21st century these measures are lagging behind on decision-making and lack predictive value. Moreover, they lack of strategic and operative measures. These measurements should be able to influence the business processes and add value, which are in line with the strategic goals of the enterprise.

It is concerned that traditional costing has several drawbacks: (1) traditional costing does not provide adequate relevant non-financial information, (2) traditional accounting results in inaccurate product costs, (3) traditional accounting does not encourage improvement and (4) traditional costing fails to allocate overhead costs (Gupta & Gunasekran, 2005). One of the critical roles of cost management is to identify and eliminate non-value adding activities, which the traditional cost fails to address. The importance of this increases when going from inner-company to an inter-company perspective, where the costs effect amplifies throughout the supply channel.

3.2 Activity-based costing

There are two ways of proceeding activity-based costing, first called the traditional way which was introduced in 1987 and the second a simplified version of this called time-driven activity-based costing. Initially the activity-based costing (ABC) was a reply to inaccurate American accounting standards (Kuchta & Troska, 2007). This new method was concerned with what was done in terms of activities instead of traditional thinking of what was spent. This new method can support management, planning and decision making, which is critical in ever changing market and competitive markets that companies face when doing international business. Activity-based costing introduced by Johnson & Kaplan (1987) has gathered many supporters along the years. The main difference to traditional costing is the number of cost pools and the variety of cost drivers (Shannon & Don, 2008), illustrated in **Figure 13**. Kennedy (1996) explains this simply in his article that ”the activity cost pool is the overall cost associated with an activity” and continues “[a cost driver] is a feature that allocates the cost and performance to a certain activity. By applying activity-based costing, implementing cost tracing throughout the whole value chain is possible: from sourcing and manufacturing (Korpunen, 2015) towards supply chain (Koivula, 2015) to all the way to a retailer and end consumer profitability analysis (CPA) (Wei, 2011). Therefore, a well-designed ABC system is a powerful aid to management evaluation and decision-making, thereby in long term, it is an invaluable tool for improving organizational performance. In fact, Cagwin & Bouwam’s (2002) results showed that there is a positive association between ABC and improvement in ROI and overall improvement in financial performance.

The most likely reason for improved financial performance is that the features gained from applying ABC can be used beyond status quo manufacturing and supply chain activities. At the turn of the millennium, researchers began to examine its usability to estimate the manufacturing costs modelling of a product that is in a conceptual design and development stage. There are already several doctoral theses made on this subject; Tornberg *et al.* (2002) made an Activity-based costing model specially for cost-conscious product design “for the evaluation of different product design options” and concluded that “activity-based costing and process modelling provide a good starting point” when product design team aspire to more cost-conscious product outline. This is due to the fact that designers become aware of relationships between the activities performed during the manufacturing and their associated costs in more detailed. Identifying non-value adding activities or product features pose a major cost reduction potential.

There is a major weakness of activity-based costing when designers want to specially track certain product feature costs. Tornberg *et al.* (2002) mention that there is “a risk for calculations to include too many activities. This makes the calculations too complicated and too slow to use. This might be major problem, because product designers might demand for detailed information. Solution for this Tornberg *et al.* suggest a model should have different levels of information, which gives possibility to get more detailed information, while still allowing quick overall picture of the overall situation. This could be done by categorizing activities into larger groups and aggregate them by certain cost nature, for example to life-cycle activities that could include activities such as life-cycle maintenance costs, life-cycle manufacturing costs and so forth.

There are several problems associated with the data gathering. Firstly, survey approach is recommended, however the data gathered by this way is always subjective and difficult to validate. Importing the data from management information system’s data is not very often readily usable, accurate or even existing as the amount of data required is huge, which is expensive to store, process and report (Namazi 2016). Rolling this method on an frequent basis in a large scale requires rather lot of work. In some companies this has led to a situation where cost modelling systems are updated infrequently due to costs of reinterviewing and resurveying. This had led to outdated and inaccurate cost information leading the process, product, and customer costs become inaccurate. In addition, the model is theoretically incorrect while it ignores the potential of unused capacity (Namazi 2016).

In many real-life cases there are many ways of performing an activity, for example various ways to ship an order to customer. Traditional ABC models often fail to capture this complexity of actual operation while not allowing significant variation in resources required, incurring new activities to be added into the model. This increases its complexity meaning that in many cases such expansion of ABC systems has exceed the capacity of typical generic spreadsheet tools, such as Microsoft Excel, but also even many ABC software packages. However, these runnability problems arise only when months’ worth of data is processed. For product development purposes this approach might prove to be too laborious.

The following stages can be concluded for Activity Based Costing (Cooper and Kaplan 1998; Bruggeman and Everaert 2007; Krumweide 1998):

1) Collecting data on resources
2) Identifying activities
3) Defining the cost of the activities
4) Defining the cost drivers of activities
5) Defining the volume of cost drivers
6) Defining unit cost per cost driver for each activity and
7) Calculating the unit cost per product or service

Creating a new ABC system begins with collecting data on resources in which the focus should be on expensive resources, mostly the direct labour and materials cost. It is important to pay attention to resources that varies significantly on consumption by product. In addition, the focus should be on resources whose demand patterns are different compared to traditional allocation measures. These are typically direct labour, processing time and materials used. After that activities are identified and categorised as value adding and non-value adding activities. Subsequently the costs and cost drivers of activities are defined. Cost drivers are based on determined cost driver activity units. After this the volumes *i.e.* consumption of each cost drivers are determined. Second to last, the unit cost per cost driver can be calculated by dividing the activity's total cost by the cost driver volume. Finally, the unit cost is calculated by multiplying the cost per cost drivers by their corresponding activity consumptions. The whole process can be also seen from **Figure 13**.

Table 5. Advantages and disadvantages of activity-based costing

Advantages	Disadvantages
• More accurate cost per unit → improved sales strategy, performance management and decision making. • Examines the actual overhead cost drivers instead of the assumption of production volume relation. • Can be applied to all overhead costs, not just production overheads. • Enables costing model's complexity bringing higher cost estimation accuracy. • Ability to implement into supply chain environment. • Enables costing from a product design and innovation perspective.	• Limited benefit if the overhead costs are primarily volume related or if the overhead is a small proportion of the overall cost. • Requirement of allocating all the overhead cost to specific activities. • Might be more complex to explain to stakeholders. • Time consuming when building a model and maintaining it. • Requires sophisticated information technology, highly competitive environment, relatively high importance of costs, relatively low unused capacity and little intra-company transactions.

Advantages	Disadvantages
• Activities can be categorized into value creating and non-value creating segments. • Decision making level can take place even by product level	• Relies on managerial estimations of cost driver consumptions (data reliability). • Ignores unused capacity and variations in activities.

Activity based costing is very good in addressing the deficiencies the model reveals including inefficient processes, unprofitable products and customers but also excess capacity.

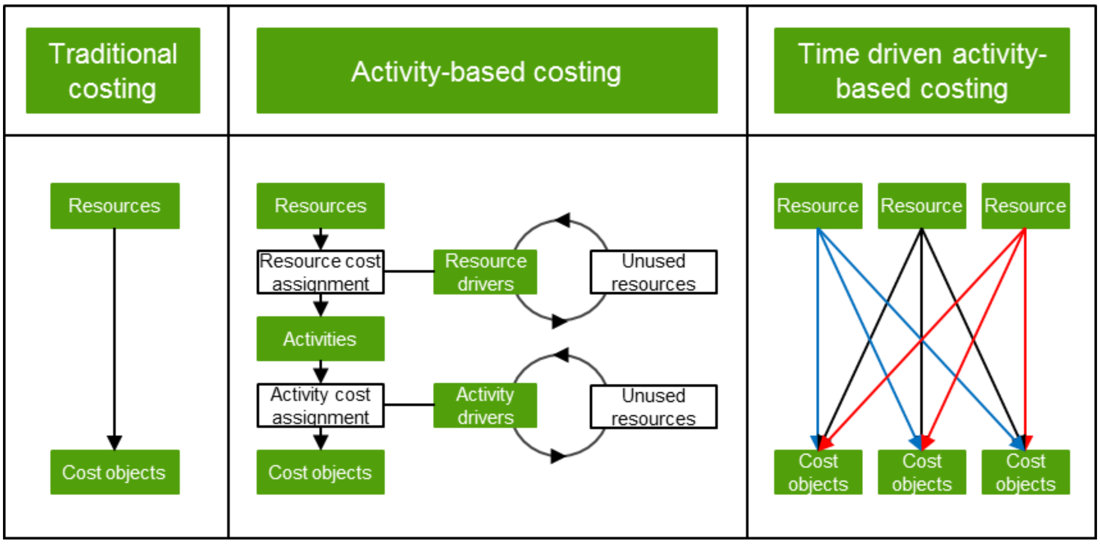


Figure 13. Illustration of three costing methods: traditional costing, activity-based costing and time-driven activity-based costing

3.3 Activity-based costing from a product design perspective

In their doctoral thesis, Tornberg *et al.* (2002) focused their attention specially on two of eleven main problems Uusi-Rauva and Paranko (1998) identified when interviewing accounting professionals (information producers) and product design managers (information users). These two were both around the same topic about how product designers would get more information about indirect costs but also better understanding of the direct cost dynamics. First, information from product structure and business process activities should be better combined. Second, product designers need more accurate and reliable cost information on product's total costs.

3.4 Time-driven activity-based costing

A problem for many companies that have tried to implement Activity based costing in their organization on any significant scale is that they have faced rising costs and employee irritation and therefore had abandoned their attempt. The time-driven activity-based costing were developed to give a solution for this. The method relies managerial estimates rather than on employee surveys, which might get too laborious. To build a traditional ABC model for a department, one would need to survey employees to estimate the percentage of time they spend on all the activities and then assign the department's resource expenses according to the average percentages gotten from the survey (Kaplan & Anderson, 2004). The TDABC makes allocation easier allowing even cost simulation model building in the product development phase.

In addition, the decision-making process in ABC becomes to take place more at the product level, meaning that it is based on actual utilization and does not identify the vacant capacity, whereas in time driven activity-based costing decisions are taken place on both production and process level. Kaplan and Anderson's (2004) article claims that even if in Time Driven Activity Based Costing activities are not taken into account, it still provides more accurate cost-driver rates, because unit times can be estimated even for complex and specialized transactions.

Namazi (2016) composes in his doctoral thesis different perspectives on time-driven activity-based costing. The study reports time driven activity based costing's applications in several strategic areas such as production cost, unutilized capacity, price setting, analysing customer profitability, and modelling complex decisions in various SMEs and large private companies, governmental companies, nonprofits and heavy manufacturing organizations.

3.5 Lean Accounting

The lean concept is a philosophy in which non-value-adding activities are recognized and eliminated in lean manufacturing systems. Lean accounting as a term refers to systematic methods that were developed for financial management based on lean principles. These methods have been standardised and in 2005 leaders in Lean Accounting reached to an agreement on a document named "The Principles, Practices and Tools for Lean Accounting. The quintessential idea of this is to aim at reduced cost over removal of waste, this is done with simplifying manufacturing processes (Blackstone *et al.* 2005). This leads to non-value-adding activities to be removed. Interestingly Time Driven Activity Based Costing were introduced just a year before in 2004, one might claim that the publication of standardised method for Lean Accounting document was a counter answer to the improved version of Activity Based Costing. According to Kennedy and Maskell (2007) Lean Accounting methods and tools support three key aspects of a lean organization: visual management, value stream management and continuous improvement. Value stream costing tools and target costing has been widely implemented in Lean Accounting and according to several papers it is a good tool for guaranteeing customer satisfaction.

Table 6. Different approaches summary for information generated from each accounting system (Adapted from Monroy et al. (2012))

	Activity Based Costing	**Time-driven activity-based costing**	**Lean accounting**
Financial reporting	Not accepted by GAAP	Not accepted by GAAP	Accepted by GAAP
Decision making	Takes place by product level	Takes place at product and process level	Takes place at value stream level
Operational control and improvement	Emphasis on financial measures	Emphasis on nonfinancial measures	Emphasis on nonfinancial measures
New product development	Suitable	Most suitable	Suitable for value chain cost perspective

Activity-based costing and time-driven activity-based costing are not accepted by GAAP, however, ABC by itself usually has little or no impact on the structure of the firm's financial accounting reports. This is because all the accounting methods no matter if it ABC, TDABC or traditional costing ultimately assign costs to the same existing accounts.

As a conclusion, one cannot obtain a perfect model just by applying one cost model. However, after being aware of the benefits and restrictions these can be taken into account and choose the most suitable model for each situation.

3.6 Life-cycle costing

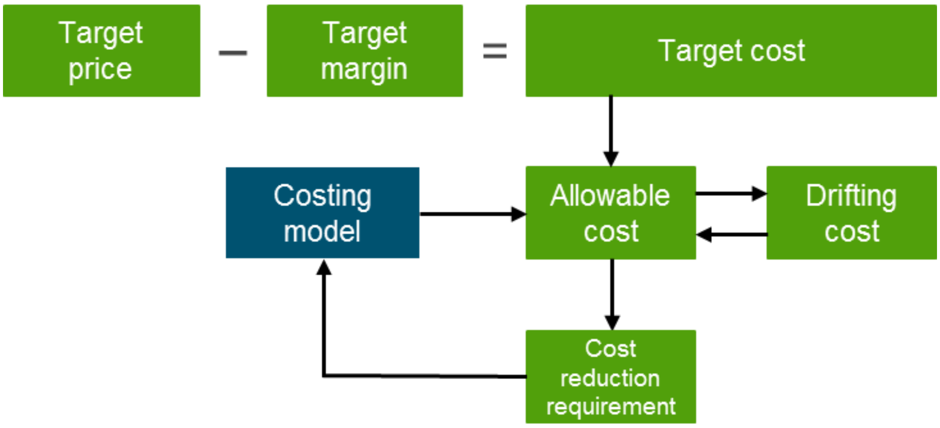
The life cycle costing (LCC) analysis is an engineering and economic optimization technique, in which the main target is to identify and choose the option which maximises the generated revenue over the product's lifetime. On a parallel, this means also lowest lifecycle cost generation (Fabrycky & Blanchard, 1991).

3.7 Target costing

Target costing is a market-driven system for cost reduction, focused on managing costs at the development and design stages of a product. It was developed in Japan in 1970s by Toyota and has been successfully used there since. However, the principles were well-known already before that, for example, back in the 1930s

Volkswagen set the sales price fixed from the start and implemented customer-orientated approach. It still took almost half a century to use target costing in innovation process, but yet again inception took place in automobile industry by Audi in the 1980s. From the very start it was a response to the intensification in competition and thus the requisite of shortening the length and cost of new product's development process (Hessen and Wesseler 1994, p. 150). The first stage of target costing is called market-driven costing. The basic principle of market-driven costing and its relation the upcoming cost model is presented in **Figure 14**. Alongside with profit margin there is one input parameter, target price, that needs to be known. The target price is determined based on market analysis and given the company's target profit margin, the target costing model gives target cost for the product.

Figure 14. The basic principle of target cost determination (Horvath *et al.* 1993)



After obtaining the target cost from market-driven costing, the process continues by product-level target costing and component-level target costing (**Figure 15**). In these steps, financial, manufacturing and customer aspects of the process are taken into account.

The following process steps are subject to product-level and component-level target costing:

1. Determination of the overall costs
2. Breaking down the overall target costs into product individual components and items (target cost breakdown)
3. Target cost implementation

When implementing the target cost, the object is to reduce cost by influencing to the so called drifting costs. These are the cost that can be reduced. This stage will be repeated until he new cost level is set somewhere between the allowable cost and the current estimated cost. The cost estimates are based on current engineering and production technologies between the allowable cost and the current estimated cost. Target costing reveals a direct link between the marketplace, corporate long-term profit goals, and cost management practices.

Some of the common objectives of target costing are following:
1) Strategic and market-oriented research and development
2) Dynamic management of costs right from the early phases of innovation process
3) Motivation and emphasis to total quality management through a focus on market needs rather than abstract objectives

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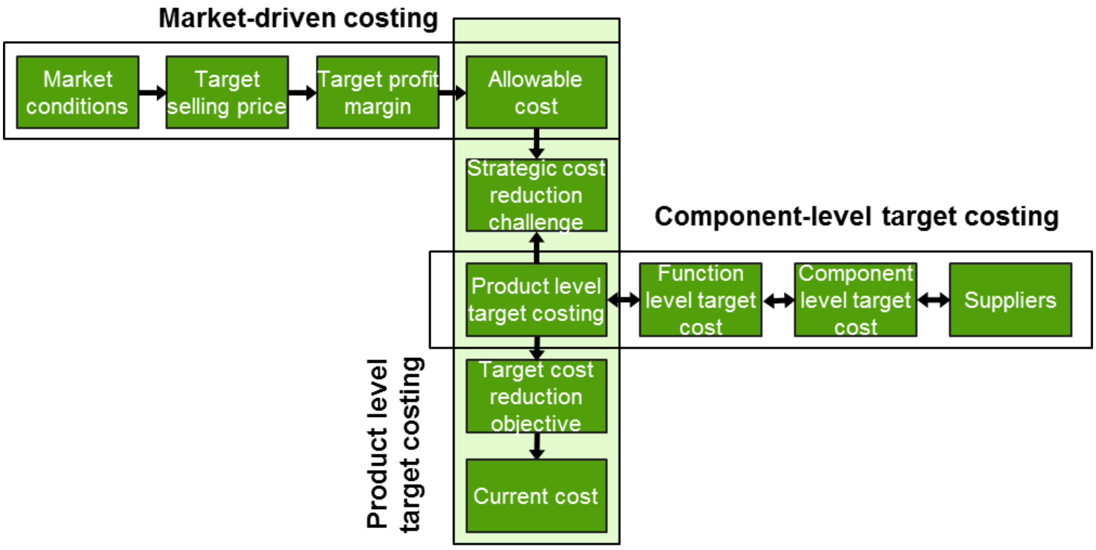

Figure 15. Target costing process (Cooper & Slagmulder, 1999)

3.8 Cost management methods in China

In China, the diffusion of western costing methods, for example activity-based costing is at best at theoretical level in universities (Wang, et al., 1999; Li, 2000; Hu, 2001; Pan, 2004). The ABC is already well covered in Chinese management accounting textbooks and used moderately often by companies. According to literature, the first comprehensive research publication of ABC implementation in Chinese manufacturing company was published in 2007 (Liu & Pan, 2007). Thereafter, ABC has been widely implemented in Chinese academic researches. The difference compared to other developing countries is notable. Whereas the diffusion of western management accounting and cost management methods is already high in China, in other developing countries it is still at baby steps. The reason for this may be found from the combination of typically competing with price and ever intensifying market competition. When competing with market shares and price, picking the right costing method is an essential success factor. Taking these factors into account, the traditional costing is inadequate and untrustworthy method to providing cost information for managers. Thus, it is well justified to use Activity-Based Costing in analysing and optimizing the cost structure. Providing accurate cost information on how the sold product affects customer's operations is highly appreciated in China.

In addition, Chinese management accounting, both academics and practitioners have keenly implemented other innovative management ideas, particularly those that are successfully adopted in the West (The implementation of Activity-Based Costing in China). For example, Economic Value Added (EVA) and Key Performance Indicators (KPIs) are well diffused and implemented (The implementation of Activity-Based Costing in China).

In the last decade supply chain management has attracted much attention in many Chinese industry sectors (Xu, et al., 2015). The focus has strongly been in manufacturing and food industries, *e.g*. agriculture industry

3.9 Financial profitability evaluation methods

The simulation results of different pulp varieties are analysed by profitability evaluation methods. Combination of various meters gives comprehensive picture about the overall profitability. Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows (Equation 1). A positive NPV indicates that the projected earnings generated by a project or investment exceeds the anticipated costs. In these cases, the time value of money is taken into account. In other words, a sum of money earned in the future won't be worth as much as one earned in the present. There are several disadvantages in using NPV while the result is highly dependable on the discount rate used. Companies have different ways of identifying the discount rate. Common methods for determining include using the expected return of other investment choices with similar level of risk or the costs associated with borrowing money that is needed to finance the project (Equation 6).

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0 \quad (1)$$

where:
C_t = net cash inflow during the time period
C_o= total initial investment costs
r = discount rate, and
t = number of time periods

Payback period is an popular metric that is often implemented as an alternative to net present value due to its simplicity. Unlike NPV, the payback method does not manage to account money's time value. Due to this, payback periods calculated for longer investment periods have a greater tendency for inaccuracy. In addition, the payback period fails to tell anything about the profitability of an investment after the investment has reached the end of its payback period.

Modified Internal Rate of Return (MIRR)

$$MIRR = \sqrt[n]{\frac{\mathrm{FVCF(c)}}{\mathrm{PVCF(fc)}}} - 1 \quad (2)$$

Where:
FVCF(c) = the future value of positive cash flows at the cost of capital for the company
PVCF(fc) = the present value of negative cash flows at the financing cost of the company
n = number of periods

Economic value added (EVA) is an estimate of the value created (*i.e.* economic profit) in excess of the required return of the company's shareholders. As can be seen in Equation 4, EVA is the net profit less the equity cost of the firm's capital. EVA is able to tell how much more, for example a process improvement, can improve the value a company generates from the funds invested in it. Through this, it is possible to assess whether the process improvement or investment is generating enough cash to be considered a good investment. The greatest advantage of EVA is that it determines whether the simulation creates wealth and returns for shareholders compared to the cost of capital or not.

$$EVA = NOPAT - WACC * (total\ assets - current\ liability) \quad (3)$$

$$EVA = NOPAT - Invested\ capital * WACC \quad (4)$$

Where,
NOPAT = Net operating profit after taxes
WACC = Weighted average cost of capital

Return on capital employed (ROCE) is a financial ration that measures company's profitability and its capital employment efficiency. ROCE differs from EVA in calculation as it uses earnings before interest and taxes (EBIT) instead of net operating profit after taxes. EBIT tells more about company's earnings without taking into account interest or taxes. EBIT is calculated by subtracting cost of goods sold and operating expenses from revenues. A higher ROCE indicates higher level of capital usage efficiency. Both EVA and ROCE are especially useful when comparing the performance of companies in various scenarios.

$$ROCE = \frac{EBIT}{Capital\ employed} \quad (5)$$

Where,
EBIT = Earnings before interest and tax

Weighted average cost of capital (WACC) is a calculation of a firm's cost of capital in which each category of capital is proportionally weighted. By calculating WACC and comparing it to ROCE, we can understand how big of an benefit the customer got from process improvement, related to cost of capital. In addition, WACC gives the discount rate that should be used for cash flows that have similar risk inside the firm's other same type of projects. If the risk is estimated to be higher, also the discount rate should be adjusted higher.

$$WACC = \frac{E}{V} * Re + \frac{D}{V} * Rd * (1 - Tc) \quad (6)$$

Where,
Re = cost of equity
Rd = cost of debt
E = market value of the firm's equity
D = market value of the firm's debt
V = E + D = total market value of the firm’s financing (equity and debt)
E/V = percentage of financing that is equity
D/V = percentage of financing that is debt
Tc = corporate tax rate

4 Development of the cost model

The critical role of product design in cost management is universally being recognized. Cost modelling content and form should vary depending who is its “client”, in this study the client is product design team whose decisions, according to various writers is among the most aspects most important for company competitiveness on the markets (Tornberg, et al., 2002). Specially for product designers the cost model should be built in a way that allows accurate and fast cost estimation (Mengoni, et al., 2017) in an early stage of product design keeping in mind the need for comparing different product options between each other. Costs may be measured on a functional level, such as total transportation or inventory holding costs, but this cost information remains too aggregated. In some applications this might be enough but, in many cases, substantially detailed reckoning is needed. Therefore, the objective is that broadly defined costs could be further evaluated among the suppliers.

On the same time the model is intended to give certain scope for the product designers about markets (cost structure, potential innovation impacts and the impact throughout the value chain. One fictitious but figurative example of the model usage could be following: preliminary research has pointed out several interesting products that fulfils determined qualification criterion (sales volume, novelty, future’s growth potential *etc*.) for moving the market research to further examination. The model is used to gain understanding of the cost structure in the whole value chain and what it takes to meet the already determined target cost obtained from the preliminary market research. The next step is to understand product design team and innovation department’s areas for potential cost reductions and what this would mean monetary terms and key performance indicator wise for the whole value chain. If the target cost is met the process should be moved to further

4.1 Requirements for the model

Considering the widespread of increasing cost pressure, the product development process should be cost efficient. Therefore, the product development time and costs must be reduced which is possible through dynamic cost feedback model. Second important reason to shorten the development time is ability to rapidly respond to changing markets and pose the ability for combing the most profitable new market frontier(s) from wide arrange of different options. In practice, the success of a product development process depends on three factors, namely: function fulfilment, keeping the costs structure in leash and finally sticking with the schedule. Model should specially be designed for giving a good idea of value chain partner's cost structure and profitability, and what factors affect it the most. After analysing these, the next step is to determine how much value addition different kind of pulp provide to the customer and finally what would be the value addition of totally new kind of pulp to the customer in terms of cost savings, increased selling price or increased sells.

When applying target cost management in product innovation, the target cost needs to be transferred to upper stream meaning that the target price should be determined effectively after every participant in the value chain, not only in one stage of the value chain. This procedure has a reverse action too. If the product concept cannot meet the target cost under the set functions and product characters, the whole proses needs to be revised. Getting to this step might require several iterations which highlights the importance of rapid but accurate modelling. By implementing target costing throughout the value chain, the market pressure is allocated to downstream and upstream firms. Furthermore, it is important to analyse the overall efficiency and profitability in order to understand the feasibility. This is done by several financial metrics. These key performance indicators are reviewed in the end of Section 3 and NPV, MIRR, EVA and ROCE were selected.

In addition, sensitivity for variations in parameters needs to be assessed to get better picture on how set values of an independent variable impact on a chosen dependent variables under a determined set of assumptions. This is done by screening which is a particular instance of a sampling-based method. The objective is to identify input variables that contribute significantly to the model's output uncertainty, rather than precisely quantifying values for sensitivity (for example by using variance). This gives precise enough information for preliminary analysis about the risk factors but on the same time has short duration and low computational cost compared with other approaches.

4.2 Building the model

The very first step in building the model is a visit in the customer's site and understanding how they operate and what are their needs for the model. After several meetings with the management team and production workers, it became clear that they were most interested in researching possibilities of lowering their operational costs with a new type of fluff pulp. For this reason, OPEX is where the modelling was set to focus on more detailed. After visiting the mill site, the building of the Cost model started.

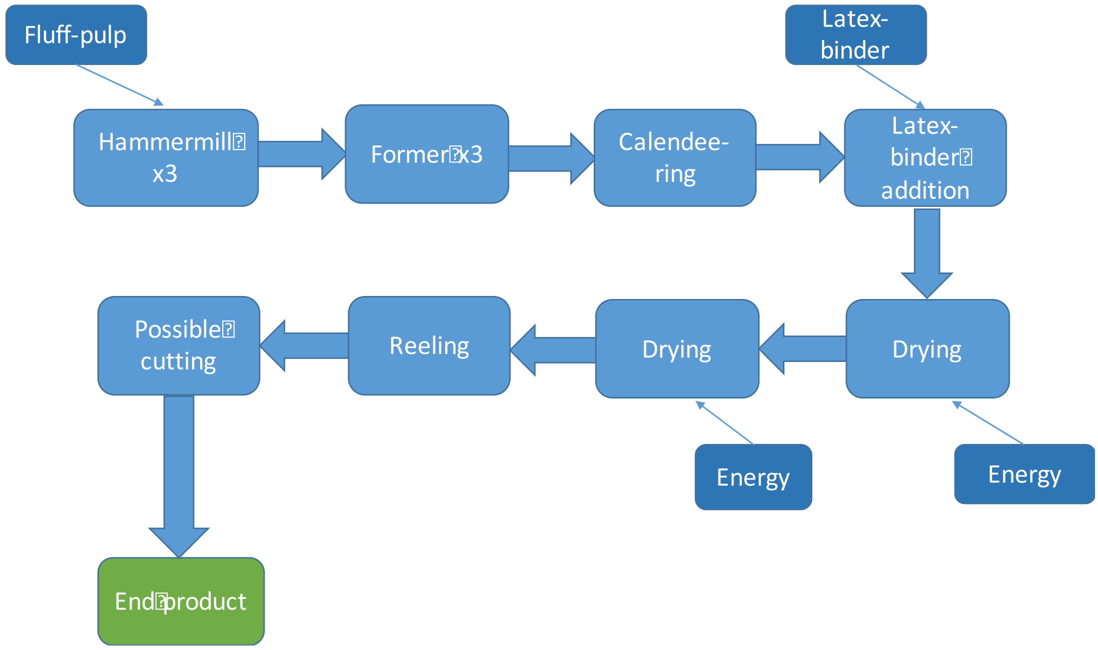

Figure 16. Value chain partner's main operations in end-product manufacturing

4.3 Modelling variable costs

The variable costs at the customer's site were identified to mainly consist of production cost related items. **Figure 16** present the main operations in our value chain partner's manufacturing of airlaid nonwoven. In the first process step, fluff pulp is infeed and defiberized with hammermill prior to forming. The fluff pulp used is fed into hammermill in rolls unlike in many other pulp end use applications which are delivered in bales. The customer had three individual hammermills where different kind of fluff pulps can be used simultaneously. The hammermill tears up the fluff pulp sheet and breaks fluff pulp into loose agglomerates of individual fibres. During this process, so called loose fibres are generated, which further on in the process cause waste, and impacts customer's product quality and is extra cost. The model takes waste cost into account as raw material consumption but also as a loss of production and monetizes it by calculating the loss of profit. This is because in the ideal situation the whole production capacity could be sold with a margin that is now lost due to the waste. In addition, waste has a fixed waste management cost as currently the fine particles have no feasible end use application.

After hammer milling the individual fibers are deposited on a moving belt, or "forming wire" into a preliminary nonwoven web which thickness (mm) and basis weight (g/m^2) depends on the forming wire speed (m/s) also known as machine speed. The web width (m) is kept constant.

The hammermill and former combination functions as the first part of the cost simulation model. The models work with the parameters described in the process description. A screenshot of the model at this stage is presented in **Figure 17.** Hammermill and former. Screenshot of the model's hammermill and former input variables in which a module for Product 1 can be seen**.** Due to customer's wish the actual fluff pulp brand and parameters used are undisclosed, *i.e.* the input variables shown are for illustration purposes.

Product portfolio	**Product 1**		
Production time (%)	**30 %**		
	Hammermill 1	Hammermill 2	Hammermill 3
Fluff pulp used	Fluff pulp 1	Fluff pulp 2	Fluff pulp 3
Basis Weight (g/m2)	705,00	710,00	765,00
Diameter (m)	1,21	1,22	1,22
Width (m)	0,86	0,85	0,85
Infeed speed (m/min)	6,70	6,50	6,50
Fibrillization energy (KWH)	24,70	0,00	0,00
Water content (%)	6 %	9 %	9 %
Formation waste (%)	4 %	4 %	4 %
Waste generation (g/min)	162,49	156,17	168,27
Infeed to hammermill (g/min)	4 062,21	3 904,29	4 206,74
Infeed to former (g/min)	3899,7216	3748,1184	4038,4656
Total output (g/min)	11686,31		
(Water amount/input (g/min)	914,58		
Machine speed (m/min)	140,00		
Web basis weight (g/m^2)	**49,10**		
Web Width (m)	1,70		

Figure 17. Hammermill and former. Screenshot of the model's hammermill and former input variables

Identical modules are made for all the products (totally 5) the customer produces. In addition, new kind of products can be added for example in a case where the customer would start producing new kind of nonwoven from our fluff pulp and on the same time keeping the old products. The data used is retrieved from "LookUp-Data sheet" where the input variables are centralized and modifiable. The model's variables in hammermill and former are presented in **Table 7.**

Table 7. List of model's variables in hammermill and former

Variable	Type	Unit
Fluff pulp basis weight	Variable based on fluff pulp used	(g/m^2)
Diameter	Variable based on fluff pulp used	(m)
Width	Variable based on fluff pulp used	(m)
Infeed speed	Variable based on fluff pulp used	(m/s^2)
Fibrillization energy	Variable based on fluff pulp used	(kWh)
Water content	Variable based on fluff pulp used	(%)
Formation waste	Variable based on fluff pulp used	(%)
Waste generation	Function	(g/min)
Infeed to hammermill	Function	(g/min)
Infeed to former	Function	(g/min)
Total output	Function	(g/min)
Machine speed	Variable based on product produced	(m/min)
Web basis weight	Function	(g/min)
Machine web width	Constant = 1.7	(m)
Latex binder addition	Variable	(%) related to fluff pulp infeed
Energy required in one temperature unit increase in water	Constant = 1.88	(kJ/kg*K)
Energy required in one temperature unit increase in nonwoven web	Constant = 4.2	(kJ/kg*K)
Operating efficiency	Constant = 65	(%)
Cost of energy	Constant = 0.04 (0.31)	EUR/kWh (CNY/kWh)

After modelling the hammermill and web formation, the next step is the bonding stage. In this stage latex binder (typically 50 % of water and 50 % of solid) is added. In the model, the latex binder infeed amount is calculated in relation to fluff pulp addition. At this stage the model calculates the total water amount as there are no further water addition in the process after this stage. This is calculated by summing the water that fluff pulp naturally contains (about 6-8%) and the water added in the binding stage. Latex product types vary by brand in water content and therefore the model allows the brand to be changed and automatically calculates the total amount of water with updated parameters. This is an important step because water content and latex addition plays a huge role in drying costs. Latex binder water content varies between 20 and 50 %. Similarly, some fibres types require less latex binder addition in relation to fluff pulp added which again effects to the raw material cost, drying costs and end product's properties. This plays even bigger role in China than in Europe, as the typical latex binder addition is higher due to the characteristics of the machinery base.

Latex brand/product specific data is retrieved from the “LookUp”-data sheet. After binding the excess water needs to be evaporated in order to get final product’s targeted water content.

So finally, the drying/curing is carried out by using natural gas fired through air dryers inside the drying unit. The typical end product’s targeted water content is 3 %. The energy required can be calculated by estimating that the typical operating efficiency of these type of drying units are 65 %. As a result, the model provides the user the total amount of energy used in the production (except other energy costs that are allocated as fixed cost) in energy units, euros per ton and per one minute of machine run. The drying part of the model is introduced in **Figure 18**. Again, due to customer’s wish, the numbers in the figure do not represent the real situation. Instead the screenshot presented is captured from a simulated situation using figurative fluff pulp properties and latex binder specifications and should be referred only to get better understanding how the model works.

Latex binder brand	Brand 1
Total Latex binder infeed amount (g/min)	2103,54
Solid addition (g/min)	1030,73
Water addition (addition)	1072,80
Latex binder infeed amount (related to inf	18 %
Water content after latex addition	10 %
Targeted water content after dryers	3 %
Water evaporation amount (g/min)	1159,84
Total output (g/min)	12251,10
Total energy consumption	
Hammermill energy used (kWH)	50573,25
Hammermill energy cost (€)	5057,33
Heating the mass	
Water heating (kJ)	9942,62
Pulp heating (kJ)	25962,21
Water evaporation (kJ)	40296,91
Cooling the mass	
Water cooling (kJ)	2448,28
Web cooling (kJ)	25962,21
Total energy needed (kJ)	104612,23
Total energy needed (KWH)	29,06
Total cost of energy (€/min)	1,16
Total cost of energy (€/ton)	98,24

Figure 18. Latex binder addition and drying section

After modelling the production, starting from fluff pulp addition and hammer milling costing and ending up to drying, the variable cost model lastly gathers all the cost information and annual production levels of products into the same place. The cost results are presented in Euros per tons and as a total figure, but the model also calculates gross and net margin (€/ton & %) for all the products (**Figure 19**) after retrieving the selling price from the “Vlookup” datasheet.

Total production annually (tons)	**1505,05**
Total waste in hammermills (tons)	59,82
Total cost of fluff waste (€)	40677,11
Total raw material usage (tons)	
Fluff pulp (tons)	1495,48
Latex binder (tons)	258,42
Total raw material cost	
Fluff pulp (€)	1072041,07
Latex binder (€)	852783,61
Total energy needed (kJ)	3569892,24
Total energy costs (€)	147853,01
Variable costs (€)	
Raw material (€)	1 924 824,68 €
Energy (€)	147 853,01 €
Total variable costs (€)	2 072 677,69 €
Variable costs (€/ton)	
Raw material (€/ton)	1278,91
Energy (€/ton)	98,24
Total variable costs (€/ton)	**1377,15**
Selling price (€/ton)	2900,00
Gross marging (€/ton)	1522,85
Gross marging (%)	53 %
Total Fixed costs (€)	1 274 347,82 €
Total fixed costs (€/ton)	846,72 €
Net marging (€/ton)	676,13 €
Net marging (%)	23 %

Figure 19. Total production, and summary of raw material usages and costs

At the end of the production line there would be still edge cutters and reeling but these are taken into account in fixed cost costing while their cost character is closer to fixed cost than variable cost.

4.4 Allocating and modelling fixed costs

Until this stage the costs determined and allocated to different products have produced accurate cost information about the real situation, as the variable costs are easier to identify, and problems do not really spring up in their allocation either. However, a problem occurs when allocating these fixed costs. The fixed costs play fairly significant proportion of the total costs (40.6 %) and therefore the correct allocation is vital. Only after obtaining this information the actual profitability by product can be calculated. In addition, it is important to understand, what kind of cost decrease impact would a process step skip bring.

Before performing the fixed cost allocations and getting to the total costs, all the fixed cost categories needed to be identified and quantified. This was done on the second visit to the customer's production site in addition to the information gathered from numerous discussions with the client. The fixed costs identified were grouped to several main groups, here listed from highest to lowest:

1) Machine depreciation
2) Indirect labour
3) Distribution costs
4) Other energy costs
5) Selling, general and administration costs
6) Site overhead
7) Machine maintenance
8) Warehouse costs for raw material and finished goods
9) Product cutting costs
10) Waste handling and
11) Machine set ups.

From the eleven main groups, the three first account over 70% of all fixed costs. Fixed costs, their breakdown to subcategories and their share of total overhead costs are listed in **Table 8**. In this model the overhead costs hold inside also distribution costs. Even though they are variable by nature, they are treated as fixed costs because customer could not give exact information about different distribution options costs, only the total amount, which was internally estimated to be 5 % of the net revenue. Indirect labour costs hold inside China's country and city specific social insurance contribution expenses. which raised the total indirect labour cost sum by 33.8%. The rates vary by province and city and for this case, the customer was able to give quite good estimation what they are like in Shanghai.

Table 8. All fixed costs

Fixed cost item	Share of total fixed costs / (Share of the main group)
Indirect labour	**31.8 %**
Production	(59.3 %)
Quality checking	(24.7 %)
Engineering	(11.1 %)
Warehouse	(4.9 %)
Machine deprecation costs	**21.3 %**
Waste handling	(4.6 %)
Hammermills	(6.9 %)
Former	(20.2 %)
Calender	(1.8 %)
Latex binder addition	(7.3 %)
Oven	(13.8 %)
Through air dryers (second dryer)	(9.2 %)
Cooling	(3.1 %)
Wire cleaning	(9.2 %)
Edge cutting	(3.7 %)
Reeling	(2.4 %)
Drive system	(13.8 %)
Cutting	(4.0 %)
Distribution costs	**18.5 %**
Selling, General & administrative	**7.0 %**
Tactical management labour	(55.3 %)
Operative management labour	(29.8 %)
Marketing labour	(14.9 %)
Other energy costs	**6.5 %**
Site overhead	**5.5 %**
Machine maintenance and cleaning	**4.2 %**
Warehouse overhead raw material	**1.6 %**
Warehouse overhead finished goods	**1.6 %**
Product cutting cost	**0.9 %**
Waste handling	**0.7 %**
Machine set ups	**0.4 %**
Total fixed costs	**100 %**

Based on the literature review, in order get better understanding about the fixed cost behaviour on products' productivity, three different approaches are implemented:

1) Traditional standard-costs system,
2) Activity-based costing
3) Time driven activity-based costing.

Moreover, results of each costs system are analysed and lastly compared with each other. Lastly, it is interesting to see how using different costing systems effects on every products profitability.

Cost allocation with traditional costing system

Cost allocation using traditional costing is carried out by a simple way, the fixed cost of each product is got by assigning fixed costs based on production volume. In the cost assignment to products production volume instead of, for example machine hours, is used because the volume is the underplaying cause of overhead. This is also the method the customer had previously used in their cost calculations which gives us a reference point to their current perceived profitability. This will be helpful when the new activity-based costing model is introduced and its benefits compared to existing way of working.

The results of traditional costing are presented in **Table 9**. As can be seen the fixed costs are allocated to products in a way that they consume resources equally much per ton (20.0 %). In addition, there is not much deviation in gross margins and net margins, except on product 4. This product is a bit different and only several producers are producing it in China, which allows higher pricing. The traditional costing suggests that the low volume products (3 & 4) would have higher profitability compared to the higher volume ones. This aligns with the findings in literature review part. Low volume products higher profitability might be caused by its drawback of failing to allocate costs accurately. It should be noted that even if relative figure in variable and costs portion of total costs per ton does not vary significantly, the Euro denominated costs per produced ton are different between the products.

Table 9. Costing from customer's point of view by using traditional costing

Parameter	Product				
	1	**2**	**3**	**4**	**5**
Production output (ton/a)	1472.6	1453.4	244.	241.2	1472.6
Variable cost portion of total costs per ton (%)	60	59	59	58	60
Fixed cost portion of total costs per ton (%)	40	41	41	42	40
Proportion of the total overhead per ton (%)	20.0	20.0	20.0	20.0	20.0
Gross margin per ton (%)	46.4	49.4	49.3	56.2	47.9
Net margin (%)	**10.6**	**13.5**	**14.8**	**24.6**	**13.1**

Cost allocation with activity-based costing

Determining costs by activity-based costing is essential, while the costs of activities are not caused by – nor they hardly correlate with production output, like in previous costs calculations they were assumed to. For example, waste handling costs per product are only distantly in relation to production output but cannot be estimated by traditional costing because the main driver is the amount of waste generated, which varies among different products. As a second example, other depreciation costs should be allocated based on machine usage time, which gives more accurate estimation of the real usage of this resource compared to using volume for allocation costs to the cost pools.

Implementing activity-based costing into cost allocation starts from the same starting point than the traditional costing. What is needed besides the cost levels, however, is the identification of main activities, their cost drivers and cost driver activity levels which are used to allocate the costs to different products.

Activities, cost drivers, cost driver activity levels and overhead application rates are presented in **Table 10**. In the model overhead items serve as activities. Cost drivers are determined based on the root cause of the activity and the cost driver activity level is the maximum amount cost driver can be consumed. These are calculated together with the customer.

Table 10. Defining overhead application rates

Overhead item/ activity	Cost driver	Cost driver activity level
Indirect labour		
Production	Machine operating hours	409500
Quality checking	Batch amount	72
Engineering	Batch amount	72
Warehouse	Number of fluff rolls handled	7712
Machine deprecation costs		
Waste handling	Waste generation	220
Hammermills	Machine operating hours	409500
Former	Machine operating hours	409500
Calender	Machine operating hours	409500
Latex binder addition	Machine operating hours	409500
Oven	Machine operating hours	409500
Through air dryers (second dryer)	Machine operating hours	409500
Cooling	Machine operating hours	409500
Wire cleaning	Latex addition	8751
Edge cutting	Machine operating hours	409500
Reeling	Machine operating hours	409500
Drive system	Machine operating hours	409500
Cutting	Number of rolls cut	150
Distribution costs	Number rolls deliveries	62569
Selling, General & administrative		
Tactical management labour	Sold tons	4884
Operative management labour	Number of workorders	72
Marketing labour	Number of customers	20
Other energy costs	Machine operating hours	409500
Site overhead	Machine operating hours	409500
Machine maintenance and cleaning	Amount of used latex	736
Warehouse overhead raw material	Used fluff rolls	7712
Warehouse overhead finished goods	Delivered nonwoven rolls	62569
Product cutting cost	Machine hours	59
Waste handling	Waste generated (tons)	209
Machine set ups	No. Of setups	72

In the next stage, cost driver activity rates are determined for every product, which allows us to allocate each overhead's expenditure to products by multiplying the overhead application rate with cost driver activity rate. As a result, we have obtained cost of each activity for every product. In the last stage, the total cost for every product is calculated by summing all the allocated overhead costs of activities. The results are seen in the **Table 11** as a percentage of their total sum.

Table 11. Costing from customer's point of view by using Activity-based costing

Parameter	Product				
	1	2	3	4	5
Production output (ton/a)	1472.6	1453.4	244.4	241.2	1472.6
Variable cost portion of total costs (%)	61	60	53	52	60
Fixed cost portion of total costs (%)	39	40	47	48	40
Fixed cost allocation increase (%)	-4.0	-4.1	27.8	28.1	-1.0
Proportion of the total overhead (%)	17.5	17.5	23.4	23.4	18.1
Gross margin (%)	46.4	49.4	49.3	56.2	47.9
Net margin (%)	**12.0**	**15.0**	**5.2**	**15.7**	**13.4**

Cost allocation with time driven activity-based costing

Compared to Activity-based costing, the model must be slightly modified in the third and last overhead cost allocation method. Time driven activity-based costing skips the activity-definition stage and therefore the whole need for allocate costs into activities the company performs. In addition, in time driven activity-based costing cost drivers are simplified to be either time, mass or area unit. This makes the model to work simpler way assigning resource costs directly to the cost objects by using a framework that require only two sets of estimations: the capacity cost rates and the capacity utilization of each cost category of the department.

In the model, first, the cost of supplying resource capacities needs to be calculated. For example, consider a process of machine set up. At first TDABC model calculates the cost of all the resources used in process, in this case personnel and supervision, which are the main costs. In the next stage, the total cost obtained is divided by the capacity of the time available for the employees actually performing the process and we get the capacity cost rate (7). Typically, this is around 80 % but varies a bit by case.

The capacity cost rate is defined as follows:

$$Capacity\ cost\ rate = \frac{Cost\ of\ capacity\ supplied}{Practical\ capacity\ of\ resource\ supplied} \qquad (7)$$

The total amount of cost centres is significantly less than the amount of activities that had to be defined in activity-based costing and by that it is also less time consuming. This was done together with the managers of customer's company. In the model, cost inputs are absolute values but due to customer's wish, presented (**Table 12**) only as relative figures.

Table 12. Product cost by using time driven activity-based costing

Resource	Cost of capacity supplied (%)
Machine deprecation	20.3
Production labour	18.7
Shipping cost	16.2
Quality labour	7.8
Management labour	6.9
Other energy costs	6.5
Site overhead	5.4
Production lost	4.1
Engineering labour	3.5
Additional delivery costs for international shipments	2.2
Additional packaging	2.2
Warehousing costs raw material	1.6
Warehouse cost finished goods	1.6
Warehousing labour	1.6
Cutting machine usage (deprecation)	0.8
Waste handling cost	0.6

In the next stage, theoretical and practical capacities are estimated. As found out in the literature review, the aim here is not to reach to full precision, but instead to get the general alignment. To estimate the practical capacity, the quantity of resources (personnel or equipment) is identified. For example, in this, production labour practical capacity is calculated as follows: number of production workers required in operations that work the equal time the machine is running plus required time for breaks, trainings and considering that not all the paid time is productive work. This leaves the practical capacity to be 70 % of the theoretical capacity. This ratio differs from 70 % (personnel) to 100 % (machinery). After calculating the practical capacity, the capacity cost rate can be calculated for all the resources.

Table 13. Capacity cost rates

Resource	Practical capacity (%)	Measure
Engineering labor	70	Time
Production labor	80	Time
Management labor	80	Time
Quality labor	70	Time
Production lost	100	Time
Cutting machine usage (deprecation)	100	Time
International shipments	80	Time
Machine deprecation	78	Time
Site overhead	100	Production time
Other energy costs	100	Production time
Shipping cost	100	Tons shipped
Packaging	100	Tons packed
Waste handling cost	100	Kilograms
Warehousing costs raw material	100	Square meters
Warehouse cost finished goods	100	Square meters
Warehousing labour	70	Time

In the second step, the TDABC model uses the capacity cost rate to process costs to cost objects by estimated demands of resource capacities that each cost objective consumes. In here what is different in TDABC compared to ABC is that it allows the time (or other measure listed below) to vary based on the specifics of processes activities or departments. For example, international orders and domestic orders have different time demands in this model, which would have been too complicated to implement in traditional activity-based costing. By this way the TDABC model simulates the reality better. In addition, it makes the model more robust against complexity compared to a traditional ABC model, in which sometimes immoderate simplicity is forced.

Resource consumption information is gathered by observations and data obtained from the customer's database. Hereafter cost centre specific costs are derived from the calculations. Based on the theory, in the next these cost centres should be allocated to different products by a cost allocation factor which would be determined upfront, however this step was not possible anymore within the visitations timeframe. Hence these cost centre costs were allocated based on the total production time, which does not fully correspond with the reality but gives rather good picture because the cost formation is similar among the products. The cost obtained and allocated by time driven activity-based costing are presented in **Table 14**

Table 14. Costing from customer's point of view by using Time driven activity-based costing

Parameter	**Product**				
	1	**2**	**3**	**4**	**5**
Production output (ton/a)	1472.6	1453.4	244.4	241.2	1472.6
Variable cost portion of total costs (%)	61	59	56	54	61
Fixed cost portion of total costs (%)	39	41	44	46	39
Fixed cost allocation increase (%)	-4.3	-3.1	15.1	16.6	-4.3
Proportion of the total overhead (%)	18.4	18.6	22.1	22.4	18.4
Gross margin (%)	46.4	49.4	49.3	56.2	47.9
Net margin (%)	**12.1**	**14.6**	**9.6**	**19.3**	**14.6**

If higher precision is sought, the cost allocation factors for cost centres can be determined each one individually, but within the scope of this research this won't bring substantial difference.

Table 14. Costing from customer's point of view by using Time driven activity-based costing

Parameter	**Product**				
	1	**2**	**3**	**4**	**5**
Production output (ton/a)	1472.6	1453.4	244.4	241.2	1472.6
Variable cost portion of total costs (%)	61	59	56	54	61
Fixed cost portion of total costs (%)	39	41	44	46	39
Fixed cost allocation increase (%)	-4.3	-3.1	15.1	16.6	-4.3
Proportion of the total overhead (%)	18.4	18.6	22.1	22.4	18.4
Gross margin (%)	46.4	49.4	49.3	56.2	47.9
Net margin (%)	**12.1**	**14.6**	**9.6**	**19.3**	**14.6**

Time driven activity-based costing brings several benefits as the model can be more comprehensible but on the same time it is easier to build and modify in the future. In addition, in all the stages, time consuming, inaccurate and broad interviews are not necessary unlike in activity-based costing.

Summary part, with traditional costing, which sometimes assigns costs using somewhat over generalized and arbitrary allocation percentages for overhead or indirect costs, result often unreal and misleading estimates. This is particularly harmful if the production of products has different characteristics. In the case company, the major differences in costs are caused by different product compositions of raw material and the latex binder that is added. In addition, the machine speed and production output have a big impact to profitability. When taking these into account, the real costs differs quite lot between products. This can be seen in the **Figure 20** where overhead costs per ton are presented by product. In traditional costing all the products have the equal amount of fixed costs allocated to them per ton. In the activity-based costing the high-volume products, the same product that consumer less latex binder and have higher machine speed (products 1, 2 & 5) have relatively lower overhead costs compared to the special products 3 and 4. Finally, the time driven activity-based costing results are something between the traditional costing and activity-based costing. Like activity-based costing, the time driven activity-based costing is allocates relatively speaking less costs to the products 1, 2 & 5 and more to the products 3 & 5, although the difference between these product groups is not as significant as in activity-based costing.

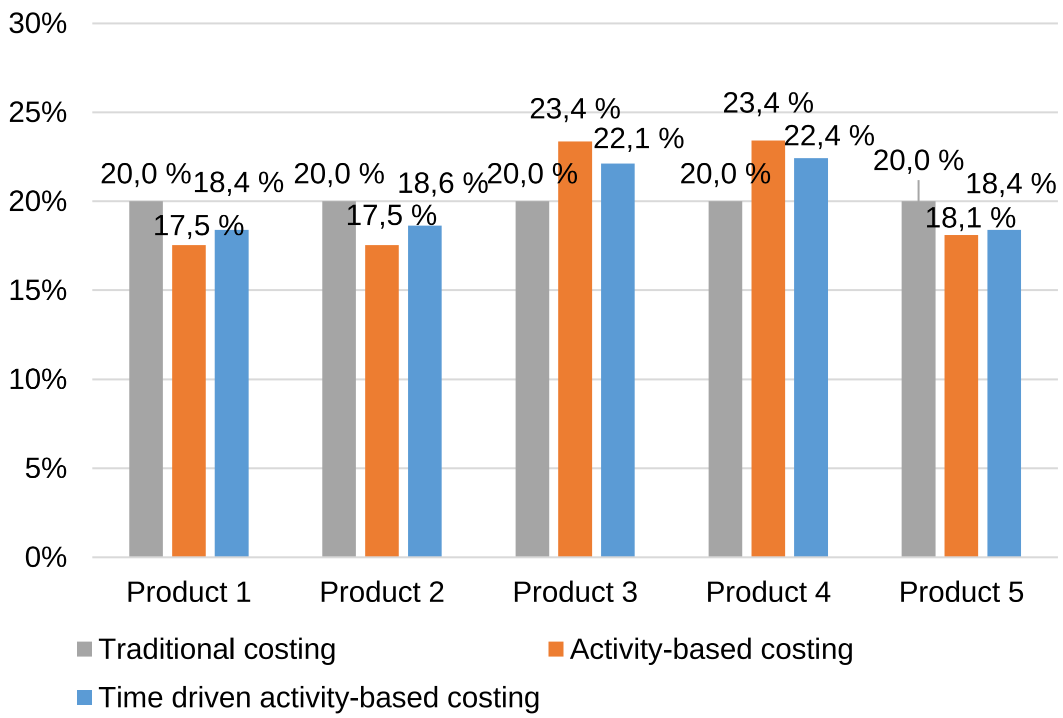

Figure 20. Proportion of the total overhead per ton by product with different costing systems

Figure 21 presents the model's results by breaking down variable and fixed costs of products by the costing systems used. The results do not vary significantly between the cost systems in the higher volume products 1, 2 & 5. The difference is from -3.4 % to -4.3 % (**Table 15**), which should be still noted as this multiplied with the total fixed cost of a product equals to 30 – 50 €/t. The more significant difference is in the products 3 and 4 where the fixed cost difference of the three costing systems result in +15.1 % to +28.1 % increase in the fixed costs compared to traditional costing. This transfers roughly to 100 – 250 €/t.

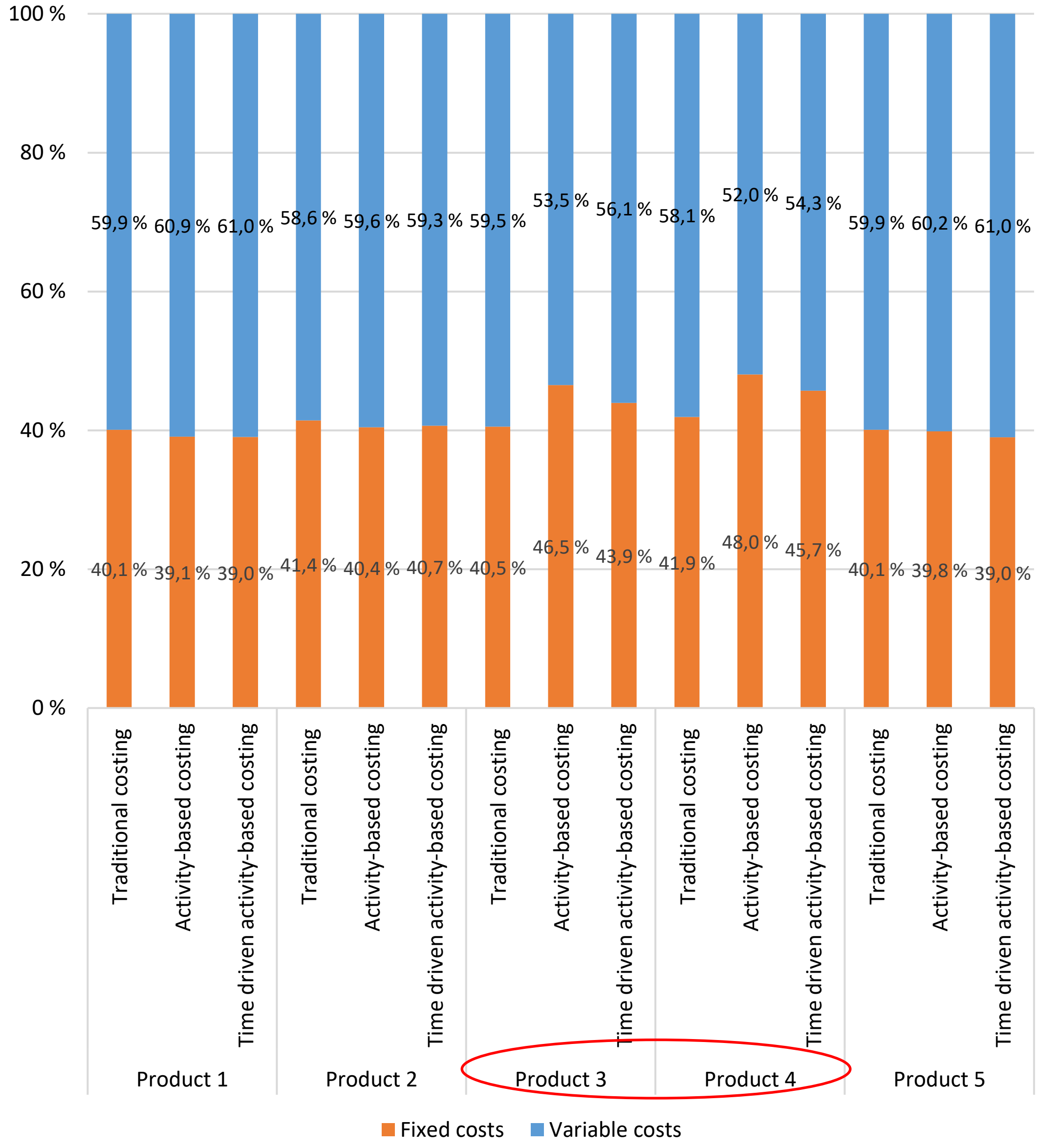

Figure 21. Cost breakdown of products to variable and fixed cost by costing system

Table 15 presents the fixed cost allocation increase/decrease compared to traditional costing, system that the customer used. This also supports the idea that activity-based costing and time driven activity-based costing are better at allocating fixed costs. In this case, the major factors are the production volume's influence, latex binder addition and machine speed. It is a bit unclear why the activity-based costing and time driven-activity based costing give different values for product 5 as in other high-volume products they are quite closely aligned. Also, it is worth noting how big of a difference traditional costing gives as a result for products 3 and 4 compared with the activity-based costing and time driven activity-based costing.

Table 15. Fixed cost allocation increase/decrease compared to traditional costing

	Product				
	1	2	3	4	5
Production output (ton/a)	1472.6	1453.4	244.4	241.2	1472.6
Activity-based costing (%)	-4.0	-4.1	+27.8	+28.1	-1.0
Time driven activity-based costing (%)	-4.3	-3.1	+15.1	+16.6	-4.3

If selling prices are considered as well, we can see that profitability among products varies too when using different costing systems (**Figure 22**). This is especially true for the products 3 and 4. With the traditional costing, it seems that the product 4 is much more profitable than the others with an 24.6 % net profit compared to other products 10 – 15 % profit margin.

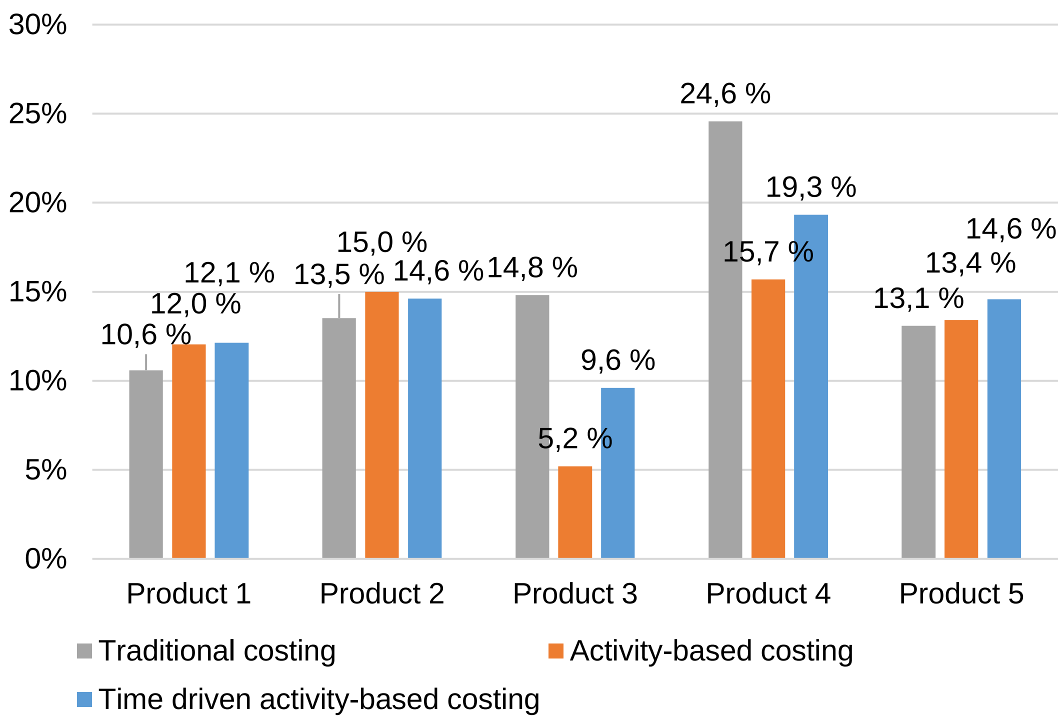

Figure 22. Net margin by product with different costing systems

In addition, the results suggest that those products that can be easily produced by other manufacturing technologies than latex bonded airlaid have lower profitability levels in traditional costing. This is most likely due to higher competition. However, the products 3 and 4 that are considered as special products and can be only produced with airlaid production technique have lower profitability when calculated by activity-based costing and time driven activity-based costing although the traditional costing would have suggested otherwise.

5 Financial and cash flow model

After obtaining the cost structure the model building goes towards financial model and modelling the value of potential new fibre. It is important to understand what matters to the customer and what doesn't. This helps the R&D department to see what is valuable for customer and therefore focus on developing right kind of fiber properties.

5.1 Development of the financial model

The financial model is built based on the cost model created earlier. The model combines the production, cost and sales price information and converts them into Profit and loss statement (P&L) which shows changes in accounts over a set period. The income statement follows the general form recommended in Generally accepted accounting principles (GAAP). It begins with an entry for revenue, known also as the "top line", and subtracts the costs of doing business, including cost of goods sold (*i.e.* variable costs), operating expenses, deprecation, tax expense and interest expense. The difference, known as the bottom line, is net income, also referred to as profit or earnings. The model calculates these values for every product but also aggregates the information into yearly figures, which is equal to financial statement format. The financial model is illustrated in **Figure 23**. The pro forma financial statement is created for other years 2-10 as well with the same structure.

	Year 1				
	Product 1	Product 2	Product 3	Product 4	Product 5
Sales revenue (€)	3 854 746.16 €	3 798 536.07 €	663 690.53 €	718 322.41 €	3 964 881.76 €
./. Variable costs (€)	2 075 025.06 €	1 920 816.78 €	337 270.38 €	317 328.98 €	2 075 025.06 €
Gross profit (€)	1 779 721.10 €	1 877 719.29 €	326 420.14 €	400 993.43 €	1 889 856.70 €
./. Fixed costs (€)	1 054 131.04 €	1 038 879.02 €	232 500.46 €	232 514.49 €	1 057 366.19 €
Operating income (€)	725 590.05 €	838 840.27 €	93 919.68 €	168 478.94 €	832 490.51 €
./. Deprecation	274 868.70 €	271 582.25 €	61 148.22 €	58 057.12 €	314 243.70 €
./. Interest (income/expence)					
./. Enterprise income tax(es)	112 680.34 €	141 814.51 €	8 192.87 €	27 605.46 €	129 561.70 €
Net income	338 041.01 €	425 443.52 €	24 578.60 €	82 816.37 €	388 685.11 €

Figure 23. Illustrative example of the financial model

Similarly, the model calculates cash flow by taking the operating income and retrieving investments, working capital demand/release and potential residual value each year (**Figure 24**). The results are presented yearly as net cash flow and cumulative net cash flow. The investments are not shown here as they are considered the same in this example and thus do not have an effect to the marginal cash flow. But any additional investment can be added and taken into account in the financial model. This enables the means for analysing various business cases, their feasibility and the viability assessment of new pulp grades.

Year(s)	1	2	3
Operating income (€)	2 393 387.51 €	2 419 980.71 €	2 526 353.49 €
Investment			
WC demand/release	92 807 €	- 5 137 €	- €
Residual value			

Net cash flow	2 486 195 €	2 414 844 €	2 526 353 €
Cumulative net cash flow	2 486 195 €	4 901 039 €	7 427 392 €

Discounted net cash flow	2 161 908.68 €	1 825 968.75 €	1 661 118.43 €
Cumulative discounted net cash flow	2 161 908.68 €	3 987 877.42 €	5 648 995.85 €

Figure 24. Illustrative example of the cash flow model

Working capital in the cash flow model is calculated by including operating activities that represents only the core accounts that make up working capital in day-to-day operations. Working capital operating activities consist of account payables (8), accounts receivables (9) and production process (10) which are calculated by using specific working capital cycles. In reality the working capital would also consist of cash and short-term financing, but as we are only interested in marginal cash flow and assuming those items are same in status quo and new production, these does not have to be taken into account.

$$Accounts\ payables = \frac{Cost\ of\ goods\ sold * Accounts\ payable\ days}{365} \quad (8)$$

$$Accounts\ receivables = \frac{Annual\ credit\ sales * Accounts\ receivable\ days}{365} \quad (9)$$

Production process is the sum of working capital bound to raw materials (11), work in progress (12), finished goods (13) and fixed costs (15). It is worth noting that in finished goods, the net profit is not included in the working capital and therefore does not have to be financed. In addition, it is important to remember to take into account the fixed costs as well as they play rather big part as the turnover rate is relatively low.

$$Production\ process = Raw\ material + Work\ in\ process + Finished\ goods + Fixed\ cost \quad (10)$$

$$Raw\ material = \frac{Material\ cost * Inventory\ days}{365} \quad (11)$$

$$Work\ in\ process = \frac{(Raw\ material\ cost + Labour\ cost) * Production\ duration}{\frac{365}{2}} \quad (12)$$

$$Finished\ goods = \frac{Cost\ of\ goods\ sold * Inventory\ days}{365} \quad (13)$$

$$Fixed\ cost = \frac{Total\ fixed\ cost * (Production\ days + Account\ payable\ days)}{365} \quad (14)$$

The illustrative example of model's results in yearly working capital demand/release calculations are presented in **Figure 25.** Thereafter this information is used in the previously presented cash flow model in WC demand/release section.

	Year 1	Year 2	Year 3
Raw material	344 448.89 €	344 448.89 €	344 448.89 €
Production	17 222.44 €	17 222.44 €	17 222.44 €
Finished goods inventory	179 427.05 €	186 836.18 €	186 836.18 €
Accounts receivable	798 580.10 €	840 762.81 €	840 762.81 €
Accounts payables	1 076 562.28 €	1 121 017.08 €	1 121 017.08 €
Variables in total	263 116.20 €	268 253.24 €	268 253.24 €
Fixed in total	10 888.72 €	10 888.72 €	10 888.72 €
In total	274 004.92 €	279 141.96 €	279 141.96 €
Increase/reduction	92 807.46 €	-5137.04	0

Figure 25. Illustration of model's working capital calculation

The cash flow calculations enable an easy way of calculating investment feasibility. This provides tools for estimating a new pulp's attractiveness to customer if it needs modifications to their existing line. In addition, it helps sales team and technical customer service team to communicate the new pulp's benefits to customers.

After calculating cash flow, all the financial metrics can be calculated. By using values the cost model and financial model result, the model calculates Net present value, Internal rate of return, Pay-back time, Economic value addition, Return on capital employed and Return on assets. In addition, EBITDA and EBITDA-% is calculated. These are given for the customer as a guiding tool. In addition, it helps them to understand the new pulp grades effects to their profitability.

All the values are calculated for one or several kinds of pulps and the results can be compared with each other. The financial model has two functions. Firstly, it can be used as a sales promotion tool for evidencing the benefits of the company's offering, which is different compared to the general pulp in the markets. Secondly it can be used for developing new kind of pulp and quantifying the potential monetary value of the novel pulp developed. For example, if a kind of pulp that requires less latex binder addition is developed, what would be its value for the customer and subsequently its potential selling price.

5.2 Introducing the financial model case study

In the case study the financial model and cash flow model and brought to an actual business case. In the first phase of financial modelling, current operating income and pro operating incomes for next nine years are calculated. After this the current cash flow and similarly pro forma cash flows are calculated for status quo and "new production". The status quo refers to the current state of things and new production refers to a situation where modifications to operations have been made. The modification can be any sort but just to give some idea, it can be for example a new pulp type which has different price, properties, machine settings, *etc*. The result is a marginal cash flow that gives a monetary value for the modifications case-by-case. In the next section we go through an example of this.

In the status quo, the three hammermills (**Figure 16**) that defibrillize pulp rolls to their own formers are infeed with two fluff pulp grades with a settings shown in **Table 16**. Fluff pulp grade is used in the upper and bottom layer of the nonwoven and fluff pulp grade Y is used in middle layer. In the New production the upper and bottom layers' the fluff pulp grade X is replaced with "new fluff pulp grade" The new fluff pulp grade differences from the regular fluff pulp grade X by better formation, even web, lower energy usage in hammer mill and lower latex binder requirement. On the other hand, the new fluff pulp grade is more expensive compared to the other pulp grades the customer used in the status quo production.

Table 16. Fluff pulp grades used before and after the modifications

Hammermill	Product layer	Status quo	New production
Hammermill/former 1	Upper	Fluff pulp grade X	New fluff pulp grade
Hammermill/former 2	Middle	Fluff pulp grade Y	Fluff pulp grade Y
Hammermill/former 3	Bottom	Fluff pulp grade X	New fluff pulp grade

The modifications from status quo to new production in this example did not require any investment. However, the cash flow model can take this into account. In addition, the production rate and basis weight were not changed even though the new fluff pulp grade would allow this due the even web and lower latex binder usage. Higher production rate and lower basis weight would have required modifications to the production line and therefore the hypothesis could not be verified.

The case study uses the previously introduce production model, financial statement model and cash flow model. So firstly, the parameters are updated. In practice, this means adding a new pulp grade to “VlookUp-table” from which the production model retrieves the data. In addition, the production model is told to use this new pulp grade in the New production and for example switch the latex binder usage amount. In this case the latex binder reduction was estimated to be 20 % lesser than in status quo. However, this can vary, and the final figure depends on customer’s final preferences. After this the financial model calculates profitability for before and after situations and marginal profitability is calculated using by subtracting new production profitability from status quo production (15) and the future cash flows are discounted to present value by using **equation (**16. This will result in case-by-case comparable figures. In addition, it will provide profitability results that only take into account the increased profitability. This is important because then the current already existing profitability can be excluded, and the real profitability improvement can be determined.

$$Marginal\ CF = Status\ quo\ CF - New\ production\ CF \quad (15)$$

Where,
CF refers to Cash flow

$$Marginal\ DCF = \frac{Marginal\ CF}{(1 + r)^2} \quad (16)$$

Where,
DCF = Discounted cash flow
r = Discount rate (WACC)

The results are presented in **Figure 26**. Compared to last period's cumulative discounted net cash flow, the new production is 42.9 % higher than status quo and the first year's marginal cash flow is 7.4 % higher. This rate decreases in later periods as the time value of the cash flows reduces the impact. The discount rate used (in this case the weighted average cost of capital) was calculated to be 9.4 %.

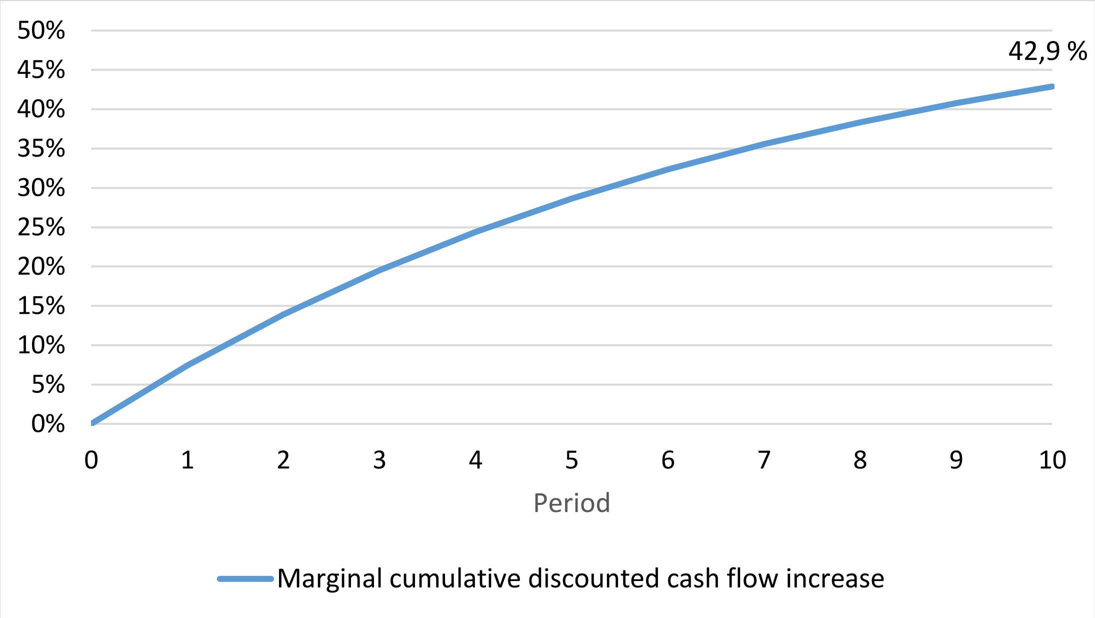

Figure 26. Cumulative marginal discounted cash flow increase

What it comes to fixed costs, there were three alternatives for cost modelling: the traditional costing, activity-based costing and time driven activity-based costing. Only one is going to be implemented here and as discussed in the Chapter 4, the most accurate one proved to be activity-based costing. Therefore, the financial model uses this to provide the cost information in product level. The new production's selling price is set to stay the same as in status quo although it could be higher than the status quo because the lower latex binder amount increases the product's hand feel softness.

5.3 Sensitivity analysis

To analyse how different values of an independent variable impact a particular dependent variable a sensitivity analysis was built in the model financial and cash flow model. The model is used within specific boundaries that depend on several input variables. A set of variables were chosen that were defined to affect most on profitability. The outcome in the other hand was chosen to be cumulative cash flow and new fluff pulp price.

Figure 27 presents the cash flow model's sensitivity results over cumulative net cash flow which is calculated by equation (15)**(16)**. Based on the results we can categorise the variables into three main groups based on slope of the curve. There are variables that are critical, important and small cash flow increase/decrease potential. Selling price and production output belong to the critical group. If selling price could be increased 20 % the cumulative net cash flow would increase 95.1 %, so nearly double. Following the same logic, if production output could be increased by 20 %, the cumulative net cash flow would increase 45.1 %. Obviously that high increase, especially in the selling price is most likely not possible, but it tells what fundamentally affects to profitability the most. On the other hand, the selling price increase is not totally impossible as the selling price is per tons, which might get higher if basis weight could be decreased. The outcome of this can be obtained by firstly following the production rate slope (same or decreased) and then the selling price slope (same or increased). Their net difference would be the cumulative net cash flow gain.

Pulp price, fixed costs, latex binder price and latex binder amount belong to the important group. Their impact to the net cumulative cash flow is significant but not as high as the critical group's. However, it should be noted that in many cases influencing these variables in operational level might be easier than those of in critical group.

The last group contains variables than have an impact to the cash flow, but not as significant as the variables in the two other groups. Namely they are hammermill energy consumption, energy cost (electricity), maintenance, formation waste and energy cost (heating). These variables importance should not be undermined as the final additional profitability can be made by making sure these are well taken care of. Due to the customer's wish, the energy cost was chosen as a variable instead if energy consumption as they though the energy price is on an upward pressure in China.

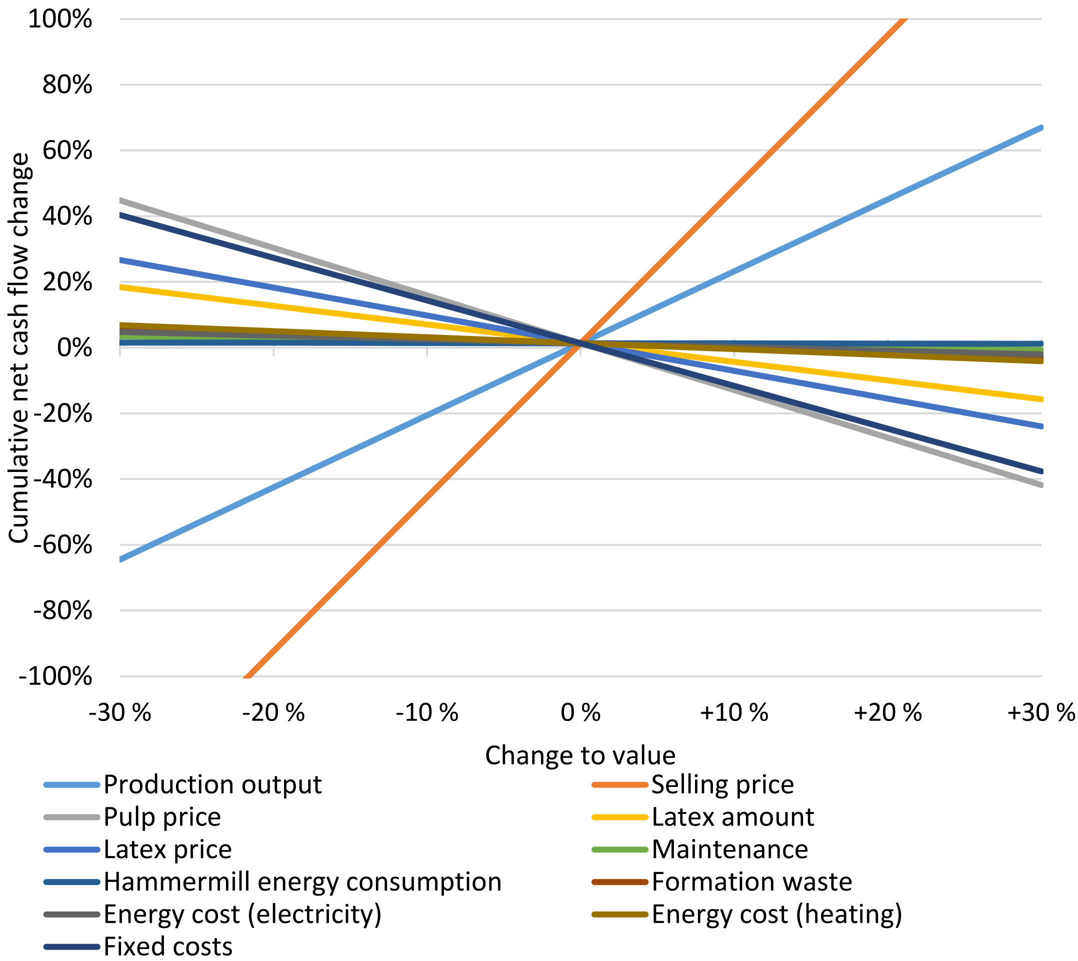

Figure 27. Sensitivity analysis: Cumulative net cash flow increase/decrease

The sensitivity model can be used in two ways. Firstly, it helps the research and development team to identify in which areas they should focus on to maximise the customer's value. On the same time, it clarifies the pulp characteristics needed and key information for calculating the potential selling price. Secondly, it can be used as a scenario analysis. For example, if the energy cost or fluff pulp price is due to increase in the future, the sensitivity model helps to identify their impact. This helps the customer and the whole value chain to focus on key risk mitigation factors and focus on the right things in the future.

6 Value creation at UPM-Kymmene

6.1 Simulated new fluff pulp price

The new selling price represents the novel pulp's selling price based on its new characteristics. For example, if the latex-binder infeed amount can be reduced by X % due to novel fibres, what could be its selling price if the benefits are shared between the pulp producer and other partners in the value chain. In this example it is thought that 25 % of the benefits are allocated to the new fluff pulp price (**Equation (17)**. The exact value of this would be determined in the price negotiations case-by-case. The benefits are simulated in the financial model based on the new variables by using the following formula:

$$New\ fluff\ pulp\ price = \frac{Marginal\ CF}{Fluff\ pulp\ consumption} * X \tag{17}$$

Where,
CF = Cash flow
X = Fluff pulp producers share of the improvement gains (25 %)

The new fluff pulp prices in different simulations are presented in **Figure 28.** The results resemble marginal cash flow results with the variable importance order, but naturally the model gives different values as it is divided by fluff pulp consumption and multiplied by fluff pulp producer's share of the improvement gains. Again, variables are categorised into three main group: critical, important and small selling price increase/decrease potential. The critical group consists of nonwoven selling price and production output. For example, if by the new fluff pulp the nonwoven selling price could be increased by 10 %, the cash flow increase of this would allow 9.8 % increase to fluff pulp price. Following the same logic, if production output increases by 10 %, the new fluff pulp price could be 4.3 % higher.

Important group consist of fixed costs, latex binder price and added latex binder amount. Their impact to the price increase/decrease is significant but not as high as the critical group's. Their potential increase to selling price range from + 3.2 % to + 8.2 % if variables are changed to value + 30 %. Especially on the fixed cost and latex binder addition this kind of change is possible. However, especially on fixed cost saving it might be hard in real situation to negotiate price increase. Example of this kind of case might be that if some process step could be totally skipped due to an innovation, then the customer might be willing to pay extra.

The last group contains variables than have a small impact to potential selling price increase/decrease. Variable belonging to this category are hammermill energy consumption, energy cost (electricity), maintenance, formation waste and energy cost (heating). Their positive impact ranges from 0.3 % to 2.4 % increase in the potential new selling price.

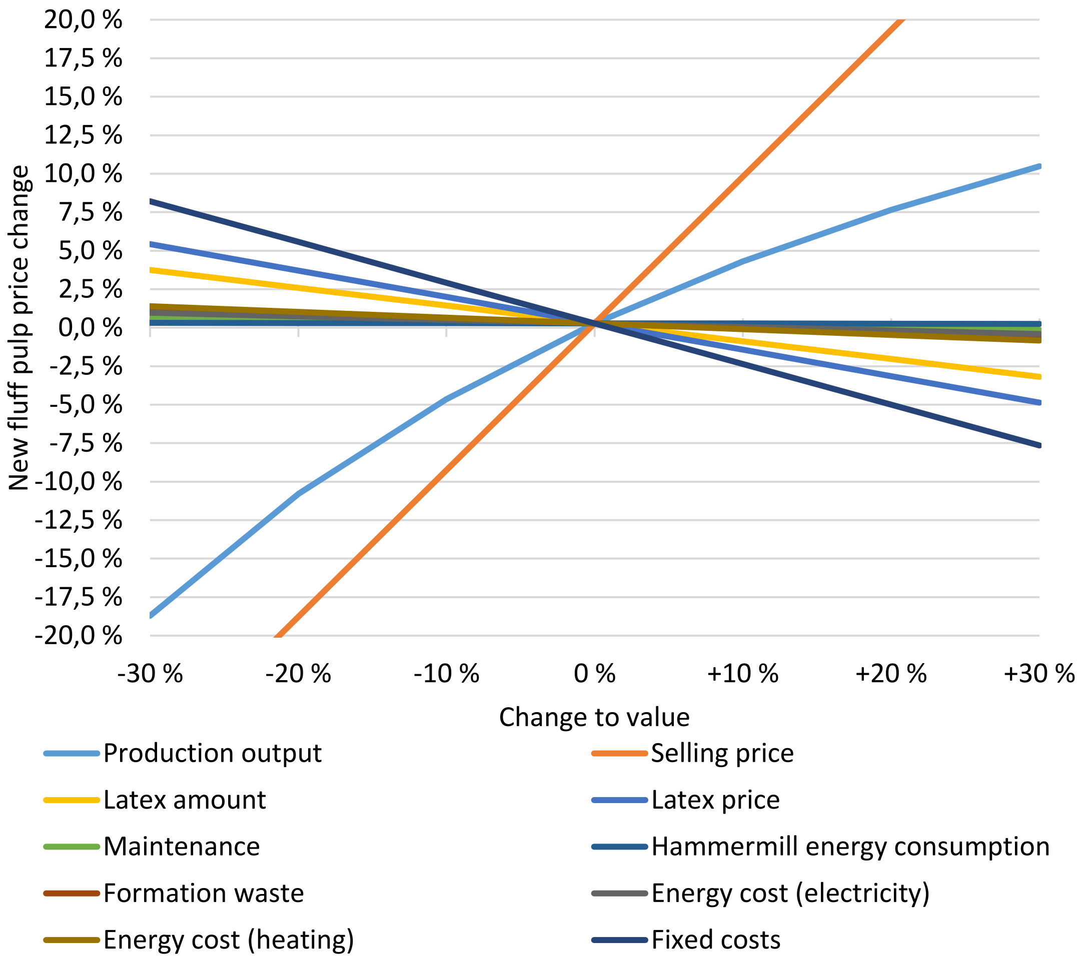

Figure 28. Sensitivity analysis: New fluff pulp price increase/decrease

It should be noted that there might be also some other qualitative variables that bring value to the customer that cannot be modelled in the financial and cash flow model. For example, especially in China customers value specialized technical customer service but also long-lasting customer relationships are known to be valuable for pulp customers. In addition, reliability of supply, pulp’s purity, low amount of dust, low static electricity build-up, standards and certification and product safety bring value to the customer but cannot be directly modelled by changing any variable in the models. However, indirectly those can be calculated by studying their cause-and-effect relationship. The lack of reliability of supply would mean that the customer must increase their inventory buffers meaning higher working capital requirement. This is a cost for the customer which can be entered as an input and the model calculates the value for this. The value of product safety, standards, certifications and forest schemes could be monetarized by changing the selling price variable as usually those products price is higher, and demand is more stable. Lesser amount of dust's value can be simulated by changing the yield parameter in the model. However, giving an exact value for these qualitative factors is impossible and not even necessary.

6.2 Value creation to R&D and target costing

After calculating what brings value to the customer and what could the selling price, we can determine the target cost (allowable costs) of new products as in Figure 15. This can be calculated by subtracting desired profit from market price as in Equation (18). Target cost refers to the same as "Total Cost" in Table 3 but in the different case.

$$Target\ cost = Market\ price - Desired\ profit \tag{18}$$

Where,

Desired profit = Market price * target profit margin

By assuming the target profit margin is 20 %, we can calculate the target cost for each sensitivity variable. The results are presented in **Figure 29.** Naturally, as the selling price and production output were the most important cash flow variables, so are they in target costs. The results also show quite clear improvement potential in latex binder addition and fixed cost. How the results should be interpreted is for example that if latex binder addition could be reduced by 10 % the cost of own production could be 1.2 % higher and would still be beneficial for both parties. Naturally, if the sum of development and production costs are lower than 1.2 %, the value chain would make more money, but the 1.2 % is the feasibility threshold. The reason why latex binder price has a bigger effect compared to latex binder addition is that the latter one has an effect to the production rate and therefore if it decreases the total amount of tons sold decreases. This leads to decrease in cash flow and its impact is even bigger than the drying energy cost savings.

Selling price (€/t) increase for customer could be achieved by reducing the airlaid nonwovens' basis weight (€/m^2) and on the same time keeping the production output in tons the same. Even a slight change to this would be highly beneficial. There is not an own sensitivity parameter for basis weight increase/decrease but adjusted selling price can be used for this. In the similar way the effect of increased absorption capacity can be estimated.

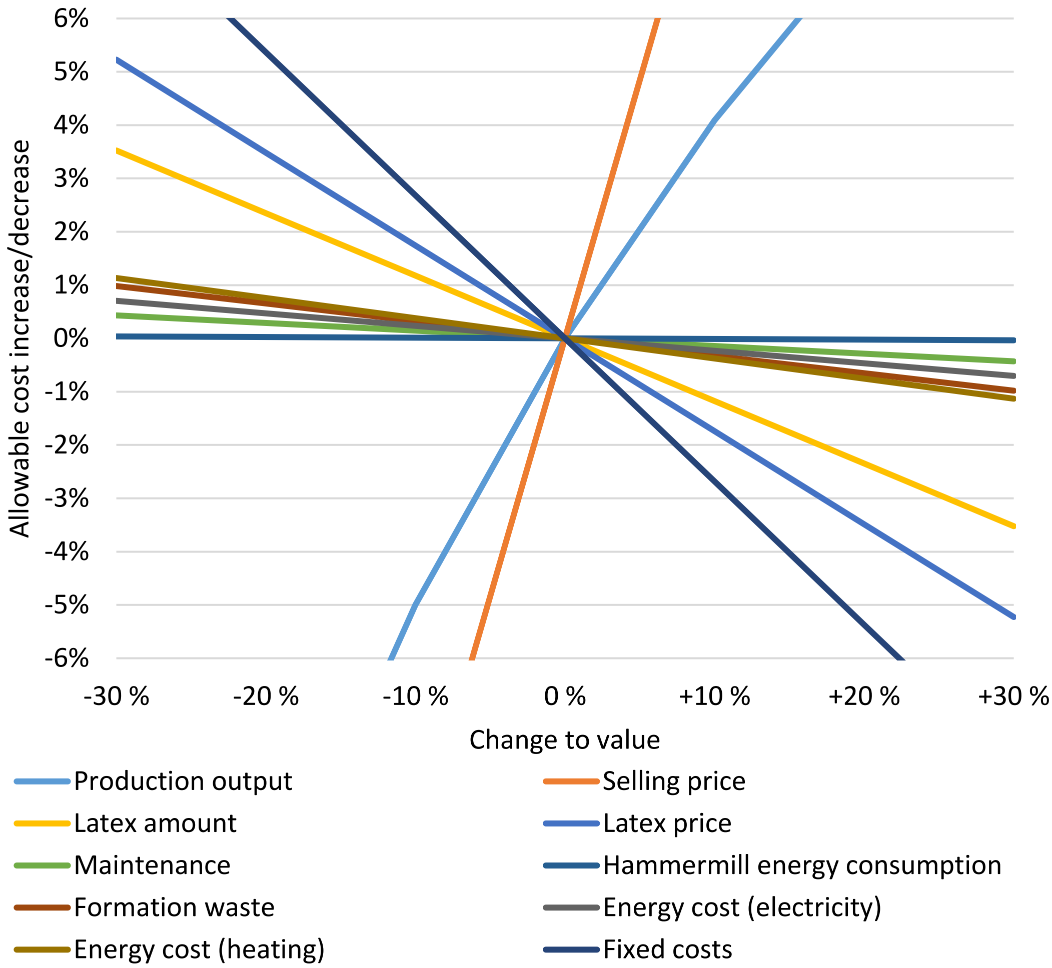

Figure 29. Allowable increase in costs in relation to fluff pulp production cost

Quite significant potential is also on finding ways to decrease fixed cost. The total cost of a pulp grade that decreases the customer's fixed costs by 10 % can be 2.6 % more expensive. In practice this could mean getting rid of a process step for example one of the latex binder addition steps. The exact cost saving of is not known but based on the potential it could be something interesting to investigate in the future. Reducing customer's formation waste would allow some but only low-cost actions in pulp production. If the customer's waste could be reduced by 30 % the pulp production cost increase must not be higher than 1 %. Tackling this issue in reality might prove to be challenging but one key element in formation waste generation is the amount of fibre bundles in fluff pulp and consistent quality. Surprisingly, energy costs and hammermill energy consumption proved to be less important as anticipated. Decreasing customers drying energy costs by 30 % would allow 1.1 % cost increase in pulp production. However, it should be noted that the energy consumption is much related to latex-binder addition. Therefore, the latex-binder addition amount is so important as it reduces the amount of latex binder. Latex binder's solid content is 50 % and when it's amount is reduced it less drying is needed to reach to nonwoven's end consistency. As hammermill energy consumption plays a minor direct role in the cost saving potential. What matters in hammermill however is the defibrillization. Consistent quality and minimal fibre bundles allow lower basis weight, higher production rate and potentially higher selling price due to higher quality in terms of better surface softness. Reducing maintenance need for customer could be also one potential area where pulp R&D could focus on. This is true especially if solutions could be found on static electricity build-up. Currently the moisture content is high in the production hall which accelerates corrosion. This results in higher maintenance costs. The potential effect of this could be even higher as the model does not take into account the fact that the machines worn out sooner. Thus, the depreciation schedule should be modified accordingly. However, this is hard to model with good enough precision. The detailed allowable increase in costs by variable can be found in Appendix 3.

There are also several benefits than cannot be modelled in a financial and cash flow model. Therefore, the customers willingness to pay for new fluff pulp's properties it might be still that they value it more and in case of overcapacity in the markets it is easier to sell and keep pulp mills operating rate high. Even this would bring value for the pulp producer and those ideas the R&D sector should also consider. For example, the R&D sector can support technical customer service on problem solving. This helps to build reliable business partnership which the Chinese customer appreciate but are not willing to pay more. In addition, opacity and environmental performance and image might be that kind of property. Especially certified production plays an important role.

When thinking about the overall cost structure and how certain modifications to fluff pulp might affect to the total increase/decrease in total production cost, the **Table 3** is a good reference point. It can be used to get the first estimations of if the target cost can be reached or not.

7 Conclusion

This chapter recaps the objectives and research questions of this thesis, summarizes, and discusses the main findings. In addition, this chapter will analyse the validity and reliability of this research and finally discuss the further research opportunities from the area and results. This thesis contributes to supply chain management and supply chain cost management. In these fields especially to financial value chain which is the value chain perspective and the logistic perspective is limited out of the scope.

This thesis had two main objectives.

1) To develop an approach for understanding fluff pulp customers' operations and cost structure in Mainland China.
2) To examine pulp R&D value creation potential in fluff pulp value chain and determine new fluff pulp prices for several variables.

From those objectives the main research question, "How Cost Management methods and financial modelling can be utilized to support pulp R&D function in novel fibre development for a customer in fluff pulp value chain in Mainland China?", was derived and split into three sub-questions.

A first sub-research question, "Which of the Cost Management methods is most applicable for creating a model that quantifies the current cost structure of a customer in Mainland China?" was derived from the first objective. This research question is addressed especially in sections 3 and 4.

Sub-questions two and three are related with the second objective.

Sub-question two, "In which way the model needs to be developed to best obtain increased customers' value of a new pulp grade and new fibre properties?", is addressed in the end of section three and in section five. These sections also discuss what is the best financial measure to demonstrate the benefits and what matters the most for the customer. Subsequently, the research gives direction on where to focus on fluff pulp development activities.

Finally, the sub-question three, "What is the new selling price and allowable additional costs of a potential new type of fibre sold to a customer in Mainland China?", is addressed in section 6 which further utilises the cash flow model and makes an estimation of potential selling prices based on the allocation method.

7.1 Theoretical implications

This thesis introduces the cost model, financial model and cash flow model. The cost model was designed for analysing the cost structure of current operations and comparing three alternative costing methods: traditional costing, activity-based costing and time driven activity-based costing. These were selected by either mapping out the most potential ones in literature as in activity-based costing's and time driven activity based costing's case or using the current costing method that the customer used - traditional costing. Analysing the cost structure by this way gives reliable information about the cost structure in Mainland China. This was important as the different costing methods deliver different results and in worst case, the current methods used might steer to focus on wrong products that were not as profitable as imagined, both in customer's decision making and pulp R&D's side. Therefore, validating research theories with a case study was important.

The results in fixed costs align with the previous research, the traditional costing leads to overly allocated fixed costs to high volume products and similarly too less fixed costs to low volume products. In the high volume products, the allocated fixed cost was around 4 % lower in terms of €/ton when comparing traditional costing to activity-based costing or time driven activity-based costing. In the low volume products, the fixed cost was roughly 28 % higher when comparing activity based costing to traditional costing and 15 -16 % higher when comparing it to time driven activity-based costing (Table 15). The reason why activity-based costing and time driven activity-based costing delivered slightly different results in product 5 remains unclear but most likely it has to do with the case that this product is a bit more complicated as it goes to cutting and other products do not.

What is most interesting is that due to the differences in cost allocation, the three costing systems provided quite different perceived net margins (**Figure 30**). This strengthens the common thinking that choosing a costing method has differences and validates this to be true also in China.

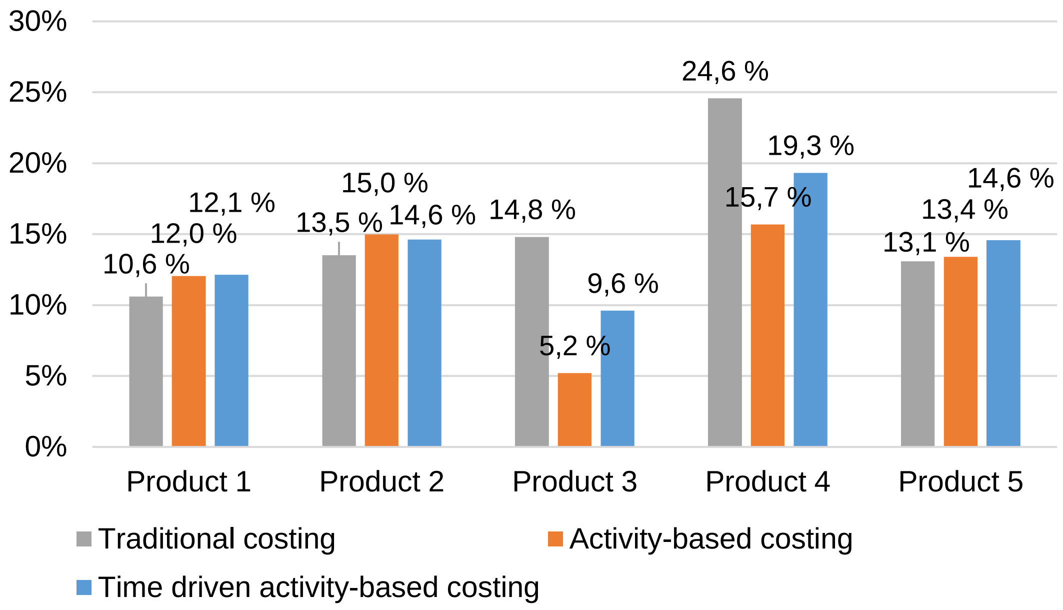

Figure 30. Variations of different costing methods to perceived net margin

Fundamentally, cost modelling brings out the cost structure but does not affect to company's profitability as all the cost are aggregated. Therefore, a step from cost model to financial model had to be taken. Theoretically this happened by gathering the information and finance modelling of basic financial statement and cash flow. Combining this information with financial profitability metrics (Chapter 6) profitability figures were able to provide to the customer. As a case example, a new type of pulp grade would increase the Cumulative marginal discounted cash flow by 42.9 % in a 10-year period (Figure 26).

In addition, from the cash flow modelling a new pulp price (target price and target cost) for R&D development actions were calculated by assuming how the benefits would be allocated in the value chain. This provides solid information on which product performance characteristics the pulp R&D should focus on, in order to provide most value to the customer. Moreover, a reasonable development cost level can be approximated by knowing how much a certain product characteristics' can cost and still create value to the value chain.

Target costing suited well in the research topic because it can be implemented inside a supply chain between two parties. In target costing, costs are perceived as a result, whereas customer requirements are seen as binding competitive constraints. It can be implemented inside a supply chain between two parties. are derived from the three dimensions' target costing has (Figure 15): Market driven costing, component level target costing and product level target costing. Therefore, as a value steam costing tool, it focuses on costs that are necessary to satisfy customers' expectations for functionality and price. This result in solid understanding on what are value creating elements for customer and what are value destroying elements. Target costing combined with sensitivity analysis creates an valuable tool for innovation processes as both the customer and R&D department can easily see what brings value to customers and how much.

This research brings novelty to supply chain management and supply chain innovation with combining target costing and activity-based costing in a supply chain environment and creating a financial model out of that. In addition, this was brought to a real life-operating environment with a case study.

7.2 Practical implications

Practical applicability of the results is tied in forest sector in pulp and paper value chain in which these results bring new knowledge to what is known about the subject. The main benefiter is pulp research and development as the model and results give monetized value for different development areas in nonwoven value chain. In addition to that, results can be used in supporting sales activates and in business development and strategy decisions.

Focusing on the main benefiter, based on the results, the R&D sector should focus on developing things that help customer increase selling price of production output (Figure 29 & Figure 30). The results also show quite clear improvement potential in latex binder addition, fixed costs and web's basis weight. Hammermill energy consumption and drying energy, which were in the beginning of this study evaluated to play an important role, did not in the end show as big of an impact as the ones previously listed. These results can be generalised to be valid not only in China but also in globally by keeping in mind there might be slight variations in different cost group's significances. However, these are considered to be small especially between first and second tier cities in China and Europe. In addition, with the sensitivity analysis those differences can be taken into account by approximating new values for the parameters which makes the model and results even more generalizable.

7.3 Validity and reliability

The disadvantage of a case study is its hardness to reproduce again. Therefore, in the beginning of this study this area was given a special attention. In overall, the cost models precision, generalisability and reliability are present on the same time. The models precision is high due to the amount of parameters and functions. The model is run with parameter figures from operating environment thought slightly adjusted due to information sensitivity which sets the reliability high. The mill used in the case example can be generalised as these kind of machinery are well standardised. The biggest differences between mills are with the pulp grade, heating source and capacity. Validating and conducting this research will be easy as all the cost and financial model's parameters are given and the model working principle and functions are explained. In addition, the sensitivity analysis supports the validability. Due to the customer's wish, some of the results were shown only in percentage increases/decreases which however does not influence on repeatability.

This research novelty partly comes from the case study, which allows high level precision, generalisability and reliability. As presented in Table 1, in Supply chain management researches only roughly 3 % contain a case study. Never before customer value in pulp's nonvowen value have been quantified and potential assessed with a case study. Partly these have been industry's silent knowledge with lots of gut feeling without facts.

7.4 Recommendations for further research

As this study only includes one case study, one recommendation for further research is a similar research set but with more different kind of nonwoven producers and technologies that use pulp as a raw material.

This research brought new knowledge to what matters to the nonwoven producer the most and how much they are willing to pay for different kind of development areas. This knowledge could be further researched in terms of what that would mean in practice. For example, what kind of changes in pulp mill's production line a new product characteristic would need and how much it would cost to produce. This could be then reflected to total allowable cost results presented in this research. From there, the development areas with highest return on investment could be chosen. In addition, more deep outlook for different pricing theories would bring value to this research's results. A one shortcoming of this research, which was left outside of the scope is the unquantified value creators for pulp which were only shortly discussed. This could be taken into account comprehensively in further research and combine it with the different pricing options.

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Appendix 1. Cash flow increase/decrease by variable

Variable	-30 %	-20 %	-10 %	0 %	+10 %	+20 %	+30 %
Production output	-65.9 %	-43.9 %	-21.9 %	0.0 %	21.9 %	43.8 %	65.6 %
Selling price	-140.6 %	-93.8 %	-46.9 %	0.0 %	46.9 %	93.8 %	140.6 %
Pulp price	43.5 %	29.0 %	14.6 %	0.0 %	-14.3 %	-28.7 %	-43.2 %
Latex amount	17.1 %	11.4 %	5.7 %	0.0 %	-5.7 %	-11.4 %	-17.1 %
Latex price	25.3 %	16.9 %	8.4 %	0.0 %	-8.4 %	-16.9 %	-25.3 %
Maintenance	2.1 %	1.4 %	0.7 %	0.0 %	-0.7 %	-1.4 %	-2.1 %
Hammermill energy consumption	0.2 %	0.1 %	0.1 %	0.0 %	-0.1 %	-0.1 %	-0.2 %
Formation waste	4.8 %	3.2 %	1.6 %	0.0 %	-1.6 %	-3.2 %	-4.8 %
Energy cost (electricity)	3.4 %	2.3 %	1.1 %	0.0 %	-1.1 %	-2.3 %	-3.4 %
Energy cost (heating)	5.5 %	3.7 %	1.8 %	0.0 %	-1.8 %	-3.7 %	-5.5 %
Fixed costs	39.0 %	26.0 %	13.0 %	0.0 %	-13.0 %	-26.0 %	-39.0 %

Appendix 2. New fluff pulp price increase/decrease

Variable	-30 %	-20 %	-10 %	0 %	+10 %	+20 %	+30 %
Production output	-19.0 %	-11.1 %	-4.9 %	0.0 %	4.0 %	7.4 %	10.2 %
Selling price	-28.6 %	-19.1 %	-9.5 %	0.0 %	9.5 %	19.1 %	28.6 %
Latex amount	3.5 %	2.3 %	1.2 %	0.0 %	-1.2 %	-2.3 %	-3.5 %
Latex price	5.1 %	3.4 %	1.7 %	0.0 %	-1.7 %	-3.4 %	-5.1 %
Maintenance	0.4 %	0.3 %	0.1 %	0.0 %	-0.1 %	-0.3 %	-0.4 %
Hammermill energy consumption	0.0 %	0.0 %	0.0 %	0.0 %	-0.0 %	-0.0 %	-0.0 %
Formation waste	1.0 %	0.6 %	0.3 %	0.0 %	-0.3 %	-0.6 %	-1.0 %
Energy cost (electricity)	0.7 %	0.5 %	0.2 %	0.0 %	-0.2 %	-0.5 %	-0.7 %
Energy cost (heating)	1.1 %	0.7 %	0.4 %	0.0 %	-0.4 %	-0.7 %	-1.1 %
Fixed costs	7.9 %	5.3 %	2.6 %	0.0 %	-2.6 %	-5.3 %	-7.9 %

Appendix 3. Allowable cost increase in relation to status quo fluff pulp production cost

Variable	-30 %	-20 %	-10 %	0 %	+10 %	+20 %	+30 %
Production output	-19.3 %	-11.2 %	-5.0 %	0.0 %	4.1 %	7.5 %	10.4 %
Selling price	-29.0 %	-19.4 %	-9.7 %	0.0 %	9.7 %	19.4 %	29.0 %
Latex amount	3.5 %	2.3 %	1.2 %	0.0 %	-1.2 %	-2.3 %	-3.5 %
Latex price	5.2 %	3.5 %	1.7 %	0.0 %	-1.7 %	-3.5 %	-5.2 %
Maintenance	0.4 %	0.3 %	0.1 %	0.0 %	-0.1 %	-0.3 %	-0.4 %
Hammermill energy consumption	0.0 %	0.0 %	0.0 %	0.0 %	-0.0 %	-0.0 %	-0.0 %
Formation waste	1.0 %	0.7 %	0.3 %	0.0 %	-0.3 %	-0.7 %	-1.0 %
Energy cost (electricity)	0.7 %	0.5 %	0.2 %	0.0 %	-0.2 %	-0.5 %	-0.7 %
Energy cost (heating)	1.1 %	0.8 %	0.4 %	0.0 %	-0.4 %	-0.8 %	-1.1 %
Fixed costs	8.1 %	5.4 %	2.7 %	0.0 %	-2.7 %	-5.4 %	-8.1 %