

LAPPEENRANNAN-LAHDEN TEKNILLINEN YLIOPISTO LUT
School of Engineering Science
Industrial Engineering and Management

Atte Jantunen

PROFIT-MAKING ABILITY OF A PAPER MILL

Master's Thesis

Examiners:

Professor Timo Kärrä
University lecturer Leena Tynninen

ABSTRACT

Lappeenranta-Lahti University of Technology LUT
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Atte Jantunen

Profit-making ability of a paper mill

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The paper industry has faced significant challenges in the recent decades. The decline in paper demand has led to overcapacity in the paper market and thus put many paper industry companies in a challenging situation. Several paper machine lines have been closed in the recent years, so the profit-making ability of an individual paper mill has been further emphasized.

The purpose of this thesis is to examine the profit-making ability of the case company's paper mill in terms of the paper grades produced at the mill. The hourly profit for each paper grade produced at the mill has been calculated based on the production data and efficiencies realized in 2019, as well as on the grade-specific costs and sales prices. The thesis consists of a theoretical part, which culminates on the calculation model of hourly profits to attain product-specific profitabilities, as well as an empirical part, in which the hourly profit of each paper grade is calculated. The empirical part includes also an evaluation on the significance of the factors affecting the generation of hourly profit.

Clear differences were noted in the hourly profits of the case company's paper mill's paper grades, so the need for optimization of the product portfolio and the potential benefit achieved from it were emphasized. However, it should be borne in mind that the mill itself does not have sovereignty over the types of paper grades produced, but awareness and computational justification of the most profitable paper grades of the mill creates a strong argument and basis for negotiations regarding the future of the paper mill's product portfolio.

TIIVISTELMÄ

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Paperiteollisuus on kohdannut merkittäviä haasteita viime vuosikymmenten aikana. Paperin kysynnän lasku on johtanut paperimarkkinoiden ylikapasiteettiin ja täten ajanut monen metsäteollisuusyrityksen haastavaan tilanteeseen. Paperikonelinjoja on suljettu viime vuosien aikana useita, joten yksittäisen tehtaan tuloksetekokyvyn merkitys on korostunut entisestään.

Tämän diplomityön tarkoituksena on tarkastella kohdeyrityksen paperitehtaan tuloksetekokykyä tehtaalla tuotettujen paperilajien osalta. Jokaisen tehtaalla tuotetun paperilajin tuntikate on laskettu perustuen vuonna 2019 toteutuneisiin tuotantotietoihin ja hyötysuhteisiin, kuten myös lajikohtaisiin kustannuksiin ja myyntihintoihin. Diplomityö koostuu teoriaosuudesta, joka kulminoituu tuotekohtaisen tuloksetekokyvyn, eli tuntikatteen laskentamalliin, sekä empiriaosuudesta, jossa jokaisen paperilajin tuntikate lasketaan, sekä arvioidaan tuntikatteeseen vaikuttavien osa-alueiden merkitystä.

Selkeitä eroja oli havaittavissa kohdeyrityksen paperitehtaan paperilajien tuntikatteissa, joten tuotantolajikirjon optimoinnin tarve ja siitä saatava potentiaalinen taloudellinen hyöty korostui. On kuitenkin tiedostettava, että tehtaalla ei ole itsemääräämisoikeutta tuotettavien paperilajien suhteen, mutta tehdaskohtaisesti kannattavimpien paperilajien tiedostaminen ja laskennallinen perustelu luo vahvan argumentin ja pohjan neuvotteluihin liittyen paperitehtaan tuoteportfolion tulevaisuudesta.

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CONTENTS

1	Introduction.....	1
1.1	Background.....	1
1.2	Objectives and limitations.....	2
1.3	Research methods and data.....	3
1.4	Structure of the thesis.....	5
2	Paper industry.....	6
2.1	History and current situation of the paper industry.....	6
2.2	Profitability.....	10
2.3	Performance.....	18
2.4	Production rate and operating rate in a paper mill.....	23
2.5	Synthesis of theory section.....	25
3	Case company.....	29
3.1	Introduction of the case company's paper mill.....	29
4	Profit-making ability of a paper mill.....	33
4.1	Paper grade-related measures.....	33
4.1.1	Saleable net production per hour.....	33
4.1.2	Variable costs.....	35
4.1.3	Fixed costs.....	37
4.1.4	Selling prices.....	38
4.1.5	Contribution margin per hour.....	39
4.1.6	Profit per hour.....	41
4.2	Key factors affecting the paper mill's profit-making ability.....	42
5	Results and analysis.....	45
5.1	Comparison of hourly profits.....	45
5.2	Optimization of the product portfolio.....	47

6	Discussion and conclusion	50
	References	53

FIGURES

Figure 1 Structure of the thesis.....	5
Figure 2 Global paper and paperboard production 2007-2017 (Diesen 2007; Statista 2020, 15)	7
Figure 3 Global paper production volume from 2007 to 2017 by type (Statista 2020, 16)	9
Figure 4 Demand volume of graphic paper products in Europe 2007-2018 (Statista 2020b)..	10
Figure 5 Reclassified income statement (Fazzini 2018, 47-48)	14
Figure 6 Contribution margin equation (Li 2018, 16-17).....	17
Figure 7 Contribution margin analysis based on (Li 2018, 16-17)	18
Figure 8 Triple P-model (Tangen 2005, 43).....	19
Figure 9 Efficiency balace of a production line (Airola 2017, 140)	23
Figure 10 Calculation model of saleable net production	26
Figure 11 Calculation model of profit per hour.....	26
Figure 12 Alternative calculation model of saleable net production.....	28
Figure 13 Cost structure of case company's paper mill in 2019	31

TABLES

Table 1 Global paper and paperboard market CAGR between 1992-2007 and 2010-2018 (McKinsey 2019).....	8
Table 2 Paper grades of the case company's paper mill	32
Table 3 Ratio of weights of the case company's paper grades	32
Table 4 Calculation of saleable net production	34
Table 5 Saleable net production of the mill's paper grades	35
Table 6 Distribution framework of variable and fixed costs	36
Table 7 Variable costs of the paper mill's paper grades	36
Table 8 Calculation of grade related fixed costs	38
Table 9 Fixed costs of the paper mill's paper grades.....	38
Table 10 Selling prices of the paper mill's paper grades	39
Table 11 Calculation of contribution margin per hour	40
Table 12 Contribution margins of the paper mill's paper grades.....	40
Table 13 Calculation of profit per hour	41

Table 14 Hourly profits of the paper mill's paper grades	42
Table 15 Sensitivity analysis of the factors affecting profit per hour	43
Table 16 Comparison of the profit per hour between the produced paper grades.....	45
Table 17 Comparison of the five most profitable and least profitable paper grades.....	47
Table 18 Comparison of average profit per hour	48
Table 19 Optimization of product portfolio	49

ABBREVIATIONS

MEUR	Million Euros
GDP	Gross Domestic Production
OECD	Organization for Economic Co-operation and Development
CAGR	Compound annual growth rate
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings before interest, taxes, depreciation and amortization
ROI	Return on investment
ROCE	Return on capital employed
ROE	Return on equity
ROS	Return on sales
TC	Total costs
VC	Variable costs
FC	Fixed costs

1 INTRODUCTION

The introduction chapter lays a foundation for the thesis by presenting the backgrounds of the study and proceeds then to represent the research questions with the support of research objectives and limitations. Used methods and data are presented before opening the structure of the thesis, which acts as the concluding chapter of the first section.

1.1 Background

Paper industry has been one of the most remarkable industries in the world thru the last centuries, but has faced many structural changes, especially in the 21st century. Product life cycle-wise, paper products can be seen to be at the maturity stage, where the provided customers are satisfied with the product, but the amount of sales are no longer increasing or are starting to decline (Hetemäki et al. 2013, 121; Lautour 2018, 58-59). Uronen (2010, 25-26) states further that paper products are commoditized, as customers have the negotiation power, switching costs are low, market growth in Europe is below GDP growth and price differentials between different providers are minimal. The impact of digital media is also very remarkable, as it has decreased the consumption of paper products in OECD countries even further (Hetemäki et al. 2013, 100). In addition, low-income countries create a major challenge and structural change for paper industry and paper manufacturers in high-income countries, as the production and consumption has increased in low-cost countries with new emerging manufacturers and customers. However, digitalization has not affected yet in low-income countries as much as in OECD countries, so the possible decrease of demand in low-income countries is yet to be seen (Hetemäki et al. 2013, 105-124). The price of paper has been declining by the combination of the factors mentioned above and thus has driven the industry to a difficult situation. Hetemäki et al. (2013, 109) express four implementation strategies for handling the structural change the industry is facing. First of all, companies can keep on cutting costs related to the production and try to increase productivity by investing in modernization of the mills. Another option is to increase to usage of information technology between business processes within the company. Lastly, an option is to reduce capacity by closing manufacturing mills or to innovate new products.

As underlaid before, demand of graphic paper has declined in Europe particularly since 2007 and has forced companies to react to the ongoing situation of the market. Lately, the declining demand of paper has created overcapacity in the paper market and has led to a tense competition from customers and orders between paper manufacturers and led to closure of many paper mills. Current situation in the paper market has emphasized the meaning and importance of profitability and cost management especially from the point of view of a singular paper mill. The analyzing process of paper mill's efficiencies and operational performances is closely tied to profitability improvement and thus a topic closely studied. Airola (2017) discussed in his doctoral dissertation about the calculation methods of efficiencies and other operational performances in paper mills and created a solid foundation for future development of the global calculation standards and guidelines in the paper industry.

1.2 Objectives and limitations

The objective of this master's thesis is to figure out the profit-making ability of the case company's paper mill by inspecting the profitability amongst the produced paper grades and the key factors that have effect on it. First, the significant and influential dimensions that affect the profit-making ability are evaluated and combined into a calculation model. Once the calculation model is achieved, the focus shifts to examining the paper grade-specific hourly profits and the key factors that affect the case company's paper mill's profit-making ability. Finally, the thesis culminates on the actions needed for increasing the profit-making ability of the paper mill.

Four research questions were formed in order to reach the objective of the study. The first research question aims to identify the structure and the measuring method of the profit-making ability in a paper mill. The second research question aims to gain the actual profitabilities of the paper grades produced in the paper mill and is followed by the third research question regarding the inspection of the key factors that have influence in the formation of the profit-making ability of the paper mill. The fourth and final research question tends to provide alternative options for improving the profit-making ability of the case company's paper mill. The research questions to support the objectives of the study are expressed below:

1. *How is profit-making ability measured in a paper mill?*
2. *What kind of profit divergence there is within the case company's paper mill's product portfolio?*
3. *What are the key factors that affect the mill's profit-making ability?*
4. *How to improve the case company's paper mill's profit-making ability?*

This study is limited to concern the case company's paper mill's product-specific contribution margins and profits. Only product-specific sales prices, variable costs and fixed costs are taken into consideration to obtain the current profitabilities of the produced paper grades. To ensure the topicality of the study, the inspected paper grades and the related production data will be limited to year 2019. However, sales prices and product-related costs are handled as they are currently. Paper grades that were produced only a minor quantity are left out of the inspection. Only the net profit the mill is achieving with the sales from the mill's production outputs is examined, as seasonal variation in the order amounts of different paper grades, amortizations, depreciations, interest and taxes are not taken into consideration.

1.3 Research methods and data

Research methodologies can be divided into three sections, that are qualitative, quantitative and mixed methods. One of the most common ways of segregating qualitative and quantitative research method is by the numeric aspect of the data. Qualitative research is considered as non-numerical data collection and analysis technique, such as an interview. Quantitative research is on the other hand a numerical data research method, that uses or generates numerical data from data analysis procedures or data collection techniques. The strict division between the two types of research methods may lead to situations where only one type of method is not suitable but features from both qualitative and quantitative methods are needed. Mixed methods research combines the two types of classic methods, both qualitative and quantitative, for data analysis procedures and collection techniques. (Saunders et al. 2016, 165-174). The motivation behind mixed methods research usage culminates on the belief that by using both research methods possible biases, weaknesses or limitations caused by one research method can be avoided and

thus the quality of the research increased. The two research methods compensate and counterbalance possible constraints related to the use of only one method. (Fidel 2008, 265)

The research method of this thesis culminates on the mixed method research, as it utilizes qualitative research for obtaining a broad and relevant view of the case company's circumstances and quantitative research for numeric data collection and analyzation. The time perspective of a research is separated into cross-sectional and longitudinal, as cross-sectional involves the study to a particular time and longitudinal to a more prolonged period (Saunders et al. 2016, 200-201). This this will be limited to be a longitudinal study, as the thesis considers and studies the current situation with the occurrences of the year 2019.

As underlaid above, on top of the mixed method research aspect of the thesis, a case study research strategy is implemented for involving the case company's paper mill to the study. Simmons (2009, 9) defines case study as an in-depth investigation of a particular system in a "real life" situation. The aim with case study is to develop a comprehensive understanding to a particular topic by creating knowledge and information for the concerned (Simmons 2009, 9-10). The thesis will focus on a single case strategy, where a unique and critical case is being examined. A multiple case strategy would involve multiple cases, but within the scope of this thesis a multiple case strategy is not considered. The case study strategy utilized in this study will also have an embedded nature, as logical sub-units of the paper mill will be examined. A holistic approach would consider the studied subject as a whole, but a more exact study of different sub-units is needed. (Saunders et al. 2016, 184-187)

The production-related data is collected from the mill's manufacturing execution system and from a data visualization application connected to it. Paper grade-specific costs are gathered from the case company's paper mill's controller and sales prices from the sales department. Participant observation is applied also as a method of data collection, where observation of local practises and systems develop an understanding of the environment in question. Participant observation can be seen as a qualitative data collection method where desired objective is observed and attempted to becoming part of for a thorough and immerse comprehension of the topic in question (Saunders et al. 2016, 354-356).

1.4 Structure of the thesis

The thesis is divided into six chapters. After laying the basis and the foundation of the study with the introduction-chapter, the thesis proceeds to the theoretical part of the study. The theoretical part is relatively wide, as paper industry is studied first as a whole and deepened afterwards into the examination of performance and profitability from the viewpoint of a paper mill. Chapter three is the point where the case company is introduced and brought to context. Chapter four is the empirical part of the study connecting the theoretical foundation to the case company's paper mill's data and discovering the current state of the paper mill's profit-making ability. Chapter five assembles the central results from the empirical chapter and analyses them further by emphasizing the possible increase in the profit-making ability of the case company's paper mill. Chapter six finally draws conclusions of the study based on the achieved results and discusses about future activities regarding the increase of the mill's profit-making ability. The structure of the thesis is expressed in Figure 1 below.

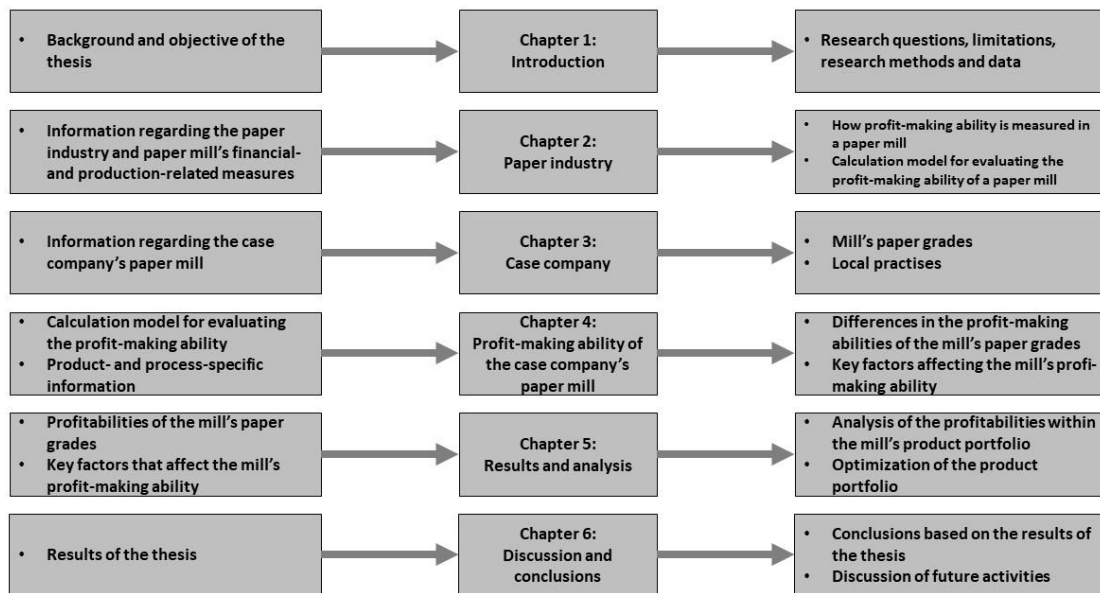


Figure 1 Structure of the thesis

2 PAPER INDUSTRY

The purpose of this chapter is to portray the current situation of the paper industry and to familiarize with the terms and factors related to the profit-making ability of a paper mill. A model for evaluating the profit-making ability and the profitability of the paper mill's products is summarized in the final subchapter.

2.1 History and current situation of the paper industry

The paper and pulp industry use wood as a renewable raw material to manufacture pulp, different types of graphic paper, packaging board and other kinds of wood-based products. The pulp and paper manufacturers create an important industry sector, that provides quintessential commodities for different kinds of needs. Even though paper has been an essential commodity through the ages, the industry has drifted gradually into a situation, where companies are forced to make difficult decisions for sustaining their businesses. Between the years 1950 and 2005 the world paper and board production grew from 43 million tons to 366 million tons, meaning a remarkable annual growth in production. In 2006, the industry was forecasted to continue its growth and reach 494 million tons in production by 2020, but in 2017 the global paper and board production reached 420 million tons, meaning a decline in the former development (Diesen et al. 2007, 10-33; Statista 2020a, 15). As in the Figure 2 can be seen, the global paper and paperboard production is continuing to grow, but in a modest manner.

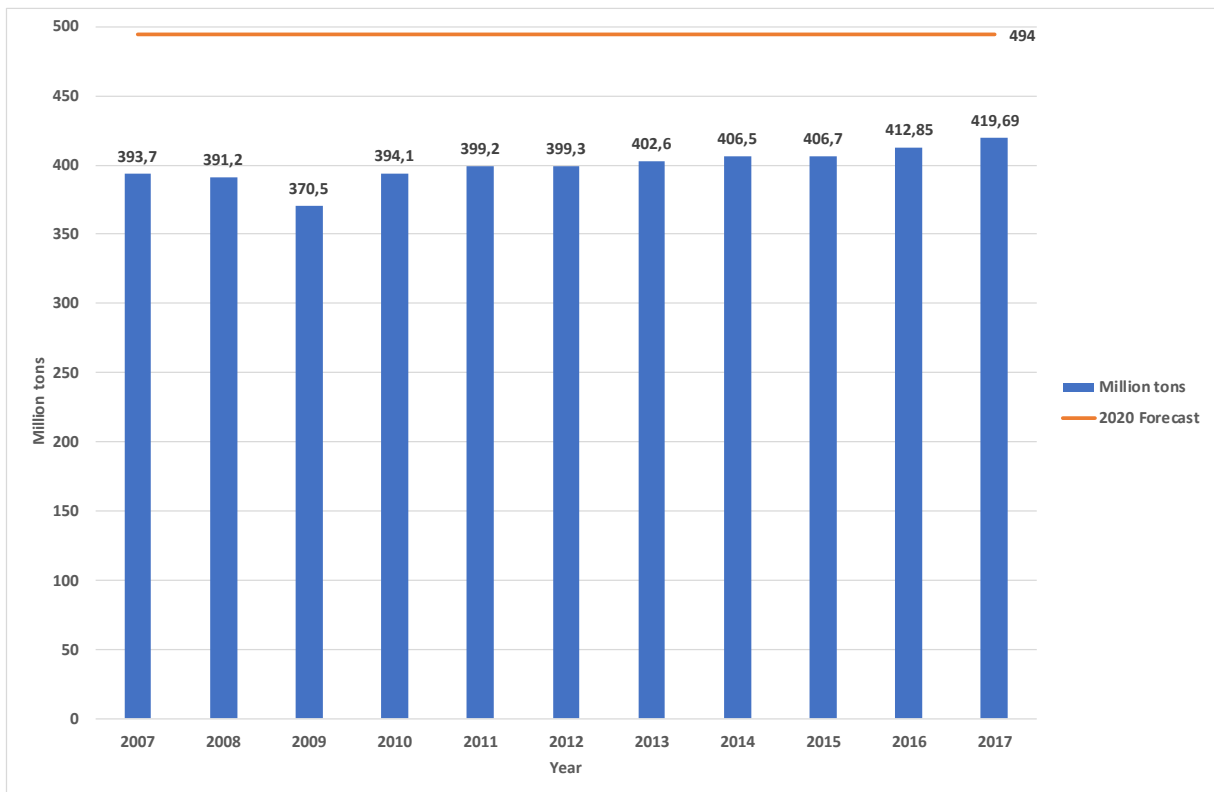


Figure 2 Global paper and paperboard production 2007-2017 (Diesen 2007; Statista 2020, 15)

The paper and paperboard industry is fragmented into three segments, that are known as graphic paper, packaging and other cellulose-based products. The graphic paper segment consists of newsprint, printing and writing, whereas the packaging segment consists of cartonboard and containerboard and finally the other cellulose-based products consist of tissue and other products, such as hygiene products (McKinsey 2019).

The annual development between these segments help us to understand the evolution of global paper and paperboard production volumes and why the growth has decelerated. Inspecting the production volumes and the compound annual growth rates (CAGR) supports the understanding of the ongoing direction of the industry. The compound annual growth rate demonstrates the average yearly growth rate of the company or of the industry.

As seen in the Table 1, the packaging and tissue segments continue to grow slowly, but the graphic paper segment is in a major decline. CGAR in the newsprint segment declined from 1.1 % to -6.1 % between 1992-2007 and 2010-2018, meaning a major decline in the industry's

growth rate. Between 1992-2007 and 2010-2018 CGAR declined in the printing and writing segment from 3.2 % to -1.5 %. The only segment with growth was the other cellulose based products, such as health products, that inclined from 0.6 % to 1.1 %. (McKinsey 2019)

Table 1 Global paper and paperboard market CAGR between 1992-2007 and 2010-2018 (McKinsey 2019)

		CAGR 1992-2007, %	CAGR 2010-2018, %
Packaging	Cartonboard	3,3	1,7
	Containerboard	4,3	2,7
Graphic paper	Newsprint	1,1	-6,1
	Printing and writing	3,2	-1,5
Other	Tissue	3,9	3,6
	Other	0,6	1,1

Naturally a similar trend can be observed when studied the development of global paper and paperboard production volumes between the years 2007 and 2017. As seen in the Figure 3, between 2007 and 2017 paperboard production increased from 199 million tons up to almost 246 million tons, while the production volume in graphic paper segment declined from 157 million tons to around 120 million tons. The segment of other cellulose products increased its production volume from roughly 38 million tons up to 54 million tons. Even though there can be drawn a conclusion that the graphic paper segment is slowly reducing, the industry of graphic paper is still producing remarkable quantities of graphic paper products. (Statista 2020a, 16)

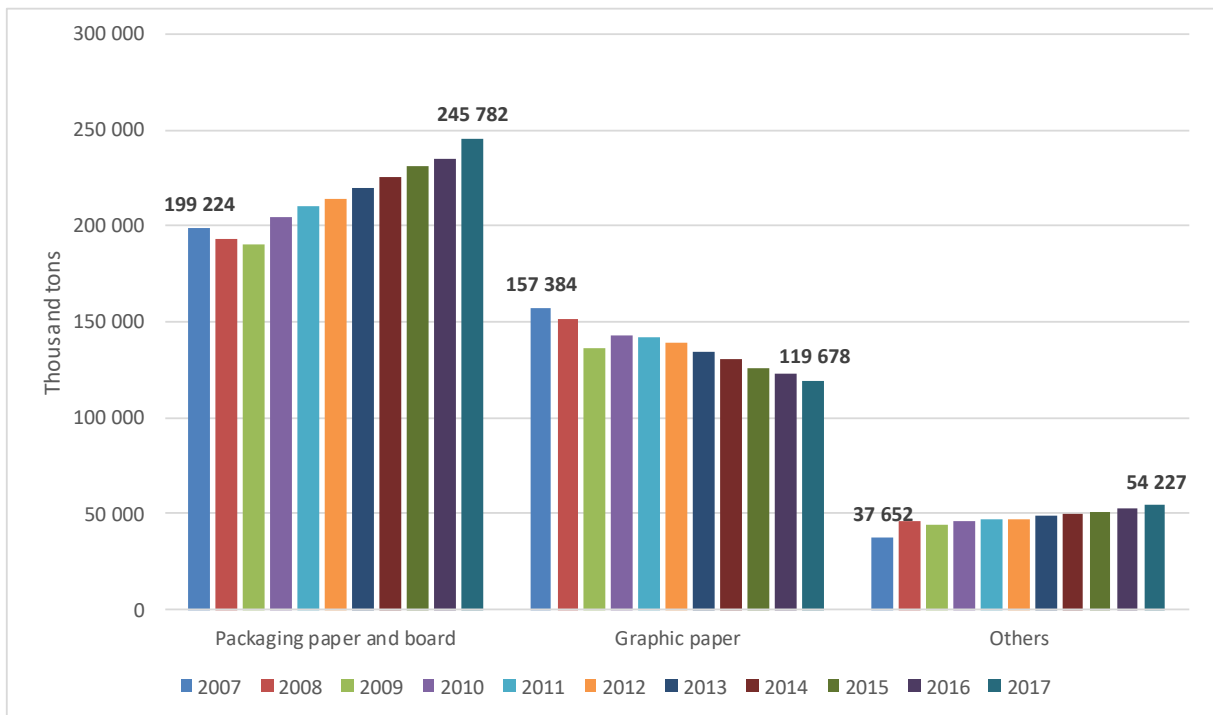


Figure 3 Global paper production volume from 2007 to 2017 by type (Statista 2020, 16)

The decline of annual growth in the graphic paper segment has accelerated the structural change in the paper industry by converting multiple paper mills into packaging board mills and even by closing a significant quantity of paper mills. There has been a stable decrease in the number of paper and paperboard mills starting from the 1990s, when approximately 1300 paper and paperboard mills were operating, but in the recent years the mill closures seem to be settling down to the approximate amount of 750 mills (CEPI 2019, 7). Figure 4 below portrays the evolution of the demand volume in Europe of graphic paper products, where a stable yearly decrease can be noted.

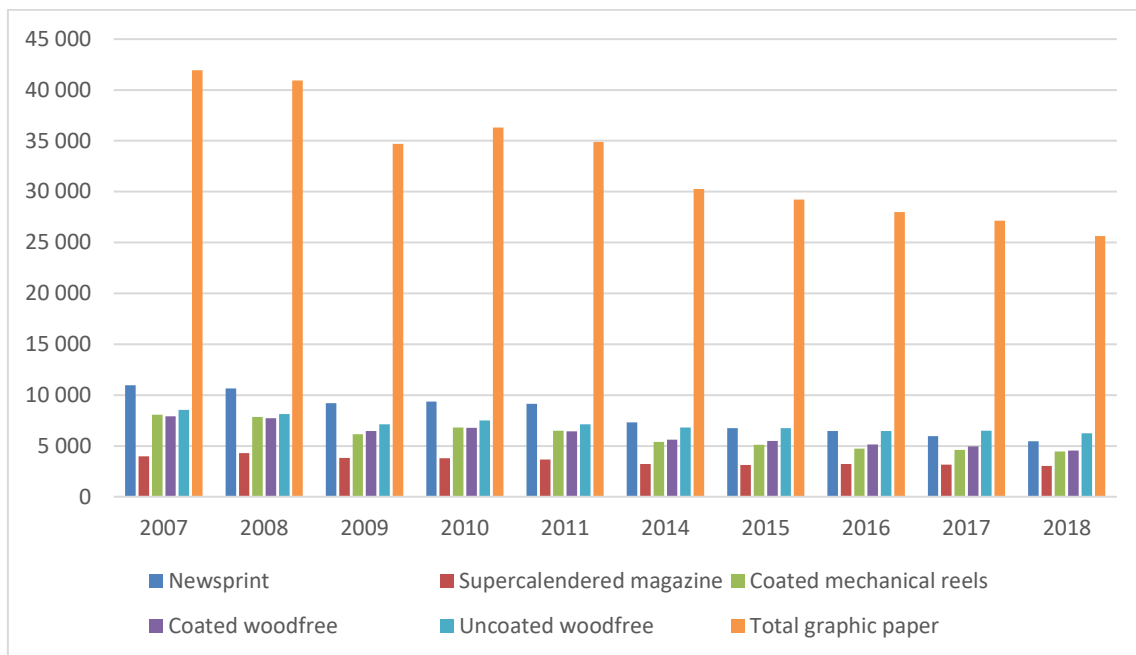


Figure 4 Demand volume of graphic paper products in Europe 2007-2018 (Statista 2020b)

2.2 Profitability

Business performance is the starting point of any business. One of the founding elements of business performance is profitability and the success within. The definition of profitability culminates on the ability of producing profit, which is based on a simple principle, where income has to exceed expenses (Rantanen 1995, 35). Profitability occurs as one of the main components of the financial aspect, because without profit there is no sustainability or competitiveness in the long run (Laitinen 1989, 189). A study was made by Davidsson, Steffens and Fitzsimmons (2009) regarding the function between profitability and growth, and it suggested that prioritizing profitability over growth leads to higher success and performance in the future. The study solidifies profitability as the basic element of any business. Profitability can be viewed and measured from many different points of views and thereby the amount of measures is wide. (Eklund & Kekkonen 2018, 72). The focus in profitability revolves principally around the monetary process of the company and thereby the profitability ratios come with a financial standpoint (Rantanen 1995).

Profitability in the paper industry is a highly studied topic due to the industry's long history and significance to the national economy of many countries. There are many factors affecting profitability in the paper mill, but according to Hämäläinen (2011a, 56-57) the selling price of paper is the most dominant factor in the economical performance of a paper mill. The study made by Hämäläinen (2011a, 56) highlighted that low paper prices result in poor profits or even losses if logistics and manufacturing costs are not decreased significantly concurrently. The study emphasized the magnitude of transportation costs as well, as many paper mills are located logistically far from major paper markets. Correlation between gross margins and transportation costs were evident in the study made by Hämäläinen (2011a, 57) and they emphasized especially when paper prices were decreasing. Hämäläinen and Tapaninen (2009, 20) support the statement of the importance of logistics costs, as decreased logistics costs can lead to significant improvement of profits. The study made by Hämäläinen (2011a, 58-73) highlighted also the significance of variable and fixed costs to gross margins, as evident correlations were found. As well as with transportation costs, when selling prices decrease, the meaning of cost control of manufacturing variable and fixed costs increase. Low profits are often the result of decreasing selling prices, as manufacturing, transportation and logistics cost remain stable (Hämäläinen et al. 2015, 5786).

Hämäläinen, Hilmola and Hetemäki (2015, 5780-5786) state that on top of cost control, delivery volumes, customer profitability and logistics functions are the three main factors to be focused into in profitability improvement. The study argues that short- and medium-term economic performance increase centers on costs and revenues, as remarkable manufacturing process improvement, and thus productivity improvement by investments is not possible. As mentioned before, the costs related to logistics functions possess an important meaning to paper mill's profitability and the magnitude highlights especially when the paper selling prices decrease. Delivery volumes relate closely with logistics costs and functions also, as larger deliveries lower the unit-level logistics costs and thus support the generation of better net profits. The study highlights customer profitability and customer profitability analysis as important topics to be carried out and deepened into. Customer profitability analysis produces important information for the planning of future business partners in terms of profitability maximization.

A study made by Hämäläinen (2011b, 945-955) regarding the cost efficiency in a paper mill emphasized four orientations for maximizing financial performance. The study suggested to improve the economic efficiencies of the paper machine lines, focus on energy efficiency, focus

on energy and raw material purchasing and focus on the continuous examination of the perfect combination of efficient paper machine line and paper quality in order to enlarge income.

As mentioned before, overcapacity in the market has led many paper manufacturers to close several production units. Hämäläinen and Tapaninen (2009, 20) argue the reason behind the closure decisions, as overcapacity in the paper market affect negatively on the prices of paper. As the previous studies argue that the paper price is the most important factor in the profitability of a paper mill, oversupply in the paper market is continuously monitored and decreased in order to minimize the decline in the selling prices of paper.

Costs are a quintessential starting point of financial evaluation and thus an essential topic to be defined. Companies face a broad amount of different costs that can be condensed into a general category known as total costs (TC). Total costs can be described as the costs that a company faces in a certain time period. The category known as total costs is indefinable and thus in need of a more precise classification. Fixed costs (FC) and variable costs (VC) are the two categories that all costs can be divided into within the scope of the thesis. The division into fixed and variable costs is based on the cost's correlation to the activity level. Costs that are not under the influence of the business's activity level are known as fixed costs. Fixed costs such as maintenance costs and most of the salaries remain stable despite the changes in the activity level. Costs that are dependent on company's activity level are known as variable costs. Production materials and energy expenses are examples of costs that depend directly on the company's level of activity, as their usage increases when the activity of the company increases. (Jegers, Edbrooke et al. 2002, 681-682)

Business's financial performance can be measured with different kinds of profitability ratios. The spectrum of metrics is wide and depended on the point of view. Profitability ratios are based on monetary calculations and generate a portrait of business's financial success. Even though the variety of profitability metrics is wide, there are certain ratios that are more used when paper industry's profitability is being measured. Profitability ratios can be divided into two different categories, that are known as margin ratios and return ratios. Margin ratios are used to describe the company's ability and efficiency turning income into profit on various levels of activity, whereas return ratios describe the capability to create profit thru equity employed (Ciurariu 2015, 95-97). The most common return ratios are Return on investment (ROI), Return on Capital Employed (ROCE) and Return on Equity (ROE). The most common

margin ratios are gross profit margin, operating profit margin, net profit margin and Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA).

To understand the components that create profitability ratios, it is important to comprehend the purpose of the income statement and of the balance sheet. Income statement and balance sheet are the basic foundations for financial contemplation and thereby the baseline for profitability measurement. (Diesen 2007, 131-136) The income statement is a financial report expressing business's financial performance and operating outcome in a certain time period, which usually occurs as one year. Financial statement analysis is the function to understanding and clarifying the financial condition and performance of the company. The financial statement analysis consists of two phases, that are known as the technical step and the interpretation step. The technical step comprises of reclassifying the financial statement and selecting the most suitable ratios for the purpose. The interpretation step is the concluding part where the business's financial condition and performance is summarized with the outcomes of the ratios. Like mentioned before, the income statement is simplified and reclassified by adding intermediate margins to comprehend the structure and functions between different measures of the income statement. The reclassified income statement is expressed in the Figure 5 below. (Fazzini 2018, 39-48)

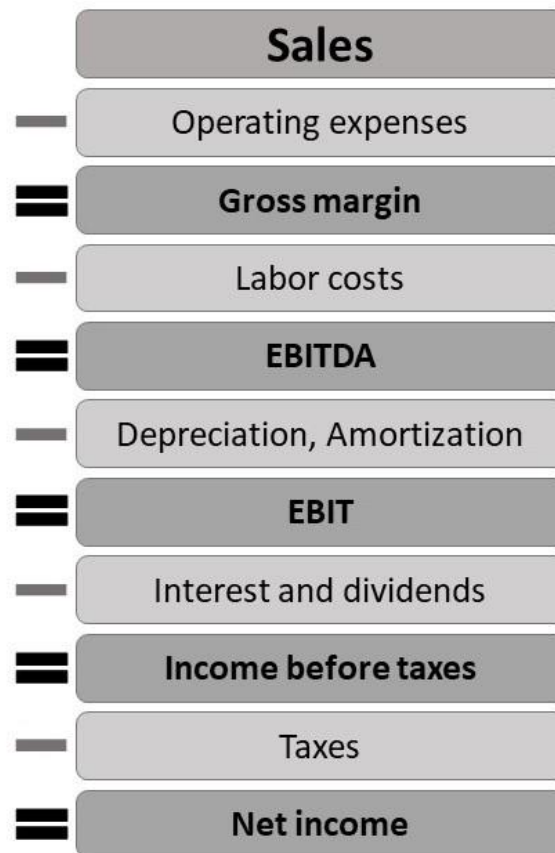


Figure 5 Reclassified income statement (Fazzini 2018, 47-48)

Return on investment (ROI) describes the efficiency of an investment by calculating the benefit received from an investment in comparison to the costs of the investment. ROI is also used to measure former or incoming investments. Return on Capital Employed (ROCE) is a measure to indicate the effectiveness of business's resource utilization, as it indicates how well profit is generated from capital employed. Return on Equity (ROE) is a ratio that describes the generated income in comparison to the shareholders' equity. ROE measures the level of how much profit is made in relation to the shareholders' monetary investments. ROE can be calculated by dividing net income by shareholders' equity. (Rist & Pizzica 2015, 90-94; Diesen 2007, 137-138)

$$ROI (\%) = \frac{\textit{Gain from investment} - \textit{Cost of investment}}{\textit{Cost of investment}} \quad (1)$$

$$ROCE (\%) = \frac{\textit{Operating profit}}{\textit{Capital employed}} \quad (2)$$

$$ROE (\%) = \frac{\textit{Net income}}{\textit{Shareholders' equity}} \quad (3)$$

As described before, margin ratios express the company's ability to turn income into profit in different stages of business's activity. The most used margin ratios that are based on business's income statement are gross profit margin, EBITDA margin, operating profit margin and net profit margin. The gross profit margin, also known as gross margin, expresses the percentual amount of how much gross profit is made with sales. Gross profit margin is calculated by subtracting the costs of goods sold from net revenue and finally dividing the remainder with net revenue. (Rist & Pizzica, 62)

$$\textit{Gross profit margin} = \frac{\textit{Net revenue} - \textit{Cost of goods sold}}{\textit{Net revenue}} \quad (4)$$

Earnings before interest, taxes, depreciation and amortization (EBITDA) is a self-explanatory, commonly used and monitored financial measure, that provides useful information for financial evaluation. EBITDA is based on Earnings before interest and taxes (EBIT) but adding depreciation and amortization to the inspection. EBITDA evaluates business's profitability without taking the business's capital structure and noncash expenses, such as depreciation and

amortization into consideration and thus enabling a more precise and realistic comparison with other businesses. Earnings before interest and taxes is as the name suggests; net revenue added up with interest and taxes. EBIT can be calculated also by subtracting operative and fixed costs from net revenue (Airola 2017, 7). EBIT is also a widely used measure to compare different businesses by normalizing companies with different capital structures. (Rist & Pizzica 2015, 47-48) EBITDA and EBIT margins display the business's operating profitability and efficiency with the same logic as other margin ratios. EBIT margin is also known as operating profit margin or Return on sales (ROS). (Fazzini 2018, 54-55). Finally, the net profit margin, also known as the profit margin, expresses the percentual amount of how much the business keeps in earnings after realized sales. Finally, the net profit margin, also known as the profit margin, expresses the percentual amount of how much the business keeps in earnings after realized sales. (Rist & Pizzica 2015, 86) The mentioned margin and return ratios, especially EBITDA and EBIT, are highly monitored in the paper industry, but in order to achieve more accurate product-level profitabilities, contribution margin analysis is the key to it.

$$EBIT = \text{Net revenue} - \text{Operative and fixed costs} \quad (5)$$

$$EBITDA = EBIT + \text{Depreciations} + \text{Amortization} \quad (6)$$

$$EBITDA \text{ margin} = \frac{EBITDA}{\text{Net revenue}} \quad (7)$$

$$EBIT \text{ margin} = \frac{EBIT}{\text{Net revenue}} \quad (8)$$

$$\text{Net profit margin} = \frac{\text{Net income}}{\text{Net revenue}} \quad (9)$$

Shifting the point of view in a business's profitability from a holistic approach to a more product-specific aspect leads to contribution margin analysis. The purpose of the contribution margin analysis is not to compare profitability between businesses, but to examine and compare the profitability between the company's products. Contribution margin analysis leans remarkably on the company's cost structure, as the analysis and calculations are based on separating the variable and fixed costs from each other. Costs as a general cost group doesn't offer much to the inspection of profitability on a product-specific level and thus need to be partitioned into more precise groups. Attained profit is formed by separating variable and fixed costs from sales. Li (2018, 16-17) also specifies further, that the subtract between sale amount and variable costs equals with profit and fixed costs combined. The contribution margin analysis is based on the equations mentioned above. Sale amount minus variable costs and profit summed with fixed costs are both equal with the contribution margin. As mentioned, subtracting fixed costs from the contribution margin generates the achieved and attained profit a production unit generates. The equation that models the calculation of the contribution margin is presented in Figure 6 below, as well as the structure related to contribution margin analysis in Figure 7.

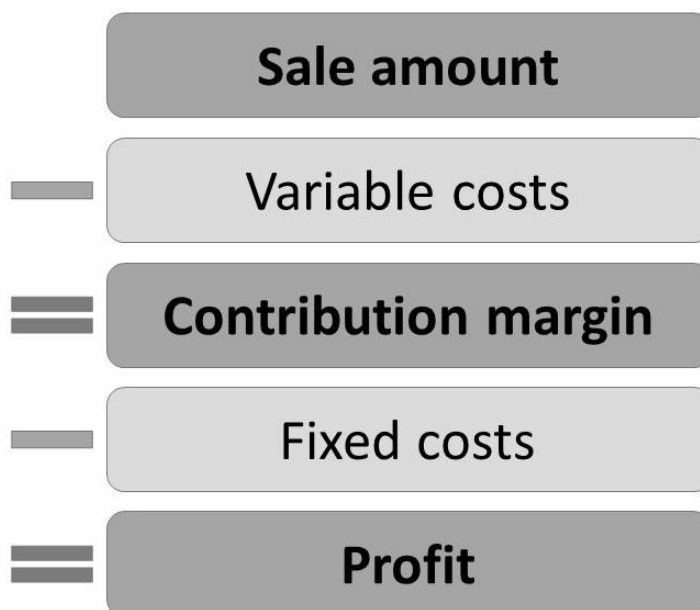


Figure 6 Contribution margin equation (Li 2018, 16-17)

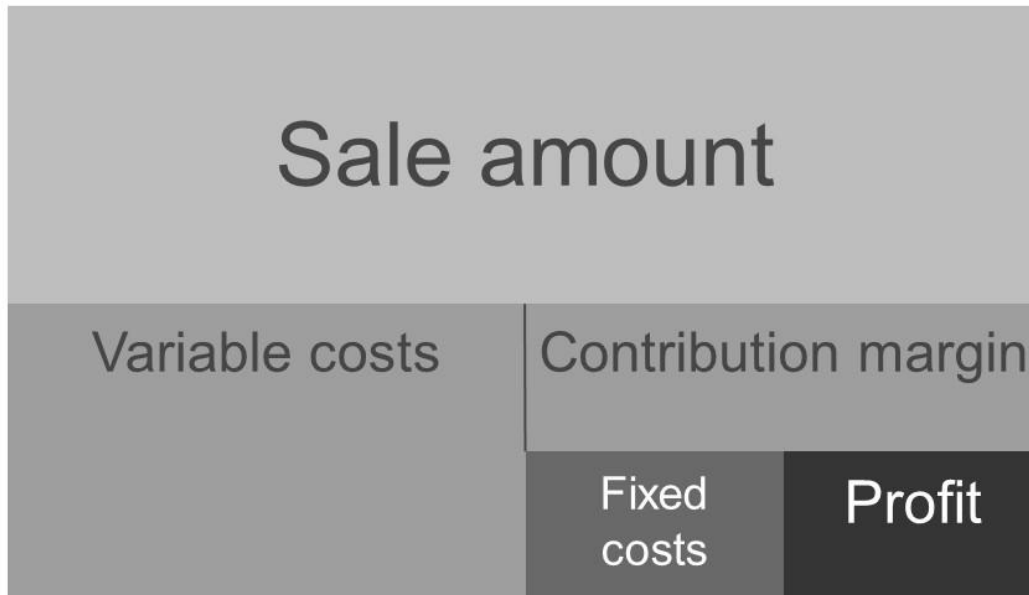


Figure 7 Contribution margin analysis based on (Li 2018, 16-17)

As expressed before, profitability culminates on the ability to producing profit. From the standpoint of a single production facility, the ability to make profit is dependent on the amount of sales and on the costs related to it. With the contribution margin analysis, contribution margins and profits of different production outputs can be achieved and measured, bringing a standpoint to the inspection of the profit-making ability of the facility.

2.3 Performance

Business's performance is an important topic to be understood before familiarizing with productivity and efficiency aspects. Performance can be viewed as the ability to meet the goals that has been set and by further deepening into organizational performance, it can be seen as a set of readiness, activity and execution (Hildén et al. 2014, 1-68). Company performance can be separated into two sectors – internal performance and external performance. Internal performance expresses the performance within the company and the analyzation of the mentioned performance is in most cases performed by the company itself. Rantanen (2005, 2-3) also states that productivity can be seen as an essential part of a company's internal

performance. External performance expresses the company's performance in the surrounding society and analyzation is often performed by external stakeholders.

Dimensions affecting performance can be studied with a layer-type model defined by Tangen (2005, 43). The Triple P-model views performance as a multi-layered field of factors affecting one another. Productivity centers the core of the model and is followed by profitability, that adds up the financial aspect with productivity and cost factors, such as price recovery. Finally, non-cost factors such as speed and quality are added to complete the field of performance. Efficiency and effectiveness influence cross-functionally, as efficiency expresses the input side of the model with the degree of how well the resources are utilized in the transformation process from inputs to outputs. Effectiveness focuses on the output side and it expresses the degree to which the predefined target or objective is achieved. The Triple P-model is represented in Figure 8 below. (Rantanen 2005, 25; Grunberg 2004)

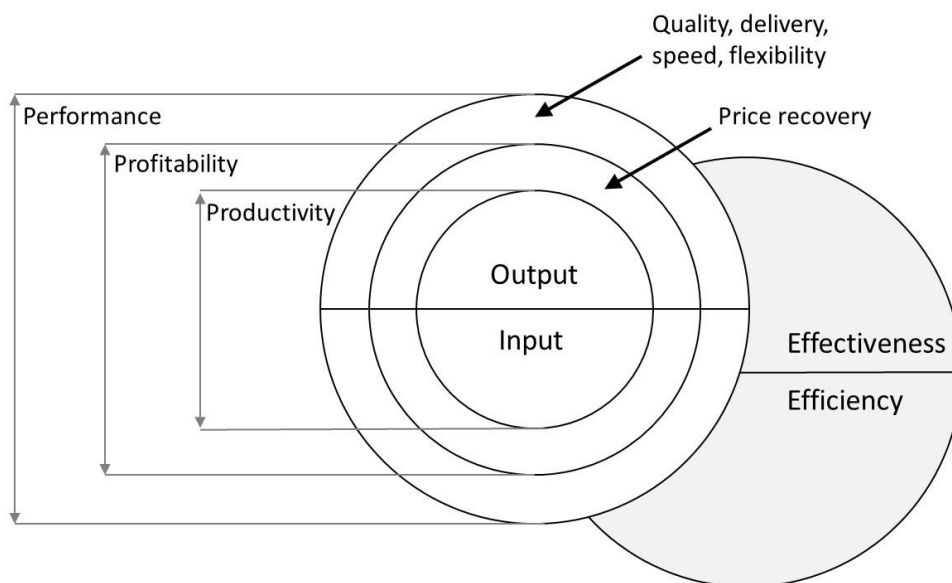


Figure 8 Triple P-model (Tangen 2005, 43)

The theoretical definition of productivity is defined as a ratio of outputs and inputs, that illustrates the performance of the company's processes in transforming production inputs to production outputs (Rantanen 2005, 8-31). Outputs can be seen as the products that a firm produces and inputs as the factors that create the outputs. The theoretical definition of productivity is rather simple, but in reality, the spectrum of inputs forming the outputs is

relatively wide and thus the aggregation and reunification of inputs as a coherent measure can be somewhat challenging (Coelli et al. 2005, 2-3). The measurement of productivity can be practically divided into total productivity measurement and partial productivity measurement. As said before, the theoretical concept of productivity is simple, but given the fact that there are several types of inputs, the measurement can be evolved into partiality. Total productivity can be measured as the ratio of total output and total inputs, but partial productivity focuses on the ratio between total outputs and a single input. These single partial inputs, also known as contributions, are typically categorized into labor, capital, material, energy (Rantanen 2005, 8).

As mentioned before, total productivity can be measured as a ratio between total output and total input. Total input is formed by summing all partial inputs together. When deepened into partial productivity, it is calculated by dividing total output with the inputs of the dimension inspected. For example, partial productivity of labor is calculated by dividing total outputs with the sum on labor inputs. The measurement of productivity in paper industry seems to follow a major guideline in the field of research. The most common measures of productivity in paper industry evolve around labor productivity and capital productivity. Labor productivity is often measured as total production in tons or kilograms per employee and correlates closely with labor costs. Labor costs can be considered to decrease when labor productivity increases. Capital productivity can be measured with production divided with the total value of assets. A high level of capital productivity correlates with an increased efficiency in the utilization of capital. (Lönstedt & Nordvall 2007, 287; Lamberg et al. 2012, 44)

Efficiency of operations is an essential topic in the paper industry as well. With a theoretical point of view, efficiency observes the ratio between inputs and outputs with the most optimal and ideal situation. In the paper industry, efficiency is often viewed as total mill efficiency, also known as operating efficiency, that includes two efficiency dimensions known as time and area efficiency. The difference between time and area efficiency inspection is that the paper machine is the main determinant of the paper mill's time efficiency, meanwhile area efficiency is affected with the whole production line. Time efficiency is the dimension that inspects the production time of the paper machine, in comparison to the maximum time available of the paper machine. The maximum time available for the paper machine reflects the time when the paper machine is theoretically capable for paper production. Deducting time not available from full calendar time, maximum time available time is formed. Full calendar time is the total time

within the inspected time period and time not available is when the paper machine is shut down due external reasons, such as strikes and lack of orders. Production time expresses the time when paper is being rolled on the paper machine reeler and is formed by reducing lost production time from maximum time available. Lost production time is formed when shutdown time and idle time are summed. Shutdown time is the time when the headbox feeder pump of the paper machine is not running caused by a planned or an unplanned shutdown. Planned shutdowns are planned beforehand, but unplanned shutdowns are caused usually by a major machine malfunction or due to lack of raw materials for example. Idle time is the time when headbox feeder pump is running but no paper is being rolled on the paper machine reeler. Idle time is in most cases formed by break time, that is caused by a malfunctions and interferences in the manufacturing process. (Knowpap 2020a; Airola, N., 2017, 138-159)

$$\text{Time efficiency} = \frac{\text{Production time of the paper machine}}{\text{Maximum time available of the paper machine}} \times 100 \quad (10)$$

As mentioned before, material efficiency is not tied only to the paper machine, but to the whole paper mill line. Material efficiency, also known as area efficiency, is the measure inspecting the length, width and finishing losses. Length efficiency starts from the produced paper length at paper machine reeler and culminates on the produced length on winder, where paper is sectioned based on customers' orders. Paper mill has many different production steps involved in the paper making process and malfunctions and interferences, such as web breaks cause length losses. These interruptions in the process decrease the saleable quantity of paper, especially lengthwise and thus affect the length efficiency significantly. Paper is also lost in the production steps as paper is left unused on the bottom of the paper reel and to the top for quality maximizing and to guarantee runnability in the process continuum. If all paper from the paper reel is used on every step of the process, continuum interruptions will cause length losses even more. Every mill has a standard for the amount of paper left unused, but anomalies in the amounts will increase length loss remarkably. Length efficiency is calculated by dividing produced paper length at winder with produced paper length at paper machine reeler. Width efficiency is based on trim efficiency, where the average order related web width after winder is divided with the maximum width of the winder. It has to be noted that width decreases gradually within the paper mill's production steps, but these width losses are not taken into

consideration in the trim efficiency. The width losses within the process steps after the paper machine and before winder are called process trim losses, but these width losses are not measured in the trim efficiency. Finally, the finishing efficiency is formed by the ratio of saleable paper area and net production area. Saleable area equals to net production area minus area of losses, that consists of rejected paper area after winder, after own warehouse, after external warehouse and of rejected paper area from customers. The only factor that decreases the area of losses is the area of good production after salvage winder, where rejected paper rolls from winder are turned into prime quality. Area efficiency is calculated by multiplying all three efficiency dimensions with each other. (Knowpap 2020a; Airola 2017, 138-159)

$$\text{Area efficiency} = \text{Length eff.} \times \text{Trim eff.} \times \text{Finishing eff.} \quad (11)$$

Paper mill's total efficiency is finally calculated by multiplying time efficiency with area efficiency. The total efficiency impacts the paper mill's overall profitability, because all produced or potentially produced outputs that are not ending up for sale means lost revenue and inefficient use of resources.

$$\text{Total efficiency} = \text{Time efficiency} \times \text{Area efficiency} \quad (12)$$

The efficiency aspect can be summarized to be dependent on time losses and area losses that the production line faces. The efficiency balance of production line is summarized in the Figure 9 below.

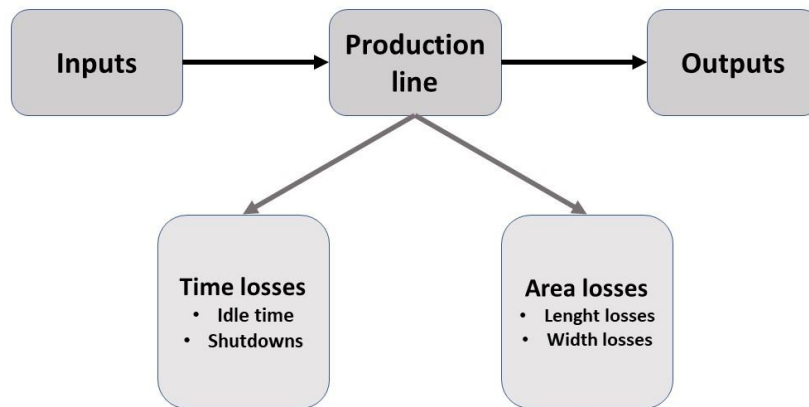


Figure 9 Efficiency balance of a production line (Airola 2017, 140)

2.4 Production rate and operating rate in a paper mill

Production rate is an essential topic to focus on, as it has a major significance in the paper mill's production costs and thus even on profitability, as higher production rate means higher amount of salable output and lower fixed costs per unit. Production rate of the paper machine is measured with tons per hour and it is depended on the momentary production. Momentary production is determined by the paper grammage, operating speed and web width of the paper machine. In theory, increasing operating speed leads to higher production rate, but in practice increasing speed is not always possible. With low-grammage paper grades paper machine's wet-end or drive limit the production speed and with high-grammage paper grades the drying capacity of the paper machine limit the production rate. Surpassing the paper machine's capabilities can lead to web breaks and quality faults. Based on these limitations of the paper machine concerning to the grammage of the produced paper, each paper grade has its own optimal production rate. That being said, paper grades with high grammages are not always the grades with the highest production rates. The optimal paper grammage for maximized production rate varies on each paper machine and is dependent on its capabilities. Calculated potential output expresses the potential saleable production a paper machine line is capable of at the current moment and depending on the paper grade in production. Calculated potential

output is the multiplication of maximum width at winder, basis weight of saleable output, average speed of the paper machine and the production time of paper machine. Calculated potential output is measured in tons, therefore for achieving the calculated potential output per hour, also known as the net production rate of saleable output, the production time of the paper machine has to be subtracted from the equation. As mentioned before, the production rate of paper machine is measured in tons per hour and thus a coefficient is needed in the equation to achieve the desired unit. It also has to be taken into consideration that the net production rate of the paper machine expresses only the potential saleable production per hour from the paper machine's view, as time or area efficiency is not taken into consideration. (Diesen 2007, 154; Airola 2017, 148)

$$MP = w \times m \times v \times 6 \times 10^{-5} \quad (12)$$

Where, MP = Momentary production of the paper machine [t/h]
 w = web width at the paper machine's reeler [m]
 m = basis weight of base paper [g/m²]
 v = operating speed [m/min]

$$CPO = w \times m_{sale} \times v \times t \times 6 \times 10^{-5} \quad (13)$$

Where, CPO = Calculated potential output [t]
 w = web width at winder [m]
 m_{sale} = basis weight of saleable output [g/m²]
 v = operating speed [m/min]
 t = Production time of the paper machine [h]

$$NProd = w \times m_{sale} \times v \times 6 \times 10^{-5} \quad (14)$$

Where, NProd = Net production rate of saleable output [t/h]
 w = web width at winder [m]
 m_{sale} = basis weight of saleable output [g/m²]
 v = operating speed [m/min]

Operating rate is also a closely monitored measure by the paper mill's management, as it expresses the ratio between maximum available time of the paper machine and full calendar time. It is important to keep a high operating rate, because every moment paper is not produced, potential saleable paper is lost. (Airola 2017, 138-159)

$$Operating\ rate = \frac{Maximum\ time\ available}{Calendar\ time} \times 100 \quad (15)$$

2.5 Synthesis of theory section

The theoretical section of this thesis has dealt with several kinds of different dimensions regarding the paper mill's performance and profit-making ability. To summarize the reciprocal influence between the dimensions, an aggregating model is assembled in order to evaluate the profit-making ability of a paper mill. Figures 10, 11 and 12 below summarize and combine the dimensions regarding the profit-making ability of a paper mill.

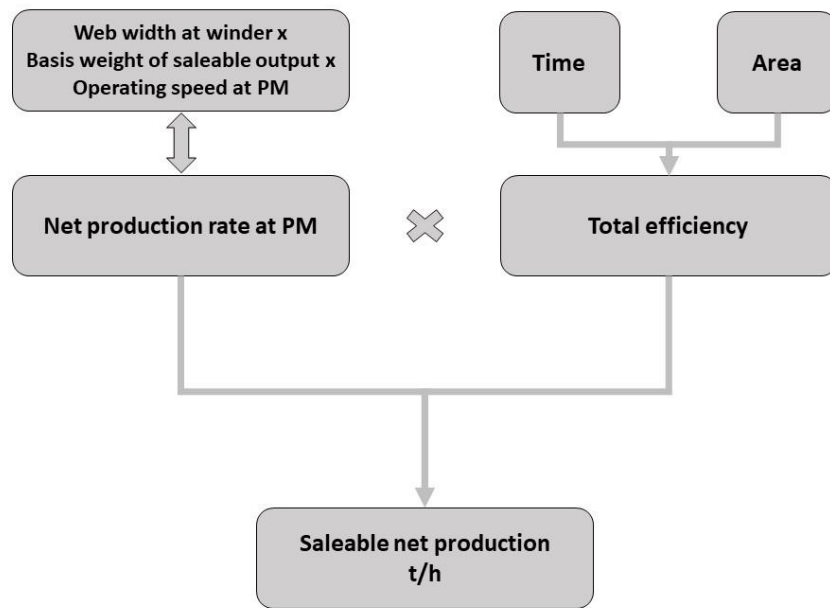


Figure 10 Calculation model of saleable net production

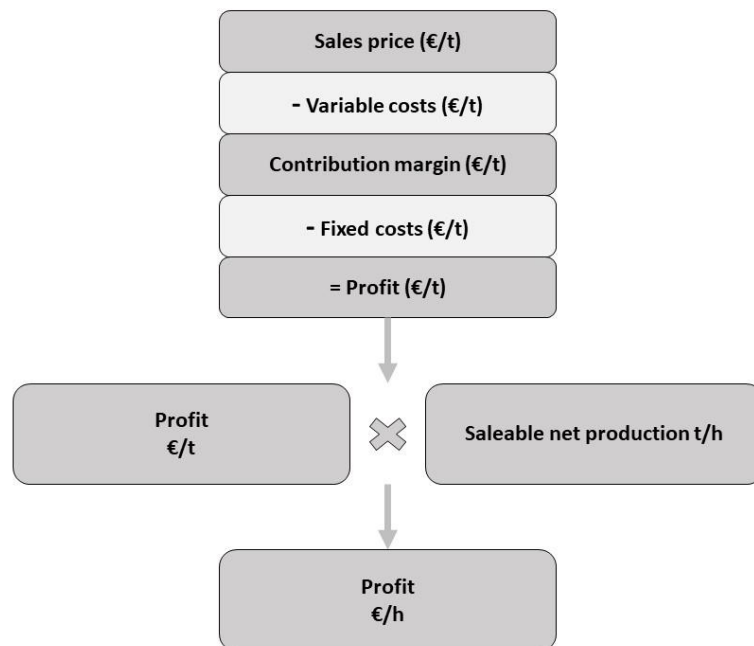


Figure 11 Calculation model of profit per hour

Figure 10 above demonstrates the calculation on saleable net production by multiplying the total efficiency of the paper grade in question with the net production rate at the paper machine. As mentioned before, the net production rate at the paper machine takes into consideration the web width at winder, the operating speed at the paper machine and the basis weight of the saleable output. It can be noticed, that the paper machine acts as the main determinant in the formation of the saleable net output. If the net production rate at the paper machine would be calculated with the basis weight of the base paper, the production rate at the paper machine would not represent the potential saleable output generated, as the weight of the paper increases in the process after the paper machine. A more detailed explanation of the paper mill's process is introduced in the next chapter. Figure 11 demonstrates the calculation for evaluating the profit-making ability of a paper mill. As the produced and saleable paper is measured in tons, costs and sales prices follow the same logic. Within the theory of contribution margin analysis, subtracting variable and fixed costs per ton from the sales price of the paper, profit per ton is generated. In order to achieve the profit per hour, that can be seen as a reflection of the profit-making ability, profit per ton has to be multiplied with the saleable net production per hour, that is generated in the paper machine.

Due to the nature of the thesis work regarding the sensible product-related information of the case company, basis weights of the saleable outputs cannot be published. In order to achieve comparable information between the paper mill's paper grades, the calculation of saleable net production can be modified to be containing a ratio of the basis weight of output and basis weight of the base paper. The ratio act as a coefficient, that converts the production rate of the paper machine to net production rate of saleable production. The modified model can be seen in Figure 12 below.

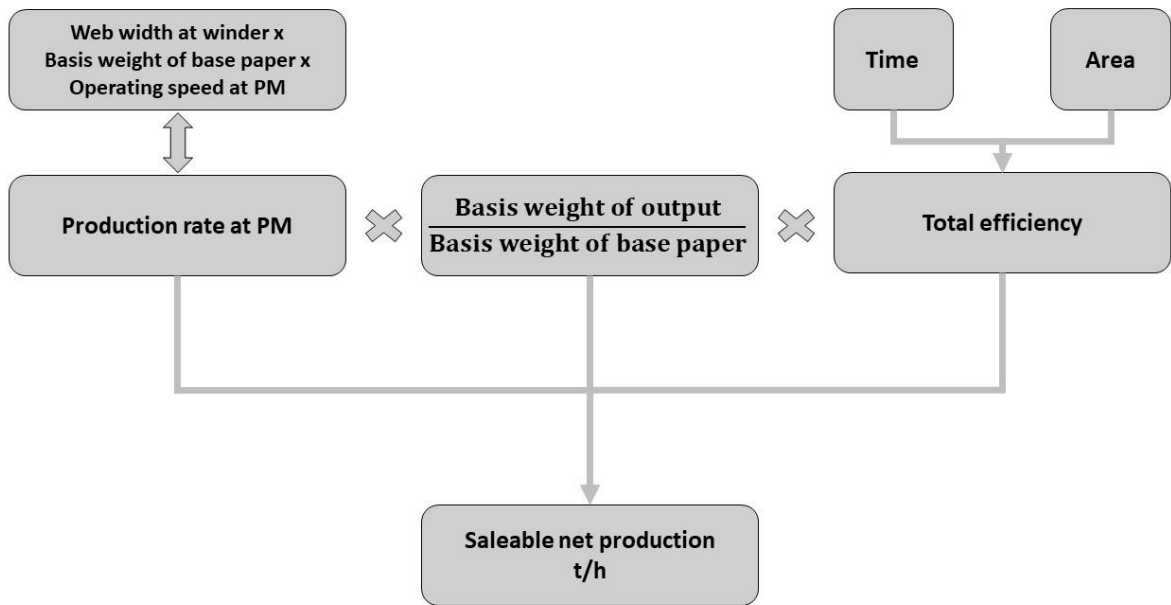


Figure 12 Alternative calculation model of saleable net production

3 CASE COMPANY

The case company of the thesis is a forest-based bioindustry manufacturer producing wood-based commodities, that operates globally in multiple different business areas. The company has production facilities, employees and customers in various countries around the globe. The total sales of the company are among the highest in the industry.

3.1 Introduction of the case company's paper mill

Paper manufacturing is a multistep process involving different kinds of machines, raw-materials, knowledge and expertise. The paper making process in the case company's paper mill is introduced briefly to acquire a general comprehension of the topic and to understand the possible sources for efficiency defect.

One of the main raw materials of paper is pulp and it is produced either mechanically or chemically. The case company's paper mill combines pulp with other components and chemicals at the paper machine, where the suspension is spreaded to the wire section as an even web. The web is strengthened by removing water gradually with drainage, pressing and drying leading to a dry matter content of 90 to 96 percent at the paper machine's reeler (Knowpap 2020b). As the paper web gets thinner, i.e. the paper grammage decreases, the quality defects and runnability issues like web break rates may increase. After paper machine the next step is coating, where a mixture of coating color and binding agent is applied to the surface of the paper. The aim of coating is to improve the appearance like gloss and brightness, and printability like smoothness and ink absorption of the product. Much like the paper machine, coating process is also a relatively vulnerable process runnability-wise for malfunctions and quality defects. Re-reeler is positioned usually after the paper machine and after the coater with a function of ensuring quality upkeeping for a successful final processing. Calendering is the next production step after coating, where the paper web is leaded through a set of nips to be compressed and glazed. The purpose of calendaring is to achieve gloss and smoothness. It has to be taken into consideration that not all paper grades are calandered, it depends on the need of the customer. If calendaring is not carried out, the paper remains with a matt effect. Before being packaged the paper reel is broken down at winder into smaller and more suitable sized customer rolls according to the customers' orders. (Knowpap, 2020c)

As mentioned before, time efficiency-wise the paper machine is the dominant factor in the measurement, but within the area of area efficiency, all the process steps after the paper machine's reeler have effect on it. Web breaks and other quality issues and malfunctions create broke and thus decrease in the already produced, but yet to be packaged salable production.

The case company's paper mill produces 28 main grades paper. Mill's product portfolio has grades with different grammages and grades for different printing methods at the customer's end. As mentioned before, paper grammage is measured as gram per square meter and the weights of the final products of the mill vary between 30 g/m² and 120 g/m². The grades that the paper mill produces can also be classified with the printing method of the customer, as offset-paper and rotogravure-paper. Printing methods are not deepened into within this thesis work, but the destination of use of the produced paper is significant for the paper mill, as especially the coating materials differ between the two types. As also mentioned before, some grades are calandered for gloss purposes and some not, but with a general financial point of view there is not a significant difference between the two types. Certainly, if deepened into costs related to calander use, there could be discovered a subgroup of expenses, but within the scope of this thesis, the expenses related to calander use can be viewed as insignificant.

Inspection of the case company's paper mill's cost structure creates an understanding on the distribution of costs in a paper mill. In 2019 energy and fibre costs formed the biggest costs dimensions, as energy costs were 20 percent and fibre costs 23 percent of the total costs. Delivery costs and coating materials were both 15 percent and were followed by other variable costs with a seven percent amount of total costs. The costs related to fillers are minor in the case company's paper mill and thus the cost group in question didn't form even one percent of total costs. Based on the amounts mentioned above, variable costs related to the company's paper mill formed 80 percent of total costs. Fixed costs are composed of wages and salaries, maintenance, service charges and other fixed costs. Wages and salaries formed together 11 percent of total costs, maintenance three percent, service charges five percent and finally others fixed costs formed one percent of total costs. As mentioned before, variable costs formed 80 percent and fixed costs in turn 20 percent of the mill's total costs. The cost structure of the case company's paper mill is shown in Figure 13 below.

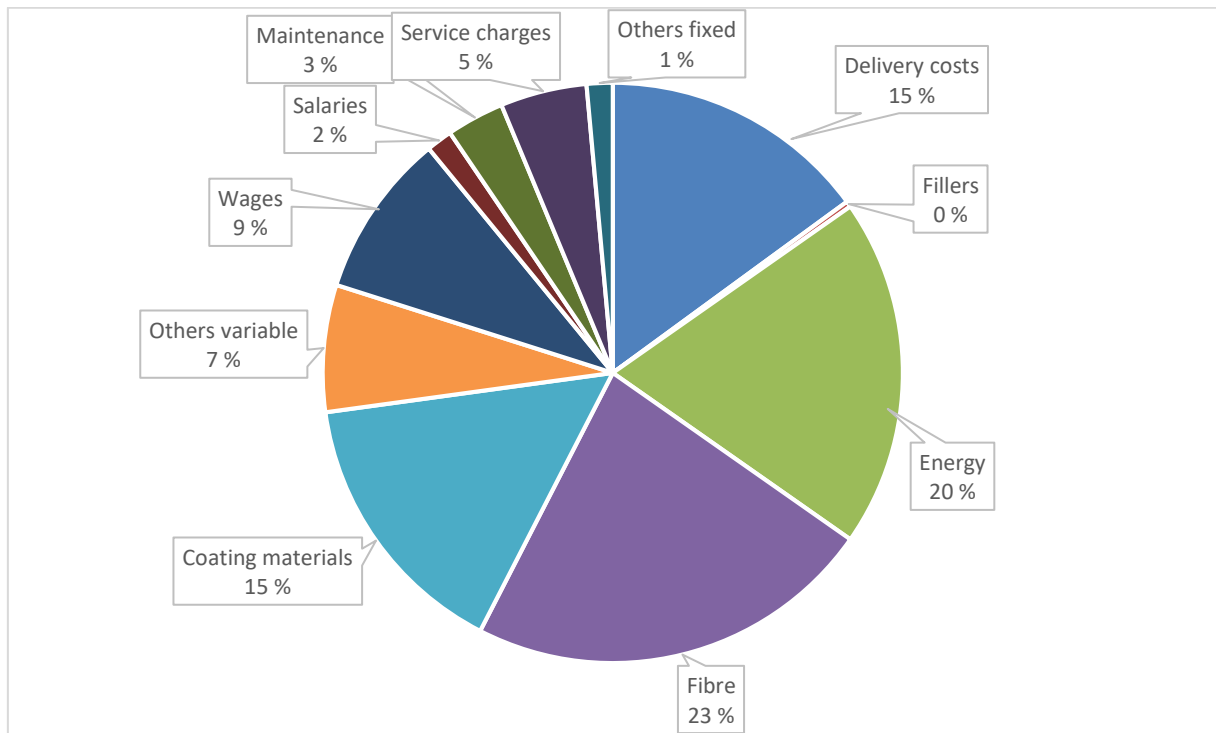


Figure 13 Cost structure of case company's paper mill in 2019

The case company of the thesis produced nearly 30 different paper grades in 2019, that can be divided into four main categories. The logic behind the categorization is based on the type of the produced paper, as different customers have different preferences and different printing methods. The paper grades within one category are similar in the terms of type and final use in the customer's end but can vary with paper grammage. The four main categories are named as "A", "B", "C" and "D" and are further subdivided into individual segments, that represent the actual paper grades. The subdivision is executed by naming each paper grade with its category identifier, for example as "A" and numbering further with an individual figure, for example as "A1". Category "A" has the largest set of paper grades the mill produces and is followed by category "B". Category "C" includes five different paper grades and category "D" only two, but it has to be taken into account, that the two grades are the most divergent from the other categories' grades. Table 2 below demonstrates the division of the case company's paper grades and Table 3 expresses the ratio of output weight and basis weight of every paper grade.

Table 2 Paper grades of the case company's paper mill

A		B		C		D	
A1		B1		C1		D1	
A2		B2		C2		D2	
A3		B3		C3			
A4		B4		C4			
A5		B5		C5			
A6		B6					
A7		B7					
A8		B8					
A9		B9					
A10							
A11							
A12							

Table 3 Ratio of weights of the case company's paper grades

A	Ratio of weights	B	Ratio of weights	C	Ratio of weights	D	Ratio of weights
A1	1,63	B1	1,72	C1	1,65	D1	1,59
A2	1,65	B2	1,80	C2	1,63	D2	1,41
A3	1,63	B3	1,55	C3	1,62		
A4	1,62	B4	1,50	C4	1,67		
A5	1,67	B5	1,52	C5	1,66		
A6	1,66	B6	1,50				
A7	1,43	B7	1,23				
A8	1,35	B8	1,19				
A9	1,34	B9	1,17				
A10	1,48						
A11	1,42						
A12	1,64						

4 PROFIT-MAKING ABILITY OF A PAPER MILL

The ability to make profit is an essential topic to be deepened into in every paper mill, as the prevalent situation in the paper industry becomes more challenging every year. Declining demand of graphic paper has resulted in overcapacity in the paper market and thus forced many paper manufacturers to shut down production lines in order to remain competitive. Profitability is one of the main determinants behind the closure decisions between the company's mills and thus a crucial factor to be maintained high. It can be concluded, that paper mills with higher profitability rates have a better safe marginal when it comes to possible closure decisions.

Firstly, paper-grade depended metrics are examined and culminated finally to hourly profits of each grade by taking into consideration the paper machine's net production rate, total efficiencies, variable and fixed costs and sales prices. Afterwards the focus shifts to investigating the key factors that affect the paper mill's ability to generate profit.

4.1 Paper grade-related measures

The case company produces a wide variety of different paper grades depending on the paper grammage and on the printing method and final use of the customer. Each paper grade produced in the paper mill has its own production related information that can be utilized to analyze and compare differences within the mill's product portfolio. Calculating differences in hourly profits amongst the product portfolio generates useful data for evaluating the current production. As mentioned before, actual production-related information or selling prices are not directly published in the subchapters, but a predefined coefficient is used to display the results in order to achieve comparable data and to inspect divergence between the mill's paper grades.

4.1.1 Saleable net production per hour

The amount of saleable net production per hour varies with every paper grade produced and it is the first field of investigation in order to achieve the hourly profits of the mill's paper grades. One of the main components of calculating the saleable net production is the production rate of the paper machine. The production rate of the paper machine is formed by combining the web

width of the winder, weight of the base paper, operating speed of the paper machine and adding a coefficient to convert grams per minute into tons per hour. The basis weight of base paper varies with each produced paper grade, as well as the operating speed of the paper machine. The web width of the winder is the only fixed dimension that every paper grade share. After calculating the production rate for every grade, total efficiency is taken under examination. Total efficiency consists of time efficiency and area efficiency, where time efficiency is tied to the paper machine and area efficiency to the rest of the paper mill's process. Time efficiency is specified as equal with every grade based on the actualized time efficiency of the paper machine in 2019. As mentioned before, area efficiency consists of length efficiency, trim efficiency and finishing efficiency. Length efficiency is the most varying measure between the produced paper grades and thus it is specified for every grade separately. Due to a standard level of trim efficiency and finishing efficiency between the produced grades, a yearly average of both efficiencies is applied evenly to each grade. After achieving time efficiency and area efficiency of every paper grade, total efficiency is calculated. As mentioned before, a ratio between the output weight and base paper weight is formed in order to convert the paper machine's production rate per hour into saleable net production rate per hour. The multiplication of these three dimensions equals to the saleable net production per hour. The saleable net production per hour can be seen as the net amount of tons the mill is producing for sale every hour, as efficiencies and other grade-specific variables have been taken into consideration. Table 4 below demonstrates the calculation of hourly saleable net production with example values. Table 5 below expresses the variation of saleable net production per hour between the mill's grades.

Table 4 Calculation of saleable net production

Saleable net production	16,7 t/h	Ratio of weights	1,5
		Total efficiency	77 %
Production rate at PM	14,4 t/h	Length efficiency	90 %
Web width at winder	6 m	Trim efficiency	95 %
Base paper weight	40 g/m ²	Finishing efficiency	95 %
Operating speed of PM	1000 m/min	Time efficiency	95 %

Table 5 Saleable net production of the mill's paper grades

A	Saleable net production t/h	B	Saleable net production t/h	C	Saleable net production t/h	D	Saleable net production t/h
A1	17,7	B1	21,3	C1	20,2	D1	19,6
A2	19,0	B2	22,9	C2	21,6	D2	15,9
A3	18,7	B3	15,4	C3	21,7		
A4	22,4	B4	17,3	C4	23,9		
A5	24,7	B5	18,6	C5	25,1		
A6	24,0	B6	17,8				
A7	15,7	B7	14,6				
A8	19,0	B8	16,2				
A9	19,5	B9	15,0				
A10	21,4						
A11	19,8						
A12	22,9						

The saleable net production rate per hour varies significantly between different grades. It can be observed that the paper grade with the highest rate of saleable net production is over 25 tons per hour and the grade with the smallest is 14,6 tons per hour. Especially cumulatively the difference is tremendous, as every hour over ten tons of saleable paper is produced more when comparing the two grades in question.

4.1.2 Variable costs

After figuring out the saleable net production amounts of every grade, the examination of variable and fixed costs takes place. The variable costs of each paper grade in the case company's paper mill can be divided into nine categories, that are known as chemical pulp, chemicals, coating, electricity, fillers, fuels, other production consumables, packing and wires and felts. The cost category of chemical pulp includes both mechanical and chemical pulp used in the paper machine. Chemicals, as the name suggests, include the chemicals needed for paper production and coating includes the raw-material needed for coating the product. Electricity includes the mill's electricity costs related to paper production and fuels include the consumption of natural gas and steam. In addition, a cost category known as fillers include the chemical components that are needed in the paper machine for production. Finally, packing includes the packaging related costs and wires and felts the variable costs related to the paper

machine's wires and felts. There is a minor cost group in addition called as other production consumables, that include minor production-related articles for instance. The logistics- and shipping-related costs are not included in the product-related variable costs, as the costs vary from customer and country. Delivery costs are dealt as a whole in the paper mill's income statement. Fixed costs are combined evenly to each grade and thus there is no variation between the paper grades. Specific variable costs of each paper grade are not shown in detail due to the nature of confidential and sensible information, but the distribution of variable costs amongst the mill's grades are expressed likewise in the chapter before, as a fixed predefined coefficient is added to the actual variable costs of every paper grade. Table 6 expresses the variable **cost's** distribution framework and table 7 the distribution of variable costs between the paper grades.

Table 6 Distribution framework of variable and fixed costs

Chemical pulp	25	€/t
Chemicals	20	€/t
Coating	30	€/t
Electricity	15	€/t
Fillers	5	€/t
Fuels	20	€/t
Other prd cons.	10	€/t
Packing	5	€/t
Wires and felts	20	€/t
Variable costs	150	€/t

Table 7 Variable costs of the paper mill's paper grades

A	Variable costs €/t	B	Variable costs €/t	C	Variable costs €/t	D	Variable costs €/t
A1	172	B1	166	C1	165	D1	171
A2	168	B2	165	C2	160	D2	169
A3	162	B3	173	C3	157		
A4	159	B4	166	C4	159		
A5	159	B5	163	C5	159		
A6	156	B6	171				
A7	167	B7	171				
A8	161	B8	168				
A9	159	B9	167				
A10	152						
A11	147						
A12	159						

As Table 7 portrays, there are no major differences in the variable costs between the mill's paper grades. The type and the grammage of the paper create only slight variations between the variable costs of the paper grades. It can be noticed that the variable costs in group "B" and "D" are slightly higher than in groups "A" and "C", but assumptions regarding the hourly profits can't be drawn yet.

4.1.3 Fixed costs

As mentioned before, fixed costs are not related to the activity level and thus handled as a fixed amount affecting every paper grade evenly. Adding a predefined coefficient to the actual amount of fixed costs per ton results in 74 EUR/t. However, in order to obtain a realistic distribution of fixed costs between produced paper grades in the paper mill, the examination will be made with an hour-based approach. By considering fixed costs as an hourly amount, there can be obtained a more realistic distribution of fixed costs, as the degree of net production per hour is taken into consideration. Hämäläinen (2015, 5782) states further, that fixed costs can be allocated to different paper grades based on the performance of the production in tons per hour. If the paper mill produces a paper grade with a low net production per hour, the fixed costs are relatively higher in terms of the amount of produced paper per hour, as a smaller amount of saleable paper is produced in comparison to a paper grade with a higher saleable net production per hour. Paper grades with a high net production per hour consume relatively a smaller amount of fixed costs, as more saleable output is produced in the same time span than with the paper grades with a small net production per hour.

In order to achieve the relative fixed costs of every paper grade, the amounts of fixed costs per hour of different paper grades must be calculated. By multiplying the average fixed costs per ton with the mill's total annual production, annual fixed costs are obtained. By further dividing the annual fixed costs with days and hours of a year, fixed costs per hour is achieved. As the aim is to achieve characteristic and grade related fixed costs for produced paper grades, the hourly average fixed costs are divided with each grade's saleable net production per hour. By these means, grade-specific fixed costs per ton are gained. Table 8 demonstrates the calculus behind grade-related fixed costs and Table 9 the distribution of fixed costs per ton of each paper grade produced in the paper mill.

Table 8 Calculation of grade related fixed costs

Fixed costs	74	€/t
Production/a	150000	t
Fixed costs €/a	11100000	€
Fixed costs	1267,1	€/h

Grade related fixed costs:	
Fixed costs €/h	1267,1 €/h
Saleable net t/h	16,7 t/h
Fixed costs	75,9 €/t

Table 9 Fixed costs of the paper mill's paper grades

A	Fixed costs €/t	B	Fixed costs €/t	C	Fixed costs €/t	D	Fixed costs €/t
A1	82	B1	68	C1	71	D1	74
A2	76	B2	63	C2	67	D2	91
A3	77	B3	94	C3	67		
A4	65	B4	83	C4	60		
A5	59	B5	78	C5	58		
A6	60	B6	81				
A7	92	B7	99				
A8	76	B8	89				
A9	74	B9	96				
A10	68						
A11	73						
A12	63						

Differences in the fixed costs of the mill's paper grades are evident, as the theoretical basis also suggested that grades with low performance in production amounts possess relatively higher fixed costs. The variances in the fixed costs between the paper grades can be considered especially cumulatively meaningful, as hourly differences rise up to 40 EUR per ton.

4.1.4 Selling prices

Selling prices are a sensible matter for every company and thus a topic mostly kept in secret. Every paper grade has a designed reference price used by the sales department, but actual

realized selling prices are affected by the sales region and from the customer relationships. The actual selling prices of paper grades produced in the case company's paper mill are not published within this thesis work, but in order to attain comparable information, a previously mentioned fixed and predefined coefficient is added to the actual selling prices. It must be noted that the selling prices are handled mainly as EUR/t in the case company. The selling prices of the case company's paper mill's products are shown in Table 10 below.

Table 10 Selling prices of the paper mill's paper grades

A	Selling price €/t	B	Selling price €/t	C	Selling price €/t	D	Selling price €/t
A1	378	B1	384	C1	369	D1	391
A2	375	B2	384	C2	366	D2	392
A3	372	B3	366	C3	363		
A4	369	B4	366	C4	363		
A5	369	B5	366	C5	363		
A6	375	B6	366				
A7	381	B7	402				
A8	375	B8	387				
A9	369	B9	372				
A10	369						
A11	375						
A12	369						

As seen in the Table 10 above, the selling prices of the paper mill's products are rather similar, but slight variation is notable. There are paper grades that stand out with higher selling prices, but before making any conclusions on the product-related profitabilities, the mentioned different dimensions have to be added up in the calculations of contribution margin per hour and profit per hour in order to obtain the actual situation of current profitabilities.

4.1.5 Contribution margin per hour

As expressed before, the function of contribution margin is to cover the fixed costs and generate profit and thus it is one of the first figures of expressing the product-related profitability. If the contribution margin doesn't exceed fixed costs, company is making loss. Contribution margin is investigated within this thesis with an hourly-perspective to achieve an equal comparison of

profitabilities between the produced paper grades. After achieving the hourly contribution margins the focus shifts towards hourly profits to gain absolute profitabilities of the mill's product portfolio. The hourly contribution margin is calculated by extracting variable costs from the selling price. After extracting paper grade's variable costs from the selling price, contribution margin is achieved. The aim is to gain the hourly contribution margin of each grade and thus the contribution margin per ton and the saleable net production per hour are multiplied together. This will result in hourly contribution margins of every paper grade produced. The path towards the hourly contribution margin is demonstrated in Table 11 below with example values. The differences between the contribution margins of the case company's paper mill's paper grades are assembled in Table 12 below.

Table 11 Calculation of contribution margin per hour

Selling price	370 €/t
-Variable costs	150 €/t
Contribution margin	220 €/t
Saleable net production	16,7 t/h
Contribution margin per hour	3667 €/h

Table 12 Contribution margins of the paper mill's paper grades

A	Contribution margin €/h	B	Contribution margin €/h	C	Contribution margin €/h	D	Contribution margin €/h
A1	4053	B1	5166	C1	4590	D1	4796
A2	4378	B2	5578	C2	4941	D2	3938
A3	4379	B3	3292	C3	4962		
A4	5230	B4	3845	C4	5420		
A5	5772	B5	4198	C5	5673		
A6	5850	B6	3852				
A7	3743	B7	3758				
A8	4500	B8	3952				
A9	4562	B9	3428				
A10	5160						
A11	5023						
A12	5356						

Table 12 expresses the hourly contribution margins of each grade and differences can be noticed. Some paper grades have a remarkably higher contribution margin per hour than others, but the ultimate comparison of profitabilities between the grades has to be carried out after hourly profits are cleared up.

4.1.6 Profit per hour

The product-level profit comparison of production outputs is an essential activity in every company. The more profit a company is generating with its products, the more competitive and profitable the company is. The hourly profit of a paper grade describes the profit a company is generating every hour when producing the grade in question, as all costs related to the product are cut out. Hourly profit is closely bound to the hourly contribution margin, as cutting fixed costs from contribution margin leads to profit. Calculating profit per hour follows the same logic as calculating contribution margin per hour, where a set of costs is extracted from a baseline. Extracting fixed costs per ton from contribution margin per ton leads to profit per ton. Multiplying the profit per ton of a paper grade with the hourly saleable net production of the same paper grade leads to hourly profit of the paper grade in question. The calculation of profit per hour is demonstrated in Table 13 below with the example values continuing from chapters before. Table 14 expresses the hourly profits of the mill's paper grades, that the paper mill generates every hour when producing the paper grade in question.

Table 13 Calculation of profit per hour

Contribution margin	220 €/t
- Fixed costs	75,9 €/t
Profit	144,1 €/t
Saleable net production	16,7 t/h
Profit per hour	2402 €/h

Table 14 Hourly profits of the paper mill's paper grades

A	Profit €/h	B	Profit €/h	C	Profit €/h	D	Profit €/h
A1	2448	B1	3561	C1	2984	D1	3191
A2	2773	B2	3973	C2	3335	D2	2332
A3	2774	B3	1687	C3	3356		
A4	3625	B4	2240	C4	3814		
A5	4167	B5	2593	C5	4067		
A6	4244	B6	2247				
A7	2137	B7	2153				
A8	2895	B8	2346				
A9	2957	B9	1823				
A10	3555						
A11	3417						
A12	3751						

As seen in the previous chapter, differences between the paper grade's hourly contribution margins were notable. Differences in hourly profits reflect the same result, as the levels of profit per hour alternate significantly through the mill's product portfolio. A remarkable disparity is perceptible as the difference between the paper grade with the highest profit per hour and with the lowest profit per hour is over 2,500 EUR.

4.2 Key factors affecting the paper mill's profit-making ability

The ability to make profit culminates on the profitabilities of the company's product offerings, as the main activity for a paper company is to generate profit with its production outputs. The chapter above culminating in hourly profits of different paper grades adduced the main factors that influence the generation of profit in a paper mill. The main key factors can be classified into four segments, that can be seen as the saleable net production per hour, selling price, variable costs and fixed costs. Saleable net production per hour breaks down further into production rate of the paper machine, ratio of weights and total efficiency. The four factors are the main influencers, because divergence within the mentioned components cause alteration in the generated profits. To obtain an understanding on the impact of the four factors to hourly profit, a sensitivity analysis is carried out. The sensitivity analysis is carried out with a ten percent change in one segment at a time and finally comparing the profit per hour to the

reference point, where all factors are stable. Saleable net production and selling price will be increased by ten percent and variable and fixed costs will be decreased by ten percent at a time. The impact of the increases and decreases are seen in the Table 15 below with the values of the paper grade “A1”.

Table 15 Sensitivity analysis of the factors affecting profit per hour

Sensitivity analysis		Profit €/h	Saleable net production t/h	Selling price €/t	Variable costs €/t	Fixed costs €/t	Profit €/t	
	Reference	2203	17,7	378	172	82	124	
+ 10%	Saleable net production	2423	19,5	378	172	82	124	10 %
+ 10%	Selling price	2873	17,7	415,8	172	82	162	30 %
- 10%	Variable costs	2508	17,7	378	155	82	142	14 %
- 10%	Fixed costs	2348	17,7	378	172	73	133	7 %

The results of the sensibility analysis in Table 15 state that the most influential factor in the formation of profit per hour is the selling price. When increasing the selling price by ten percent, profit per hour increases by 30 percent. The second most influential factor are the variable costs, as the decrease of variable costs by ten percent results in 14 percent increase of profit per hour. Increasing saleable net production per hour by ten percent increases the hourly profit by ten percent also and the decrease of fixed costs by ten percent results in seven percent increase in profit per hour. The impact of increasing and decreasing one factor at a time differs with different paper grades, but a clear conclusion can be drawn on the major significance of the selling price to the hourly profit. It must be noted that multiple coefficients were used in the previous subchapters that cause the difference in the hourly profit of paper grade “A1” between the current and previous chapter. However, the difference doesn’t affect the results, as the previous chapter generated comparable data of hourly profits between the grades and the current chapter gained data with the relation of the factors influencing the generation of hourly profit within one paper grade. As mentioned before, saleable net production is affected by the net production rate of the paper machine and by the total efficiency. The production rate of the paper machine can be increased by increasing speed or the weight of the base paper, as the width of the paper machine reeler is always fixed. However as mentioned before, constant increasement of other factor will lead to limitation of the other factor, as the capability of the paper machine will come to a limit. Total efficiency is the other dimension that can be increased

by the optimization of the production line, as lower waste of paper within the process means higher efficiency.

As the theoretical section also underlaid, the selling price of paper is the most meaningful factor in the generation of profit in a paper mill. The significance of costs was known also, but in the case company's paper mill the magnitude of variable costs is more significant regarding the generation of product-related profit than of the fixed costs. The quantity of saleable net production is a major factor also and combined with efficient logistics functions and delivery volumes would result in major profit increase.

5 RESULTS AND ANALYSIS

One of the main goals of every company is to maximize the ability of generating profit with its products. Continuous and comprehensive inspection of profitabilities amongst the company's production outputs is an important task to be executed, as recognizing the products least profitable leads to a possibility of potential optimization of the product portfolio. Clear differences were discovered in hourly profits between the case company's paper mill's product portfolio as total efficiencies, production rates of the paper machine, selling prices and variable and fixed costs of each grade were taken into account. The hourly profits are examined more closely in chapter 5.1, whereas chapter 5.2 carries out an approximate calculation for demonstrating the effect of the possible production portfolio optimization.

5.1 Comparison of hourly profits

The differences were clear between the hourly profits of the mill's paper grades when taken into consideration the production-related capabilities and realizations of the year 2019. Table 16 expresses the ten paper grades with the highest hourly profit with the color green, the ten paper grades with the lowest hourly profit with the color red and the rest of the paper grades in between with the color gray.

Table 16 Comparison of the profit per hour between the produced paper grades

A	Profit €/h	B	Profit €/h	C	Profit €/h	D	Profit €/h
A1	2448	B1	3561	C1	2984	D1	3191
A2	2773	B2	3973	C2	3335	D2	2332
A3	2774	B3	1687	C3	3356		
A4	3625	B4	2240	C4	3814		
A5	4167	B5	2593	C5	4067		
A6	4244	B6	2247				
A7	2137	B7	2153				
A8	2895	B8	2346				
A9	2957	B9	1823				
A10	3555						
A11	3417						
A12	3751						

As seen in the Table 16 above, paper grade group “A” holds the highest amount of the most profitable paper grades regardless of being the biggest paper grade group. Group “B” and “C” both include two of the most profitable paper grades, but group “D” none. The overall profitability of the paper grade group “C” can be seen as the highest of all groups, as none of the grades in group “C” are amongst the grades with lowest hourly profit. The clear identification and partition of the most and least profitable paper grades generates a clear logic for the possible product portfolio optimization.

For gaining a deeper explanation for the occurred differences, a comparison of the five most profitable and five least profitable paper grades is carried out. Averages of saleable net production per hour, selling prices, variable costs and fixed costs were calculated for the two groups and then compared with each other. As Table 17 below expresses, the hourly amount of saleable net production and fixed costs are the two factors that differ the most between the paper grades with the highest hourly profits and with the lowest hourly profits. As it was mentioned before, paper grade-wise high fixed costs are a consequence of low degree of net production per hour and thus a logical difference in the comparison. Five paper grades with the lowest hourly profits possess a 35 percent lower rate of saleable net production per hour and averagely 55 percent higher fixed costs. As it is known that the saleable net production per hour is dependent on the production rate of the paper machine and on the total efficiency of the paper mill line, the two mentioned dimensions are the first steps on the path to financial improvements. For increasing the production rate at the paper machine of the five least profitable grades leads to a somewhat challenging situation, as the basis weights and the width of the winder are invariable, therefore the only dimension that can be affected is the operating speed. As mentioned before, increasing the operating speed of the paper machine is not always possible due to the paper machine’s paper grade-related speed limitations. If the operating speed of the paper machine can’t be increased to the pursued and desired level, major modifications and investments are needed. Total efficiency is the other dimension that can be affected in order to increase the saleable net production. Enhancing and focusing on the paper machine’s time efficiency and on the area efficiency of the rest of the process will ultimately lead to higher total efficiency and thus to higher saleable net production.

Variable costs are six percent higher within the grades with the lowest profit and interesting enough, selling prices are a few percent higher also in the mentioned grades. Continuous cost

control is essential for the mill's profitability and thus a topic to be deepened into especially within the mill's least profitable paper grades. Table 17 expresses the comparison of the five most profitable and five least profitable paper grades and the percentual differences between the main dimensions.

Table 17 Comparison of the five most profitable and least profitable paper grades

Average	Saleable net prod. t/h	Selling price €/t	Variable costs €/t	Fixed costs €/t
Highest profit	24,1	370,8	159	60
Lowest profit	15,6	377,4	169	93
Difference %	-35 %	2 %	6 %	55 %

5.2 Optimization of the product portfolio

Previous chapters demonstrated that there are significant differences in the hourly profits between the case company's mill's paper grades. One way of increasing the profit-making ability of the case company's mill is with an optimization of the product portfolio. The fact that there are major differences in the hourly profits allows clear results for the possible optimization. The basis for the optimization of the product portfolio is initiated with a calculation of the average hourly profit of all produced paper grades. For gaining perspective, the average profit per hour of the ten least profitable paper grades is carried out afterwards. Finally, the potentially attainable profit per hour with the optimization of the product portfolio with the ten most profitable paper grades is calculated. The mentioned calculations are seen in table 15 below.

Table 18 Comparison of average profit per hour

	Highest profit €/h		Lowest profit €/h	Average of all grades €/h
A6	4244	B3	1687	3016
A5	4167	B9	1823	
C5	4067	A7	2137	
B2	3973	B7	2153	
C4	3814	B4	2240	
A12	3751	B6	2247	
A4	3625	D2	2332	
B1	3561	B8	2346	
A10	3555	A1	2448	
A11	3417	B5	2593	
Average	3817	Average	2201	

The average profit per hour of all grades of the mill combined is approximately 3,000 EUR/h, whereas the average hourly profit of the ten grades with the lowest profit per hour is around 2,200 EUR/h. By centralizing the production of the paper mill to the ten paper grades with the highest hourly profit increases the average profit per hour to over 3,800 EUR/h. The significance of the optimization of the product portfolio can be expressed with two examples. Assuming that the paper machine produces paper 330 days a year with an time efficiency of 95 percent will lead to a total of 7,524 hours of production. The first example considers the optimization of the product portfolio by centralizing the production to the ten paper grades with the highest profit per hour. The approximate difference between producing 7,524 hours of the current portfolio's paper grades and producing ten of the most profitable paper grades is over 5,7 MEUR. Focusing and producing only the ten most profitable paper grades would generate over a 26 percent increase in the annual profit generated. The other estimate considers the optimization of the product portfolio by cutting out the ten paper grades with the lowest hourly profits. The yearly difference surpasses 3,2 MEUR and generates a 15 percent increase in the generated profit regarding the saleable output. However, it must be noted that the calculations of the possible product portfolio optimizations are rough average estimates, that are only to bring indicative information of the impact an optimization of the product portfolio would induce. The potential optimizations consider only the viewpoint of the mill, where the

optimization is based solely on the hourly profits of the paper mill's grades. The calculations of the potential optimizations are seen in Table 19 below.

Table 19 Optimization of product portfolio

Optimized product portfolio – ten most profitable paper grades		Optimized product portfolio – ten least profitable paper grades cut out	
Days available	330 d	Days available	330 d
Hours	7920 h	Hours	7920 h
Time efficiency	95 %	Time efficiency	95 %
Production time of PM	7524 h	Production time of PM	7524 h
Profit €/h	3817 €/h	Profit €/h	3469 €/h
Current average profit €/h	3016 €/h	Current average profit €/h	3016 €/h
Difference (€/a)	6 030 799 €	Difference (€/a)	3 408 108 €
Difference (%)	26,6 %	Difference (%)	15,0 %

6 DISCUSSION AND CONCLUSION

Due to the current situation in the paper market, the significance of profit-making ability has been emphasized in the paper mills. The higher the profit-making ability of the paper mill is, the more competitive and profitable the mill is. The profit-making ability of a paper mill within its core activity can be evaluated by calculating the hourly profits of the paper grades the mill produces and analyzing the results within. The discovery of the differences in the hourly profits amongst the mill's production portfolio enables a possibility for the product portfolio's optimization and thus to an increase in the profit-making ability. By centralizing the production to the paper grades with the highest profit per hour would gain remarkable annual financial benefits. However, the optimization of the product portfolio can be seen as a slightly idealistic event in the pursuit of higher profitability, as the decision of the produced paper grades is not in the hands of the mill itself. Nevertheless, with the calculations of the actual hourly profits of each paper grade and the potential benefit that could be achieved by optimizing the product portfolio creates a solid argument and foundation for lobbying, as the production-related information and actual realizations of efficiencies and capabilities have been taken into consideration. By optimizing the product portfolio, the profit-making ability and thus the profitability of the paper mill would increase, as well as the profitability of the company.

As it became clear in the previous chapter, the selling price of the paper is the most meaningful factor regarding the profit-making ability of the paper mill. Previous studies related to the topic support the argument about the significance of the selling prices to the overall profitability. However, selling prices are not under the influence of the paper mill and thus a topic not to be only focused on. Price decreases due to oversupply in the paper market are topics handled in the company level, whereas the focus in the mill must be within its production related matters. The two most meaningful factors the mill has effect on are variable costs and saleable net production. By constant innovation and examination of alternative options for decreasing the product-related costs increase the hourly profit. Previous studies proved that focusing on raw-material and energy purchasing is a topic not to be ignored, as potential cost savings will help to increase the mill's financial performance. Increasing the saleable net production by increasing the production rate of the paper machine or by improving both area and time efficiency leads to higher profit-making ability as well. As Hämäläinen (2011b, 945-955) emphasized, combining paper quality with an efficient paper machine line and improving

economic efficiencies will lead to increased financial performance. Even though fixed costs possess the least effect on profit generation in the case company's paper mill, it is nonetheless a topic that should not be forgotten. As previous studies highlighted, fixed costs hold clear correlation in the generation of profit, especially when paper prices decrease. Focusing on the costs and revenues of the mill creates the most rapid pathway towards better economic performance, as major productivity increases require investments and thus more time.

Previous studies proved the relevance of customer profitability and logistics functions to the overall profitability, opening an important field for follow-up research. As the paper-grade related profitabilities are now known, investigating further the link between the known profitabilities, current customers, logistics and transportation costs could adduce new aspects to the inspection of the paper-grade related profits and thus new information for the optimization of the paper mill's portfolio. Unprofitable customer relationships from the mill's point of view could be revealed also. In addition, inspecting the hourly profits of produced paper grades in every paper mill of the case company would create a broad view on the current situation regarding the profit-making ability of the case company's paper mills. The optimization of product portfolios between the case company's paper mills would ease, as comparable data between the paper mills would be available. As mentioned before, constant product development is one way of increasing economic performance and thus an investigation on the possibility of producing alternative paper products or even paperboard in the case company's paper mill would be intriguing.

It must be noted that the optimization process is not a simple task, as paper mills within the company can differ with their production capabilities. It is possible that a vastly ordered paper grade can be produced solely in one of the company's paper mills, which leads to a situation where alteration of the produced grades between different paper mills is not possible. As the demand of paper is decreasing, paper grades with low profitability are nonetheless important for the paper mills in order to maintain operating rates as high as possible. The contribution that the paper mill can make to the mill's profit-making ability is the effort to lower manufacturing costs, especially product-related variable costs and to maximize the amount of saleable net production by increasing total efficiency or increasing the speed of the paper machine as much as possible. As it is known, when the paper prices decrease, the meaning of cost control in manufacturing and transportation increase remarkably.

As concluding remarks, the optimization of the case company's paper mill's product portfolio would bring significant benefits to the paper mill, as well as to the company itself. On top of the possible product portfolio optimization, the mill must continue cutting costs, increase productivity in the long-term with investments or in the short-term by increasing production efficiencies or increasing the saleable net production rate by rising the speed of the paper machine as much as possible.

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