The Cost Efficiency of the Supply Chain in a Nordic Paper Mill: A Case Study

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This paper focuses on examining the cost efficiency in a Nordic paper mill. Recent years this topic has been under wider interests especially in Finland. The economic efficiency per machine hour is an essential research area from the point of supply chain. This topic has been scantily examined in previous journals and discussions. Our purpose was to examine if the development of economic efficiency might give any explanations to vast mill closures particularly in Finland after 2002. The empirical data was retrieved from a very large paper mill, which is exporting 90 % of the production. The research data consists of machine hours, variable and fixed costs and contribution margins and covers the years between 2002 and 2008. The study presents interesting results how economic efficiency of supply chain has developed during the research period. Our findings demonstrate that cost efficiency per machine hour have been under serious pressures during past years in the case mill. Additionally this empirical study concludes that in a supply chain (SC) examination is worth to make by utilizing mill specific time series data in order to yield valid and specific results.

1. Introduction

The purpose of this case study is empirically to examine the cost efficiency of the Nordic paper industry. Our research is based on detailed longitudinal data from the large integrated mill. This economic data covers on a monthly basis years 2002-2008. We studied how the mill succeeded to maintain the efficiency to stay competitive. Our interest was also to reveal if the development of the costs efficiency could explain for its part the closures of paper machine lines during the past years in Finland.

In the paper industry, cost efficiency of supply chain has been examined only marginally in the Nordic countries, particularly with empirical mill data. One reason for this absence might be the lack of a paper mill data, which is not easy to acquire. Only few articles have been published in journals (see e.g. Arlbjørn, Jonsson and Johansen, 2008; Elmuti, 2002; Koskinen, 2009, b; Lähtinen, 2007). Hämäläinen and Tapaninen (2008 and 2010)) demonstrated that smaller delivery shipments lower the margins and that there are large monthly variations in paper deliveries at the country and also customer level. These heavy fluctuations are probably one reason for the inefficient logistics and costly warehousing, which Koskinen (2009, a) and Koskinen and Hilmola (2008) addressed in their studies. The need of constantly improve performance has become more acute in all industries but especially in manufacturing industries due to rapid demand and costs changes in the market. This is particularly valid in the European paper industry due to the decreasing demand for printing paper (RISI 2009), which constrain the producing units to all the time find more performance in whole production machinery.

In Finland the paper industry is still a significant sector and its share in the total exports

is nearly 20 % in 2008. The Finnish board and paper mills export around 13 million tons of paper products valued at EUR 10 billion (2008) yearly, mainly to Europe (Forestindustries, 2009). The Finnish paper companies have made enormous efforts to solve economic problems by various means, such as closing paper machines, rebuilding some machine lines and acquiring inexpensive pulp from South America. The years covered by this study have been extremely difficult particularly for the Finnish paper industry (Tappi, 2008; Forestindustries, 2009).

In this study we are exploring economic efficiency in euro per machine hour, which provides a fresh research angle for discussions. In our examination, the terms 'anticipatory', 'budget', 'estimations' and 'forecast' are used synonymously to describe planning functions. Comparably, the terms 'reported, 'actual' and 'realized' show how efficiency actually developed in reality. We placed some research questions to reveal economic efficiency particularly on the paper machine basis:

- Was mill been able to anticipate development of cost efficiency accurately?
- Could the mill make any improvements in economic efficiency during research period?
- Have the machine lines and grades deviations between each other in hourly costs efficiency?
- How does efficiency can be observed in revenues in a grade level?

The structure of this study is as follows: the theoretical perspectives that contributed to the composing of this paper and the case study features are presented in section 2; our ideas of the costs efficiency and paper mill characteristics in this paper are presented in section 3; empirical material sources are addressed in section 4; in the empirical section 5, we present the results and explain with different with costs factors how our integrated multi-machine line mill has contrived to develop economic efficiency ; and finally in section 6, the conclusions discussions of the study are presented, while in section 7 we suggest some considerations and ideas for further studies.

2. Background

In this section we oriented ourselves in some theoretical discussions, which offered ideas to compose this study regarding efficiency. Measuring the performance of supply chain and manufacturing has become a very important topic (Griffis et al. 2007) and understanding performance has long been of interest to logistics and supply chain researchers. Supply chain management helps achieve competitive advantages through managing the entire flow of materials and manufacturing. Many studies have focused on manufacturers' attempts to build up processes to more efficiently and effectively manage the purchasing and supply function (Harwick 1997; Carter et al. 2000; Gardner, 2001). Youngdahl (2000) described elements as necessary components in any supply chain effectiveness: planning and making. Elmuti (2002) addresses that regardless its importance and popularity in the academic press, there is little empirical research that investigates SCM's impact on the firm as a whole. Consequently, more information is

needed to understand successful or unsuccessful supply chain management. Supply chain management tries to remove non-value-added activities and increase firm's revenues (Leenders and Fearon 1997).

Brewer and Speh (2000) note that supply chain efficiency traditionally measures "hard facts" such as costs and manufacturing volumes in time unit. Mentzer and Konrad (1991) defined performance as effectiveness and efficiency in performing supply chain activities. Langley and Holcomb (1992) argue that excellence in supply chain performance requires superiority when compared to competitors (i.e., differentiation). Supply chain performance is multi-dimensional and is defined as the degree of efficiency associated with the accomplishment of manufacturing activities (Bobbitt 2004; Cameron 1986). The SC function has long been under pressure to demonstrate its contribution to organizational performance (Rutner and Langley 2000). Previous research has shown that excellence in performing supply chain activities and capabilities is associated with superior organizational performance (Lambert and Burduroglo 2000; Lynch, Keller, and Ozment 2000). In attempting to drive performance improvements, managers often struggle with multiple and sometimes conflicting objectives (Steers 1975). For instance Ozdamar and Birbil (1999) reported that energy costs constitute large part of the unit production cost in many manufacturing companies.

A lack of understanding logistics functions (e.g. Christopher 2000) may have implications for organisational efficiency and discourse. Töyli et al. (2008) note that surprisingly little empirical evidence has been presented of a relationship between financial and logistics performance in general. Neither do the studies discuss the efficiencies in the paper industry. Fogelholm (2000) stresses that in a paper mill a paper machine is considered as bottle neck and all the efforts should be focused to the improve the efficiency of machinery. Koskinen (2009, b) addresses that the performance of exporting logistics in the paper industry is not efficient.

The published and mainly theoretical articles have omitted to present economic efficiency especially in the paper industry. However researchers address that there should be more empirical oriented studies in supply chain discussions. In this context, this study reveals from a manufacturing perspective how a mill has managed develop economic efficiency. Therefore this examination for its part fills in the gap in theoretical discussions on logistics and supply chain management.

2.1. Some considerations of a case study as a research method

In this section, we take a brief look at the case study as a research method for the examination of Finnish paper industry through a single large paper mill. Yin (2003) in particular emphasizes that there really is a distinctive need for conducting case-study research, because there is an inquisitiveness to understand complex phenomena. A case study can be defined as an empirical inquiry that investigates a contemporary phenomenon within its real-life context and where the investigator has little control over events (Yin, 1993, 2003). Eisenhardt (1989, p. 534) defines a case study as "a research strategy which focuses on understanding the dynamics present within single settings."

The case study aims at gaining an understanding of the phenomenon studied using a limited number of observations (Hilmola, Hejazi and Ojala, 2005) and extrapolating from a case to another instance can be dangerous (Stuart et al. 2002). An examination targeting the paper industry might be worthwhile and even interesting, if and when it is approached through the detailed mill data, instead of corporate level aggregated data from annual reports. Flyvbjerg (2006) points out that case study research can provide micro-economic discoveries that are not possible to acquire through other methods (McCutcheon and Meredith, 1993). Lewis (1998) considers that in case studies, their iterative triangulation employs systematic iterations between literary review, interviews, case evidence, and intuition. In this study, we conducted some interviews, which were particularly informative about how the case mill carries out the forecasting process and how the actual figures are compared with the forecasted ones. The case data can be considered, in a sense, as opposite to the purely theoretical models used in economically oriented studies. In this matter, Martin (1999) and Scott (2004) encourage to use an empirical approach in the examinations, because it can reveal hidden and actual factors in the real world of economics.

The results obtained in these settings and based on the theory can usually be generalized to some extent. Dubois and Araujo (2007) consider that the case selection is an important methodological decision to reveal poorly known phenomena. It is generally recognized that cases usually are not selected randomly, and especially in studies of this type, random selection cannot be considered as the only way of acquiring the source data. The mill used in this study was selected among the Finnish mills on the grounds that it was seen to be a typical representative of the Finnish paper industry with multiple machine lines. Consequently, as the research object was selected a large printing paper mill that is located in Southern Finland and that exports on an average 90% of its production, mainly to Europe.

3. Economic features of a paper mill

A paper mill has continuous manufacturing process and machinery is running seven days and 24 hours round a year besides some service stoppages and unplanned breaks. The supply chain system covers a complicated mix of material preparation, production, converting, cost functions and information flows from customers in different markets to the mill and back to the customers (see e.g. Lehtonen, 1999; Fogelholm, 2000). All the raw materials are ordered beforehand and delivered just-in-time to a mill. Correspondingly paper demand the mill strives to understand detailed circumstances and competition in the paper market from the perspective of grades and customers. After the mill has accepted the demand volumes derived from different geographical markets by sales offices, the budgeted supply chain/target costs are calculated monthly by summing up all the manufacturing costs based on the machine specific grades used in the sales estimations. The material and energy costs are forecasted together with the suppliers to acquire the best possible knowledge of costs. Reporting of the realized monthly figures is normally based on customer invoices, realized monthly production tons and supply chain costs in different machine lines. The actual material costs, such as fibre, energy and chemicals, are

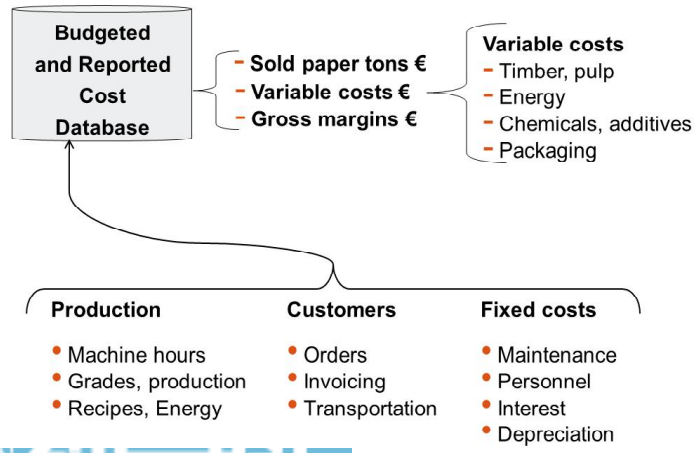
derived from the purchasing database monthly and allocated to the grades manufactured during the reporting period. In this process, grade recipes are used to allocate the material costs and consumption figures in the machine lines and grades.

In terms of the demand, the SC efficiency in the paper industry is at the core of the success of the whole business; there is the lowering demand and paper prices, the grades must be more or less pushed to the markets (Diesen, 1998; Forestindustry, 2009; Hämäläinen and Tapaninen, 2010). Therefore economic efficiency and cost perspectives have become even more pressing in recent years, especially with soaring energy prices. Paper mills have put a lot of efforts to improve cost effectiveness in paper machine lines during years. Time based data is valuable and essential in the examination development of performance of paper machine lines, which is otherwise somewhat impossible to highlight. A paper machine as most expensive device is normally a bottle neck in a paper mill and therefore the main objective in efficiency discussions.

4. Empiric data and survey methodology

In this section, we take a closer look at how the research data was obtained from the mill database and how this time period data was analysed. The budgeted and reported empirical data covers the period between 1/2002 – 12/2008. We retrieved the data from the case mill's manufacturing and economical database (Figure 1). This database is continuously updated by the sub-systems, which are delivering controlled numerical values from different supply chain processes. This extensive quantitative database is a depository of the mill's past, present and target production and economic data, which is verified by the auditors. The data contains paper machine hours, production times, fixed and variable costs as well as margins. These numerical reliable values have been transformed into a single large dataset and within the dataset the processed figures are proportionate and valid.

Fig. 1 The origin of the research data: the case mill's basic data sources and the mill database



Performance in a paper mill and in a single machine line can be measured in many different methods (Fogelhom, 2000). When researching efficiency of supply chain, the outputs per machine hour are particularly essential and commensurate attributes:

1. Saleable packed net tons per machine hour (tons/h).

2. Unit costs and margins per saleable packed net ton (€/ton).

3. Costs per machine hour (€/h).

In this study we selected to explore costs and margins in euro per machine hour which enables relevant comparisons between machine lines and grades. The calculation results are shown as ratios to maintain business confidentiality, and the key objective was to determine the relevant research variables. From the viewpoint of triangulation, we conducted a number of interviews with the financial management of the case mill and one foreign mill. These interviews helped us significantly to focus our research on relevant topics and to understand the phenomenon of economic efficiency is a mill.

The research data was transferred into Excel spreadsheet, which was used to draw the figures from the raw data. All the economic figures were reported for research purposes only. Due to reliable and valid mill data, this examination enables us to make some generalizations of the research results. These results could contribute to the manufacturing costs research concerning Nordic paper mills. In this examination, we clearly distance ourselves from the less interesting mill-level average values, which obscure the supply chain and economic specialties.

5. Results

In this section, we present with different empirical variables how the economic efficiency has developed in the case mill. Accurate cost budgeting per machine hour is an important topic for a paper mill. The budgeting is made beforehand on the grade and the machine line basis and later summed up on the mill level. The composed figures help us to demonstrate how planned and reported efficiency developed during the study period. The empirical results show that the variable and fixed costs per machine hour have developed rather uniform in the explored two paper machine lines PM 4 and PM 6 during time series (Figure 2 and Figure 3). In the PM 4 during 2002 and 2003 the mill budgeted higher variable costs per machine hour that actually were realized. The variable costs developed quite moderately on the machine hour level until 2007, when the costs started to increase rabidly and more than forecasted. Our empirical data demonstrates that the mill can forecast relatively well the fixed costs even there are some fluctuations between years. In PM 6 the actual fixed costs per machine hour have not been increased and this might have helped the budgeting process to anticipate costs accurately. Comparably variable costs in euro per machine hour have increased, which addresses that economic efficiency has lowered clearly. The variable costs have increased substantially 7000 €/machine hour up to 9000 €/machine hour, which is a remarkable increase. It is a burdensome increase especially when sales prices have lowered (RISI, 2009; Forestindustry, 2009).

We also studied economic efficiency on the grade level. Same paper qualities but different

base weight have somewhat similar raw material and cost structure, which can be observed in the Figure 4. The figure presents economic efficiency of one important grade with two base weights (70 gr and 90 gr) produced in PM 7. The figure demonstrates that the variable costs have increased significantly during past years. After 2006 the cost efficiency has rabidly lowered and this is rather challenging to compensate by any means.

Fig. 2 Development of the budgeted and reported variable and fixed costs per machine hour in PM 4 during 2002-2008, 84 months (in ratio).

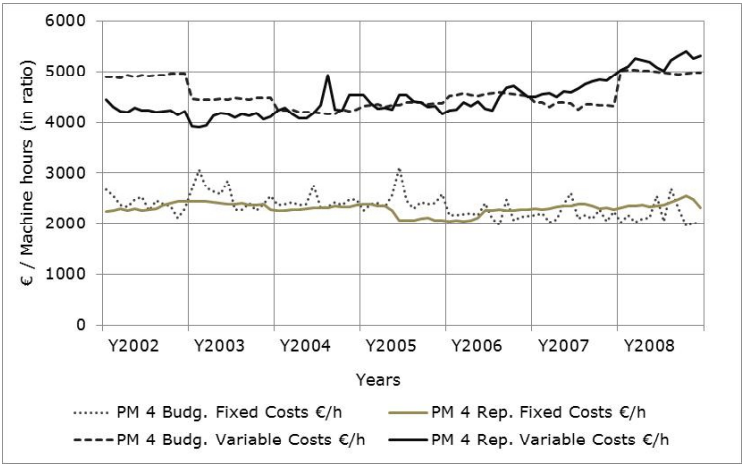
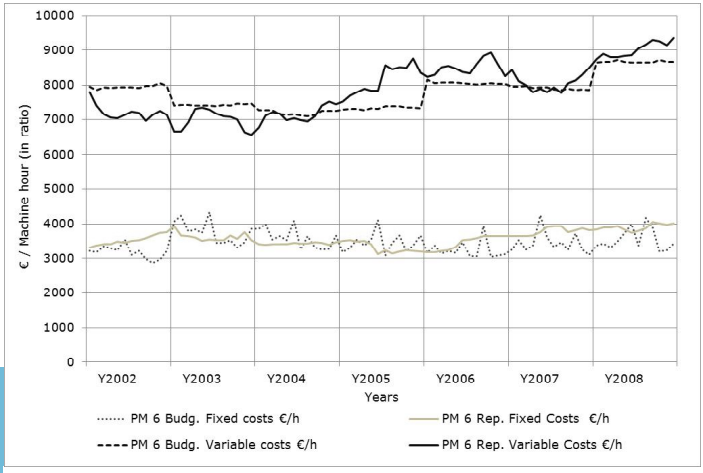


Fig. 3 Development of the budgeted and reported variable and fixed costs per machine hour in PM 6 during 2002-2008, 84 months (in ratio).



The case mill consumes mainly two different energy types; electricity and steam and sometimes natural gas. Paper machine consumes enormous amounts of energy, especially in the Nordic mills, which usually have own pulp making units like pressure ground wood machineries. These devices have large electric motors, which can consume electricity as much as the paper machines. Figure 5 presents development both total costs in PM 6 in

Fig. 4 Development of the variable costs with 70 gr and 90 gr in €/ hour in PM 7 monthly 2002 - 2008, 84 months (in ratio).

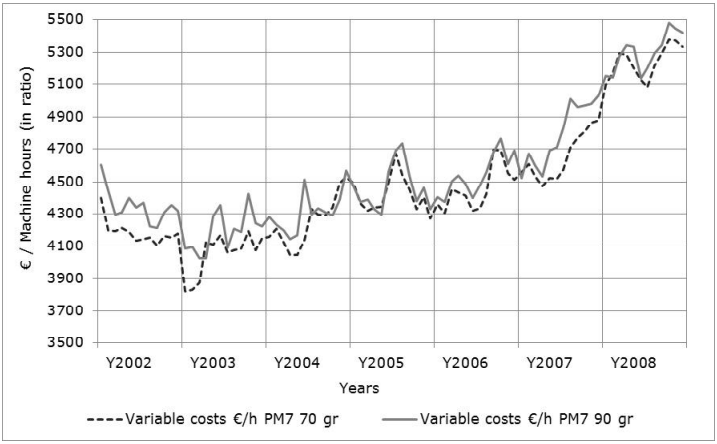
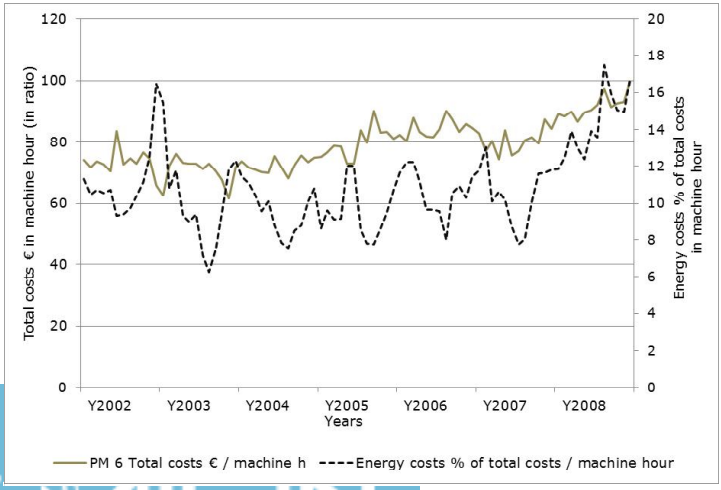


Fig. 5 Total costs € per machine hour and % proportion of energy costs of total costs in PM 6 monthly 2002 - 2008, 84 months (in ratio).



euro per machine hour and also percentage of energy costs of total costs per machine hour. Proportion has varied between 7 and 12 %, even the yearly fluctuations have been large. Past years energy costs have reached round 15 % of the total costs. Efficiency presented in total costs and separately in energy costs has lowered regardless paper mills continuously try to make machineries more effective with new investments. Intensive efforts have been focused on the proper maintenance of facility towards minimizing energy losses e.g. when removing water from paper web in the drying section. In the

Fig. 6 Development of contribution margin per €/machine hour in PM4 and PM6 with same base weight (65 gr) monthly 2002 - 2008, 84 months (in ratio).

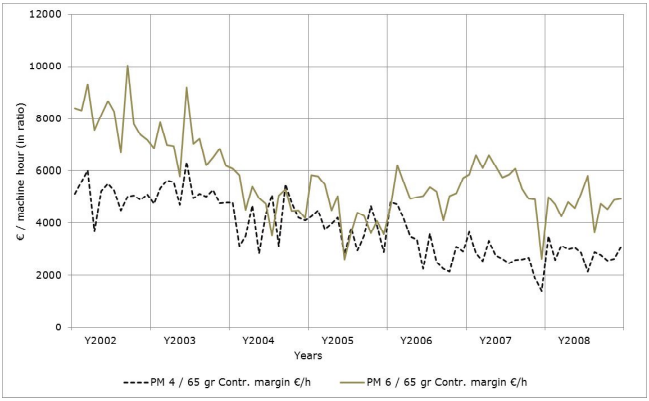
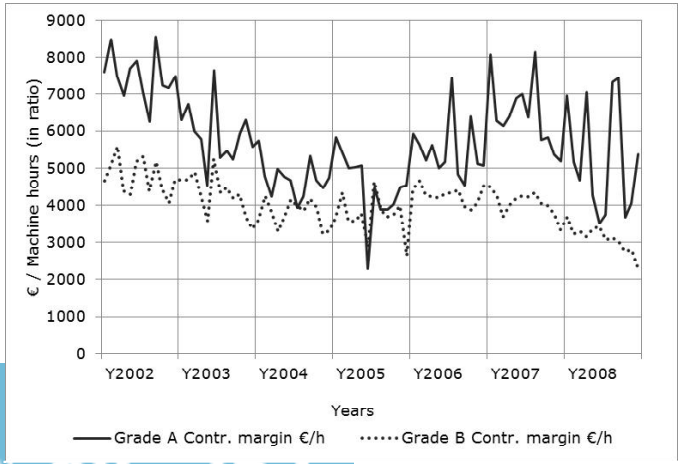


Fig. 7 Development of contribution margin per €/machine hour in two different grades monthly 2002 - 2008, 84 months (in ratio).



paper making process energy losses are quite unavoidable and Figure 5 indicates that if successful efforts could be made towards minimal energy losses in order to achieve an optimum, so there is a lot to gain.

Previous figures demonstrate distinctly that cost efficiency in the studied paper machines has lowered, which indicates that this weak performance inevitably pertain to margins. Figures 6 and 7 present that the contribution margin per hour ((= price – transport + variable costs) /hours) on the machine line level has decreased. Figure 6 shows the development of the margins through one important base weight (65 gr) produced in two different paper machines, PM4 and PM6. The figure addresses that the revenue per machine hour differs greatly between machine lines with same base weights. Certainly paper companies and mills try to find the most cost effective machines for each paper quality to maximize income of the production machinery as much it is reasonable. Figure 7 presents how the gross margins of two different sales grades can differ from each other. These sales grades are produced with two different paper machines and include many base weights. The customers are expecting specific grams for their printing machines even the paper quality is basically the same. Grade B have had lowering trend in costs per machine hour during the whole time series while other grade A appears produce higher revenue even if more variation during the research period. Obviously a case mill tries to focus on these grades, which are making the most of the incomes and have the best demand outlooks on the markets.

The empirical material clearly demonstrated that the case mill have struggled nearly whole research period with lowering economic efficiency. The results of this case study may help us better understand why the paper companies have closed over 20 machine lines since 2002 (Forestindustry, 2009) exclusively in Finland. The competitive position of the Finnish mills has weakened definitively and the companies have forecasted that difficult times may continue by closing the ineffective sites.

6. Conclusions and discussion

The purpose of this study was to explore how cost efficiency per machine hour had developed during past years. We tried to reveal if the development of the costs efficiency could explain for its part the closures of machine lines during the past years in Finland. The empirical research material of this case is based on data from one large integrated paper mill in Southern Finland, which exports 90% of its total production. The results indicate that the case mill had problems to improve costs efficiency in the machine lines. The research period of 2002-2008 has been a very challenging time for the paper industry in all in Finland. The general empirical findings can be summarized as follows:

- The mill has been able to estimate fairly adequately efficiency of the variable and fixed costs per machine hour.
- Total costs per machine hour have increased clearly.
- Alarming is that the contribution margins per machine hour have decrease in grade level lowering revenues.

Elmuti (2002) addresses that there is little empirical research that investigates SCM's impact on the firm as a whole so in that sense this study removes this absence. The results demonstrate that economic performance of the supply chain has weakened, which might bring out extra challenges to the mill in the future. The empirical results disclose some mill-level managerial implications, which can be summed up as follows:

- The mill should focus to improve economic efficiency of the machine lines.
- Energy efficiency should in the center during the coming years.
- Mills should focus on raw material and energy purchasing
- Management should examine continuously to find efficient machine line and paper quality combinations to maximize the income.

The dominant supply chain theories (see e.g. Christopher, 1992; Fogelholm. 2000: Pesonen, 2001; Koskinen, 2009; Töyli et al. 2008) have neglected to verify cost efficiency per machine hour in the manufacturing industries, especially in paper industry. This study aims to fill in the existing gap between theoretical discussions and current situation in the paper industry regarding efficiency topics.

From the point of generalization we selected a large exporting mill as a research object for this case study and we examined the mill with reliable and valid data. Yin (1993) pointed out that generalization of results is made into theory, which in this study was derived from supply chain management. The results of this study can give new perspectives to understand other paper mills located in the Nordic countries obviously paper industry generally. The results of this concise data showed that a case study offers a relevant method for exploring the paper industry. However we should be cautions when generalising the results from one even if a large mill, and to think especially about the location of the case mill when comparing results to those of other similar mills.

The printing paper mills must actively explore ways to solve the problem of increasing manufacturing costs and decreasing paper demand – oversupply imbalance and obvious challenges in economic efficiency. There is at the moment a real risk that Nordic mills will lose part of the low-profit paper markets to the local European competitors for good.

Further research

In the paper industry, there are evident research issues that should be examined empirically in order to better understand the dependencies of supply, demand, paper prices, costs and margins. The empirical economic and logistics factors should play a more central role in future examinations, especially those at the customer and grade levels, by using data from several mills in the Nordic countries. More wide-reaching and detailed market studies are needed in order to get a closer and more reliable picture of the supply chain in the Nordic paper industry.

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