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Economics of a Nordic paper mill - case study

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Purpose – The aim of this case study is to reveal how the prices, costs and logistics develop in the case mill and how these variables correlate with profits, and finally to give suggestions for improvements.

Design/methodology/approach – A typical Finnish paper mill was selected for the basis of the case study. The complete data for the mill for the years 2001 to 2007 at a monthly level was used. The data was obtained from the mill's financial management system and transferred to Excel. Statistica 4.1 software was used to run the statistical correlation analyses. The results can with certain limitations be generalized to paper manufacturing located at a long distance from its customers.

Findings – This paper gives an important insight in the economics of the Finnish paper industry. From theory building point of view, our empirical process data shows that the variation in production lines was minimal, but there were important variations in paper deliveries. A lot can be gained in the logistics processes. Larger volumes delivered in tons also tend to increase profits. From the mill to the consignees, fluctuations in the process and paper sales grow substantially, which indicates longer storage times.

Research limitations/implications – The results of the case study are based on the data of a single large integrated paper mill in Finland covering the years 2001-2007, so the results cannot be directly generalised to concern all Nordic paper mills. In May 2005, there was an industrial blackout, which considerably affected the production and deliveries of all Finnish paper mills in that year.

Practical implications – The competitive advantages of the Finnish paper industry are undermined by low paper prices and costly logistics. The mill managers should increasingly focus on overcapacity and cost issues and also delivered volumes, which all could contribute to higher profits.

Originality/value – In this paper, we study the Finnish paper industry through a time series, economic geography and statistical tools. This approach is a novel method and gives new insights in this research object. We study the mill's economic variables, such as paper prices, profits, and logistics and manufacturing costs, and the characteristics of these issues in a spatial context.

Keywords: Paper mill, prices, costs, logistics, geography.

Article Type: Case study

1. INTRODUCTION

The purpose of this paper is to examine the economics of a paper mill with interdisciplinary tools. We analyzed the past development of the Finnish paper industry through a large Finnish integrated paper mill. The paper industry is bulk production, which is connected with the mill location and geographic realities. The mills are significantly dependent on well-managed and practical logistics processes from the forests to the consignees. This specific topic, the paper industry, has been only marginally examined in Northern European countries from the viewpoints of economic issues, logistics costs and geography (see e.g. Lähtinen, 2007, Arlbjørn et al. 2008). The main reason for this deficiency might be a shortage of reliable empiric mill data.

At the moment in Finland, the professionals in the paper industry are discussing, how to maintain our competitiveness against the world markets (Oinonen, 2008)? Hetemäki and Hänninen (2009) forecast that in the following years until 2020, the Finnish paper production will drop dramatically, as much as by 30%, from 13 million tons down to 9.4 million tons. If this scenario materializes, it would dramatically change the structure of the Finnish export industry. Losses in annual export income would be hundreds of millions of euro. Dieter and Englert (2007) consider that Finland has comparative advantages, particularly in the sector of pulp and paper products, due to the abundance of wood and water. Their article was composed using data preceding the year 2002. However, after that year, there has been a dramatic change in the economics of the Finnish paper industry. Between 2001 and 2008, Finnish paper companies have closed down over 20 paper and board machine lines including some large mills, so that paper production has decreased by millions of tons (see e.g. Oinonen, 2008; Tappi, 2008). The latest closure took place in 2008, as UPM-Kymmene closed down their Kajaani paper mill with three machine lines producing 640.000 tons of newsprint (Tappi, 2008). Hämäläinen and Tapaninen (2008) found in their case study that the manufacturing and transportation costs have remained at a high level, while paper prices have gone down considerably during 2001-2008. This has deteriorated the economic situation especially in the Finnish paper mills (Forestindustry, 2009).

Finnish researchers have produced a number of studies in the paper industry (see e.g. Eloranta, 1994; Haarla, 2002; Hameri and Lehtonen, 2001; Koskinen, 2008; Koskinen and Hilmola, 2008; Lehtonen, 1999). At the core of these discussions are both the JIT concept (just-in-time) and inventories of the supply chain. Fogelholm (2000) and Fogelholm and Hämäläinen (2003) focus on the paper machine because it is usually considered a bottleneck in the mill and stress the efficiency of the machine line itself. In his teaching paper, Vepsäläinen *et al.* (2004) used a fictitious mill to simulate the average logistics costs from various harbours to the market. As a conclusion, they noted that in the paper industry, the share of logistics costs in product prices is significant.

The key motivation for writing this case study was that all the above-mentioned discussions leave out profitability issues and real detailed costs in euro per paper ton linked to logistics at the country and customer level. Koskinen (2009) also considers that logistics issues in the paper industry have not been studied widely in logistics literature.

In this paper, we study the Finnish paper industry through a time series, economic geography and statistical tools. This approach is a novel method and gives new insights in this research object. As mentioned earlier, this research approach and topic has been neglected in the literature before this study. We study the mill's economic variables, such as paper prices, profits, and logistics and manufacturing costs, and the characteristics of these issues in the spatial context. We explore how the research variables behave at the level of example countries and consignees in 2001-2007, which is a new approach to examining the Nordic paper industry.

The background and theoretical ideas used in this study are presented in Section 2. The case study methods, research questions, data sources, and data processing and statistical analysis methods are described in Section 3. In the following Sections 4 and 5, we take a closer look at the paper mill's functions and the current situation at the paper market. The detailed results of the statistical analysis based on our large body of case data are presented in Section 6. The discussion and conclusions are summed up in Sections 7 and 8, and finally in Section 9, we introduce some future research topics concerning the paper industry in the Nordic countries.

2. BACKGROUND

In this section, we take a look at the background and theories of logistics, economic geography and variation. There is a long research tradition which emphasizes the fact that economic issues should be linked to a spatial context (see e.g. Krugman, 1991, 1995 and McCann et al. 2002) in order to obtain and see the heterogeneity in the micro-economics within the exporting industry. Arbia (2001) also found that transport geography characteristics have been regarded as irrelevant factors in many economic studies. Behrens et al. (2009) point out that although transport costs are a key ingredient of economic geography, the transport sector is usually abstracted away from the analysis. Freight rates are taken as parametric and are not set by the market. According to Knowles *et al.* (2008), multidisciplinary ideas have been neglected when studying logistics. Differences in relative location remain critical to the availability of possibilities to economic actors. The location decisions are relevant, as discussed by Fujita and Thisse (2003), because the movement of goods through space does create costs. Similarly, Sheppard (2005) emphasizes that the unevenness of space is a vital starting point for geographical analysis. Despite having decreased, transportation costs will be no less important in the future, and there is no guarantee that these costs will continue to decline (Oosterhaven and Elhorst, 2005).

Browne (2002) notes that the logistics strategies, such as the concentration of production and storage locations and flexible production techniques, have become increasingly significant. Logistics costs play a critical role in all theoretical explanations for the spatial concentration of economic activities (Brakman *et al.*, 2004). Spatial differentiation means that some firms, because of advantageous locations, will always make better profits than others (Seppälä, 1997; Sheppard, 2005).

According to Henstra *et al.* (2007), there have been 'waves' in logistics processes since the 1960s. New forms of collaborative networks are emerging, and there is a growing need for flexible logistics structures, which aim for increasing cost and asset efficiency. Consolidation and collaboration are the logical ways to generate lower costs per freight unit. In the forest industry today, Carlsson and Rönnqvist (2005) consider it a central opinion that competitiveness lies in improved integration between different parts of the supply chain from the mill to the customers. Also, Groothedde (2005) considers that collaboration and the synchronization of logistics activities create affordable deliveries.

Currently in the paper industry, there is an urgent need to decrease the manufacturing and logistics unit costs due to lowering paper prices and decreasing demand for many grades

(Hetemäki, 2007; Hämäläinen and Tapaninen, 2008; RISI, 2009). Holweig *et al.* (2005) stress that unpredictable or non-transparent demand patterns have been found to cause artificial demand amplification, which leads to high inventories. In the paper industry, the efforts to reduce stocks by lean operations and to increase efficiency of logistics and assets are still in progress, while Koskinen and Hilmola (2008) found in their case study that paper rolls remain an average of 45 days in intermediate inventories, which is too long (see also Eloranta, 1994). AMR Research (2009) found in its annual ranking of enterprise supply chains Apple No. 1 and Dell No. 2. This ranking focuses on companies that used their supply chain to monitor demand and adjust to a declining economy rapidly. No paper companies were found in this ranking list. One of the problems is the nature of heavy bulk products like paper rolls, which need heavy common and slow means of transport. Small electronic packages can be sent by air freight to customers all over the globe at a low cost. Interestingly, Rodrique *et al.* (2006) comment that originally, geographic inherited advantages (e.g. hydropower, timber in paper industry) are nowadays affected by spatial frictions like distance (e.g. expensive inter-nodal transports to the market in the paper industry).

The core of economic geography has been the geographical variation in what firms produce and how they produce it (Massey 1984). Dicken and Lloyd (1990) consider that spatial variation in capital, labour, production, logistics costs, and also in technical knowledge, is fundamental to the production process. Spatial variation may be captured through the correlation structure or through the specification of a spatial response function that refers to the means of the process (Haining 2003). Understanding variation in phenomena and their causes is essential to the understanding of any system (Deming 1988), because variation usually adds costs. It is useful to understand this research view when analyzing the paper mill's functions from the viewpoints of prices, logistics, costs and demand.

The significance of costs in the logistics processes is mentioned in almost every research paper concerning economy-related topics such as logistics, transportation and industry location. Therefore, in the discussions, it is important to study the actual effects of these costs on the real figures of the mill selected for the case study to see the possible impacts.

3. THE CASE MILL AND EMPIRIC DATA

The paper industry was selected as a research topic due to the importance of the sector in Finland, and because the topic has been studied minimally from the viewpoint of logistics

costs and geography together. The significance of logistics costs differs greatly from country to country, partly due to geographical distance. In this paper, we address the linkages between prices, logistics and the importance of the whole value chain in delivering paper rolls to the main market in Europe. We selected some typical and important European exporting countries to illustrate the economic characteristics of paper exports from Finland. As a background, the authors have profound experience in the paper industry, and we found that a case study is a relevant method for studying this topic.

Lewis (1998) notes that case studies offer a potentially effective means for comparing complex and disparate operations settings and their iterative triangulation employs systematic iteration between literature review, case evidence and intuition. Case study research aims at gaining an understanding of the phenomenon under study using a limited number of observations (Hilmola et al. 2005). According to Baxter and Chua (1998), there are practical difficulties in conducting case study research because of the lack of access to field sites. Ballou (2001) stresses that the acquisition of correct and reliable data is crucial to the successful practical application of any model. Yin (2003) emphasizes that the “distinctive need” in conducting case study research lies in the “desire to understand complex phenomena”. The case study method is well suited to produce context-dependent knowledge (Flyvbjerg, 2006), and case study research can provide discoveries which are not possible to acquire through other methods (McCutcheon and Meredith, 1993).

Our case mill is a Finnish integrated printing paper mill with several machine lines. The integration means that a mill has its own fiber lines – pulp, pgw (pressure ground wood) and/or tmp (thermo mechanical pulp) lines – and the use of more expensive purchased pulp is minimal, averagely less than 10% of the fiber use. The mill was selected as a research object because it is an excellent example of a typical printing paper mill. The mill has customers and paper sales over a large area mainly in Europe, where paper is delivered in tens of thousands of tons monthly. Therefore the results of this study can be generalized, to some extent, to cover all Northern European paper mills. The case mill exports 90% of it’s production mainly to Europe (an average value in the Finnish paper industry), so the home market has a minor role in its sales.

The extensive mill data obtained contains a time series extending from 2001 to 2007 (84 months). The data was inquired and captured at the monthly level from the mill's cost management database system (Figure 1). This system collects manufacturing, cost and sales data from the different sub-systems and allocates all these variables at the level of grade, customer and country. The research data was transferred into Excel spreadsheets and into Stat 4.1 for a statistical correlation analysis. The source figures, based on the packed tons and euros, were calculated by the financial controllers using the mill's modern cost management

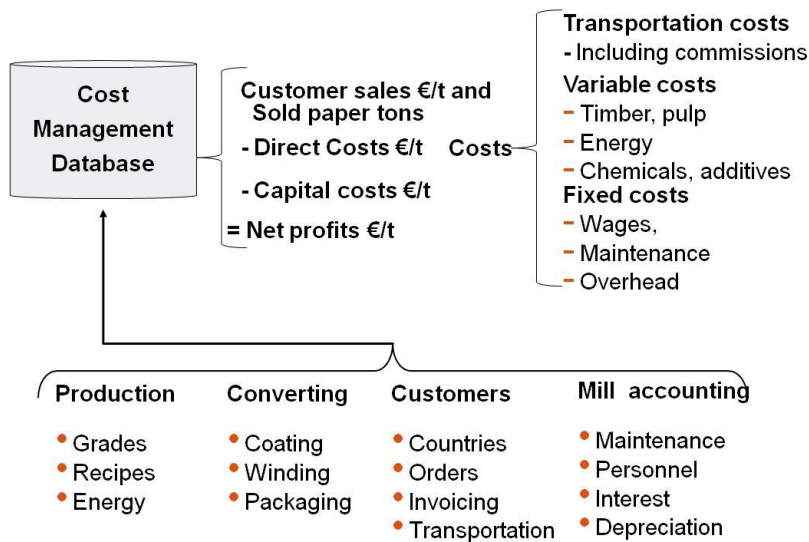


Figure 1. The origin of the data: the case mill's data sources, the mill cost management database (cost allocations) and calculations in euro per ton.

system. The figures were controlled by the official authors, after which these values were reported in the mill's monthly economic reviews. This accurate process assures that the study data is reliable. The selected variables are homogenous and valid at all levels, and they were calculated in similar ways over the time series. They are listed as follows:

- Paper sales in euro/t; Total sales based on customer prices in €/ton by research countries.
- Transportation costs (including commissions) in euro/t; Transportation costs based on delivered customer orders by research countries.
- Variable costs in euro/t; Pulp, other fiber, energy, chemicals, packing materials, additives, total and product specific variable costs based on delivered customer orders by research countries.

- Net Profits in euro/t; Paper sales - transportation (including commission) – variable costs – fixed costs – capital costs = net profits, based on delivered customer orders by research countries.

Non-economic variable: Sales tons; Amount of paper tons delivered to different customers and countries based on delivered customer orders by research countries.

All prices and costs were calculated in euro per paper ton as an equal key indicator. The values were reported for research purposes only. We combined these figures with a single large dataset, which was indexed to prevent the release of confidential business information. However, the figures are valid and fully comparable between each other within the dataset. Two different analysis methodologies were used. Firstly, we used a descriptive method to show the development of different research variables over the timeline. Secondly, we used statistical correlation and multiregression analysis to show how the economic variables, such as sales prices, logistics costs and sales volumes, correlate with net profits.

Additionally to this data, we had several discussions with the financial managers of the mill and also with some other paper mills to get an in-depth view of the paper industry. These discussions helped us significantly in focusing our study on relevant topics.

The main analysis questions were:

- How have prices as well as variable and logistics costs developed during the past seven years in the case mill?;
- Are there any demand/sales fluctuations in a paper mill at the country and customer level?;
- Is there any correlation between sales volumes, logistics costs and net profits?;
- Is there any correlation between logistics costs vs. net profits?

Lynch and Whicker (2008) note that the word ‘logistics’ is a confusing term even for the logistics professionals. In this paper, logistics is understood as a process in which packaged paper rolls are transported from the mill warehouse to distribution centres with common means of transport and intermediate inventories. The logistics costs cover all these logistics phases, including commissions and excluding packaging costs. The actual variable costs include direct manufacturing costs like timber, fiber, chemicals, energy and logistics costs (including packaging costs). The sales prices are the actual prices, which we obtained from customer invoices. Variation is understood primarily as fluctuation of the key economic

parameters in the paper mill; sold paper tons, variable costs, prices, logistics costs and net profits. All costs and prices have been sorted out at the country level to examine the interesting geographic differences.

4. SOME CONSIDERATIONS CONCERNING THE PAPER MILL'S FUNCTIONS

A capital-intensive paper mill firmly functions in a demand-oriented manner and focuses on customer demand (Figure 2). The paper grades are manufactured on a -to-order basis, which means that jumbo reels are converted and packaged into customer rolls. These rolls are transported from the Nordic mill by different modes to European distribution centres, where the consignees pick up the rolls. Due to these complicated demand and logistics processes, there is a high probability of costly differentiations which arise for different reasons: 1. Customer orders include several paper roll and grade combinations manufactured in several different lots. 2. The end customers are located over an extensive area and mainly far from the Finnish mills. 3. The life cycles of the products vary, the logistics costs of the modes may

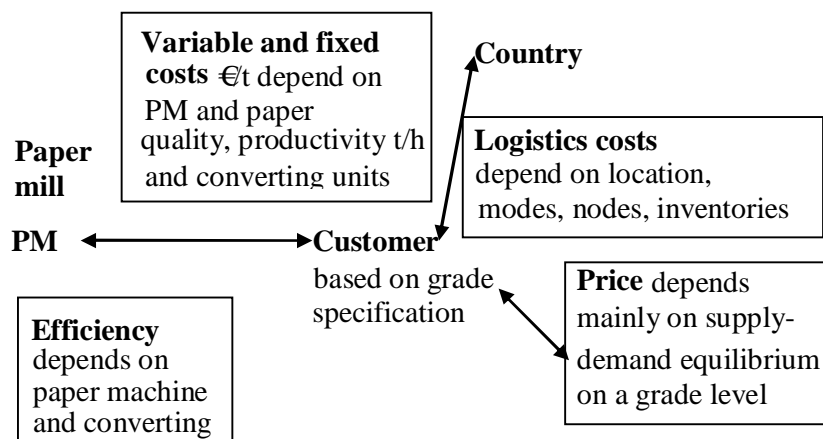


Figure 2. Main sources of economic variation in a paper mill's (PM) production and logistics functions.

change and also the price of wood, fiber and other raw materials tends to rise. 4. Competitors open a new and more efficient paper mill nearer the markets. 5. Finally, fluctuations in currency exchange rates between the euro vs. the dollar vs. the Swedish krona can be quite significant.

Northern European paper mills normally are integrated units covering fiber and paper production. The different machine lines and production departments have been organized to

operate as an efficient value chain channel to deliver products as flexibly as possible to the market. Thus, the grades will fit the customers' demand and quality specifications adequately. Normally, the paper machines at the mill are running as predicted. Stoppages are mainly caused by e.g. planned shutdowns and machine maintenance, and rarely by e.g. unplanned stoppages, such as breaks in paper tracks or by other machine errors.

Approximately one ton of fiber is needed to manufacture a ton of paper, and depending on the paper quality, additionally fillers, additives, energy, steam, water, coating colours and machine time. Paper production should be balanced in terms of customer orders and deliveries to allow the expensive production machinery together with the logistics channel to work as economically as possible. Paper mills tend to make long-term sales and delivery agreements with the customers, this way trying to forecast material purchases, demand, production and supply more accurately.

At the site, the raw material flows, the logistics and the paper production including finishing are organized on a just-in-time basis. The variation and storage volumes in the paper mill's logistics channel essentially arise straight after the mill. We will present these characteristics in more detail in Section 6, but first we will take a brief look at the current situation at the paper market from the Finnish point of view.

5. SOME OBSERVATIONS OF THE CURRENT PAPER MARKET

For an extended period, Finnish paper mills have fulfilled a growing demand for paper in Europe with paper products manufactured mainly from virgin fiber (see e.g. Forestindustries, 2009). At the present moment, the supply-demand equilibrium is not good at the paper market, and there is extensive flexibility in the sales-purchase prices between buyers and sellers (RISI, 2009). European paper suppliers occasionally complain about cheap imports due to weakness of the dollar against the euro. This makes European exports to the USA unprofitable. European printing and publishing houses are not always as willing to conclude long-term delivery deals with paper producers as before.

The Finnish board and paper mills annually export some 13 million tons of paper products to the value of €10 billion (2008) mainly to Europe (Forestindustries, 2009). The sector's share in the total exports in 1995 was as high as 50%, and round 20% in 2007. The paper industry in Finland is a value-add sector, which normally covers timber harvesting, pulp cooking, paper manufacturing and logistics to European printing houses. The Finnish paper

mills export over 90% of their total production because the local markets are very small (Forestindustries, 2009).

The economic environment around the paper industry has changed dramatically during the past 10 years for many reasons, such as environmental issues, soaring energy prices and lower paper demand in Europe (see e.g. Hetemäki and Hänninen, 2009 and The Future Group of The Finnish Paper Industry, 2006). RISI (2009) announced that printing paper grades are facing severe price and demand pressures, and overcapacity has a negative impact even on contract price negotiations for the year (2010).

Finland is part of the EU monetary union, and Forslid et al. (2002) stress that a common worry in the Nordic peripheral regions is that economic integration may lead to loss of industries and jobs in these areas (see also Krugman 1991). Hetemäki and Nilsson (2005) consider that, besides excess capacity, paper prices are also put under a major pressure by substitute products and services like the Internet and paper-free development like e-invoicing at offices. If this trend continues, it will to some extent threaten the existence of Northern European printing paper mills and their expensive production machinery. The EU market is large and immensely concentrated. All the largest printing houses and 250 million consumers can be reached within a day from the paper mills in Central Europe, but unfortunately this is not the case for the Finnish mills.

6. CASE STUDY ANALYSIS AND FINDINGS

The production process in the paper machines is kept stable (Figure 3) by means of state of art automation equipment to avoid all unnecessary and costly variations in production. Any unplanned stoppages and breakdowns easily increase the manufacturing costs by lowering available production time. After the mill, the logistics chain from a Nordic paper mill to the European market consists of a large amount of nodes, because the main part of a mill's customers are in 25 to 30 different countries, reached by multimodal transport routes. Figure 4 demonstrates the development and variations of the sales to four export countries at monthly levels in 2001 – 2007. Each country includes data from dozens of customer orders of different sizes and paper grades. This empiric data shows clearly that the monthly differences in paper sales are remarkable inside the country and between different countries. The average of tons sold to a single large country has gone down substantially, as much as over 60%, which indicates e.g. price competition in that market. From the mill's point of view, it is important to

be able to produce reliable forecasts for this kind of sales development. The information about estimated demand volumes at the country level should be obtained from as many consignees as possible to acquire a realistic picture of the market in the coming months. In the middle of the year 2005, industrial action took place in the Finnish paper mills, resulting in a major drop in the sales. Ryu *et al.* (2008) considered that the “forecasted demand distributing method” (FDDM) is a valuable tool throughout the SC in electronic industry including the improvement of inventory levels and service level to market demand. Correspondingly, Helo,

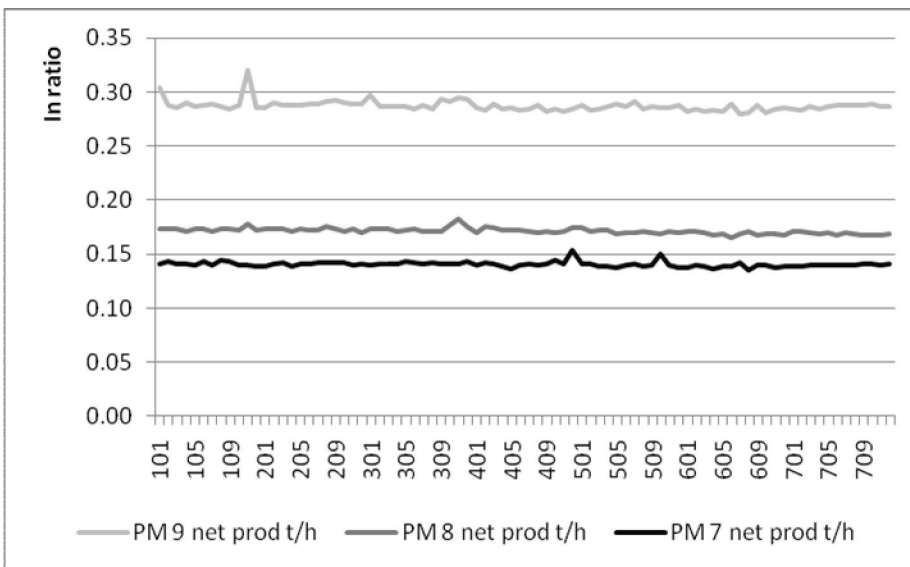


Figure 3. Monthly production variations in three paper machine lines in tons per machine hour in 2001 – 2007.

(2004) considers that the uncertainties in electronics demand and manufacturing require a wide implementation of Enterprise Resource Planning (ERP) packages and advanced planning systems. Companies need to be proactive in the face of market uncertainties in a productive way. Price erosion is forcing electronic firms into flexible operations and fast inventory turnover rates. All the mills, including the mill in the study, are using some kind of forecasting methods to estimate the future market demand. However, there are considerable fluctuations in deliveries that probably depend on the traditional and slow logistics methods used in the bulk industry. Lynch and Whicker (2008) show in their case study that business processes should be developed across functional departments to get increased business performance and customer satisfaction. The delivery process from the paper mill to the distribution centres can take up to one or two weeks in Europe, and the demand can increase and decrease regularly or irregularly. The logistics functions should be scrutinised intensively

if a mill wishes to increase its delivery performance. At present, intermediate inventories seem to balance out for the demand of printing houses at distant markets. The end users, such as printing houses, pick up the paper rolls in these inventories financed by the paper mill just before they are needed in the printing processes. Fawcett *et al.* (2008) consider that supply chain managers perceive customer satisfaction and service as more enduring than cost savings. It is obvious that a part of the paper mill's customer value is stored even for months at the inventories in which the costs increase in relation to time. Paper mills actively try to

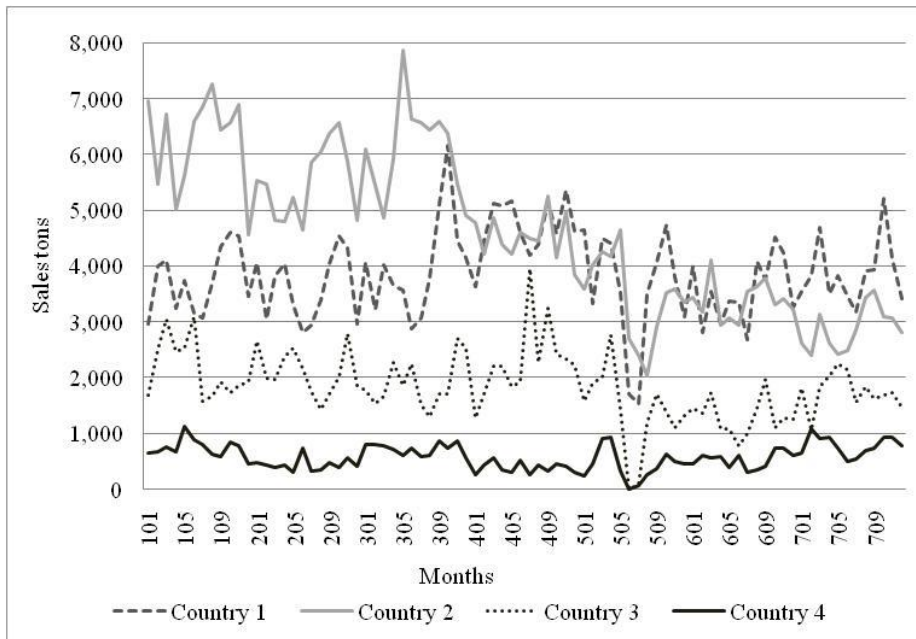


Figure 4. Monthly variations of the sold paper tons in a Finnish paper mill in 2001-2007 in four countries.

interlock the paper grades, orders and deliveries together to keep paper production as uniform as possible. This helps to minimize unnecessary and costly breaks, occasional shutdowns and especially waste producing grade changes.

Figure 5 illustrates monthly paper sales and variable costs incurred by two example customers in two different countries. The variable costs went down in 2001-2004 and started to increase again after 2005 due to higher raw material, energy and chemical prices. The cost differences between the customers depend mainly on paper qualities, which contain different material combinations in the manufacturing processes.

Figure 5 additionally shows that significant fluctuations in sales may take place at the customer level. From the viewpoint of the mill, paper sales can decrease or increase from month to month unpredictably, but also regularly. These continual variations support the

concept that intermediate inventories balance out the supply-demand differences over several months, and this cannot be affordable for a mill. The monthly differences are up to 800% in paper sales, which also makes forecasting the demand highly challenging. A mill's sales-order-supply chain is maintained by means of modern order-sales-production planning systems like ERP, which sends the order data to the product planning and trimming systems. However, the packaged heavy rolls must still be transported by means of intermodal logistics to the hundreds of consignees all over Europe through different nodes.

These big supply-demand differences may hide serious economic risk factors. Because

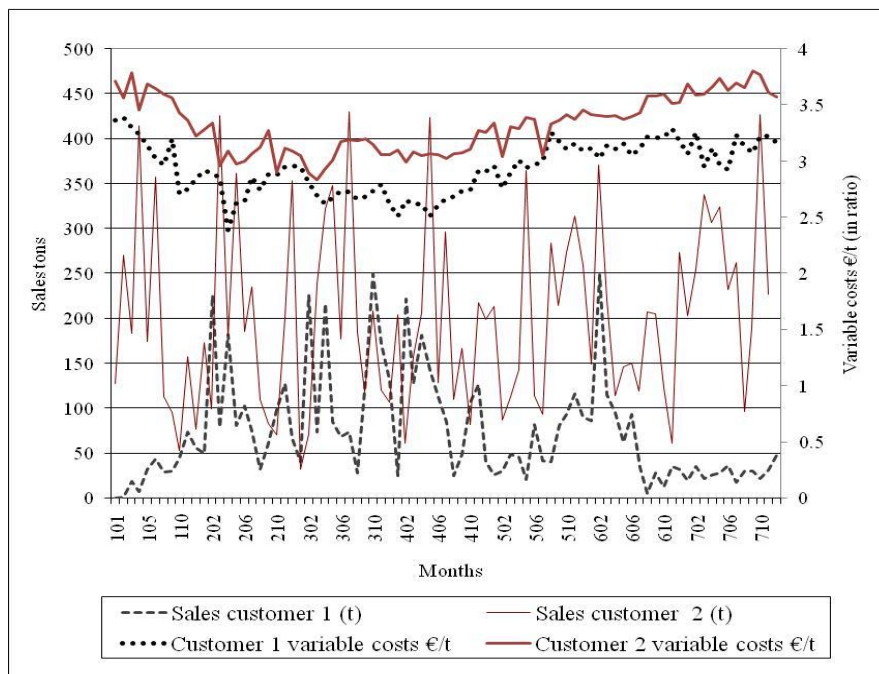


Figure 5. Variation of sales (t, left Y) and variable costs (€/t, right Y) in tons in a Finnish paper mill to two customers in two countries in 2001-2007.

of this demand behaviour, especially *ex post* based anticipatory systems can presumably give very misleading estimations of the customer demand level. Information sharing between a mill and its customers should be increased, as Chan (2003) points out in his analysis, to balance the supply and demand and to improve efficiency. Koskinen (2008) in his case study of a paper mill stresses that some of the business divisions do include a certain amount of supply chain management aims in their strategies, but there is no real corporate supply chain strategy.

As we explored the development of the average paper prices and logistics costs (Figure 6) at the country level, we noticed that prices have gone down significantly from

approx. €710/t to €600/t in the period 2001-2004, and after 2004 the prices have not fully recovered. This trend has made the economic situation of paper companies challenging (see also RISI, 2009). These two countries represent some 25% of the total sales of the case mill, covering over one million tons of delivered paper. In these countries, the logistics costs in euro have increased by approx. 10 to 15% per paper ton. This price erosion and significant increase of the logistics costs in the Finnish mills may partly explain the closures of over 20 machine lines in 2001-2008.

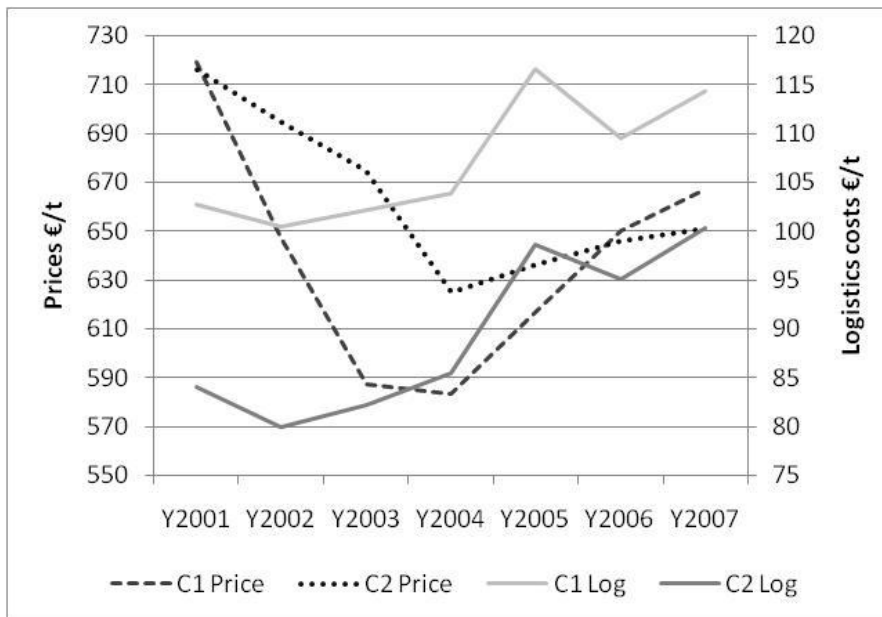


Figure 6. The development of sales prices and logistics costs in a Finnish paper mill in 2001-2007 to two main export countries.

We also examined net profits and logistics costs components through sales prices (Figure 7). In this Figure, the sales prices increase from left to right, and the data covers sales to one of the most important export countries for the case mill. We can see that the net profit curve closely follows sales prices, even if there were important variations in the net profits over the timeline. There is a strong positive correlation between net profits and prices ($R^2 = 0.6306$). In this case, the sales prices explain over 60% of the net profits. The present oversupply situation (RISI 2009) does not allow an increase in sales prices, which can be very crucial. It is difficult to improve profits, if prices do not recover.

Our empiric data shows that there is quite a strong correlation between net profits and logistics costs (Figure 8). Approx. 34% of the increased net profits in €/t can be explained by the lower logistics costs. This is why mills in the periphery of Northern Europe are in a

challenging position, which the soaring oil prices may even make worse in the future. As it is difficult to increase paper prices and the manufacturing costs have remained high in the past years, logistics has become more crucial for paper mills. To illustrate Figure 8, based on the data of our mill we calculated that the value of storage costs are approximately EUR 0.20 - 0.30 per paper ton per day. For example, if a customer order is 100 tons and the average

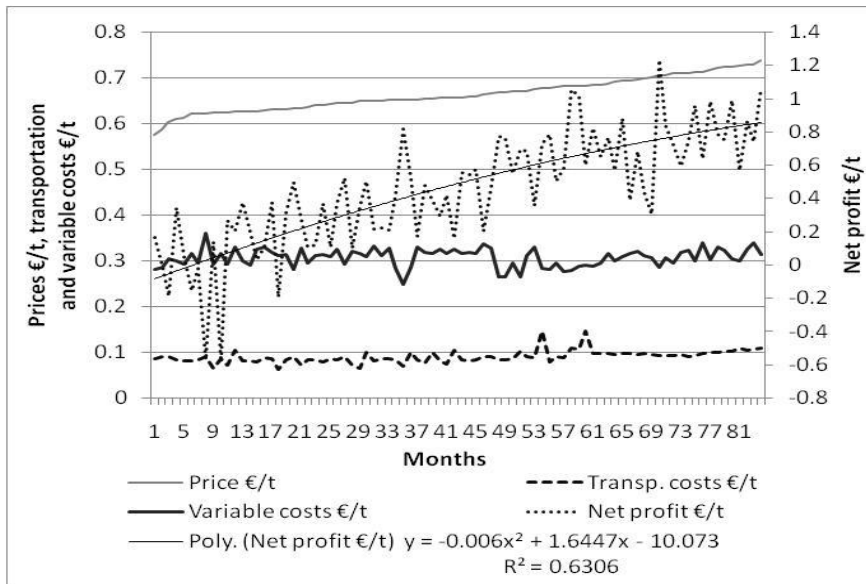


Figure 7. Paper exports to a large export country with its own harbour and trucking. The sales price is lowest at the left and all other variables have been sorted according to sales prices (in ratio).

storage time in total is 45 days (see e.g. Koskinen and Hilmola 2008), the inventory costs are around EUR 1,120 for the mill (= 45 days x 100 tons x 0,25 euro). If the storage and lead times could be shortened to 20 days with more efficient logistics functions, the warehousing costs would be approx. EUR 500 per 100 tons. The annual sales of paper produced by a large machine line can be as high as 400,000 tons, so the gain from lower inventory levels could be around €2.5 M per year.

The annual sales of the case mill are hundreds of thousands of tons of paper rolls in total, and thus the monthly logistics volumes are enormous. From this point of view, Figure 9 shows that there is some positive correlation (.11) between net profits €/t (blue, left Y) and the sales volumes in tons (X). The logistics costs €/t (red, right Y) vary notably, which indicates that in a large export country customer orders are delivered over a vast area and in different sizes. Our example shows that when sales volumes increase (X), the logistics unit costs decrease (-.3385), which concurrently supports higher net profits in euro per ton. Hämäläinen

the emphasis in Finnish economic-technical discussions has been on studying a paper machine's efficiency and storage times.

As our empiric data covers a single large Nordic mill, this limits the generalization of the results. However, all Nordic paper mills have rather similar manufacturing methods and

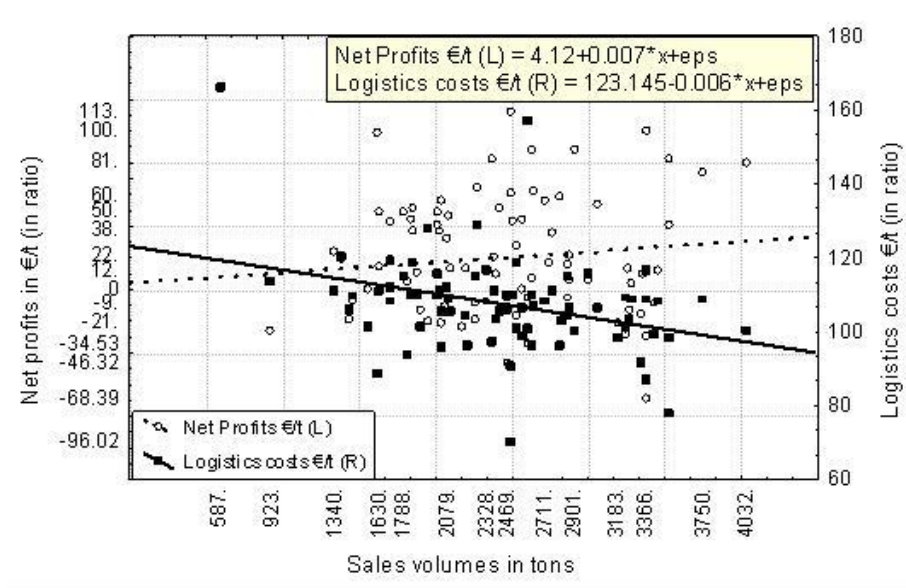


Figure 9. Correlation between monthly net profits (Left Y), sales tons (X) and logistics costs (Y Right) to one export country.

Marked correlations are significant at $p < .05000$

N=84

Net profits €t
Sales tons $r^2 = .11$

Marked correlations are significant at $p < .05000$

N=84

Logistics costs
Sales tons $r^2 = -.3385$

export logistics functions to the European markets with large volumes.

The pure logistics costs of Finnish paper mills located in the periphery are extremely difficult to decrease due to the nature of heavy bulk products. Additionally, oversupply is a problematic issue that results in decreasing paper prices (RISI, 2009) in our case mill. This forces the paper mills in the periphery to organize their logistics as efficiently as possible and to balance out the enormous variations in deliveries to decrease storage times. At present, demand differences are balanced out by the inventories (see e.g. Koskinen and Hilmola, 2008). A prerequisite for reducing intermediate storage is faster lead times in product

deliveries similarly to the electronics industry (Helo, 2004). Unfortunately, this may increase the amount of grade changes in paper machines, resulting in more waste, losses, breakdowns and less available production time (see e.g. Fogelholm, 2000). These imperative logistics expenses should be approached concurrently with shorter lead times, more efficient proactive ERP tools and by scaling the production.

The efforts to lower variable costs, such as those of pulp, labour, chemicals and wood, can be very challenging, similarly to increasing the efficiency of older machines. In order to stay in business, Finnish paper companies must deal with these problems. The comparative advantages of the Finnish paper industry are undermined by the decreasing paper demand, low prices, costly logistics, and by the heterogeneity of the geographic elements. In Finland alone, more than 20 paper and board lines have been closed down since 2001. Paper mills should develop their logistics functions that are as lean as possible, because the total logistics costs can be up to 18% of the paper mill's turnover (see e.g. Paper and Timber, 2008). In smaller order volumes, efficiency of logistics practiced as JIT can play a major role in lowering logistics costs. However, the logistics circumstances must be mapped out carefully country by country, because of the economic and geographic differences between them.

8. CONCLUSIONS

The research traditions of case studies and economic geography topics with time series in the Finnish paper industry are scant, as e.g. Koskinen 2009; Lähtinen 2007 and Arlbjørn et al. 2008 have noted. These few studies mainly focus on warehousing and supply chain issues in the paper industry, leaving aside the economic topics in spatial heterogeneity, which we have addressed in this paper. In this study, we used real paper prices in euro per ton, and also freight rates as euro per ton as a new research perspective, which Behrens et al. (2009) consider important but very unusual in the literature. Additionally, a totally new thing in this paper is a time series of real economic data, which fully covers the timeline 2001-2007, or a total of 84 months.

The main findings of this case study were the following:

- The sales prices have decreased by approx. 10% between 2001 and 2007 at the country level in euro per paper ton, and during this time, the logistics costs have increased significantly.
- The mill has not succeeded in lowering the variable costs during the study period.

- There are big variations in paper deliveries at the country level, and very marked and unpredictable changes at the customer level.
- Logistics costs and paper prices correlate strongly with mill profits, and larger delivery volumes also make higher profits possible.

Hetemäki (2007) and Oinonen (2008) have stressed the economic challenges faced by the Finnish paper industry in recent years. This is reflected in the case mill's country based sales data, which shows that paper prices have decreased significantly. Partly due to this process, Finnish paper companies have closed down more than 20 machine lines after 2001. The case data also shows that the mill has not succeeded in lowering the variable costs, which have instead slightly increased (see also Hämäläinen and Tapaninen, 2008).

From theory building point of view, our empirical process data shows that variations in the production lines were minimal, but there are important variations in paper deliveries. Variation and its impact on a firm's functioning is a topic that e.g. Deming (1988) points out as important issues to understand, because variation in the economic systems usually increases costs. In the case mill, the monthly sales differences were marked and unpredictable, even up to 800% between various months at the customer level. According to Holweig *et al.* (2005), this unpredictable demand amplification leads to high inventories. The challenge facing the Finnish paper industry is decreasing the storage time with such huge variations in the supply and demand. The marketing and logistics have somewhat different perspectives (see also Lynch and Whicker, 2008).

The key practical gains and recommendations of this case study can be summarized as follows:

- Mill logistics managers should try to decrease variation in the logistic processes from the mill to the consignees, which can help to lower storage times in delivery centres.
- Paper mills should start actively lowering their logistics costs, because these actions offer significant possibilities to improve profits.
- Paper prices correlate heavily with profits, and therefore paper companies must continue to decrease oversupply at the market and, simultaneously, make serious efforts in the area of product development.

- Paper mills should make their customer deliveries as large as possible, because this supports higher net profits, to some extent due to the decrease in the unit logistics costs.
- Paper mills should use more anticipatory methods and advanced planning systems.

The empiric data showed that a lot can be gained in logistics processes that are delayed by the spatial frictions, as Rodrique et al. (2006) point out. Carlsson and Rönnqvist (2005) consider that the competitiveness of a paper mill lies in improved integration between different parts of the logistics function. The expensive logistics, which correlates strongly with profits, brings location issues up to the surface also in the paper industry, as discussed by Fujita and Thisse (2003).

This paper was able to produce novel and fresh results, which are revealing and contribute new insights to the economics and logistics research tradition of the Finnish paper industry. The subject is worth studying concurrently with statistical methods and economic geography, as emphasized especially by Krugman, (1991, 1995) and McCann et al. (2002). Also Arbia (2001) considers that transport geography characteristics have been regarded as irrelevant factors in many economic geographic studies. This study showed that a spatial approach gives new possibilities of looking at the economy of peripheral mills, where major changes in the operating environment are forecasted to continue in the coming years, especially in the Nordic countries.

9. FURTHER RESEARCH

In the paper mill's logistics process, the variation in sales at distant locations and near the market increases stock volumes, having a negative impact on profits. In Northern European mills, the logistics costs add to the total costs. It is obvious that the marked variation in demand and sales is partly affected by the paper production and business logic itself (the paper machine is still in the centre of the supply chain management). Therefore this topic should be examined further in more detail from the viewpoint of several mills located in different Nordic countries. This might help to examine the fundamental reasons for these high variations and show how to decrease and avoid them.

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