Spatial characteristics of the transports in the paper mill's supply chain

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This paper examines the impacts of transportation costs to the supply chain management of the Nordic paper industry from a transport geographic view point. The discussion is illustrated by complete cost management accounting data from one paper mill. The main research questions are: What are the transportation costs and how have they developed during the study period concerning the exports to the market? How have the supply chain costs developed? Do order size and transportation costs have any causality in cost per unit of paper? So far, the transportation costs concerning Finnish paper mills have been examined rather scantly. We perceive that transportation costs together with sales costs have crucial effects on the mill profits. The costs rise due to the spatial heterogeneity of the European market. In paper industry, the freight transportation costs have not decreased as in many other industries. The transaction of a small customer order can cost more than twice as much as a large one to the same export markets. In addition, the productivity of aged paper machines has not improved as expected, while the paper sales prices have decreased due to the continuous oversupply. In some geographical ranges, the location planning of paper industry may transform towards local production units near the market.

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Introduction

The main purpose of this paper is to examine the past years' development of the transportation costs and their effects especially on the paper industry. Even though Nordic geographers have widely examined transportation, the specific topic of our study, paper industry, has not been within these studies (see e.g. Arlbjørn et al. 2008). According to Bowersox and Closs (1996), transportation costs do not usually increase systematically in relation to distance, because of many other factors, e.g. customs, handlings in ports, lower containerisation costs, plus loading and unloading processes. It is therefore justified and also innovative to look at paper freight transportation costs from the spatial point of view. Rodrique et al. (2006) consider that "looking through spatial lenses" would give a more comprehensive insight into the nature of transportation and its geographical dimensions.

It must be noted that paper industry is a significant sector of the Finnish economy and employment. The sector's value of the total exports in 1995 was ca. 50 per cent and was still as high as 18 per cent in 2007. The Finnish board and paper mills export annually around 13 million tons of paper products valued 10 billion euro (2007) mainly to Europe (Forest Industry 2008). In Finland, there is a discussion going on of what to do in paper industry in order to maintain future competitiveness in the global markets (Oinonen 2008). It is worth examining the issue in more detail also from the geographic perspective, particularly with valid case-mill data, to get a clearer picture of the development during the past years.

Lately, paper industry has put effort into assuring the prominence and competitiveness in their sectors (Forest Industry 2008). However, transportation costs have been on the side ways in these researches. There have been inventory-based exam-

inations concerning paper mills (e.g. Eloranta et al. 1994; Lehtonen et al. 1998; Lehtonen 2000; Koskinen et al. 2008). These studies put aside the spatial heterogeneity and distance as a relevant research issue. In paper deliveries to the distant markets, inventories play an important and generally costly role in the supply chain by allowing spatial specialization balance supply and demand.

In this paper, supply chain (SC) from the view of a paper mill is understood as a total process from the point of timber-yard to the consignees covering all the cost components between. In this process, the transportation costs cover the physical functions and costs outside the mill, where the packed paper rolls leave an inventory at the paper mill and finally arrive at the consignees of printing houses. The physical delivery covers truck-short sea–truck modals and is a time consuming, costly and continuous function. Usually large paper mills sell, manufacture and deliver customer orders of different dimensions to dozens of countries and to hundreds of customers. Well-managed supply chain functions are inescapably the driving forces in international trade. These are crucial for the immobile and peripheral heavy industries. These are firmly bound to a certain location and cannot be easily moved to a different and probably affordable manufacturing location with lower wages or other production costs.

Different approaches to supply chain management

The Nordic forest industry is heavily dependent on the export markets in Europe. It has to ensure that its costs and revenues are competitive. This means that it has had to increase or maintain the efficiency of all its operations. Carlsson and Rönnqvist (2005) consider that a central opinion in the forest industry today is that the competitiveness lies in improved integration between different parts of the supply chain from the mill to the customers.

Supply chain management (SCM) was introduced in the early 1980s (see e.g. Christopher 1992; Drucker 1998). Stank et al. (2005) describe supply chain as a strategic concept. According to Mohanty and Deshmukh (2005), SCM is a loop, which starts with a customer and ends with a customer and through the loop flow all materials, finished goods, information, and transactions. Ho et al. (2002) and Larson et al. (2007) note that the underlying topic is the integration of processes throughout the supply chain with the goal of adding value to the customer. Kosior et al. (2006) consider supply chains "open-loop" systems whereby goods are produced and distributed in the marketplace according to historical or anticipated demand. Respectively, a rising demand for shipping and delivery, particularly of smaller units, creates a higher frequency (Suarez-Villa 2003). Chopra and Meindl (2004) stress, that supply chain performance is optimized when an organizational strategic approach is adopted by all chain partners. From the view of a paper mill, Fogelholm et al. (2003) consider that the smaller demand batches in paper manufacturing increase costs by scaling up the grade-changes, trim waste, recycling and lost production time and therefore lower margins. More frequent shipping may decrease warehousing costs per unit, but tend to raise both production unit costs and shipping unit costs.

These supply chain functions, including transportation, can be modelled and examined from the cost point of view (Kaplan 1988), from the supply chain point of view (Porter 1985), from the point of time (Stalk 1988), and from the point of location and transportation geography (Weber 1929, Hoover 1948, Lösch 1967, Dicken and Lloyd 1990, Hesse et al. 2004, Rodrique et al. 2006 and Preston and O'Connor 2008).

In supply chain process, Kaplan (1988) emphasizes the importance of the cost of a product as the sum of the cost of all activities required to manufacture and deliver the product to end customers. According to Porter (1985), every firm's value adding chain is composed of activities which are linked to each other and to the activities of its suppliers, channels and buyers. From the view of time management, Stalk (1988) notes that time-to-market decisions are essential elements for a successful business; a company that can bring out new products faster than its rivals, enjoys a huge competitive advantage. Originally developed by Toyota car manufacturer (see e.g. Monden 1981), Just-In-Time (JIT) does not bring the hoped improvements in paper industry. In outgoing flows from the mill, inventories increased from 45 days in 1979 up to 75 days by the end of the 1980s JIT when introduced by (Eloranta et al.1994). Respectively, Koskinen and Hilmola (2008) considered in their recent article, that still the paper mill's supply chain process from the mill inventory takes averagely 45 days before the rolls are delivered to the consignees in foreign locations. This indicates that some parts of the paper rolls are stored in the in-

ventory for several months resulting in capital costs before reaching the consignees. The higher the level of inventories a firm has, the lower its rate of returns (Koumanakos 2008). Diesen (1998) notes, that in cyclical paper industry, a supply driven distribution system is mainly based on the function for inventory. Production taking place in large batches is simply pushed to the market with the hope that what is being produced will be sold. It is obvious that the intermediate inventories balance the demand variations coming from the market, and JIT does not function from the mill to the distance consignees as hoped.

Some considerations on transportation geography

Transport geography is a sub-discipline of geography (see e.g. Rodrique et al. 2006) concerned about movements of freight, people and information. It links spatial constraints and attributes with the origin, destination, extent, nature and purpose of the movements (Miller and Shaw 2001, Black 2004). Rodrique et al. (2006) note, that transportation is a geographic process, which has elements that non-geographical analysis techniques do not capture. In particular, geographic processes often exhibit properties of spatial dependency and spatial heterogeneity.

The old school geographer Weber (1929) noted that three factors would influence costs and location: transport costs, labor costs, and the cost savings from agglomeration or deglomeration. Later Hoover (1948) considered that the fundamental feature is proximity, which is an important aspect of agglomeration economies, formed in order to reduce transaction costs thereby eliminating the influence of distance. Finally Lösch (1967) detected that because of the transportation costs, the demand will decrease when going farther away from production unit to another unit, and also the price will not increase because of the competitive suppliers. This kind of a phenomenon is natural especially in bulky paper industries, which are not able to move after the customers or due to cheaper manufacturing costs.

Especially the economic and environmental implications of the spatial uncertainties will provide subjects to transport geographers. The Nordic paper industry is a relevant research target offering an enormous supply chain and transporting varieties to be examined from the spatial point of view.

Hobbs (1996) notes that transaction costs, and their reduction, lie at the heart of the interest in supply chain management. In a recent study, Fawcett et al. (2008) considered that supply chain managers perceive customer satisfaction and service as more enduring than cost savings, which is understandable because it is cheaper to hold existing customers than to acquire new ones. Unfortunately, most transportation researchers – other than geography originated – seem to forget that supply chain, including transportation, is mostly space and time related activity. This notion has been raised by several transport and location geographers like Hall et al. (2006), Eddington (2006b) and Knowles et al. (2008).

Major improvements in transport technologies and falling transport costs, not least thanks to cheap oil, changed the role of transport and these improvements were very effective in putting transport out of consideration in economic geography (Hall et al. 2006). Also Hesse et al. (2004) stress that geography has not paid adequate attention to logistics, as the focus has mainly been on individual mobility issues. Textbooks on urban or general transport geography, like those edited by Taaffe et al. (1996), Hoyle et al. (1998) and Knowles et al. (2008), raise more freight connected questions than they did in earlier editions, particularly with regard to trade and ports. Other spatial implications of transportation have been directly addressed in geography only by a few authors who have developed an insight in to wholesale activities and their geographical distribution (see e.g. Glasmeier 1992, Seppälä 1997, McKinnon 1998, Riemers 1998). McCann (2005) discovered that in the models constructed by the new geographical economists, transport costs themselves were brought into these models in a highly abstract and often inaccurate fashion. It is understandable, while transportation costs are usually very difficult to obtain for research and there exists no abstract model for them. This strongly supports the idea that there is a need for geographic based empiric case study on the transportation costs.

Friction in transportation geography

The theme of friction is not generally found outside transportation geography. According to Rodriques et al. (2006), the comparative advantages between countries are disturbed by the frictions of space and this is central to many geographical

considerations of economic processes. Dicken (1998) notes, that the classic trade theory dismisses the role of transport, particularly the fact that transport costs have a fundamental impact on the amount of trade and goods exchange. Transport geography is emphasizing on those spatial dimensions, which are mainly affecting on the origins of those cost components. These occurrences are called frictions in transporting geography. The present trend of increasing transport costs because of higher fuel prices will strengthen the possibilities for using sea transport in combination with fast modes to curtail the frictions (Henstra et al. 2006).

For the Finnish paper export industry, intermodal truck/train-short sea-truck transporting is the backbone of the international trade. This obligatory and costly function should be eliminated by some other supply chain advantages like higher production efficiency. Hall et al. (2006) emphasize, that globally, the physical amount of freight increased during the last twenty years because of the lower costs. This situation may change substantially in coming years and there will be a strong 'reality check' due to fuel prices for less expensive transportation and spatial structure as short sea transporting. The space economy is a complex non-linear dynamic system (Plummer et al. 2006). Respectively, Hesse et al. (2004) notice that there is a need for empirical research: since distribution is closely related with the value chain interdependencies with production system, the networks and markets are relevant subjects of examination. This means to study the degree to which supply chain principles as transportation costs are becoming decisive for location decisions of such firms.

The Nordic paper producers have financed the export inventories to minimize the delivery time to the customers to serving customers smoothly. This costly warehousing may affect essentially the paper mill's profits, because the paper prices are under strong competition pressured down and no extra is gained from the customers for a shorter delivery time.

Empirical data and survey methods

The significance of transportation differs greatly from country to country due to the distance. Our key subject was to examine the main components of the supply chain costs in the mill level, and to also review in more detail how the total transportation costs of the finished packed products were developed during the study period. According to Baxter and Chua (1998), there are practical difficulties in conducting case study research because of the lack of access to field sites. Correspondingly, Ballou (2001) noted, that the acquisition of correct and reliable data is crucial to the successful practical application of any model. The best model, if implemented with incorrect data, will produce false supply/demand chain configurations. Yin (2003) emphasized that the "distinctive need" in conducting case-study research lies in the "desire to understand complex phenomena". Lewis (1998) notes, that case studies offer a potentially effective and efficient means for comparing complex and disparate operations settings. Their iterative triangulation employs systematic iterations between literature review, case evidence, and intuition. 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).

The paper industry was selected as the research objective because of the importance of the sector to Finland, and also because the topic has been studied minimally from the view of transport geography. The writers have a deep experience from the paper industry. In this study, we address linkages between the paper mill, transportation costs and the importance of transportation in the whole supply chain management in delivering paper rolls to the main markets in Europe. The transportation is defined by using costs in euro per paper ton as a key meter to show how the transportations function as a part of the supply chain from the mill inventory to the consignees.

Our case mill is a Finnish integrated printing paper mill with several machine lines. The case mill was selected as a research topic because it describes very well a typical printing paper mill, which has customers, paper sales and deliveries in a large area, mainly in Europe. Therefore the results can be generalized in some extend to cover all the Nordic paper mills. The acquired empirical mill data contains complete years from 2001 to 2007, 84 months in total. This valid and reliable quantitative data was queried and captured from the mill's database and transferred to Excel spreadsheets. These source figures, based on in packed net tons and euro per ton, were calculated by the mill economics by using the mill's cost management accounting system. We combined these numbers to a single large dataset, which was in-

dexed to prevent the release of confidential business information. However, inside the dataset the processed figures are valid and fully comparable between each other. The paper manufacturer gave the data for the research purposes and we also had several discussions with the financial managers of the case-mill and also with some other mills to focus our study on the relevant issues.

In this study the supply chain costs cover the total costs from the timber-yard at the mill through manufacturing and converting units to consignees: variable, fixed, capital, warehousing and transportation costs. The variable costs include timber, fiber, chemicals, energy etc. and the fixed costs cover wages, maintenance and overhead. The capital costs contain the interests and depreciations. The transportation costs have been sorted out from the data on the country level to find out the spatial differences. The transportation costs cover the truck transporting from the mill to the harbor, the short sea transporting, the truck transporting to the distribution center and final delivery to the consignee. We studied separately the sales costs, which in our study cover the commissions to the sales agents, and mill warehousing and inventory costs at the export harbor and at the import harbor at the target country, and also possible other intermediate inventory costs in foreign loca-

tions between the harbors and consignees. All these costs we have summed up to the level of export countries.

Our problem statement is to explore the characteristics of the transport costs to the paper mill as a part of the supply chain costs. How has the supply chain costs developed during the study period? Has the order size and the transportation costs any causality in euro per paper ton? Has the productivity of the paper machines increased in saleable packed net tons per hour? How have the paper prices and the supply chain costs developed on the mill level? How does the distance affect the transport costs from the mill to Western Europe?

Some findings from the empiric data

Due to the fact that the paper mills are using similar raw materials (pulp, chemicals and paper machines) and common transportation means, the results from this study can be generalized in some extend to cover all Nordic mills. The sales costs cover all the warehousing costs in different locations and the commissions to the sales agents. The total supply chain costs (= total costs of the mill) in the mill developed moderately during 2001–2007 (Fig. 1) depending on the cost type. In 2005 there
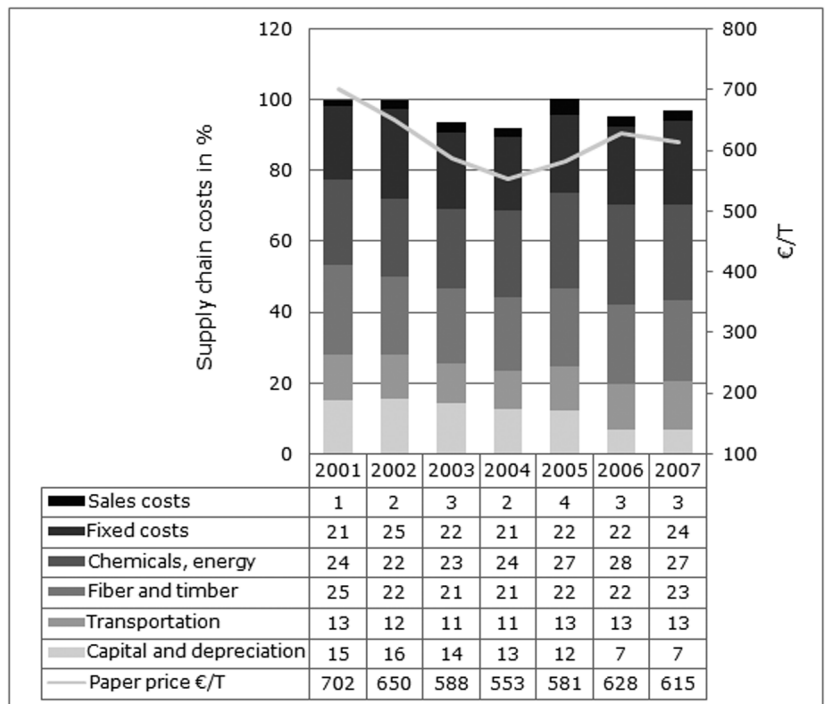

Fig. 1. Development of the supply chain cost components in % in one Finnish paper mill (2001 = 100) and paper price development in €/t 2001–2007.

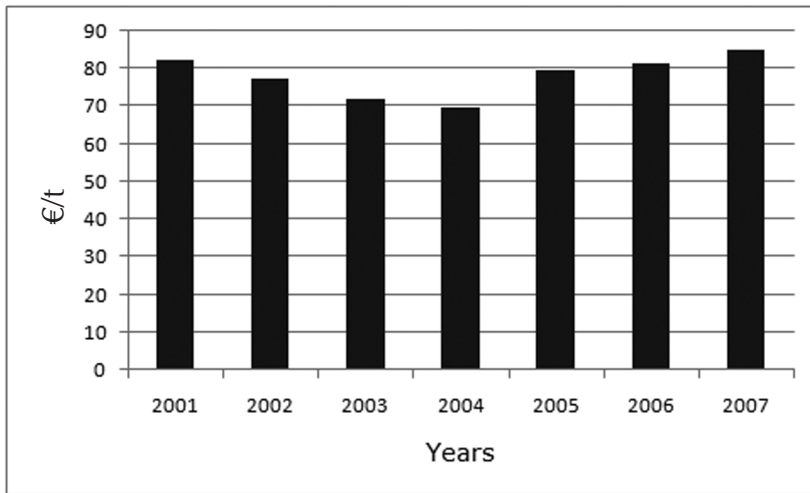|	2001	2002	2003	2004	2005	2006	2007
Sales costs	1	2	3	2	4	3	3
Fixed costs	21	25	22	21	22	22	24
Chemicals, energy	24	22	23	24	27	28	27
Fiber and timber	25	22	21	21	22	22	23
Transportation	13	12	11	11	13	13	13
Capital and depreciation	15	16	14	13	12	7	7
Paper price €/T	702	650	588	553	581	628	615

Fig. 2. Average transport costs (€/paper ton) calculated as a comparable index to main export countries 2001–2007 from one Finnish paper mill.

was the industrial block out, which increased the sales and especially the warehousing costs, because the mills produced a lot of stock orders beforehand, which were delivered during the block-out period.

The capital costs as interests and depreciations have lowered during the study years indicating that the investment level has decreased in some measure. The chemical and energy costs have increased and the average paper prices have lowered substantially. RISI (2007) has estimated that the development of sales prices in paper products will not be satisfactory because of oversupply and lowered demand in main markets in Western Europe and the USA. Respectively, in whole Asia, paper demand is growing, but the long transportation limits the paper deliveries from Europe. Also the production capacity has increased steadily in that area.

The printing houses, which are mainly purchasing the paper products, constantly have a deep knowledge of the paper markets, so that they aim to acquire products at the lowest price. Local paper producers derive an obvious advance in form of delivery time and transportation cost. This is called locational advantage (Curry and Sheppard 1982). According to ELA (2004), transporting costs generally have been cut almost in half since 1987, the main reason being efficient outsourcing. In our empiric peripheral paper mill, far from the main markets, the average transporting costs in euro per ton have varied to some extent, but remained at a high level all the time (Fig. 2).

An obvious consequence of the above described progress is that the Finnish paper industry faces economic challenges. The bulky paper products, production methods, transportation and the whole supply chain process do not fundamentally differ according to the country the paper grades are manufactured in. This means that the efficient and profitable value adding chain, which Porter (1985) stresses, is difficult to achieve, because a paper product is relatively easy to replace with comparable but more affordable grade produced by a competitive supplier.

We looked at the transportation costs more deeply through the spatially sorted data, and our material shows (Fig. 3) that the transport costs from the mill increase clearly as a function of distance. This means that the average values in the mill level give a meager picture of the transportation costs. It is obvious that the domestic transportation is affordable, but to the main markets in Europe the costs are much higher due to multimodal transportation. There are not many real choices to lower the intermodal transportation costs in a paper mill due to the type of the industry. In the future the fuel costs and the environmental issues will put more pressure on the truck and even on the short sea transport costs (Winebrake 2008).

We also studied if there is any correlation between the order size and the transportation costs by using the order data. The order data is based on the sales to one important overseas country and all these orders have been transported by using multimodal means. The data covered different sizes of orders, 2386 in total. These have been delivered during 84 months to the consignees, on average 28 orders per month. According to the material the

transportation costs of the small customer orders, such as a few tons or some hundred kilos of packed paper cost even twice as much as larger ones (Fig. 4). The consignees don't normally have large inventories of their own. Instead they pick the rolls from the distribution center when they need them in printing machines. Figure 4 also shows the interesting finding, that the variation of the order sizes is huge. This supports the studies that the large inventories balance the demand at the mar-

ket and the JIT, delivering smaller units, do not bring the expected lower costs in paper industry from the mill to the consignees. It is obvious that the significances of the geography impacts to Finnish paper industry are very crucial. Our findings from the empiric data support the theoretical views mentioned in previous chapters, that when researching paper freight transport, the spatial dimensions should be used in these examinations to see the variation in the marker more clearly. The
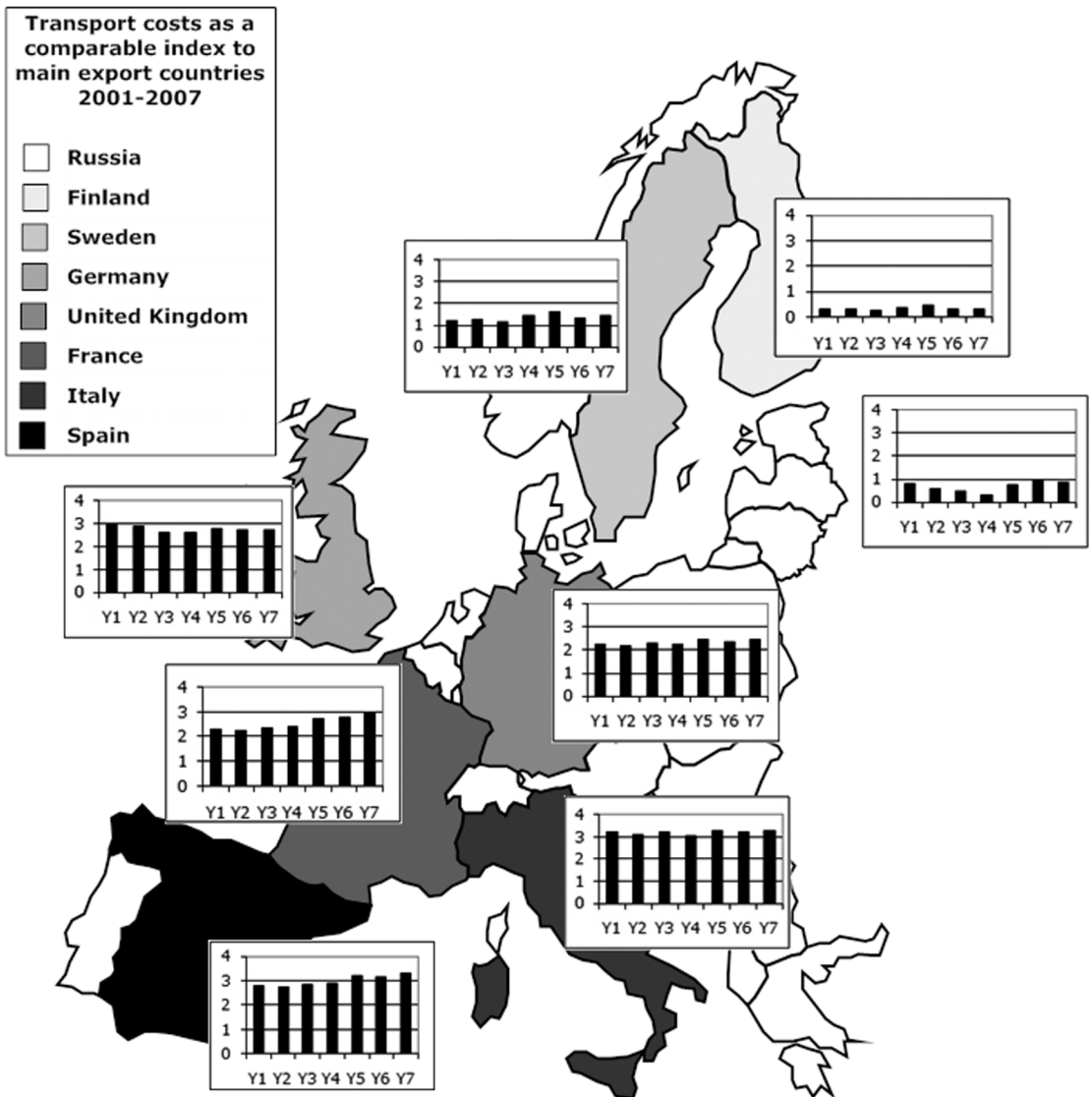

Fig. 3. The development of the average transportation costs €/t from the mill inventory to the consignees during 2001–2007.
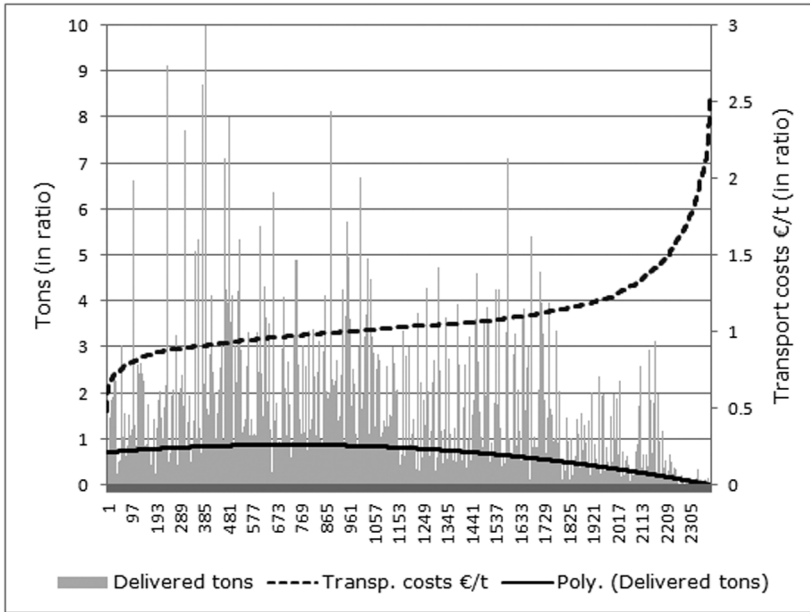
Fig. 4. Relation between transportation costs €/ton and delivered orders to one over sea country in Europe during 2001–2007. N = 2386 orders, average order size = 0.65 units and average transportation cost = 1 unit.

average mill values do not show the interesting geographic heterogeneity.

Without an exception, all the industries are working incessantly to make manufacturing more efficient in time unit when fighting against the rising costs. This is important for the whole Nordic paper industry far from the main markets with lowering paper prices and printing paper demand especially in Western Europe. There are perpetual discussions if the paper machine lines have become more productive by using the continuous remedy, automation and other improvement methods. Lamberg et al. (2006) note, that productivity in paper industry has risen enormously due to larger machines and increase of speed. Our empiric mill data shows that the efficiency of these older paper machine lines (PM 9, PM 8 and PM 7) has barely increased at all (Fig. 5). This demonstrates also explicitly, that the total supply chain costs per manufactured paper ton have not decreased during the same period. It is obvious, that if the costs do not follow the decreasing paper prices, these
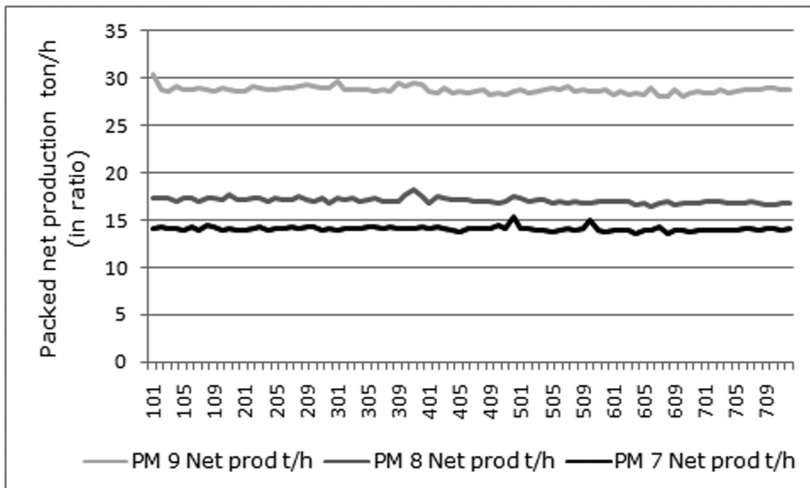

Fig. 5. Packed net production efficiency, monthly development in tons per machine hour in three older paper machines in one paper mill during 2001–2007.

older mills in periphery are soon facing serious economic problems.

The main purpose of these investments is, in reality, to increase machine speed to produce more saleable packed net tons. Instead of the efficiency investments, Haarla (2003) suggests that there is great potential in product differentiation, which will become more important due to the growing number of aged paper machines. This process concerns more and more topically Finnish paper business, because the comparative advantages of the Finnish paper industry are noteworthily disturbed by the frictions of the spatial elements. These geography heterogeneities and distances directly affect the economic future of the Nordic mill through the transportation and sales costs especially in older paper mills.

Discussion and conclusions

The paper industry, which is an extremely important industry sector for the Finnish economy, is in challenging economic situation due to many reasons. The study showed that the total supply chain costs have remained on a very high level in a periphery paper mill both absolutely and relatively when comparing them with the paper price development. This process concerns more and more topically Finnish paper business, because the comparative advantages of the Finnish paper industry are clearly disturbed by the frictions of the spatial elements. These geographic heterogeneities and distances directly affect the economic future of the Nordic mill through the transportation and sales costs especially in older paper mills. The transportation costs are worth looking through the spatial presence, because the average costs figures forget the geographic diversity. Small size orders are very expensive to deliver, and therefore should be avoided. Also the variety of the orders is huge. The productivity of the aged paper machines in packed net tons and in time unit has not improved. Also during the past years the investments have lowered presumably because of the tight economy.

The above described development distinctly demonstrates that the transportation and sales units costs €/t, which are impossible to avoid, must be surpassed by some other fashions than only by the productivity investments on the older machinery. This indicates that these older paper machines situated in periphery will meet more tightening competition from the paper mills closer to the market in Europe. These non-avoidable transportation costs cannot be covered with higher paper prices, as long as there is an oversupply situation in the market. As a result, the mill management should look carefully at the whole supply chain costs including transportation costs and sales costs of the country and even customer level.

The paper industry has worked intensively for years to stay competitive in Finland mainly by using larger and faster machines. Transportation and sales costs, fixed costs, energy prices, fiber costs, capable site management, paper demand and produced grades are irrevocably steering mill shut downs and location decisions in the coming years in the Nordic Countries.

There are not many relevant tricks to lower the intermodal transportation costs in a paper mill due to the type of the industry. In the future, the fuel costs and the environmental issues will possibly put more pressure on the truck and even the short sea transport costs. As a conclusion, we see that if the present development of the paper prices and the supply chain costs continues in the Finnish paper industry, then:

- there will be further mill shut downs, firstly due to negative costs development and secondly due to oversupply, which should be eliminated as soon as possible, to get paper prices up again.
- smaller order transports and deliveries to the consignees should be avoided, if possible.
- the mills should focus more on the transporting issues, and also to lower the intermediate inventories, both together and intensively.

On the whole, the supply chain costs together with transport costs are to increase, so there are indications that the paper industry is transforming, in some measure, into a more local based industry instead of a global one. The transportation costs together with the sales costs (15–17% of the whole supply chain costs, see Fig. 1) are a considerable part of the costs in a paper mill. In the case of a small single order, the transportation costs can be up to 30% of the SC costs depending on the customer's location from the mill. The paper companies located in Finland and other Nordic countries are working intensively to adapt to this challenging economic and demand situation, mainly by closing the unprofitable machine lines and mills.

Our study contains the complete supply chain costs data from one typical inland paper mill. So the results cannot be generalized in such, but still

our study gives some indications of the other paper mills and paper manufacturing, because these processes are common. It can give interesting and useful insights to the whole supply chain research field, which especially the Finnish and Nordic paper industry far away from the European markets, should utilize more actively.

Geography as a science has not studied largely the supply chain costs concerning the paper industry, and this paper is published to fulfill a part of this shortage (Arlbjørn et al. 2008). Future research would benefit from focusing to cover several mills to get a deeper picture of the Nordic paper industry. Transport geographic studies concerning paper industry could focus in more detail on the supply chain management and the variations on the consignee and paper grade level. These customer based orders should be examined in more detail as they might expose how the transportation costs behave and aid in finding an optimal order size in relation to the transportation costs. SCM studies in the future should cover a larger number of paper mills and machine lines to deepen the knowledge of this research topic.

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