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SOURCES OF INNOVATION IN THE ESTONIAN FOREST AND WOOD CLUSTER

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Abstract

The paper aims to identify the role of different sources of innovation for the Estonian wood sector. Comparing data from survey of *Innovation in Estonian Enterprises 1998-2000* with similar Finnish data reveals that linkages in Estonian forest and wood cluster are relatively weaker regarding innovation sources. Universities and research institutes are the weakest part identified in the knowledge flows of the emerging Estonian wood cluster. Technological capabilities of Estonian wood and forest industries have passed the absorption phase and entered the adoption phase, but still the absorptive capacities remain relatively low, as indicated by the high importance of internal innovation sources and the low intensity of using R&D institutions and universities as innovation sources.

We applied binary logit model in order to identify the role of different sources of innovation for the Estonian wood sector.

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Suppliers are the most significant partner for innovation cooperation and also the second innovation source after internal sources. Customers are more used for innovative products and by those companies that lack knowledge about markets. The internal information of concerns is not diffused to other firms. The future development of the Estonian forest and wood cluster should be oriented towards the development of high-end production capacities in the value network. This requires joint efforts of the government and industries, as well as collaboration-oriented behaviour of Estonian companies.

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INTRODUCTION

Forestry provides one of the few renewable resources in Estonia and therefore the forest, wood and paper industries have always played an important role in the Estonian economy. During the last ten years, the export of Estonian forest, wood and paper products have grown steadily. Recently, however, the speed of the growth has slowed down. Wood and forest products are in the maturity phase of their product life cycle, which makes it especially important to study their competitiveness and the possibilities of enhancing it. Considering the small scale of the Estonian market and its rather limited financial resources, it is very difficult to compete with the world's leading forest and wood industries. Thus, it is of vital importance to develop collaboration between different sub-sectors to increase the competitiveness and innovativeness of the industries under discussion.

The development of similar sectors in other countries shows that internationally successful forest-based industries (for example, in the Nordic countries) have a complex structure of forest, wood and paper industries patterning the development of industrial clusters. These clusters typically comprise all forest-based industries belonging to the respective value networks. In this paper, the forest and wood cluster comprises only core industries: forestry, wood processing, pulp and paper, and the furniture industry.

The aim of this paper is to identify the role of different sources of innovation for the Estonian wood sector using the cluster approach. This involves defining the industrial cluster first and thereafter analysing the growing role of innovation in the life-cycle of an industrial cluster.

The innovation cluster of the Estonian forest and wood sector is here analysed and compared with a strong innovation cluster of those industries in Finland. This analysis cannot be supported by traditional quantitative cluster analysis, because no respective input–output tables are available for describing recent developments. Additionally, the factors that influence the choices of innovation sources across innovative companies in wood industries are analysed and compared with other sectors and companies in the economy in order to find sector- (or cluster-) specific factors. Throughout the paper, problems that hinder cluster formation in these industries are discussed, along with the possibilities of involving the government in promoting the expected development of the industries into an industrial cluster.

The paper proceeds as follows. In the first section the theoretical basis for analysing industrial clusters and the role of innovation in clusters is described. Thereafter, the recent developments in the Estonian forest industry are reviewed. Subsequently, innovation in the Estonian forest cluster in comparison with the Finnish forest cluster is assessed and the factors behind the choices of innovation sources are analysed more deeply. The final section concludes.

1. Theoretical framework

The concepts for analysing industry clusters

In today's world of intensified globalisation and competition, the concept of the competitive advantage of a country or an industry has changed. The costs of inputs as determinants of competitive advantage have been replaced by effective utilisation of inputs, which demands ongoing innovation and is based on the relationships of knowledge and collaboration. Paradoxically, lasting competitive advantages in a global economy lie increasingly in local matters — knowledge relationships and motivations that distant rivals cannot match (Porter, 1998).

The advantages of the cluster approach over traditional competitiveness analysis mainly derive from the fact that, as well as the traditional industry classification, it covers the relevant relationships and complementarities between companies in the fields of technology, knowledge, information, marketing and client needs. A significant amount of research has been conducted on industrial clusters in both developed and developing countries (Basant, 2002). The empirical evidence from this research suggests that horizontal collaboration between small and medium-sized enterprises could produce collective efficiencies in lower transaction costs, accelerated innovation through easier problem-solving and greater market access. Besides, positive externalities are generated by agglomerations through the availability of: (a) skilled labour and inputs; (b) certain types of infrastructure; and (c) innovation generating informal exchanges.

An industry cluster can be defined as a group of companies and other organizations in which each cluster member has a significant role in advancing the competitiveness of any other cluster member (Bergman, Feser, 1999). The main characteristic of an industry cluster is the interdependence of the companies, that is, the competitiveness of a cluster member depends on one, several or all of the other cluster members. The cluster members can be connected through seller-buyer relationships, similar technology, similar consumers, common distribution channels or similar labour.

A cluster’s boundaries are determined by linkages and complementarities between the industries and institutions that are most relevant for competition. Although clusters often match with political boundaries, they may overlap state or even national borders (Porter, 1998). It has to be noted that there is a certain academic scepticism about clusters because of the eclecticism involved in the way ideas have been used (Benneworth et al, 2003). At one end, the term refers to national groups of industries and firms that are strongly linked, but dispersed over several different locations within a country. At the other end, clusters are identified as local groupings of similar firms in related industries within a highly spatially concentrated area.

Since the late 1990s a new interpretation of clusters has been gaining popularity. In this approach, the crucial dimension is the mode of interaction between actors in the cluster. On a more general level, a distinction is made between tangible and intangible linkages, that is, transaction and information (or innovation) linkages, which act as basic determinants in defining clusters (Viitamo, 2001). The interpretation of a cluster as an innovation network has its origins in the 1980s, when national innovation systems were evolving into a separate theoretical framework for the design of technology and science policy (Roelandt, den Hertog, 1999:10–12). The national innovation system approach views industrial clusters as *reduced-scale national innovation systems* with equivalent dynamics, system characteristics, and interdependencies (Roelandt, den Hertog, 1999:12). This is reflected in the definition of industrial clusters as:

> networks of production of strongly interdependent firms (including specialised suppliers) knowledge producing agents (universities, research institutes, engineering companies), institutions (brokers, consultants), linked to each other in a value adding production chain (Roelandt, den Hertog, 1999:9).

This kind of change in understanding clusters has also caused a change in the concept of cluster policies, which have taken the sectoral focus and industry-specific measures from industrial policy. Currently the awareness is rather widespread that regional economic growth is dependent on the interaction of businesses, institutions (such as universities) and wider environmental factors, such as the labour market and infrastructure from regional development policies. Cluster policies have acknowledged the importance of developing the capacity of individual (particularly smaller) businesses to overcome their growth challenges through policies directed at small and medium-sized enterprises (Benneworth et al, 2003).

The role of knowledge flows

In earlier contributions to the cluster literature, the division of labour, transaction costs and agglomeration effects were used in order to explain the process of clustering. The major focus was typically on input–output linkages or the so-called traded relations. More recent studies, however, have focused on dynamic efficiencies that emanate from learning at the cluster level. Storper has indicated that the focus should be shifted to untraded interdependencies, which include different methods of knowledge creation, sharing and utilisation (Storper, 1995). Storper stresses the idea that untraded interdependencies create observed input–output linkages (traded interdependencies), but they are more enduring. Untraded interdependencies between enterprises in a cluster, apart from input–output linkages, contribute to knowledge flows and learning. This has caused a more rigorous exploration of cluster-specific innovative activities and the role of knowledge flows and their determinants in industrial clusters (Basant, 2002:5–12).

The above ideas of changing relative importance of material and relational linkages inside clusters were linked with the life-cycle of clusters by Formica, 2003 (see also Figure 1). According to his ideas, in the first phase of cluster development, companies collaborate by adjusting to existing technologies, and the relationships are mainly based on tangible resources (raw materials, components, and so on). In information exchange, personal relationships matter, collaboration is informal and tacit knowledge is transmitted. Experience from the coordination stage and existing supply chains leads the most innovative companies to invest in 'untraded' or non-commercial factors of interdependency, such as educational attainment, developing team work, communicating and promoting favourable attitudes towards industry (Storper, 1995).This means that joint rather than individual benefits are maximized. The later stage, 'co-opetition', is characterized by the same companies cooperating and competing with one another at the same time. As noted by Bengtsson and Kock, 2000 the advantage of co-opetition is the combination of a pressure to develop within new areas provided by competition and access to resources provided by cooperation. Regarding innovation, the globalization of competition is enhancing innovative linkages in order to accelerate technological change.

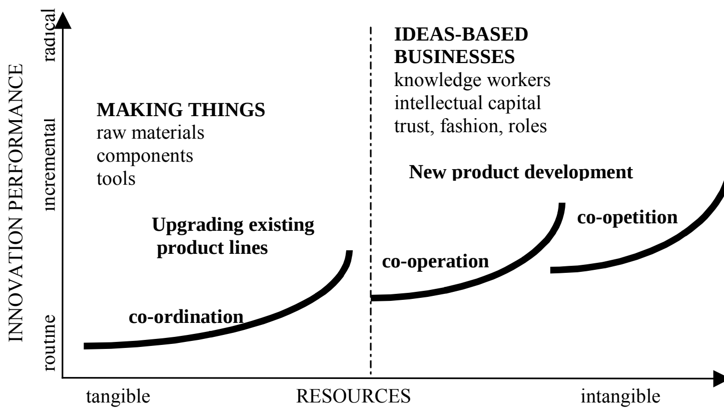

Figure 1. Forms of business collaboration in an evolving cluster (Formica, 2003: 59).

As discussed previously in this paper, the effective utilisation of inputs is becoming more relevant than traditional cost advantages. The capabilities to absorb, use, adapt and build upon technical knowledge must deepen with time if the companies want to maintain their competitive edge (Lall, 1999). As illustrated in Figure 2, technological capabilities are increasing as the intensity of knowledge utilization concerning products, processes and practices increases. The essence of competitiveness is to move from imitable assets (such as absorptive capabilities) to more proprietary assets (adaptation, improvement and innovation) (Lall, 1999:8).

Industrial firms are gaining ideas for innovating from a wide variety of different sources and their innovative performance depends on how successfully they can appropriate knowledge from these sources (Cohen, Levinthal, 1990). Both internal capabilities and openness towards knowledge sharing are important for upgrading innovative performance. The use of external resources depends on internal capabilities, which incorporate absorptive capacity (Cohen, Levinthal, 1990).

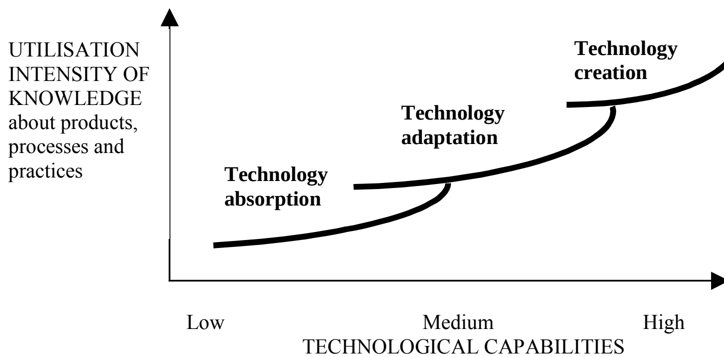

Figure 2. Development of companies' technological capabilities**.** Source: author's derivation based on Lall, 1999: 8.

Considering the sector specificities of innovation and technical change, most of the wood industries under discussion belong to supplier-dominated sectors (Pavitt, 1984). This means that among the predominant sources of technology and information are suppliers, government-financed research institutions and (less frequently) large users. In these industries, competitor collaboration may often be present. Since supplier-dominated firms are believed to make only a minor contribution to their product and process technology, one would anticipate a limited association between internal resources and innovation (Freel, 2003).

In contrast, according to Maillat, 1991, external resources are of little use for firms with incremental innovations, because usually the resources needed for these innovations can be found inside the firm. Firms with radical product and process innovations would require more than limited internal resources can provide. Oerlemans, Meeus and Boekema, 1998 find that firms with incremental innovations compared to radical innovators use both types of sources — internal as well external — more intensively. The reason is that the gradual development of technology makes it easier to connect internal and external resources, since the gap is smaller. In supplier-dominated industries, large suppliers and buyers and other companies in the same industry are especially important innovation sources. They find public technology policy as an additionally important contributing factor in innovation in these sectors.

The role of customers or buyers as a source of information for innovation has been recognised since the 1970s (Von Hippel, 1976). Customers can influence product and process innovations in the following ways: by providing complementary and tacit knowledge, by establishing the set of user requirements, by providing information about new or changing needs, by providing information on post-launch improvements, and by enhancing the likelihood that the innovation will be adopted by other firms within the same user community (Amara, Landry, 2005). Amara and Landry suggest that clients are used as information sources by firms that institute novel innovations, as world-first introductions rather than incremental innovations (Amara, Landry, 2005).

Suppliers are also sources that are used similarly to clients for innovation information. However, the information linkage is based on making or buying relations (hence, transaction flows). The tendency in recent decades has been towards firms' downsizing and focusing on core competencies, which is likely to increase the role of suppliers in innovation processes (Amara, Landry, 2005).

Competitors as sources of innovation information have been studied more in the literature of strategic alliances. Openness of knowledge may speed up the pace of innovation as competitors are able to build on other innovators' advances, rather than being allowed to block progress (Foray, 1997). Based on the existing literature, Amara and Landry have flagged the following motives for choosing this information source (Amara, Landry, 2005). The information obtained from competitors is related to the increased complexity and intersectoral nature of new technologies, reduction of uncertainty and costs of research and development (R&D); it is associated with market access or can be related to development of product and process innovations (acquisition and appropriation of partner's tacit knowledge, uptake of codified knowledge and reduction of the period between invention and market introduction). Caloghirou, Kastelli and Tsakanikas find that innovativeness is increased by usage of partnerships in alliances or strategic collaborations (Caloghirou et al, 2004).

The use of universities as a source of innovation depends on the average absorptive capacity of firms in the sector. According to Laursen and Salter, 2003 larger firms and firms with stronger R&D intensity use universities as sources of innovation relatively more extensively. However, there are large differences across industries in the use of universities as innovation source.

From the theoretical and empirical literature one can conclude that not all innovation sources are equally gaining in importance. Due to the specifics of the wood sector, suppliers and non-profit R&D institutions are more important than, say, universities.

2. Dynamics of the sub-sectors belonging to the Estonian wood sector

The industries in the wood sector are important because they use and add value to the local renewable natural resource, while having a paramount role in the development of the entire Estonian economy. Here not only the direct value chains related to wood and its processing but also value networks are considered. In the past ten years, the relative importance of forest, wood, furniture and paper industries in the Estonian economy has continuously grown (see Figure 3). In 2002, these industries provided 25 per cent of the total output of Estonian manufacturing industries. According to the data of the Statistical

Office of Estonia, in addition to the manufacturing industries belonging to the wood sector, forestry accounts for about 5 per cent of Estonia's GDP.

Even more important is the contribution of the forestry and wood sector to Estonian exports. For example, in 2001, the wood industry made up 28.8 per cent of Estonian exports being the main balancing force against Estonia's negative foreign trade balance. The wood sector is basically the only sector of the manufacturing industries that balances the negative foreign trade balance created by other industries.

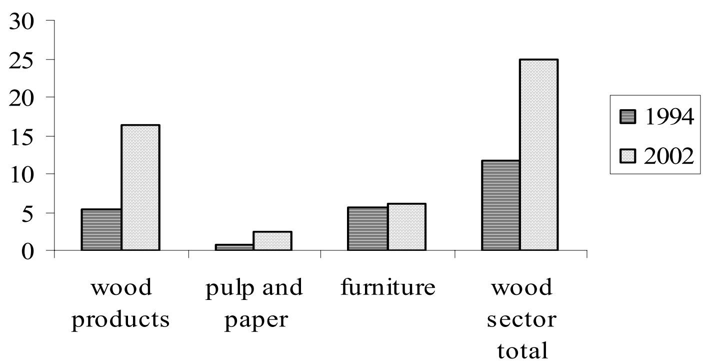

Figure 3. Contribution of wood industries to total turnover of Estonian manufacturing industries in 1994 and 2002 (%). Source: Estonian Statistical Office (2003).

The wood, paper, and furniture industries are much more oriented towards foreign markets than the manufacturing industries on average. According to the Statistical Office of Estonia's data, in the year 2001, the importance of exports in sales was 60.7 per cent in wood processing, 68.7 per cent in the paper industry, and 74 per cent in the furniture industry (the average respective indicator in manufacturing was 53.4 per cent). The exports of the forestry and wood sector have grown rapidly, which is illustrated by figure 6.4. One can also get some evidence of the tendency towards exporting goods with higher value-added: the export of roundwood is gradually being replaced by the export of processed wooden materials.

The main export articles in the forest and wood industries are sawnwood, wooden furniture, raw wood, wooden construction materials, and prefabricated wooden buildings. The main target markets are Finland, Germany, the UK and Denmark. In the last few years in the German market Estonia has increased its market share most of all in coniferous roundwood and veneer. In the Swedish market its share of fibre- and particle-board as well as of non-coniferous sawnwood has grown, while high market shares of filings and wooden chips have been retained. In the Finnish market, the share of Estonian products has increased in almost all product categories. In the British market the shares of filings and chips have increased, as have chip-boards in the Danish market (Lättemägi, Vahter, 2004).

On the basis of niche market analysis, one can conclude that Estonia has already entered or has a sale potential based on price advantages in the growing markets of Japan and Egypt. General competitiveness analysis, based on different competitiveness indexes, has shown an increase in the competitiveness of the Estonian forestry and wood sector.

In addition to their export orientation, the forest and wood industries have also higher productivity than the average of the entire manufacturing sector. The only exception here is the furniture industry, where the labour productivity level is below the average for manufacturing (Ukrainski, Vahter, 2004). A considerable amount of foreign direct investments have flowed into the Estonian wood processing companies, but the share of foreign capital is still below the average level of the manufacturing industry. The superiority in productivity of foreign-owned companies over domestically owned firms in the wood sector is much lower than the average for Estonian manufacturing. Here again, the furniture industry is an exception, having greater differences in productivity between foreign-owned and domestic companies.

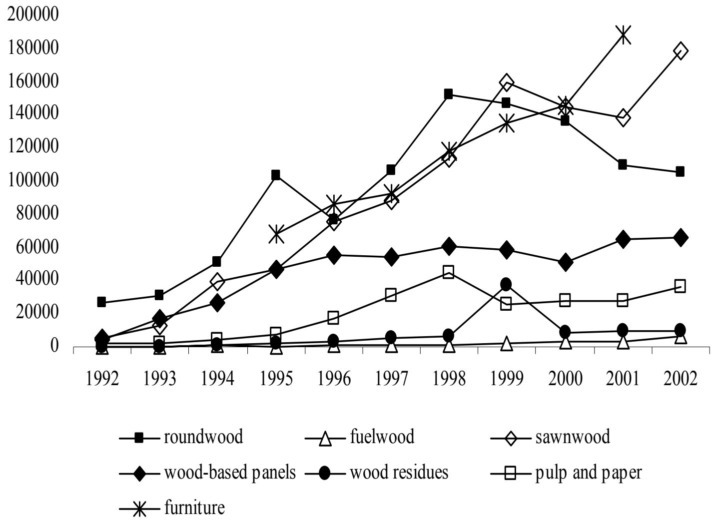

Figure 4. Exports of Estonian forest, wood, paper and furniture industries 1992–2002 (in thousand USD)
Source: Estonian Statistical Office (2003), FAOSTAT (2003).

The Estonian forest sector firms have advanced significantly in the last 15 years.[3] At the beginning of the 1990s, technology absorption (mainly in the form of technology import that was also FDI-dependent) started, and had matured by 1995 (Kolk, 2003). Here strong information and technology flows can be observed from the forest clusters in Finland and Sweden, but also from the other Nordic countries. As can be generally concluded from interviews, most companies are now in the adaptation phase (Kuldkepp, 2003), but there are firms that are innovating and creating new products and technologies (Arula, 2003).

On the basis of industry interviews, there can additionally be observed a tendency towards the development of inter-company

[3] The analysis here is based on interviews with industry leaders and covers larger and more successful companies, so it is not representative, but gives some indication about the developments of leading companies in the sector.

collaboration in the Estonian forestry and wood sector. The value-chain based interaction between the procurement, sawn-wood and sales companies that are part of the same foreign concern is gaining in importance (Arula, 2003). Since the essence of competitiveness is to move from absorptive capabilities to adaptation, improvement and innovation, it is of critical importance to the Estonian forest industries as to how they manage to evolve through the technology absorption phase and start innovating actively.

3. Innovation sources of Estonian wood sector companies

In the following analysis, the survey of *Innovation in Estonian Enterprises 1998-2000* is used (see review in Kurik et al, 2002). The survey is generally based on the same methodology as the community innovation survey developed by the European Commission and Eurostat. From the 3161 companies covered by the survey, here only those enterprises are included which have experienced product or process innovation in the period 1998–2000. The sample then consists of 1052 innovative companies; of which 112 belong to the wood industries (6 to paper, 66 to wood and wood processing, and 40 to the furniture industry).

From the total of 335 wood sector companies covered by the survey, 24.2 pes cent performed product innovation and 23.3 per cent process innovation in the years under observation. Innovation cooperation activities were present in 9 per cent of all the wood industry companies. The cooperation partners used most for innovation were suppliers (80.0 per cent) and customers (73.3 per cent), followed by other companies within the concern by 43.3 per cent and competitors by 40 per cent. Different educational and research institutions in all categories were under 20 per cent. The importance of those cooperative relationships was estimated to be the highest within the concern (84.6 per cent of the companies that cooperated did so within the concern), while the lowest importance was in cooperation with consulting companies, companies offering R&D services and universities (50 per cent of the companies assessed this kind of cooperation as having low importance for innovation).

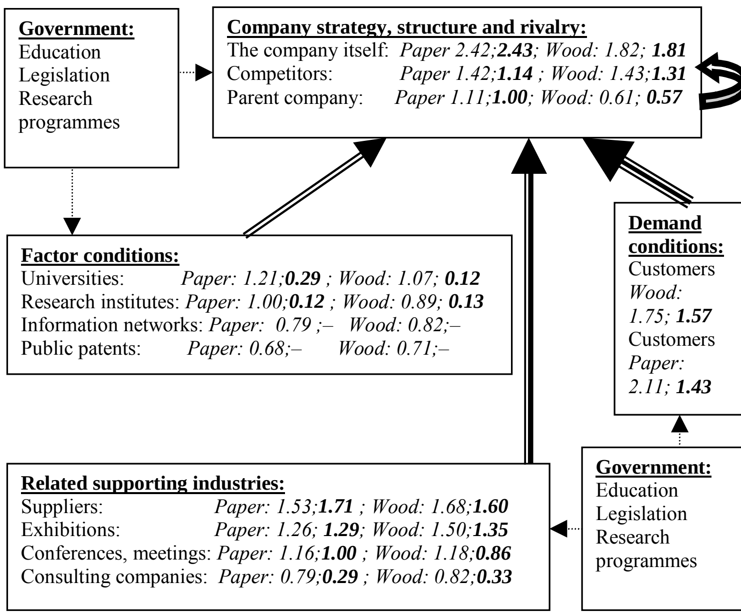

Figure 5. Sources and their relative importance in innovation activity in the Finnish and Estonian wood industries[4]

An analysis of innovation sources (sources of innovation-related information) revealed that they were of relatively similar importance (within the company (28.4 per cent), suppliers (26.4 per cent), customers (25.8 per cent), competitors (24.9 per cent), and exhibitions (24.6 per cent)). Such innovation sources as universities and other non-profit R&D institutions scored just

[4] The figure shows mean scores of the responses. Finnish figures are first followed by Estonian figures in Bold. The Finnish data are from 1997, the Estonian data for 1998-2000. In both cases the respondents were asked to rank alternative innovation sources by importance (0 = no importance, to 3 = very important).

3.7 per cent and 2.9 per cent, respectively. The importance of innovation sources was assessed most highly by users of the concern (55.2 per cent of users of this innovation source) and much the lowest (76.9 per cent) by users of universities. Relative importance of different innovation sources in comparison with the Finnish forest cluster is illustrated in Figure 5.

As noted by Viitamo, 2003, although the innovation survey was not designed to analyse the cluster framework, the innovation sources can be analysed through Porter's diamond model. If one looks at the general picture, the relative importance of information linkages has very similar patterns in the Finnish and Estonian wood industries. However, some interesting differences are revealed if the strong and mature Finnish forest cluster is compared with the just developing Estonian wood cluster.

In discussing the Estonian paper industry, one has to take into account that the industry is relatively small (here only six companies were used for calculating the mean scores) and extremely concentrated (two companies have more than 100 employees and others are micro-companies) (Varblane, 2004). Looking at general information intensity, one can see that Finnish paper companies rely more on universities and research institutes. Here too the tremendous size differences of the Estonian and Finnish paper companies play a relevant role, but in addition the weakness of respective institutions is a more general problem for the whole sector as stressed by the industry leaders (Botvinkina, 2003). The smaller weight of innovation sources from the concern or mother companies of Estonian firms can be explained at least in one case by the fact that the mother company is not active in the field of paper production (since there are few companies in this sector, this could influence the mean significantly). In the case of supporting industries, Estonian paper companies rely relatively more on suppliers, while customers as information source are less important.

In the case of wood industries, one can see that Estonian wood and furniture companies are assessing all information sources with lower intensity for innovation. The innovation sources that are almost non-existent for Estonian wood and furniture companies are universities and other research institutions (the respective means are 0.12 and 0.13). One explanation here is that the industry is absorbing modern technologies and is not using and creating new or novel knowledge. An additional explanation is that wood technology research and schooling is lagging behind actual industry needs. In fact, there are also hardly any pulp and paper technology or log-house technology specialists educated at the tertiary level in Estonia. The research and development activities of those branches are extremely weakly developed, as recognised also in developing strategies for the wood and forest sector (Ministry, 2003). This part of the knowledge system is very weakly developed so far and can hinder the development of the whole sector.

The analysis showed that generally the importance of all innovation sources is assessed as being low in comparison with Finnish companies, which indicates that the intensity of the use of knowledge is lower in the Estonian wood sector. In the following section, the factors that either hinder or encourage the choice of information sources are identified in a more detailed way.

4. Factors determining the choice of innovation sources

Internal and external information sources are needed in any company for suggesting new innovation projects or contributing to the implementation of existing projects. In the following analysis the choices of companies regarding the innovation sources are analysed separately. The following innovation sources are analysed: within the enterprise, other enterprises in the concern, suppliers of equipment, materials, components or software, clients or customers, competitors and other firms from the same industry, consultants, universities and colleges, their units and institutes, public and private non-profit R&D institutions, professional conferences, meetings and journals, fairs and exhibitions.

In practice, not all these alternative information sources were available to all companies, but since the availability of alternatives cannot be detected from the data, a simplifying assumption is made that all alternatives are available to all companies. Additionally, several information sources are used by companies simultaneously in different combinations which are not studied here. The present purpose is to analyse the respective knowledge flows from the perspective of the national innovation system supporting the industry, hence the innovation sources and underlying factors are analysed separately.

For each information source, a binary logit model is constructed, modelling the specific choice behaviour explaining it by a set of explanatory variables. The dependent variable in the models has two values: 1, if the information source is chosen and 0, if it is not chosen. The probability of choosing the innovation source is p and the probability of not choosing the respective innovation source is *1-p*. To estimate the model, the maximum likelihood method is used. The likelihood function estimated has the following form (assuming linearity in parameters, but not equivalently in attributes or variables Ben-Akiva, Lerman, 1985:63):

$$L = \beta_0 + \beta_1 X_1 + ... + \beta_i X_i . \quad (1)$$

The link function estimated is: $\eta = \ln \frac{p}{1-p}$,

where: $p \in [0,1]$, $\eta \in [-\infty, \infty]$ (2)

From (2): $\frac{p}{1-p} = e^{\beta_0 + \beta_1 X_1 + ... \beta_i X_i}$ (3)

and hence: $p_i = \frac{e^{\beta_o + \sum \beta_i X_i}}{1 + e^{\beta_0 + \sum \beta_i X_i}}$ (4)

is the logistic function (Aldrich, Nelson, 1984:32). This function is continuous and can take values from 0 to 1. If $\beta_0 + \sum \beta_i X_i$ is indicated as *Z*, one can say that the function is 0 when *Z* approaches negative infinity, and 1 in case *Z* approaches infinity, while between those values the function is monotonically growing. The theory underlying the decision about the choice deals with a single firm, whose preferences or tastes are implicitly contained in the form and parameter estimates of Z.

The method of maximum likelihood is based on the choice of the regression coefficients that maximizes the likelihood that the respective set of choices is obtained. The function under maximization is the following (Ben Akiva, Lerman, 1985:85-86):

$$\ln L = \sum_{i=1}^{n} \left[Y_i \ln p_i + (1 - Y_i) \ln(1 - p_i) \right] \quad (5)$$

The independent variables, that is, the factors influencing the probability of choosing a specific innovation source, are also formed from considering the survey questionnaire and the particular interest in the wood sector. From the set of individual variables those that are considered in the final models are only those that changed the likelihood of the wood sector model (choosing the respective information source) by more than 0.01 per cent (for this purpose, the backward stepwise method in SPSS is used).

The following variables are entered in the final models:

1) Attributes of companies:
   Lnturnover: logarithm of the annual turnover in 2000;
   Export: share of exports in turnover in 2000;
   Foreign: binary variable (=1 if foreign ownership was present and 0 if not);

2) Innovativeness of companies:
   Costs: share of innovation costs in turnover (2000);

Prodinno: binary variable (=1 if the firm implemented product innovation, meaning a good or service which is either new or significantly improved with respect to its fundamental characteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user–friendliness);
Procinno: binary variable (=1 if the firm implemented process innovation, which includes a new and significantly improved production technology, new and significantly improved methods of supplying services and of delivering products. The outcome should be significant with respect to the level of output, quality of products or costs of production and distribution).

3) Barriers to innovation. All these variables can take 4 values (0 = no barrier, 1 = low barrier, 2 = medium barrier, 3 = high barrier):
B_risk: excessive perceived economic risks;
B_*org*: organisational rigidities;
B_*law*: insufficient flexibility of regulations or standards;
B_*nofinance*: lack of appropriate sources of finance;
B_*labour*: lack of qualified personnel;
B_*consumer*: lack of customer responsiveness to new goods or services;
B_*technknow*: lack of information on technology;
B_*marketknow*: lack of information on markets;
B_*cost*: innovation costs are too high.
4) Cooperation arrangements of innovation activities with other enterprises or institutions. All these variables can take 4 values according to the importance of cooperation activities for innovation (0 = not used, 1 = low importance, 2 = medium importance, 3 = high importance):
C_suppliers: suppliers of equipment, materials, components or software;
C_nonprofit_R&D: public and private non-profit R&D institutions;
C_competitors: competitors and other firms from the same industry;
C_concern: other enterprises within the concern;

C_consultants: consultants, enterprises offering R&D services;
C_consumers: clients or customers.

In order to assess whether the wood sector companies have different behaviour in choosing the source of innovation (stemming from different resource provision, competitive environment, demand conditions or other industry specificities) the likelihood ratio test is conducted to identify the differences between the estimated coefficients across sectoral segments. This procedure was originally designed by McFadden, tie and train.[5] In order to determine whether the wood sector's choice factors could be generalised to other sectors in the economy, that is, whether other sectors have the same estimated parameters in the choice equations, the following steps were undertaken:

1. The data were classified into segments according to whether they belonged to the wood sector (wood, paper and furniture industry) or not;
2. Subsequently unrestricted models were estimated according to the two segments described above;
3. The restricted model was estimated with the same specification (all sectors);
4. The hypothesis is tested that the estimated parameters are the same across the different sectoral segments, hence the null hypothesis is as follows: $H_0 : \beta^{wood \cdot \sec tor} = \beta^{other \cdot \sec tors}$, where β^g are the parameters for sectoral segment g (here the segments are the wood sector and other sectors).

[5] D. McFadden, W. Tye and K. Train, 'An Application of Diagnostic Tests for the Irrelevant Alternatives Property of the Multinomial Logit Model', *Transportation Research Record*, 637 (1977): 39–46.

The null hypothesis is rejected if:

$$-2(L_N(\beta) - \sum_g L_{N_g}(\beta^g)) > \chi^2((1-\alpha), df) \quad (6)$$

where: $L_N(\beta)$ – maximum likelihood of the restricted model

$L_{N_g}(\beta^g)$ – maximum likelihood of the model for industry segment g

df – degrees of freedom = difference in no. of parameters between models = $(\sum_g K_g) - K$

α – level of significance

The results of these estimated models are shown in table 1. The test results show that the segmenting of the firms by industrial sectors is meaningful for explaining most alternative choices of the information source. The innovation choices where the null hypothesis could not be rejected were suppliers, consumers and consultants. This result means that the choice factors analysed in those models do not differ for the wood sector compared to other sectors in the economy.

Table 1. Log-likelihoods of the estimated binary choice models

$L_{ng}(\beta^g)$ in models	All sectors	Wood sector	Other sectors	Df
Within the enterprise*	-467.7	-33.3	-422.9	6
Within the concern*	-473.2	-34.4	-424.2	8
Suppliers	-554.7	-49.4	-501.4	4
Consumers	-524.4	-48.8	-472.3	5
Competitors*	-618.1	-49.1	-554.0	8
Consultants	-535.1	-51.3	-479.6	5
Universities*	-500.9	-27.9	-461.8	7
Non-profit r&d institutions*	-313.0	-18.4	-285.0	6
Conferences, meetings*	-682.6	-67.6	-596.0	5
Fairs, exhibitions*	-626.0	-52.5	-565.7	5

Notes: * Models where the null hypothesis was rejected at 5% level.

As can be seen from the Table 2, larger turnover is significant for the wood sector as well as other sectors in the economy. This result is generally to be expected as smaller firms tend to have more limited financial and human resources, are less ready to access information and have shorter time horizons (OECD, 1999:51). In addition, they are generally considered to be more risk-averse and reluctant to seek outside help, except for very specific short-term needs. In the furniture industry, the industry interviews also revealed the opinion that small firms do not acquire information concerning innovation because they are not able to make use of it (Kull, 2003).

Table 2. Innovation source within the enterprise

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Lnturn	0.130***	0.047	0.548**	0.241	0.115**	0.049
B_risk	0.091	0.087	1.274***	0.519	0.034	0.090
B_nofinance	0.026	0.077	-0.497*	0.269	0.069	0.093
B_labour	0.269***	0.085	1.493***	0.448	0.201**	0.089
B_law	0.143	0.093	-0.983**	0.473	0.182*	0.098
ASC	-0.151	0.466	-3.974*	2.203	0.017	0.485
-2LL	935.403		66.518		845.895	
Nagelkerke R^2	0.048		0.427		0.038	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

The companies in the wood sector that claimed to lack qualified personnel for innovation tended to choose internal innovation sources. At first sight this seems very contradictory, because the use of internal innovation sources would generally presume having qualified personnel in the company. However, if one looks at the composition of the labour force in the firms in the database, one can see that companies in wood industries have relatively low shares of employees with a higher or secondary vocational education by comparison with other industries. The view that blue-collar workers' education is unsatisfactory in Estonia is supported by the interviews in different sub-sectors – furniture, wood-based panel, and window production. The lack of skills of employees (especially of factory workers) was even stressed in an interview with one of the forest sector managers as the main impediment to technological change. The main problems with the skills are insufficient knowledge of modern information and computer technology (lack of computer skills and skills for working with electronics), international skills (knowledge of languages — very important in the case of fitters working with the clients abroad, for example), professional skills, but also motivation (Kull, 2003).

The situation described above is limiting companies' absorptive capacities. They are not able to use the wide range of knowledge available from different sources and rely mainly on innovation sources located within the enterprise itself. Consequently, these firms are more inclined to limit themselves to incremental innovations.

Table 3. Innovation source within the concern

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Export	-0.094	0.232	3.721***	1.296	-0.276	0.253
Foreign	2.085***	0.173	1.953***	0.662	2.110***	0.184
Cost	0.012	0.023	0.688	0.521	-0.349	0.415
B_labour	0.133*	0.080	-0.016	0.306	0.122	0.085
B_nofinance	-0.353***	0.090	-0.956***	0.383	-0.301***	0.097
B_cost	0.344***	0.094	1.431***	0.414	0.279***	0.100
Local market	-0.818***	0.233	2.990**	1.394	-0.943***	0.239
ASC	-1.944***	0.204	-5.561***	1.305	-1.785***	0.212
-2LL	946.385		68.833		848.354	
Nagelkerke R^2	0.316		0.592		0.314	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level

Companies with a strong export-orientation and foreign- ownership chose members of their concern as sources of innovation (see also table 3). Here it has to be noted that this alternative was probably available only to concern members, and most of them (over 70 per cent) belonged to a foreign concern. The rest comprise domestically owned concerns that could be more oriented towards local markets and even more strongly exchanging knowledge. The analysis here falls short of clarifying this result, but a disparity between foreign-owned and domestic concerns would not be surprising. However, the results show that the knowledge accumulation process takes place at the concern level and is not diffused to other companies in the sector.

As can be seen from table 4, suppliers are mostly used as innovation sources by firms with process innovations and by companies claiming to lack sufficient technological knowledge for innovation.

Table 4. Suppliers as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*Bi*	S.E.	*βi*	S.E.	*βi*	S.E.
Procinno	1.041***	0.110	1.275***	0.157	1.039***	0.157
B_org	0.304***	0.107	1.384***	0.553	0.225**	0.113
B_techknow	0.465***	0.090	0.632**	0.269	0.446***	0.103
ASC	-0.157	0.133	-0.626	0.515	-0.132	0.138
-2LL	1109.347		98.811		1002.890	
Nagelkerke R^2	0.143		0.276		0.136	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

These factors generally influence the wood sector and other sectors in a similar way. This is the expected result, because if one looks at the general composition of Estonian manufacturing and services industries, then it appears that Pavitt's supplier-dominated traditional manufacturing sectors are prevalent. This means that among the predominant sources of technology and information are suppliers, government financed research institutions and also large users. The in–house R&D and engineering capabilities are weak in these sectors and the technological trajectories are defined in terms of cutting costs (Pavitt, 1984: 356).

Customers as sources of information are used more by firms with product innovations and by companies not having enough market knowledge for innovation (see also table 5). The results are also similar for all sectors, as in the case of suppliers as a source of knowledge. For the wood sector, the barrier of lacking finance for innovation seems to hinder the use of this particular source of information.

Table 5. Customers as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*Bi*	S.E.	*βi*	S.E.	*βi*	S.E.
Prodinno	0.966***	0.166	1.462**	0.533	0.940***	0.177
B_nofinance	-0.041	0.064	-0.500**	0.222	0.005	0.068
B_org	0.485***	0.115	0.761*	0.437	0.473***	0.120
B_marketknow	0.406***	0.095	0.721**	0.300	0.367***	0.101
ASC	-0.038	0.173	0.159	0.553	-0.061	0.183
-2LL	1048.754		97.594		944.533	
Nagelkerke R^2	0.140		0.289		0.131	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

The role of competitors as a source of innovation in the wood sector is rather different from that in other sectors. In the wood sector, the information from competitors is relevant to more export-oriented companies and those not belonging to the concern. The fact can be partially supported by reviewing the interviews, according to which domestic companies are not real competitors (sawmills can be considered as exceptions, as they are competing domestically and are also in large part members of concerns). Other sub-sectors are mainly exporting and not selling much in the domestic market. Very often the companies collaborate in order to strengthen their competitive edge in foreign markets (Kull, 2003; Agasild, 2003; Kuldkepp, 2003). The results indicate that concerns are closed units that do not cooperate with domestic firms in the same industry. Generally, in this industry imitation is rarely used but intra-firm transfer of knowledge is preferred. This is specific to the wood industry as can be seen from table 6.

Table 6. Competitors as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Export	-0.286	0.198	2.243***	0.767	-0.619***	0.206
B_risk	0.278***	0.071	0.557*	0.332	0.274***	0.074
B_org	0.492***	0.096	1.008**	0.429	0.483***	0.100
B_consumer	-0.054	0.073	-0.461*	0.275	-0.051	0.077
C_suppliers	-0.218***	0.073	-0.599*	0.337	-0.205***	0.076
C_concern	0.002	0.095	-1.074***	0.402	0.085	0.101
C_competitors	0.844***	0.153	2.932**	1.347	0.775***	0.153
ASC	0.205*	0.123	-0.189	0.476	0.218**	0.129
-2LL	1236.119		98.271		1107.932	
Nagelkerke R^2	0.139		0.361		0.147	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Throughout the economy, consulting firms are used as innovation sources by those firms that find innovation to be too costly (see table 7). There is no large difference from other sectors in using this particular source of innovation. Universities have low importance in creating knowledge for innovations in wood sector companies.

Table 7. Consulting firms as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Prodinno	0.317*	0.188	1.043**	0.627	0.259	0.200
Procinno	0.778***	0.183	1.211*	0.626	0.749***	0.192
B_cost	0.215***	0.067	0.639***	0.239	0.178***	0.071
C_consult	1.908***	0.207	0.897*	0.499	2.011***	0.228
ASC	-2.295***	0.263	-3.629***	1.803	-2.151***	0.274
-2LL	1070.174		102.683		959.235	
Nagelkerke R^2	0.28		0.232		0.291	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

This situation has already been revealed in the previous sections of this paper. This source of innovation is more intensively used by foreign-owned companies and by those that find risks being a barrier to innovation, and also companies who cooperate with suppliers (see also table 8).

Table 8. Universities as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Foreign	-0.046	0.182	1.566**	0.759	-0.163	0.191
Procinno	0.456***	0.184	7.886	26.316	0.379**	0.188
B_risk	0.423***	0.072	0.817**	0.387	0.395***	0.074
C-supplier	0.068	0.092	0.911**	0.451	0.019	0.094
C_client	0.071	0.092	-0.681	0.495	0.103	0.093
C_concern	0.187**	0.090	-0.366	0.444	0.232***	0.093
ASC	-2.368***	0.195	-11.403	26.323	-2.190***	0.198
-2LL	1001.773		55.707		923.639	
Nagelkerke R^2	0.097		0.387		0.092	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Larger companies make more use of conferences and meetings to obtain information in the Estonian economy as a whole, but companies with foreign ownership use these source less than domestic ones (see table 9). Here the complementarity of different information sources could also be seen: foreign-owned companies rely more heavily on information within their concern and use less information from outside sources.

Table 9. Conferences as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Lnturn	0.122***	0.039	0.507***	0.175	0.160***	0.042
Foreign	-0.216***	0.460	-1.032**	0.513	0.209	0.156
Costs	0.202	0.168	0.059	0.072	2.615***	0.631
B_risk	0.369***	0.061	0.601***	0.228	0.332***	0.065
ASC	-1.085***	0.364	-5.057**	1.616	-1.505***	0.407
-2LL	1365.162		135.125		1192.089	
Nagelkerke R^2	0.067		0.219		0.091	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Fairs and exhibitions are used by larger companies and by companies having cost barriers to innovation (see table 10). For encouraging this particular innovation source, governmental financial support has been extended for many years to domestically owned companies, and hence this source is also available to firms with a low level of finance for innovation. The barrier of labour is relevant for companies using this source of innovation in the wood sector and also other sectors of economy.

Since public and private non-profit R&D institutions are almost non-existent in Estonian wood processing, the companies use such sources outside Estonia. The fact that foreign institutes in Finland and Great Britain are used for innovation is supported by the industry interviews (Botvinkina, 2003).

Table 10. Fairs as innovation sources

Independent	All Sectors		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Lnturn	0.188***	0.038	0.713***	0.202	0.160***	0.039
B_cost	0.360***	0.063	0.397*	0.239	0.356***	0.066
B_labour	0.269***	0.068	0.699***	0.273	0.251***	0.071
B_law	0.072	0.073	-0.608*	0.318	0.116	0.075
ASC	-1.947***	0.379	-6.504***	1.895	-1.729***	0.392
-2LL	1251.982		104.966		1131.341	
Nagelkerke R^2	0.123		0.327		0.116	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Lack of funds decreases the probability of choosing R&D institutions as sources of innovation (see table 11). Those companies who claim to have too little market knowledge have higher probabilities of choosing information from R&D institutions.

Table 11. Innovation sources in non-profit R&D institutions

Independent	Full model		Wood Sector		Other Sectors	
Variables	*βi*	S.E.	*βi*	S.E.	*βi*	S.E.
Prodinno	-0.673***	0.247	-3.170***	1.229	-0.585**	0.262
B_marketknow	0.455***	0.115	1.601***	0.592	0.404***	0.121
B_nofinance	0.063	0.095	-1.335**	0.559	0.150	0.100
C_nonprofit_R&D	2.234***	0.266	2.959**	1.420	2.262***	0.289
Local market	0.266	0.243	3.498***	1.381	0.104	0.254
ASC	-2.522***	0.275	-2.012**	0.885	-2.583***	0.295
-2LL	625.912		36.257		570.065	
Nagelkerke R^2	0.243		0.490		0.250	

Notes: *** significant at 1% level; ** significant at 5% level; * significant at 10% level.

Regarding the determinants of choosing sources of innovation, there are many found to be in line with earlier empirical research by others — the larger size of a company increases the probability of choosing several innovation sources (internal resources, but also conferences, fairs); firms with product innovations use customer information and those with process innovations suppliers as innovation sources.

There are several barriers to the innovations studied in the choice models. The lack of finance for innovation can be considered as a major barrier for wood sector firms. This factor diminishes the probability of using multiple information sources. However, risk aversion and lack of knowledge about the market or technology force companies to search for information from several sources. The internal barriers of companies, lack of qualified personnel and organisational rigidities seem to prevail in all firms.

CONCLUSIONS AND POLICY IMPLICATIONS

The wood and forest sector comprises an important part of Estonian economy. In this paper, the clusters approach has been proposed for analysing the industries related to wood and its products. This has several advantages over the traditional analysis of competitiveness, because it embraces the whole value network of production with all the underlying relationships between cluster members. However, empirical assessment of cluster relationships is not easy to accomplish.

In recent years, steady growth has characterized all branches of the wood and forest sector. This sector has become the main stabilizer of Estonia’s negative trade balance. In exports, a positive tendency has been observed whereby products with lower value-added (industrial roundwood) are losing their importance and products with higher value-added have increasing shares in exports (furniture, but also sawnwood).

Several foreign direct investments have been made in the Estonian wood and forest sector, but their relative importance remains at a lower level than in manufacturing on average. Generally, the sector has higher productivity than the other manufacturing industries, an exception here being furniture manufacturing. Productivity differences between foreign-owned and domestically owned firms are not as large as is common in other sectors. The export orientation of wood industries is relatively high: the main markets lie in the Nordic countries but also in Germany; however, Estonian producers are discovering also such developing wood-consuming markets as Japan and Egypt.

From the cluster analysis, one can conclude that there are relatively weaker linkages regarding innovation sources compared to the Finnish forest cluster. Universities and research institutes are the weakest part identified in the knowledge flows of the emerging cluster. Technological capabilities of Estonian wood and forest industries have developed quite significantly — they have passed the absorption phase and entered the adoption phase, some are creating new products and technologies. Still the absorptive capacities remain relatively low, as indicated by the high importance of internal innovation sources and the low level of intensity of using R&D institutions and universities as innovation sources.

Suppliers are the most significant partner for innovation cooperation and also the second innovation source after internal sources. This information source is used by companies that perform process innovations and lack information about technology. Customers are more used for innovative products and by those companies that lack knowledge about markets. The internal information of concerns is not diffused to other firms.

Judging by the results, one can foresee a decisive role for government and industrial associations in improving knowledge creation and diffusion in the wood sector of Estonia. The future development of the Estonian forest and wood cluster should be oriented towards the development of high-end production capacities in the value network. This requires joint efforts of the government and industries, as well as collaboration-oriented behaviour of Estonian companies. The government's role is seen in improving the inefficiencies in the structure of the Estonian vocational education system and creating industrial research and development competence. Industrial associations face the task of encouraging industries' close liaison with educational and research institutions, and promoting the positive image of forestry and wood professions. A reform of vocational education along with industry support is needed to remedy the problem.

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KOKKUVÕTE

Eesti metsa ja puiduklastri innovatsiooni allikad

Antud töö oli suunatud Eesti metsa ja puidusektori innovatsiooniprotsesside uurimisele. Töös kontsentreeruti peamiselt innovatsiooniallikate analüüsile, kasutades 1998–2000 toimunud uuringu Innovatsioon Eesti Ettevõtetes tulemusi ja Eesti metsa ja puidusektori ettevõtete juhtidega teostatud intervjuude materjale. Töös kasutati võrdlusena ka Soomes läbi viidud analoogilise innovatsiooniuuringu tulemusi.

Eesti ja Soome metsa ja puiduklastrite võrdlemise tulemusena selgus, et Eestis on selle klastri seosed innovatsiooniallikategaga palju nõrgemad. Kõige tagasihoidlikumad on teadmiste vood ülikoolide ja uurimisinstituutidelt metsa ja puiduklastrile. Eesti metsa ja puiduklastri tehnoloogiline võimekus on üsna kiiresti paranenud — läbitud on kopeerimise ehk ülevõtmise etapp ja jõutud tehnoloogia kohandamiseni. Üksikutes Eesti puidusektori ettevõtetes tegeldakse ka juba tehnoloogia loomisega. Siiski on tehnoloogia kasutamisvõime tervikuna suhteliselt madal, millele viitab sisemiste innovatsiooniallikate väga suur osatähtsus ja ülimadal ülikoolide ja teiste teadusasutuste kasutamine innovatsiooniallikatena.

Töö empiirilises osas rakendati erinevate innovatsiooniallikate olulisuse analüüsil binaarset logit mudelit. Analüüsi tulemusena selgus, et kõige olulisem innovatsiooniallikas Eesti metsa ja puidusektoris on ettevõte ise. Tähtsuselt järgmine innovatsiooniallikas on pakkujate rühm. Seda kasutasid eriti protsessi-innovatsioone teostavad ettevõtted, kellel puudus informatsioon tehnoloogiatest. Tarbijaid kasutatakse innovatsiooniallikana

nende ettevõtete poolt, kes omavad vähem teavet turgude kohta. Kontsernisisene informatsioon ei levi teistele sama sektori ettevõtetele.

Eesti metsa ja puiduklastri edasine areng peaks suunduma võimekuse arendamisele, mis lubaks pakkuda enam lisandunud väärtust sisaldavaid tooteid ja teenuseid. See nõuab valitsuse ja ettevõtete ühistegevust parandamaks teadmiste loomise ja vahetamise protsessi. Valitsuse tegevust on eriti vaja Eesti kutse- ja kõrghariduse süsteemi korrastamisel ja sektoripõhise teadustegevuse arendamisel. Haruliitudel on väga tähtis tekitada sidemed olemasolevate teadus- ja uurimisasutuste ning ettevõtete vahel. Samuti peaks haruliidud senisest enam tegelema ettevõtete omavahelise koostöö arendamisega.