THE INFLUENCE OF INNOVATION, TECHNOLOGICAL AND RESEARCH PROCESSES ON WOOD INDUSTRY

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Abstract

Slovenia is entering global markets and approaching EU and the comparability with related industrial branches in Europe is thus becoming one of the key indicators of the state of business processes. Statistical indictors serve as an excellent support is this research. These, together with the knowledge on background, which influences statistical data, give an opportunity for an in-depth and systematic analysis of the situation, causes and trends. In this paper, we described Slovenian wood processing industry, especially in the field of innovation and technological processes. The research was run in five steps. Firstly, we selected a group of variables from statistical data on the basis of standardised method which has been applied by the Slovenian Statistical Office. The group thus selected was then integrated in our analysis. In our second step, some additional variables were defined beside aforementioned ones. In the third step, the variables were dispersed among the following categories: input, process, output indirect and output direct variables. In the fourth step we calculated mutual correlations among particular variables (Spearman's correlation coefficient). In our last step, we defined mutual correlations among particular variables and focused on the most important ones when interpreting them.On the basis of illustrated methodology, we determined the influential input and process variables, which clearly indicate not only the sequence of activities but also particular areas of innovation activities where additional efforts need to be invested.

***Key words**: Wood, innovation, R&D, technology, benchmarking.*

1. Introduction

When discussing the improvement of competitiveness of the economy, we are inclined to think about many factors which all retain innovativeness as a common denominator. Yet the situation does not reflect only the problem in wood processing industry but the entire Slovenian economy and EU as well.

Since the wood processing industry remains among the least innovative in comparison to the other branches, its competitiveness requires that the company is prepared and capable to manage its own invention-innovation and also R&D processes. A prerequisite for such an activity is their understanding and comprehensive management of the mentioned processes. Nonetheless, we cannot neglect a fact that innovation is a complex process which fails to be mastered sufficiently by a large part of the Slovenian companies. Economic entities strive to increase a level of innovation with various, mostly partial, approaches that frequently remain inefficient. The problem derives from the fact that the improvement of state relates to numerous factors which often represent a Gordian knot; where to start, considering all strategic aspects, defining the most important fields which call for improvements – defining key influential factors,

implementing concrete steps, and similar. But primarily, how to approach the analysis and improvement of state systemically and systematically. (Mulej 2002; Mulej 2005; Markič 2003). The prerequisite is therefore a clear understanding which needs to be based on qualitative as well as quantitative evaluation of the most significant factors of innovativeness (Likar 2002). Hence, knowing which activities in company's operating are important for achieving innovativeness and consequently better economical results.

2. Methodology

As regards various existing studies (Carayannis E 2004; Hauschildt 1991; Iansiti 1997), the presented research is based on standardized procedures and methodology that has been applied in EU and also Slovenia for many years. In Slovenia, the said methodology is carried out by the Statistical Office of the Republic of Slovenia (hereinafter SURS) (SURS 2003). The advantage of the existing data is also in the fact that Statistical Office provides a precise methodology to complete a questionnaire, which is a basis for aforementioned research carried out by SURS/Eurostat. This is particularly important since the filed of evaluating and managing innovation processes represents a considerable novelty for most companies in Slovenia. Definitions and their interpretations vary despite the fact that for part of the definitions standards were already set a few years ago by OECD (Frascati) and were later adopted also by Slovenia.

The data provided by SURS represented a basis for an in-depth analysis in our research. According to the Classification of Products by Activity (CPA 2004), our research encompassed Slovenian companies from statistical classes: 20 (wood, wooden, cork, and wickerwork products, except furniture) and 21 (fibres, paper and paper products, publishing and printing services).

The purpose of our research was to establish which are the most important factors that influence the innovative capabilities of the company.

The data was processed in numerous steps:

1. Primarily, the data integrated in our analysis is also encompassed by the SURS methodology.
2. In addition to SURS variables, we defined some additional variables for the purpose of this research and later grouped them in two subgroups:
   - In the first subgroup the data applied comes from income statement or a combination of SURS variables and Income Statement. The latter provided us with the following variables: "net sales revenues" (AOP 090), "operating expenditure" (AOP 103) and 'operating profit' (AOP 125, in case of loss AOP 126).
   - In the second subgroup we defined some new variables by using the existing SURS variables (for example, "the proportion of employed people with at least higher education" which is defined as "a number of all employees with at least higher education"/"number of all employees").

3. The variables were divided into the following categories:
   - Input variables.
   - These are variables, which represent a frame for innovation activities, and influence not only innovative and innovation process but consequently also the results of such activities.

- Process variables.
- These are variables related to innovative or innovation process. Innovative process is directly connected to the transformation of invention into innovation. While the innovation process is associated with strategic aspects, management and organisational activities by encouraging and apprising creativity and innovativeness, overcoming obstacles, organising innovation process, and similar).
- Output indirect variables.
- Indirect yet important results of innovation activities may be observed (significant improvements of goods, marketing processes, and similar).
- Output direct variables.
- End results of activities may be observed (market share, profit, and similar).

Input variables

Variables:

- Total number of employees (s1)
- Proportion of employees with at least higher education (s2)

Variable group: Other important strategic and organisational changes in your company

- Strategy - Implementation of new or significantly changed corporate strategies (s49)
- Management - Implementation of advanced management techniques within your company (s50)
- Organisation - Implementation of new or significantly changed organizational structures (s51),

Variable group: Expenditure for innovation activity

- Intramural research & experimental development (R&D) expenditure (s9_1)
- Extramural research & experimental development (R&D) expenditure (s9_2)
- Expenditure for acquisition of machinery and equipment (s9_3)
- Expenditure for acquisition of other external knowledge (s9_4)
- Expenditure for training personnel directly aimed at the development and/or introduction of innovations (s9_5)
- Design, other preparations for production/deliveries expenditure (s9_7)
- Total innovation expenditure (s9_8)

Process variables

Variable group: Innovation co-operation within Slovenia

- Suppliers of equipment, materials, components or software (co21)
- Consultants (co51)
- Universities or other higher education institutes (co71)

Variable group: Sources of information for innovation

- Within the enterprise (s22)

Variable group: Factors hampering innovation activity

- Lack of appropriate sources of finance (s33)
- Organisational rigidities within the company (s34)
- Lack of qualified personnel (s35)
- Lack of information on technology (s36)

Output indirect variables

Variable group: Introduction of innovations

- Did the company introduce onto the market any new or significantly improved products? (s3)
- Did the enterprise introduce onto the market any new or significantly improved? procedures (s4)

Variable group: Factors hampering innovation activity

- Lack of customer responsiveness to new goods or services (s39)

Variable group: Other important strategic and organisational changes in your company

- Marketing - Changing significantly your enterprise's marketing concepts/strategies (s52)
- Aesthetic change (or other subjective changes) - Significant changes in the aesthetic appearance or design or other subjective changes in at least one of your products (s53)

Output direct variables

Variable group: Profit

- profit/employee (s11)
- profit/total revenue (s12)

Variable group: Effects of innovation

- Increased market or market share (s14)
- Improved quality in goods or services (s15)
- Improved production flexibility (s16)
- Increased production capacity (s17)
- Improved environmental impact or health and safety aspects (s20)

4. We defined mutual connections among individual variables.

Key part is connected to comparison/correlating of input, process and output variables. Since the majority of the variables remain ordinal, we applied Spearman's coefficient of correlation (SCC) when calculating them.

Connections between particular variables are to be shown in accordance with the register, which is represented in Table 1.

5. We selected the connections (correlations) and demonstrate them.

Among all mutual connections, we concentrated on those representing important information on the influential quantities on the innovation process and the results of the latter.

CORRELATIONS variables (X,Y)	input 1	input 2,...	process 1	process 2,....	output – indirect 1	output – indirect 2,...
input	1	✓	✓✓	✓✓	✓✓	✓✓
input 2,...		1	✓✓	✓✓	✓✓	✓✓
process 1			1	✓	✓✓	✓✓
process 2...				1	✓✓	✓✓
output – indirect 1					1	✓
output – indirect 2,...						1

Table 1. The table indicates types of connections/correlations which we assessed. The sign ✓ refers to the connections within the input, process or output group. The sign ✓✓ refers to correlations between the variables of the aforementioned groups. These were particularly interesting to us since they indicate the influence of input effects on particular innovation process and both of them on the final results of innovation endeavours in the company.

3. Results and discussion

3.1 Connections input : input

Important correlations were established within the input variables group. Implementation of new or significantly improved corporate strategies (s49) is closely related with implementation of advanced management techniques (s50) and with implementation of new or significantly changed organizational structures (s51) (0.39<SCC<0.47; sig=0.0001; n=116). The latter is in strong correlation with implementation of advanced management techniques (s50) (SCC=0.54540; sig=<0.0001; n=116).

Introduction of important strategic and organisational changes in the company may thus be considered as one of the basic innovation-oriented steps. Within the scope of these activities are: implementation of new or significantly improved corporate strategies (s49), implementation of advanced management techniques (s50) and implementation of new or significantly changed organizational structures (s51)

Statistically characteristic connections were established between the number of employees (s1) and proportion of intramural and extramural research & experimental development (R&D) expenditure (s9_1 and s9_2) - (0.31<SCC<0.39; sig=0.0001; n=116).

The size of the company is therefore related to the expenditure connected with R&D. Larger companies can obviously afford to invest in development more easily. This

means that additional governmental measures for encouraging R&D in SME (small and medium-sized enterprises) are required.
Beside the said, the number of employees (s1) is linked to proportion of expenditure for acquisition of machinery and equipment necessary for the implementation of innovation (s9_3) (SCC=0.37016; sig=<0.0001; n=116), proportion of expenditure for training personnel directly aimed at the development and/or introduction of innovations (s9_5) (SCC=0.28543; sig=0.0019; n=116). Furthermore, larger companies earmark larger proportion of all expenditure for innovation (s9_8) than smaller (SCC=0.43550; sig=<0.0001; n=84).
Also the final data speaks in favour of the fact that support offered to smaller companies needs to include also support for innovation activity where training definitely remains an important factor.

3.2 Connections input : process

In contrast to demonstrated positive aspects of larger companies, we ascertain also the negative impact of the number of employees (s1) which is related to organisational rigidities within the company (s34). The latter is also linked to proportion of expenditure earmarked for acquisition of machinery and equipment necessary for implementing innovation of product, services and procedure (s9_3) (SCC=0.21622; sig=0.0214; n=113). We can declare that rigidity of the company hinders its capabilities for acquiring innovation-oriented machinery and equipment.
It is extremely interesting that the proportion of employees with at least higher education (s2) is in negation relation with the lack of appropriate sources of finance (s33) (SCC=-0.2371; sig=0.011; n=113).

3.3 Connected input : output indirect variables

There are extremely distinctive correlation between number of employees (s1) on one side and data which speaks about new or significantly improved products (s3) processes (s4) and design of the goods (s53) as well as the fact that the company changed significantly its marketing concepts/strategies (s52) (0.43<SCC<0.30; sig=<0.0008; n=116).
It is essential to consider these connections with due reservation since one change in the entire company is enough to generate a positive answer in the research which fictively speaks in favour of companies with higher number of employees. To put in other words: company with 200 employees and one improvement is according to statistical data just as successful as the company with only 10 employees and for example five improved products.
The research indicates the importance of strategic level; link between implementing new or significantly improved corporate strategies (s49) and significant change in marketing concepts/strategies (s52) on one side (SCC=0.26868; sig=0.0035; n=116) and significant changes in design or other subjective changes (s53) on the other (SCC=0.26868; sig=0.0035; n=116). Strategies (s49) are also related to the introduction of new or significantly improved products (s3) and processes (s4) (0.29<SCC<0.34; sig<0.01; n=116).
On the level of strategic and organisational changes, we can institute also the relations between implementation of new or significantly improved organizational structures (s51) and significant change in marketing concepts/strategies (s52) (SCC=0.40767; sig=<0.0001; n=116), significant changes in the aesthetic appearance or design or other subjective changes (s53) (SCC=0.32924; sig=0.0003; n=116) as well as introduction of

new or significantly improved products (s3) and processes (s4) (0.21<SCC<0.34; sig<0.02; n=116).
Revealed connections emphasise the importance of opening steps of every company; steps oriented towards reaching innovativeness, namely the influence of strategy on improving organisational structures and thus improved products and processes as well as significant changes in marketing approaches.
The influence of proportion of intramural research & experimental development (R&D) expenditure (s9_1) on significant improvement of products (s3) and processes (s4) (SCC>0.76099; sig=<0.0001; n=116) is very interesting. Yet the aforementioned expenditure IS NOT characteristically related to lack of customers response. We also established a positive correlation between the proportion of extramural research & experimental development (R&D) expenditure (s9_2) on one side and significant improvement of products (s3) and processes (s4) on the other (SCC>0.48480; sig=<0.0001; n=116). In contrast to "intramural expenditure for R&D", the negative correlation between the proportion of extramural expenditure for R&D (s9_2) and lack of customer responsiveness to new goods or services (s39) (SCC=-0.1868; sig=0.047; n=113) speaks for itself.
We thus establish that investing in intramural R&D helps improving products yet fails to offer help in improving poor customer responsiveness. The latter is in fact a consequence of poor integration of external R&D organisations (aforementioned negative correlation). This may also be explained by frequently applied companies' approach where R&D is technology and production driven. The development is therefore not a consequence of market needs. We thus came to an important conclusion that cooperation with external R&D organisations proves necessary given that it brings those novelties, which are also accepted by the market (innovations).
Extremely important factor which effects the introduction of new or significantly improved products (s3) and processes (s4) is an expenditure earmarked for acquisition of machinery and equipment necessary for implementation of innovation of product, service and process (s9_3) (SCC>0.82197; sig=<0.0001; n=116).
Slightly lower yet still characteristic is the influence of the proportion of expenditure allocated for acquisition of other external knowledge on innovation (s9_4) which influences the introduction of new or significantly improved products (s3) and processes (s4) (SCC>0.30905; sig<=0.0007; n=116).
An important factor which influences the introduction of new or significantly improved products (s3) and processes (s4) is the expenditure for training personnel directly aimed at the development and/or introduction of innovations (s9_5) (SCC>0.59822; sig=<0.0001; n=116).
Statistically related are also the proportion of expenditure for design, other preparations for production/deliveries expenditure (s9_7) and introduction of new or significantly improved processes (s4) (SCC=0.41973; sig=<.0001; n=116).
We may establish that expenditure earmarked for acquisition of machinery and equipment, the proportion of expenditure for design and other preparations for production/deliveries, training personnel as well as acquisition of other external knowledge on innovation activity strongly influence the development of new or significantly improved products.
As expected, the connection remains the strongest between the proportion of total innovation expenditure (s9_8) and successful introduction of new or significantly improved products (s3) and processes (s4) (SCC>0.85740; sig=<0.0001; n=84).

And thus, the most effective mechanism for achieving enhanced market products remains investing in innovation activity.

3.4 Connections input : output-indirect

There is an interesting connection which is not directly related to innovativeness; number of employees (s1) holds a negative correlation with profit/total revenue (s12) (SCC=-0.3477; sig=0.000; n=116).

Proportion of employees with at least higher education (s2) represents an important aspect of influence on innovation activity - improved production flexibility (s16). A strong correlation exists between both variables (SCC=0.46234; sig=0.0401; n=20) which points towards the significance of education.

Similarly as previously demonstrated influence of education on the introduction of new products, we may also establish its positive impact on improvement of production flexibility and deliveries of services. This coincides with the guidelines of EU programmes related to training and lifelong learning.

We may establish negative relations between the proportion of intramural research & experimental development (R&D) expenditure (s9_1) and profit/total revenue (s12) (SCC=-0.2149; sig=0.020; n=116) yet strong positive connections with improved production flexibility and deliveries of services (s16) (SCC=0.61109; sig=0.0042; n=20).

We have already documented that internal R&D influences on the improvement of market goods yet does not necessarily relate to customer responsiveness. The said finding is additionally highlighted by negative connection between intramural expenditure earmarked for R&D and company's profit. Two explanations appear evident. Either intramural expenditure for R&D fails to be directed appropriately or it is a matter of long-term investments which requires a certain period (a few years) of investing while the financial results follow later.

There is a characteristic correlation between the proportion of extramural expenditure research & experimental development (R&D) expenditure (s9_2) and improved environmental impact or health and safety aspects (s20) (SCC=0.43569; sig=0.0548; n=20). This indicates some sort of research outsourcing in environmental ethics.

Interestingly, improved environmental impact or health and safety aspects (s20) is related to expenditure for training personnel directly aimed at the development and/or introduction of innovations (s9_5) (SCC=0.45006; sig=0.0465; n=20).

The findings yet again indicate that the environment, health and safety influence positively not only on extramural R&D but also on training.

Surprisingly, the proportion of expenditure allocated for acquisition of machinery and equipment that is necessary for the implementation of innovation of product, service and process (s9_3) correlates negatively with the profit per employee (s11) (SCC=-0.1924; sig=0.038; n=116).

This may be explained with inappropriate investing into machinery and equipment – it is thus also an expenditure which influences on the improvement of goods (as previously established) yet effects the final result, i.e. profit negatively. We may talk about an area, which needs to be studied thoroughly, and a method of efficient exploitation of machinery and equipment needs to be found.

And the most important result of all endeavours, the proportion of profit (s12) is negatively connected with the proportion of total innovation expenditure (s9_8) (SCC=-0.2847; sig=0.008; n=84).

Also this data is surprising at first glance. We previously established that investing in innovation is the most efficient mechanism for achieving enhanced market products. However, this is still insufficient for improving financial results. Obviously, a substantial proportion of expenditure is still directed into inappropriate fields or the financial results have not been revealed yet. It is probably a combination of both since wood industry even now proves to be non-innovative or it has started to encourage innovation processes only recently.

3.5 Connections process : process

Hindering factors of innovation represent a problem. Organisational rigidities within the company (s34) represent an extremely strong negative correlation with innovation cooperation with Slovenian suppliers of equipment, materials, components or software (co21) (SCC=-0.7312; sig=0.010; n=11) as well as exploitation of sources of information for innovation within the company (s22) (SCC=-0.7085; sig=0.000; n=20). The latter is in connection with a lack of qualified personnel (s35) (SCC=-0.4755; sig=0.034; n=20). Despite a small amount of data, it is a matter of statistically characteristic and extremely strong influences within the innovation process.
An explanation for poor financial results is partially hidden in extremely strong hindering factors. As the most important ones, we ascertained organisational rigidities within the company and capabilities of exploiting sources of information for innovation within the organisation which is related to inappropriate education.

3.6 Connection process : output-indirect

Strong negative correlation was established between the level of cooperation with consultants (co51) and a lack of customer responsiveness to new goods or services (s39) (SCC=-0.6030; sig=0.049; n=11).
We may say that an active participation of consultants in R&D groups and innovation projects characteristically increases customer responsiveness to new goods and services. Obviously, it is an effect of similar factor as represented by cooperation of external R&D organisations.

3.7 Connections process : output-direct

There is also a strong connection between a lack of information on technology (s36) and improved quality in goods or services (s15) (SCC=0.58792; sig=0.0064; n=20).
Obviously, we could improve quality of market products with enhanced exploitation of information on technology.

3.8 Connections output-indirect : output-indirect

There is an interestingly strong correlation between significant changes of company's marketing concepts/strategies (s52) and significant changes in the aesthetic appearance or design or other subjective changes in at least one of the products (s53) (SCC=0.45911; sig=<0.0001; n=116).

3.9 Connections output-direct : output-direct

Important connections were found also between increased market or market share (s14) on one side and improved quality in goods or services (s15) and improved environmental impact or health and safety aspects (s20) on the other (SCC>0.44445;sig<0.0496;n=20). Improved quality in goods or services (s15) is also

strongly linked to impacts on the environment and health (SCC=0.51627;sig=0.0198;n=20).
In contrast to aforementioned new or improved market products, which are not characteristically connected to increased market or market share, the latter is strongly influenced by the quality of products.
In the group of impacts of innovation activities, increased capacity of production or deliveries of services (s17) and improved flexibility of production or deliveries of services (s16) prove characteristically correlated (SCC=0.51210;sig=0.0210;n=20).

4. Summary of results

In our study of connections between input-input variables, we establish that a clear decision made by the management is a cornerstone of innovation. Improvement in corporate strategies is closely related to the next step – introduction of improved techniques of management and improved organisational structure. New or significantly improved strategy is also connected to improved organisational structures and consequently to improved quality of goods and processes as well as important positive changes in marketing approaches.
The proportion of intramural expenditure for R&D holds an extremely strong influence, which is demonstrated in improved quality of market goods. Improved quality of goods is also positively influenced by the expenditure earmarked for acquisition of machinery and equipment, proportion of expenditure allocated for design and other preparation for production. A personnel training remains extremely imperative. At the same time, we establish that the quality of goods could be additionally improved with the use of information on technologies.
Yet at the same time, we establish that improved goods are not enough since the responsiveness of the market to the mentioned improvements continues to be unfavourable. Analysis points out to the consequences of insufficient integration of outside R&D organisations (negative correlations). This may be explained with frequent approach of "self-sufficient" companies where the corporate strategy may be described as technology and production driven and definitely not sufficiently market driven. It is therefore a strategy that is inconsiderate to market needs. The finding confirms an important fact, i.e. new or significantly improved goods do not characteristically influence on increased market share – which should be one of the fundamental objectives of innovation (however, increased market share is strongly influenced by improved quality of goods). Cooperation with external development organisations as well as external consultants obviously brings fresh approaches and consequently novelties, which are better accepted by the market. This is an important finding which speaks in favour of strengthened cooperation between the industry and academic sphere.
We may establish that an important part of opportunities remains unexploited, in particularly, intramural expenditure for R&D, expenditure earmarked for acquisition of machinery and equipment, proportion of expenditure allocated for design and other preparation for production. We are convinced that by directing these sources into creation of goods and services which are more attractive for the market and at the same time take into consideration also the internal characteristics of the company (technology + market driven) we could exploit invested sources and efforts considerably better.
Notwithstanding the increased proportion of intramural expenditure for R&D and expenditure allocated for training already indicates positive results in the impacts on

environment, health and safety. In the long run, this is of extreme importance from employees and nature/environment point of view. We may expect a positive influence of training also on the other, i.e. economic results.
Previously stated findings which state that "wood" companies are not oriented sufficiently towards the market needs is clearly confirmed also by the data on effectiveness of the expenditure allocated for acquisition of machinery and equipment necessary for implementation of innovation. The latter correlates negatively with profit per employee – as one of the most important results of innovation endeavours.
When speaking about the successfulness of introducing new of significantly improved goods, we can establish that the strongest factor of improving these goods is investing in innovation. However, obviously this is not enough for achieving innovativeness (useful novelties which reflect also in better business results). The most important indicator – profit – is negatively linked to the proportion of expenditure earmarked for innovation. This is confirmed by the fact that beside inadequate development and exploitation of technology, a noticeable part of innovation endeavours remains directed inappropriately.
The explanation for poor financial results is partly hidden in extremely strong hindering factors. We established that the main hindering factors are organisational rigidity of the company and (in)capability of exploiting sources of information for innovation within the organisation which is related to inadequate education.

5. Conclusions

On the basis of all aforementioned, we cannot provide a simple conclusion or magic recipe. Yet the results clearly illustrate the path which the company needs to take as well as important individual factors. The first step is definitely a decision reached by management and clear innovation strategy. Further steps are linked to the construction of adequate organisation and organisational atmosphere (which SURS' research does not take into consideration). It is essential to implement numerous activities among which rise in creativity (also not encompassed by SURS), appropriate R&D activity and most of all training. We are strongly convinced that creative thinking in relation to knowledge and determination proves to be the most important factor.

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