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Parameters influencing innovation, R&D and technology in mechanical industry

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ABSTRACT

Purpose: The objective of the research was to establish the most important factors aimed at achieving optimal business performance in the machinery and equipment manufacturing industry in Slovenia and in so doing, we focused on innovation, technology and R&D processes.
Design/methodology/approach: The research was run in five steps. Firstly, we selected a group of variables from statistical and in the second, we added some important variables. In the third steep, the variables were grouped in four categories (input, process, output indirect, output direct). In the fourth step, we performed the ordinary statistics and calculated correlations among individual variables. In the last step, we defined mutual correlations among particular variables and focused on the most important ones. At the same time the results of the simple statistics were taken into account.
Findings: On the basis of the presented research methodology, we determined the key input and process variables, which clearly indicate the sequence of activities and also particular areas where additional efforts need to be invested as well.
Research limitations/implications: The research limitations are connected with statistical data which fails to cover all the important topics related to the innovation performance within a company. There are also some misleading questions/definitions in the SURS/Eurostat which partially result in subjective results. Therefore, an improvement of the aforesaid statistical methodology or a separate data collection would advance the research.
Practical implications: The findings also represent a set of concrete guidelines in which companies, support environment organisations and also national policy leaders should put their efforts.
Originality/value: The way of analysing and interpreting the data deriving from the mechanical industry are new. Besides, the results and conclusion are also original and may be applied by the aforementioned target groups.
Keywords: Productivity and performance management; Benchmarking; Innovation; Machinery

1. Introduction

According to the statistical data [1, 2] only 21.1% of Slovenian companies are innovative; 28.2% in the manufacturing sector. When examining the machinery and equipment manufacturing industry (statistical class DK29) [3], it was established that 34.9% of companies in this sector are actively engaged in innovation. It may be concluded that the machinery and equipment manufacturing industry in the EU and also in Slovenia is relatively well developed yet the opportunity for improvement still exists!

Therefore, the key influential factors should be defined primarily representing a base for the implementation of concrete steps. A systemic and systematic approach is essential [4].

The literature touches numerous types of approaches in pursuing innovation. One of the basic approaches is through analysis of innovation processes according to input, process and output groups of indicators. The selection of the latter remains varied. Input indicators - the so-called "investment" - encompass, for example, expenditure on R&D or the training given to employees [5]. The process indicators cover the organisation or management of innovation processes, the application of adequate management techniques (market research, techniques of problem analysis and idea creation, forecasting techniques and suchlike), as well as the innovation environment within the company. While the output indicators define the results, for example the number of patents and new products, market share, revenues from the sales of innovations and innovative products and suchlike [6]. Even though there are many approaches directed towards solving the mentioned problem - establishing the key influential factors, the appropriate method has not been developed so far. Another important limitation of the mentioned methods is that they were tested on a relatively small sample of companies and were not focused on the machinery and equipment manufacturing industry.

2. Design of the research

The data on target industry provided by SURS and collected on the basis of standardized methodology [7], [8] represented a basis for a systematic research. According to the Classification of Products by Activity [3], our research encompassed Slovenian companies from statistical class DK29: manufacture of machinery and equipment. The Statistical Office of the Republic of Slovenia encompassed a total of 152 companies in its research for the period of 2001-2002. The research was conducted in the following steps.

2.1. Definition of variables

Initially, a group of variables was selected from among the statistical data collated using the SURS/Eurostat methodology. In addition to the SURS variables, some additional ones were defined for the purposes of this research.
The variables were then grouped in the following categories: input variables (henceforth: v), process variables (henceforth: p), output indirect variables (henceforth: ip), output direct variables (henceforth: in).

2.2. Data analysis

The results of simple statistics encompassed number of companies included, mean value and standard deviation.

The crucial part pertains to the comparison – through correlation – of input, process and output (indirect and direct) variables. The Spearman's coefficient of correlation (henceforth: SCC) was applied in calculating the correlation coefficients. The SCC were defined with restriction to those with SCC>=0.2 and p<=0,05.

2.3. Correlations of variables

So-called retrospective demonstration [9] was selected to be applied in our analysis (see Figure 1). The expected results, which are presented as "output direct" variables, served as a starting point. The focus was given to a part of these variables which were regarded as dependent: enterprise's revenues arising from new product or service/net revenues from sales (in1), market's revenues arising from new product or service/net revenues from sales (in2), enterprise's profit (in5) and increased market or market share (in8).

On the basis of these selected variables, the influential independent "output indirect" variables, which are related to "output direct" with the highest SCC. Pursuant to thus defined "output indirect" variables (in this step dependent), the process was repeated and defined "process" variables (independent) connected with "output indirect" variables.

After defining these important "process" factors, attention was paid to their correlation with "input" variables. The procedure was repeated and "input" variables (independent), which correlate with "process" (now dependant) variables, were thus defined.
Beside the aforementioned influencing variables, we also identified those which strongly influence a few of the dependent factors.

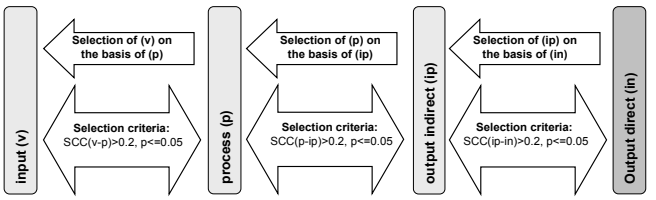

Fig. 1. The picture indicates the method of variables selection and types of connections/correlations assessed

3. Results-correlations among variables

3.1. "Output direct" and "output indirect"

An extremely strong effect may be established by implementing new or considerably improved products (ip1) and process (ip2). These variables influence the revenues arising from the introduction of new product or service for the enterprise (in1 – i.e. a product which is new for the company yet already exists on the market) and also the portion of revenues arising from the introduction of new product or service which represents a novelty on the market (in2). Calculated SCC values are 0.80-0.60.

The same output variables are also influenced (0.20<SCC<0.25) by the following variables: marketing – a significant modification of your enterprise's marketing concepts/strategies (ip12); reduction of requisite material or energy per produced unit/transaction (ip8) and an increase in production capacity (ip6).

Important influencing variables concerning in1, in5 or in8 are also: significant modifications in the aesthetic appearance or

design (ip13); improved environmental impact or health and safety aspects (ip9) and an increase in the offer of products and services (ip3). Calculated SCC values are (0.29<SCC<0.36).

3.2. "Output indirect" and "process"

Based on the identified "output indirect" variables from the previous section, the aim of this step was to identify the influencing process variables.

The most important correlations were observed among the variables from the two aforementioned groups: innovation cooperation with customers (p3); research institutes in SLO (p8); EU or EFTA member states consultants (p13) and suppliers (p10) on one side and number of domestic patents (ip14) and consequentially an increased offer of products and services (ip3) on the other side. Calculated SCC values are in the region of 0.50. Sources of information from suppliers of equipment, material, components, software (p19) and from competition, meetings, publications (p24) strongly influence the improved environmental impact or health and safety aspects (ip9), where SCC is over 0.50. Other important factors (0.37<SCC<0.39) are sources of information from clients and customers (p20), the state or private non-profit research institutes (p23), competition within a branch (p21) and fairs, exhibitions (p25).

It proves most interesting to have a look at the hindering factors influencing the possibility to reduce requisite material or energy per produced unit (ip8) and to increase production capacity (ip6). The most important influencing factors (0.33<SCC<0.41) are a lack of information on technology (p31), a lack of qualified personnel (p30) and rules, regulations and standards (p33).

A lack of information about the markets (p32) represents another hindering factor (SCC=0.23) in introducing new or considerably improved products (ip1). The other negative factors (0.20<SCC<0.23) influencing significant modifications in the aesthetic appearance of product are excessive innovation costs (p27), organisational rigidities within the enterprise (p29) and excessive risk involved (p26).

3.3. "Process" and "input"

In the previous section (Correlations among "output indirect" and "process" variables) we established that innovation cooperation with suppliers of equipment, materials, components or software in SLO (p2) is one of the important parameters. If the influencing input factors are examined, strong correlations (0.55<SCC<0.67) with the following input variables: design, other preparations for production/deliveries expenditure (v12) and with expenditure for training personnel directly aimed at the development and/or introduction of innovations (v10) may be observed.

Various sources of information (p22, p24) also proved to be important (correlated with other process variables) and they mainly correlate (0.30<SCC<0.44) with: extramural research & experimental development (R&D) expenditure (v7), innovation activities coverage – subsidies, endowments (v15) , innovation activities coverage – revenues arising from performing own activities (v14) and intramural research & experimental development (R&D) expenditure and total number of employees (v6).

Other influencing factors (0.23<SCC<0.28) are a total innovation expenditure (v13), the expenditure for marketing new products and services / total expenditure of a company (v11), an introduction of new or significantly improved organizational structures (v5) and an introduction of advanced management techniques within the company (v4).

4. Discussion

In the following section the most important results of simple statistics results and presented correlation shall be summarised.

Increased market share and consequently revenues and profit may be regarded as the most important result of the innovation activity. Output indirect variables have the most significant direct influence on the aforementioned, namely the introduction of new or considerably improved products (ip1) and processes (ip2). Only 25% of such companies may be found in Slovenian machinery and equipment manufacturing sector. Most of the enterprises thus perform only a small portion of appropriate activities. The fact that an enterprise – regardless of its size – is classified in the statistical group of innovative enterprises by introducing only one new product needs to be taken into consideration. It represents a "statistical benefit" for large companies. The next important parameter is a significant modification in the aesthetic appearance or design (ip13), yet there are still 63% of all enterprises failing to perform such activities. Concerning the aforementioned output results, it is important to mention a moderate influence of modifications in marketing concepts/strategies (ip12) which are introduced by only 28% of enterprises and reduced required material or energy per produced unit/transaction (ip8) which may be established in 36.8% of analysed enterprises. Last but not least, the environmental factor (ip9) seems to become more and more important. The eco-management [10] is especially important for countries in transition as well as for less-developed countries.

An important result of the innovation activity is also an increased market or market share (in8), which is significantly influenced by increased offer of products and services (ip3) – the answers also indicate that this factor is regarded as important by companies (value 2.2 on scale 0-unimportant, 1-low, 2-medium, 3-high).

Surprisingly, an improved environmental impact or health and safety aspects (ip9) moderately influences the enterprise's profit (in5), which seems to be a positive side-effect of global environmental efforts.

When analysing correlations among "output indirect" and "process" variables, the highest values are established among the increased offer of products or services (ip3) on one side and the sources of information obtained from customers and clients (p3, 37.5% of all companies are using such sources) and also research institutes (p8, 33% of all companies cooperate with them) on the other. We should not neglect the fact that there is no significant correlation between innovation cooperation with suppliers of equipment, materials, components or software (p2, even though 46% of all companies cooperate with them) and introduction of new/improved products/procedures (ip1, ip2).

We could reasonably expect that a leading strategy was influenced considerably more by the information received from the suppliers of equipment, material, components, software as well as universities and research institutes and also by adequate quality management [11] yet the influence proves to be moderate. According to the mentioned facts, we could conclude that the companies pursue the strategy of followers yet there are some indices that some of the companies strive to follow the leading strategy.

Hindering factors are also significantly related to the overcoming of the extant state, namely a lack of information on technology (p31), a lack of qualified personnel (p30) and rules, regulations and standards (p33). Despite the fact that the companies fail to find the said factors very important (values of simple statistics around 1 on the scale of 0-unimportant and 3-high), we are convinced that these factors are crucial!

Concerning the "process" and "input" variables, the most important influencing input variables were established: design and other production/deliveries preparations expenditure (v12, its value is almost 0!) and the expenditure for training personnel directly aimed at the development and/or introduction of innovations (v10, again its value is almost 0!). It may easily be established that these influencing parameters are very important even though the companies fail to make any investment into the said activities - but they obviously should! Other influencing factors are intramural/extramural R&D expenditure, innovation activities coverage – subsidies, endowments as well as revenues arising from performing own activities (v6, v7, v14, v15).

5. Conclusions

Despite many encouraging indicators and at times somewhat misleading statistical data, only a moderate portion of innovative potential of enterprises is exploited. The fact remains that the influence of innovation on the entire profit as well as on revenues arising from the new products remains too low.

We thus believe that a clear strategy [12] of innovation and with the latter related further activities prove to be the most important factor in a comprehensive management of innovation processes within the enterprise [13]. According to the research results, an adequate training [14], which is also one of the priorities of the European Union programmes, is one of the first steps. Further steps are related to the establishment of adequate organisational environment (which the SURS research fails to encompass). It is also crucial to use all available resources - national and international and to strive towards improving cooperation with organisations having knowledge (universities, R&D institutes), also of forthcoming technologies. It definitely leads to a significantly increased value added! The design is very important as well [15]! The conditions need to be prepared in order for the inventions to become innovations within the company. According to the results of the research, there are some parameters/activities which are extremely important but are not recognised and not financed as crucial. It is very important where to invest efforts and other resources.

A comprehensive and systematic approach is required since the innovation on the market is only the last link of the invention-innovation chain. The important step is definitely "innovation of management" and later on the management would efficiently manage the innovation process. We are strongly convinced that creative way of thinking is an essential value and in relation with knowledge and determination even the most important factor.

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