Innovation Process – Managing Complexity through Financial Aspects

Borut Likar
Faculty of Management
University of Primorska
Koper, Slovenia
borut.likar1@guest.arnes.si

Peter Fatur
Faculty of Management
University of Primorska
Koper, Slovenia
peter.fatur@fm-kp.si

Abstract - **The research investigates one of the most complex parts of the business system – innovation process. The relationship between the company's innovation inputs and its innovation performance was studied on a sample of 2503 companies from manufacturing and selected service sectors. The research was based on official Eurostat statistical data. As these data were essentially not adapted for analysis of companies' innovation performance, the methodology for companies' innovation-business performance was developed. The groups of non-innovators, innovation followers and innovation leaders were formed. In the group of leaders, ROE is 40% higher as regards the group of innovation followers. Each euro invested into innovations yields 13.9 Euros in the same group. But an increase in investments is related with the growth of productivity of invested assets only in the group of followers. Interestingly, increasing a portion of »breakthrough« innovations reduces the productivity of these assets in the group of leaders. On the basis of these findings recommendations are provided as to which policies of innovation investments should different types of innovation followers adopt so as to catch up with the group of innovation leaders.**

Keywords – innovation; R&D; technology; economic performance; productivity; complex systems

I. INTRODUCTION

The research investigates one of the most complex parts of the business system – the innovation process and its performance. Community Innovation Survey [1] represents the basic statistical instrument for innovation performance measurement in the EU countries. Its methodology is standardized and it is relatively well known among respondents/companies and a number of respondents is very high (as filling out the questionnaire is compulsory). However, the methodology was prepared for benchmarking primarily at the country level. Therefore, the data are not very constructive for studies focused on input-output innovation relations. One of the basic aims of our research was to develop a methodology which would enable the use of EU statistical data connected with innovation-business performance. Besides, our research is oriented towards identifying differences of influential factors as to the innovation/business performance.

The paper is organized as follows. Section II introduces the theoretical principles of innovation measurement and its limitations. Section III is the methodology. In section IV the results of the analysis are presented and findings are discussed. Section V is the conclusions, where findings are summarized and the innovation policy recommendations are given.

II. LITERATURE SURVEY AND LIMITATIONS

The survey providing the core data for our research is the most recent Community Innovation Survey [2] for Slovenia. Literature addresses several approaches to the monitoring of innovation. One of the fundamental methodological approaches is the analysis of input (investments), process and output (results) groups of indicators. The selection of indicators proves extremely diversified. Expenditure for research and development activities [3] or a number of days dedicated to education/training of employees [4] are used as input indicators representing "investments" in organizational system. Process indicators help us establishing the state of innovation process management (organization, planning, management, and supervision). Output indicators reflect the results of innovation processes, for example the number of patents and new market products, market share, revenues from sales of innovations/innovative products and suchlike [5].

Various researches discuss the relation between innovation strategy and economic successfulness of an organization. Many of them show that the connection is positive yet weak [6]. The researches highlight also the importance of strategic decision to innovate in achieving economic results [7, 8]. Besides, the proportion of intramural expenditure on R&D is supposed to have an extremely valuable influence, which is manifested in an improvement of product quality [9].

In the mentioned studies, we face the problem of defining process and output indicators. The role of the innovation process is often not clearly defined – it is a result of inputs (e.g., financial inputs) or it could be treated like the innovation input. Besides, outputs often represent an indirect output (e.g., number of patents, new products etc.) which do not obviously lead to improved business performance. Therefore, we took into consideration the inputs, which represent the basic step towards mastering the innovation process and those outputs which clearly present the financial situation.

 ISBN:978-1-61208-114-4

III. METHODOLOGY

The research is focused on 2503 Slovenian companies from manufacturing and selected service sectors. The Slovenian contribution to the CIS 2006 survey includes data for the period from 2004 to 2006 on the enterprises' product (goods or service), organizational and process innovations, innovation activities and expenditures, co-operation in innovation and the effects of innovation. In addition, company's financial data (balance sheet, profit and loss account and some key financial ratios) was collected from the official statistical database on companies (the Agency of the Republic of Slovenia for Public Legal Records and Related Services), while the third statistical database (Statistical Register of Employment - SRDAP) provided data on the educational structure of employees. The first challenge was developing a methodology which could enable measuring the relation between company's innovation inputs and innovation performance.

The two key variables that represent a measurable output from the innovation process were defined as: RII ("Index of revenues from innovation"), i.e., a proportion of total turnover resulting from innovations (either new to the market or new to the company only), and RMI ("Index of revenues from market innovation"), i.e., a ratio of turnover from innovations new to the market to total innovation turnover.

In the following phase of the research, the companies were divided into 5 groups. The first one is a group of companies (group 0) having no revenues from innovations (RII=0). The groups recording any revenues arising from innovations (RII>0) were divided into four groups pursuant to the value of indices RII and RMI. As a limit of division the medians were set, thus ensuring equal representativeness of companies across all four groups. Dividing the RII/RMI matrix in points predefined with both medians, 4 quadrants are obtained.

After the development of the innovation performance matrix, the relationship between the innovation and business performance was explored. The 5 innovation groups were in pairs compared using nonparametric tests (Mann-Whitney and Kruskal Wallis Tests) so as to establish in which variables the groups significantly differ. The variables in comparison are the ones included in the CIS 2006 survey (innovation related variables), supplemented by the companies' business performance variables.

The same statistical method (Mann-Whitney nonparametric test) was applied to the innovation investments variables to compare the proportions of financial assets that the companies appertaining to a particular group invest into innovation and how efficiently do these companies turn such investments into revenues arising from innovations, i.e., to test the extent and productivity of innovation investments.

IV. RESULTS AND DISCUSSION

A. The innovation performance matrix development

As demonstrated the values of the two primary output indices of the invention-innovation process (RII and RMI) served as criteria for grouping the companies. These values are indicated in Table I separately for non-innovative (0) and innovative (1 & 2) companies (these are further divided into 4 subgroups 1a, 1b, 1c and 2); see Figure 1. Accordingly, the innovation leaders are companies having a high portion of turnover from innovations and a high portion of turnover from "radical" innovation in total innovation turnover (high RII and high RMI). Non-innovators is a group (0) of companies having RII/RMI=0 – no turnover based on innovation.

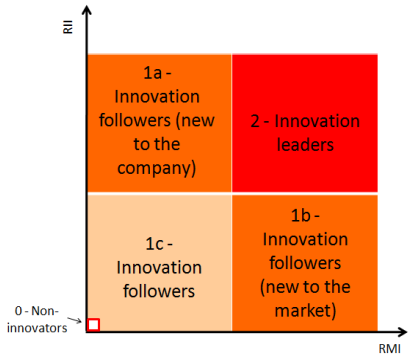

Figure 1. RII/RMI matrix

B. Relationship between the innovation and business performance

So far the method of dividing the companies active in the field of innovation into 5 groups on the basis of RII and RMI indicators has been demonstrated. Companies classified in different groups differ at least pursuant to the volume and structure of their revenues from innovation, i.e., direct results of innovation recorded on the market. However, differences in the revenues from innovation do not necessarily indicate also differences in the companies' business performance. Furthermore, revenues arising from innovation do not provide any conclusions as regards the organisation of innovation systems in the companies.

Let us therefore have a look as to whether there are any differences among the groups regarding their business performance. The Mann-Whitney rank sum test is applied to compare the financial ratios for the groups 0, 1 (a, b, c) and 2. As it compares medians, which are insensitive to outliers compared to means, the Mann–Whitney test is less likely to spuriously indicate significance than the t-test because of the presence of outliers – i.e., Mann–Whitney is more robust.

We would like to focus on most important performance indicators – on those, where the Mann-Whitney test showed significant differences (Table I); these were observed between groups 0-1 and simultaneously between 0-2. It is very interesting, that the Group 1 (even though with better innovation results concerning RII/RMI compared to Group0) is performing in total (as to ROE and average growth of net revenues) worse than the non-innovators (Group 0). On the other hand the company's financial performance of Group 2 is much better; ROE proves to be 40% higher in the group of innovation leaders that among followers and non-innovators, the average growth of net revenues is 33% higher compared

 ISBN:978-1-61208-114-4

to group 0 and even 41% better than the innovation followers (Group 1).

TABLE I. BASIC STATISTICS FOR INDICES RII AND RMI AS PER INNOVATION GROUPS.

Group	N	Variable	Median	Mean
Non-innovators (0)	1790	RII	0.00	0.00
		RMI	-	-
Innovators in total (1 & 2)	713	RII	20.00	29.31
		RMI	40.00	41.89
Innovation followers (1c)	206	RII	10.00	9.39
		RMI	0.00	6.60
Innovation followers (1b)	195	RII	10.00	10.59
		RMI	100.00	79.39
Innovation followers (1a)	163	RII	48.00	52.42
		RMI	1.01	11.83
Innovation leaders (2)	149	RII	50.00	56.05
		RMI	71.43	74.48

At the same time the revenues appertaining to the group 2 recorded between 2006 and 2007 increased by 7%, while the average revenues from 2003 to 2007 increased by 41%.

Similar relations may be observed between the groups 0 and 2; additionally, statistically significant differences in return on sales (ROS) and return on assets (ROA) may be observed. Companies appertaining to the group 2 pay out 6% higher salaries than the companies in the group 0.

On the basis of the aforementioned findings it may be concluded that the companies appertaining to the group 2, which in comparison with the groups 0 and 1 innovate more successfully (achieve higher values of RII and/or RMI), record also better company's performance assessed with the financial ratios.

C. *Extent and productivity of innovation investments*

What portions of financial assets do companies appertaining to a particular group invest into innovation and how efficiently do these companies turn such investments into revenues arising from innovations? To answer these two questions the group of followers (1) shall again be examined by dividing it into three subgroups as indicated in Figure 1, i.e., 1a, 1b and 1c. A company of type 1a may enter into the category of innovation leaders (2) by increasing its RMI; a company of type 1b by increasing its RII, and a company of type 1c by increasing both RII and RMI. In order to make the examination simpler let us suppose that simultaneously only one of both coefficients may be increased, i.e., a path from the subgroup 1c into the group 2 leads either through 1b or through 1a.

Using Mann-Whitney's test it shall be established in which variables the groups 1b and 1a significantly differ from the group 2 and between each other. A comparison with the group of non-innovators (0) is not possible since this group fails to record any costs of innovation. The efficiency of turning the invested assets into revenues arising from innovations – productivity of investments – shall be expressed with a CRIT variable (share of innovation expenditure to total revenues arising from innovations – see also Figure 2), representing a reciprocal value of the productivity of investments which enables its calculation also for the companies which recorded revenues arising from innovation in the period in question (as in the case of groups 1 and 2), yet did not record any innovation costs.

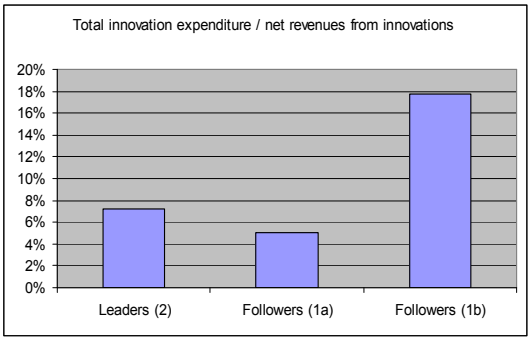

Figure 2. CRIT - Total innovation expenditure / Net revenues from innovations.

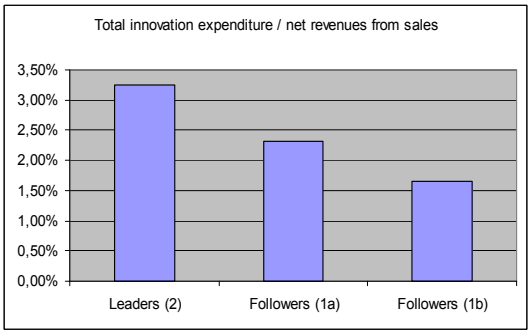

Figure 3. Share of innovation expenditure - Total innovation expenditure / Net revenues from sales.

Table II shows medians of innovation expenditure and productivity of investments (CRIT) for the groups 1a, 1b and 2 (see also Figure 3). Statistically significant correlations are indicated in bold. Comparison of the groups 1a and 2 indicates that the companies appertaining to the group 2 invest significantly more than the companies in the group 1a (innovation costs as a portion of revenues from sales in the group 2 are higher by 1.4).

TABLE II. COMPARISON OF MEDIANS OF THE FINANCIAL RATIOS AS PER GROUPS

Variable	Description	Median			Mann-Whitney test; Sig. (2-tailed)	
		Group 0	Group 1	Group 2	0vs.2	1vs.2
F_03_a	Operating efficiency ratio	1.02	1.02	1.02	0.67	0.90

F_03_b	Return on sales – ROS	0.02	0.03	0.04	**0.02**	0.28
F_03_c	Pre-tax return on sales	0.03	0.03	0.04	**0.04**	0.29
F_03_d	Total revenues per employee (€)	82183	85601	81794	0.90	0.41
F_03_e	fit per employee (€)	1906	2439	3079	0.17	0.53
F_03_f	Gross profit per employee (€)	2332	2905	3490	0.25	0.55
F_03_g	Operating profit per employee (€)	2963	3168	3976	0.37	0.57
F_03_h	Labour costs per employee (€)	17690	18396	18884	**0.01**	0.20
F_03_i	Average salary per employee (€)	12613	12962	13345	**0.02**	0.19
F_03_j	Return on equity – RO	0.10	0.10	0.14	**0.01**	**0.00**
F_03_k	Return on assets – ROA	0.03	0.04	0.05	**0.04**	0.17
F_03_m	Sales-to-Assets	1.33	1.27	1.26	0.21	0.66
F_03_n	Return on equity before taxes – ROEBT	0.13	0.12	0.17	**0.02**	**0.00**
F_04_d	Growth of net revenues 07/06 (%)	3.63	3.60	3.84	0.06	**0.01**
F_04_e	Average growth of net revenues 2003 to 2007 (%)	9.62	9.06	12.81	**0.01**	**0.00**

Regarding the groups 1b and 2, companies appertaining to the group 2 invest more than the group 1b (innovation expenditures in the group 2 are higher by 1.9). Productivity of innovation investments is significantly higher in the group 2 than in the group 1b. The companies in the group 2 succeed in making an average of 13.9 Euros from every Euro invested into innovation (or almost 2.5 times more than the companies in the group 1b), see Table III.

The groups 1a and 1b do not differ regarding the costs yet only as regards the productivity of innovation investments. Productivity of innovation investment is 3.5 times higher in the group 1a than in the group 1b. Each euro invested into innovations yields 19.6 Euros in the group 1a and 5.5 Euro in 1b. This result may be explained by the fact than investing similar amount of financial assets the group 1a on average generates higher revenues from innovation (RII).

Which type of innovation investment policies do companies appertaining to the groups of innovation followers (1a or 1b) need to adopt in order to reach the group of innovation leaders (2)? The company in the group 1a needs to increase investments into innovation in order to increase RMI and thus enter into the group 2 (by factor 1.4 on average at unchanged exploitation of these assets).

So as to increase RII and enter into the group 2 the company in group 1b needs to ensure simultaneous increase in investments and increase in the efficiency of their exploitation. Therefore, a transition through the intermediate level (1a) is in this case reasonable.

Transition from the group 1b into 1a shall not demand an increase in the invested financial assets yet it shall require a substantial increase in the efficiency of exploiting the existing assets (by factor 3.5 on average). The next step, transition from the group 1a into the group 2 shall – on the other hand – demand company's more intensive investments into innovation, at unchanged efficiency of their exploitation.

TABLE III. COMPARISON OF MEDIANS OF INNOVATION EXPENDITURE AND PRODUCTIVITY OF INVESTMENTS AS PER GROUPS

Variable	Description	Median			Mann-Whitney test; Sig. (2-tailed)		
		Group 1a	Group 1b	Group 2	1a vs. 2	1b vs. 2	1a vs. 1b
A_e2_i	Total innovation expenditure / Net revenues from sales	2.3%	1.7%	3.3%	**0.048**	**0.001**	0.205
A_e2_v	Total innovation expenditure / Number of employees (€)	1920	1391	2623	0.059	**0.001**	0.269
A_x1_b	CRIT (total innovation expenditure / revenues from innovations)	5.1%	17.8%	7.2%	0.112	**0.000**	**0.000**
I/A_x1_b	I/ CRIT = Productivity of investments = revenues from innovations/ total innovation expenditure	19.6 EUR	5.6 EUR	13.9 EUR			

V. CONCLUSION

The main findings are summarised hereunder.

A. *The innovation performance matrix*

As the statistical indicators (Eurostat) were basically not adapted for analysis of companies' innovation performance, the indicators cannot directly serve as a reference for the companies' performance improvement. However, based on the research we defined the innovation performance matrix consisting of five innovation groups (non-innovators, 3 groups of innovation followers and a group of innovation leaders). The matrix is based on two parameters – RII ("Index of revenues from innovation") and RMI ("Index of revenues from market innovation").

B. *Crucial financial performance indicators*

The return on equity (ROE - net income divided by the shareholder's equity) as a fundamental indicator from the investor's point of view was also proved as an important indicator regarding the research's aims.

Besides, the return on sales (ROS) and the return on assets (ROA) are the output financial indicators which were considered important.

Another important indicator is the average growth of net revenues, measured during the period of four years.

C. *Financial results –innovation leaders and followers*

The group of innovation leaders innovate more successfully (record higher values of RII and/or RMI) and achieve also better business performance, assessed with the financial ratios. Company's performance in terms of ROE is 40% higher in the group of innovation leaders than in the groups of followers and non-innovators.

Beside ROE, significant differences between the groups 0 and 2 as well as between 1 and 2 were observed regarding the growth of revenues from sales. Average growth of net revenues is 33% higher compared to group 0 and even 41% better than the innovation followers (Group 1).

 ISBN:978-1-61208-114-4

If the profit is an economic category on which it is possible to influence by way of accountancy, e.g., with an objective to lower taxes, then the "growth of revenues from sales" (indicates entering new markets, increase in market shares on the existing markets or, last but not least, achieving higher selling prices) proves to be a more »factual« category.

Surprisingly, the group of followers (1) – even though with better innovation results concerning RII/RMI compared to non-innovators – is performing worse than the non-innovators (0) as to ROE and average growth of net revenues.

D. Productivity of innovation investment

The relationship between the financial investments into innovation and the revenues arising from innovation (productivity of investments) is confirmed only partially. Significant difference may be observed between the groups 1b and 2, yet not between the groups 1a and 2. While the groups 1a and 2 transform their innovation investments into revenues with a similar efficiency (measured as the CRIT variable), the efficiency of both are approx. 3 times higher than the one in the group 1b.

Each euro invested into innovations yields 19.6 Euros in the group 1a and 5.5 Euros in 1b while in group 2 (innovation leaders) this value counts 19.6 Euros.

We can conclude, the impact of innovation investments is quite high, but seems not to be linear; increased investments do not (necessarily) result in an improved innovation performance.

E. Innovation policy recomendations

Which policies of innovation investments are thus to be selected by the companies appertaining to the group of innovation followers (1a or 1b) so as to enter the group of innovation leaders (2)? A company appertaining to the group 1a needs to increase investments into innovation in order to increase RMI and thus enter the group 2 (at unchanged efficiency of exploiting these assets). So as to increase RII and enter the group 2 the company 1b needs to ensure simultaneous increase in investments and increase in the efficiency of their exploitation. Therefore, a transition through the intermediate level (1a) is in this case reasonable. Transition from the group 1b into 1a shall not demand an increase in the invested financial assets yet it shall require a substantial increase in the efficiency of exploiting the existing assets (by factor 3.5 on average). The next step, transition from the group 1a into the group 2 shall – on the other hand – demand company's more intensive investments into innovation, at unchanged efficiency of their exploitation.

ACKNOWLEDGMENT

Authors would like to thank the Slovene Research Agency ARRS for the support provided for this research with grants J5—0425 and J2—2039.

REFERENCES

[1] European Commission, "The Community Innovation Survey 2006", http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/, 2009, Accessed on 25. 11. 2010.

[2] Eurostat, "Fourth Community Innovation Survey", More than 40% of EU27 enterprises are active in innovation Co-operation with customers, Office for Official Publications of the European Communities, Luxembourg, 2007.

[3] R. G. Cooper and E. J. Kleinschmidt, "Winning Businesses in Product Development: The Critical Success Factors," Research-Technology Management 50 (3), 2007, pp. 52-66.

[4] A. A. M. Leenders and B. Wierenga, "The effectiveness of different mechanisms for integrating marketing and R&D," The Journal of Product Innovation Management 19 (4), 2002, pp. 305-317.

[5] M. Michalisin, "Validity of annual report assertions about innovativeness: an empirical investigation," Journal of Business Research, Vol. 53, 2001, pp.151-161.

[6] B. Milfelner and A. Petejan, "Vpliv inovativnosti na uspešnost poslovanja v slovenskih podjetjih; Impact of Innovation on the Successfulness of the Slovenian Companies", Ekonomsko-poslovna fakulteta, Maribor, 2003.

[7] P. Fatur and B. Likar, "Statistical Analysis for Strategic Innovation Decisions in Slovenian Mechanical Industry," Journal of Mechanical Engineering 56, no. 7-8, 2010, pp. 489-496.

[8] V. Potocan and M. Mulej, "Development economics' view on growing entrepreneurship in Slovenia," International journal of entrepreneurship and innovation management 8 (3), 2008, pp. 305-319.

[9] B. Likar, "The influence of innovation, technological and research processes on the performance of Slovenia's woodworking industry," Wood research 53 (4), 2008, pp. 115-120.

 ISBN:978-1-61208-114-4