BUSINESS PERSPECTIVES

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COGNITIVE ANALYTICAL TOOLS FOR COST MANAGEMENT OF INNOVATION ACTIVITY

Abstract

Promotion of innovations on the market is hampered in Ukraine by the lack of methodological approaches for analyzing the efficiency of innovative projects. The lack of appropriate methodology leads companies to refuse to innovate because of the uncertainty of final economic outcomes. The introduction of project based methods for innovation activity management allows, on the one hand, to reconcile strategic and operational objectives within the innovation process, innovation activity and general financial and economic activity of the enterprise, and on the other hand, to implement cognitive approaches to organization of company's innovation management.

The research argues the possibilities of applying the canonical correlation method for structuring the causal links between the determined components of a company innovative capability, such as innovation potential, innovative business opportunities and system margin. As these components may be further assessed by quantitative indices, the method of regression analysis is also used to develop analytical tools for innovation management, which allow to reveal the interrelated impact of expenses on the results of innovation activity. The paper analyzes changes in a company innovative capability that can be provoked by increased material, depreciation, labor and information costs and discusses directions of interrelated changes. Practical testing of submitted proposals is realized based on the Ukrainian companies' statements for 2012–2017.

INTRODUCTION

The progressive experience of the most successful foreign companies in the world market shows that active, systematic and consistent innovation activities are necessary to ensure sustainable competitive advantages and to increase capital value. At the same time, innovation activity significantly increases the uncertainty of dynamics and performance of the company. Therefore, the prerequisite for success is the ability of enterprises to anticipate and respond to changes in the external environment, to avoid or prevent destructive effects of negative factors and threats. In today's conditions of exacerbation of socio-economic contradictions, the problem of constructing and ensuring the functioning of the special management system, which allows balancing the driving and restraining factors in innovation activity is of vital importance; development of special analytical instruments for management of innovation costs and expenses has relevant scientific meaning and practical significance.

1. LITERATURE REVIEW

Practical sounds of the problems of innovation led to a wide scientific interest among Ukrainian and foreign researchers. Scientific works of Freeman and Engel (2007), Kanter (1985), Robertson (1971), Van
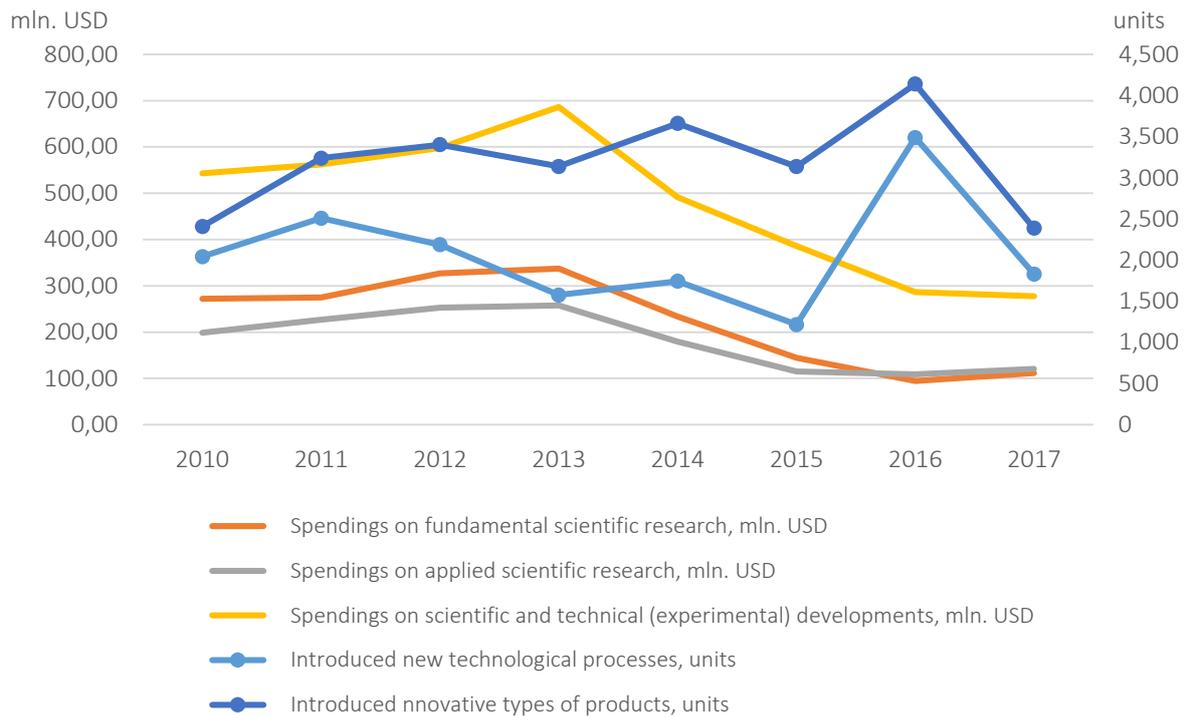
Figure 1. Innovation activity inflows and outputs in Ukraine

de Ven, Angle, and Poole (1989) and others lay the fundamentals for further scientific search. A significant positive feature of modern scientific research in the area of innovation is the accumulation of scientific developments at different levels of economic system management.

On the other hand, in majority of applied researches such as Alves, Barbieux, and Reichert (2017), Ponomarenko and Gontareva (2017), Rasmussen and Petersen (2017), Kolodiziev, Chmutova and Lesik (2018) innovations continue to be identified with the functional management of individual industries, and not with the corporate development of the enterprise as a whole. As a result, in practice, national companies devote for innovations insufficient financial and human resources and do not use full potential of new technologies.

The mainstream understanding that innovations are created at the intersection between established and emerging technologies, specialized capabilities available in and around the innovating firm, and market demand (Kanter, 1985; Ponomarenko & Gontareva, 2017; Van de Ven, Angle, & Poole, 1989) provokes the researchers to focus on commercialization results of innovation activity. So

Sharp, Iyer, and Brush (2017) suggest that the effect of executives on innovation can be better understood by explicitly separating innovation into the component processes of invention and commercialization. Pine and Gilmore (2014) conclude that to succeed in the rapidly evolving experience economy innovative executives must think differently about how they create economic value for their customers.

However, some researchers pay attention to company's capabilities to innovate. Thus, Herstad, Sandven, and Ebersberger (2015) suggest that the effectiveness of innovation activity depends upon the ability of the company to utilize effectively the know-how.

Official Statistic Office shows that during 2010–2017, total spending on R&D in Ukraine increased slightly from 8,107.1 to 13,379.3 mln UAH, but this increase was fully destroyed by currency exchange rate blast-off from 799 to 2665,5 UAH per 100 USD during this period, so Figure 1 demonstrates the decrease of R&D spending in USD.

The structure of R&D spending is quite permanent: 22%-28% is directed to fundamental research and from 50.8% (in 2012) up to 59.8% (in 2015) is

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spent on experimental developments. Dynamics of innovation outputs is not so smooth: in 2016, significant increase of implemented new processes (in 2.86 times in comparison with previous year) and products (in 1.32 times) was fixed, but in 2017, companies implemented less product innovation than even in 2015.

Promotion of innovations on the market is hampered in Ukraine by the lack of methodological approaches for analyzing the efficiency of innovative projects. Their development is mainly based on the types and scale of the technology being introduced by companies in previous periods. The lack of appropriate methodology leads companies to refuse to innovate because of the uncertainty of final economic outcomes. Until recently, the problem of dynamic correspondence between innovative, strategic and marketing activities of the enterprise is not researched. This, in turn, restrains implementation of the latest technological advances and, as a consequence, improving product quality, meeting the ever-increasing needs of consumers and increase the competitiveness of the enterprise.

Aims

The main purpose of the paper is to develop cognitive analytical tools that allow management to identify and justify managerial decisions upon costs of innovation activity.

2. RESEARCH METHODOLOGY

The essence of company's innovation activity management consists in determining the direction of the innovative development of products, processes organization and marketing by means of selection of options in accordance with company's innovative capacity, general purpose of innovation activity in the chosen horizon of managerial influence, business plans of the enterprise. One of the important managerial tasks is the formation of general portfolio of innovative projects that can be implemented in the period.

To achieve the purpose of the research, a system of general scientific and special methods and approaches was used, in particular: scientific abstraction – for morphological and semantic analy-

sis of the categories "innovative activity", "innovation changes"; systemic and structural analysis – to substantiate the characteristics of the classification of innovations; statistical methods of comparison, generalization and formalization, methods of multidimensional statistical analysis (software Statistica 8.0) – for assessment and analysis of domestic enterprises' innovation activities results on the basis of the systematic nature of innovation changes.

The introduction of cognitive methods for innovation activity management allows, on the one hand, to reconcile strategic and operational objectives within the innovation process, innovation activity and general financial and economic activity of the enterprise, and on the other hand, to implement rhizomatic approaches to organization of company's economic security system. The effectiveness of implementing innovative projects that are characterized by a high degree of risk depends upon the efficiency of managerial decisions on adjusting activities in response to changes in the external environment. In addition, the essence of innovation project grounds risk-based approach to cost management. The project approach in organization of innovative activity management allows prompt reaction to deviations in the system of innovative activity cost management (IACM). Construction of IACM system according to the linear hierarchical principle of managing influence allows coherent development of systems and ensures maximum efficiency of recourses consumption during innovations.

Selection directions of innovative development conducted by company's management involves primarily selection the kind of innovative implementations, which should form the company innovative projects portfolio. Selection and implementation of such projects should be based on the development and analysis of scenarios, on the conditions and results of their commercialization, within the use of common management methods in the IACM system taking into account the specifics of the enterprise. Ensuring the requirements for the selection of innovative projects, as well as the definition of the total amount of expenditures in the period, is realized through the sequential use of grids in following main procedures:

1) selection of types of innovations, formation innovative projects portfolio;

2) development of implementation scenarios for different types of innovations and innovative projects portfolios;

3) selection innovative projects and determining the amount of costs.

The main task of the enterprise during the implementation of the processes identified in the first procedure is to choose the type of innovation and the formation of a portfolio of innovation projects for each particular type of innovation that can be implemented based on assessment and analysis of:

- directions, goals and indicators of innovation activity effectiveness based on the analysis of external factors (competitive environment) and emerging innovative ideas and general goals of the enterprise's economic activity in the period;

- the level of innovation capability of the enterprise in the previous period;

- maximum allowable expenditures, based on cost-sharing in general object-oriented system of cost management company to meet the needs of other activities.

Ensuring the implementation of the tasks is due to the application of the grid selection of a set of indicators characterizing the implementation of management functions, aimed at the transfer of the corresponding characteristics of the innovation activity system in a new state by the results of the implementation of innovations. Formally, the general process of selection of innovative implementations can be described as:

$$SFE^x \left\{ \mu_0 : \left(IOOP_0, ISOP_0, V_0, \hbar_0 \right) \right\} \rightarrow$$
$$\rightarrow G_1 \rightarrow \left\{ \mu_1 : \left(IOOP_1, ISOP_1, V_1, \hbar_1 \right) \right\}, \qquad (1)$$

where SFE is a set of functional effects on the part of object-oriented management systems of the enterprise, aimed at a plurality of objects, which causes a dynamic reaction and transfer of objects to a new state at the end of the period,

G_1 is a grid selection of parameters characterizing a new state of the enterprise, μ_0, μ_1 are parameters, that reflect the plurality of states of the subject-oriented plane of management influence at the beginning and end of the period, $IOOP_0$, $IOOP_1$ are indicators of the object-oriented plane on the beginning and end of the period, respectively, which can be uniquely reliably estimated on the basis of the company's reporting data and selected on the basis of a cognitive approach, the systematization of which occurs through the processing of the results of expert analysis of a group of experienced specialists, at the level of a separate enterprise, the evaluation of indicators is carried out by means of mitigating cognitive management tools, at the level of a branch or regional cluster – by applying canonical correlation methods that allow setting the marginal deviations of the indicators for individual cluster enterprises, $ISOP_0$, $ISOP_1$ are indicators of the subject-oriented plane, which can be uniquely reliably estimated on the basis of enterprise reporting data and selected on the basis of normalized (formalized by the methodology) selection on the beginning and end of the period, respectively, V_0, V_1 are indicators that contain verbal characteristics of the state of the system and can be included in the plane of consideration, based on the use of methods of fuzzy logic the beginning and end of the period, respectively, $\hbar_0$, $\hbar_1$ are the levels of influence of random unpredictable factors of threats of the external and internal environment at the beginning and end of the period, respectively. Their presence and significant influence on the results of innovation activity of enterprises is proved by the results of conducted canonical correlation analysis based on the companies' statistical and financial reports.

On the first selection steps, the methods for evaluating the indicators for inclusion in the selection grid differ significantly.

Set $IOOP$ includes indicators determining maximum allowable amount for a certain company expenses and the level of costs that depend on the overall performance efficiency costs of activities and specific objectives of economic activity, standing in the period, as well as subjective understanding of the policy and prospects of innovation activity from the top management. The first group of indicators characterizes the level of innovation ca-

pability, which can be formalized according to the methodology proposed previously by Labunska, Petrova, and Prokopishyna (2017).

Another group of factors referred to the set *ISOP*, which form the plane of selection, are not defined clearly or do not fit into the mathematical description and can only be formed by methods of expert verbal assessment. This concerns the evaluation of the purposes of the innovation activity with other objectives of the enterprise, the availability of innovative ideas for determining the direction of innovation development, the availability of innovative products on the market that can be realized for a particular company, etc. Such a set is formed according to specific, coordinated in time, needs of the enterprise and cannot be strictly formalized.

The fourth group of factors ɦ can be summarized evaluated only by the results of their manifestation, is not predictable, is determined in the process of manifestation and is crucial for the formation of a general reserve of expenses aimed at overcoming the effects of such factors in future periods. Canonical correlation analysis allows to evaluate these factors by the results of their manifestation, however, for the purposes of innovation activity management, it is particularly important to forecast them with an acceptable level of reliability. In order to take into account these factors in the process of planning of individual innovation projects and innovation development of the company as a whole, it is necessary to apply the methods and tools of cognitive management.

The formation of cognitive analytical base on the proposed structure allows using elements of scenario modeling at the level of operational management of innovation activity. Operational modeling horizon is justified firstly by increased volatility in economic conditions of modern realities of crisis in national economy, secondly, high-cost and risky innovations, fast diffusion of information resources during the introduction of innovation processes, and thirdly, the presence of the mutual influence of objects of the object-oriented plane, on the general results of the state of the IACM system.

Given the above, it is advisable to implement managerial tools in the following order:

Step 1.

Identification of priority directions of innovative implementation and grouping of existing innovative projects by types of innovations.

Step 2.

Determination of the main factors and indicators of the influence of the external and internal environment on the overall results to be obtained by the enterprise under the conditions of the project implementation and their ranking according to the degree of influence.

Step 3.

Formation of the logic of the script, definition of the logical rods and scenario driver that determines the variety of specific scenario developments.

In order to define the variants of development of events in driver points, it is necessary to consider mutual ground impact indicators, which are under direct management influence of the IACM system. This is especially true definition of mutual influence in object-oriented plane of indicators that make up the basic for selecting the direction of innovation development in stage 1, and highlight the set, provided the results of standardized approach to peer review.

Determining the main set of drivers involves predicting the results of managerial influence on the indicators that are assigned to target definition of the implementation of a particular innovation project, characterized not only by changing the main project value (for example, the complexity of the product), but the associated effect on the other. An assessment of the components of innovation capability can take place on the basis of cognitive maps (Labunska, Iermachenko, & Prokopishyna, 2017) to construct realistic scenarios for analyzing such an impact and involving all components into the overall model that describes the innovation capability in dynamics and takes into account the interrelated effects of changes of its components: innovation potential (IP), innovative business opportunities (IBO) and system margin (SM).

To identify causal relationships between sets of signs in economic research, methods of canonical

correlation analysis are widely used. Canonical correlation methods allow to reveal maximum correlation with the help of canonical functions defined as linear combinations of initial attributes. During the research, canonical correlation analysis was performed in the module "Multivariate Exploratory Techniques\Canonical Analysis" of Statistica 8.0. Since the value of the components of the innovation capability of the company varies by type of innovation, the establishment of links between sets of variables is conducted in the context of product, process, organizational and marketing innovations.

3. EMPIRICAL RESULTS

Statistically significant canonical roots are constructed as a result of the calculations. These models are characterized by high correlation coefficients (correlation coefficients for models of links between system margin and innovation potential are more than 96%, correlation coefficients for models of links between system margin and innovative business opportunities are more than 67%) (Table 1).

However, composed canonical models explain the dispersion of innovative capability components not in all cases: thus, based on system margin indices, it is possible to explain only 17.58% of the

dispersion of the variables that characterize innovation potential and 9.45% dispersion of the IBM indicators (for product innovations). Identified qualities inherent in innovation capability components without dependence on innovation type (for process, organizational and marketing innovations – 15.26% and 9.13%, 19.48% and 9.18%, 18.14% and 9.94%, respectively).

The innovation potential has a significantly greater effect on the formation of system margin: canonical models based on the innovation potential indicators explain over 89% of the variability of the integral index of the company's system margin.

As a result of the canonical analysis of the sets of variables characterizing innovation potential and innovative business opportunities, 7 canonical roots were obtained, the canonical correlation coefficient was 99.81%; all 7 roots describe 100% dispersion of the set of IBO indicators and 42.17% – the set of IP indicators. Appling IBM indicators the obtained canonical models explain on average 34.14% of the dispersion of variables that make up innovation potential and 76.79% of the variability of innovative business opportunities indicators. Since the requirement $p < 0.001$ is maintained only for the first three systems of canonical variables, these canonical models are statistically significant. Composed canonical models aggregate the indicators (see Table 2) according to innovation capability structure.

Table 1. Statistical characteristics of the interconnection of innovation capability components by types of innovations

Type of innovation	Canonic model	Innovation capability component	Explained variance, %	Common irregularity, %	Canonical correlation coefficient
Product innovations	The impact of system margin on innovation potential	SM	100.00	90.33	0.97906
		IP	19.22	17.58	
	The impact of system margin on innovative business opportunities	SM	100.00	36.51	0.68208
		IBO	29.06	9.45	
Process innovations	The impact of system margin on innovation potential	SM	100.00	89.48	0.97936
		IP	16.97	15.26	
	The impact of system margin on innovative business opportunities	SM	100.00	33.26	0.67106
		IBO	29.22	9.13	
Organizational innovations	The impact of system margin on innovation potential	SM	100.00	90.64	0.97734
		IP	21.069	19.48	
	The impact of system margin on innovative business opportunities	SM	100.00	34.82	0.67207
		IBO	28.94	9.18	
Marketing innovations	The impact of system margin on innovation potential	SM	100.00	89.46	0,.96648
		IP	20.10	18.14	
	The impact of system margin on innovative business opportunities	SM	100.00	37.27	0.69246
		IBO	29.66	9.94	

Table 2. Indicators of company's innovation capability

Component	Indicators of component
Labor resources component of innovation potential	Coefficient of staffing (P1111), acceptance turnover ratio (P1112), coefficient of stability of personnel (P1113), coefficient of labor discipline (P1114), coefficient of salary motivation (P1115), coefficient of professional development (P1116), coefficient of intellectual level of personnel (P1117), coefficient of workers average level (P1118), coefficient of recruitment of highly skilled personnel (P1119), share of engineering and scientific workers in personnel total number (P1110), labor productivity coefficient (P1121), coefficient of innovative activity (P1122)
Material resources component of innovation potential	Coefficient of fixed assets suitability (P1211), coefficient of fixed assets renewal (P1212), coefficient of fixed assets growth (P1213), fixed assets share (P1214), coefficient of raw materials availability (P1215), return on fixed capital ratio (P1221), return on raw material ratio (P1222), coefficient of deficiency (P1223)
Financial resources component of innovation potential	Share of own working capital in equity (P1311), coefficient of autonomy (P1312), coefficient of provision of stocks by own funds (P1313), share of own working capital in the total amount of working capital (P1314), profitability of assets (P1321), profitability of invested capital (P1322), return on equity (P1323)
Information resources component of innovation potential	Information cost rate (P1411), coefficient of information completeness (P1412), coefficient of information security (P1413), coefficient of information accuracy (P1414), share of R&D expenditures (P1415), the coefficient of information contradiction (P1416), productivity of information (P1421), profitability of information (P1422)
Innovative business opportunities	Quick liquidity ratio (P2111), turnover rate of trade payables (P2121), turnover rate of accounts receivable (P2131), operating leverage (P2211), the profitability of sales (P2311), product profitability (P2321), organizational structure compliance level (P2411)
System margin	Coefficient of system margin (P3111)

The first system of canonical variables explains 25.63% of the dispersion of variables characterizing IP; it is possible to explain 25.54% of the dispersion of the IBO indicators based on the equation of the first canonical model (2) and values of the indicators of innovation potential.

Using the equation of the first canonical model (2) based on the values of the indicators of innovation potential, it is possible to explain 25.54% of the dispersion of indicators of innovative business opportunities:

$$U_1 = 0.108 \cdot P_{1111} + 0.065 \cdot P_{1112} + 0.151 \cdot P_{1113} +$$
$$+0.143 \cdot P_{1114} + 0.424 \cdot P_{1115} + 0.266 \cdot P_{1116} +$$
$$+0.436 \cdot P_{1117} + 0.217 \cdot P_{1118} + 0.234 \cdot P_{1119} +$$
$$+0.435 \cdot P_{1110} + 0.675 \cdot P_{1121} + 0.655 \cdot P_{1122} +$$
$$+0.270 \cdot P_{1211} + 0.300 \cdot P_{1212} + 0.152 \cdot P_{1213} -$$
$$-0.092 \cdot P_{1214} + 0.261 \cdot P_{1215} + 0.487 \cdot P_{1221} +$$
$$+0.257 \cdot P_{1222} - 0.031 \cdot P_{1223} + 0.254 \cdot P_{1224} +$$
$$+0.250 \cdot P_{1311} + 0.201 \cdot P_{1312} + 0.370 \cdot P_{1313} +$$
$$+0.272 \cdot P_{1314} + 0.640 \cdot P_{1321} + 0.455 \cdot P_{1322} +$$
$$+0.432 \cdot P_{1323} + 0.374 \cdot P_{1411} + 0.745 \cdot P_{1412} +$$
$$+0.829 \cdot P_{1413} + 0.837 \cdot P_{1414} + 0.788 \cdot P_{1415} +$$
$$+0.434 \cdot P_{1416} + 0.636 \cdot P_{1421} + 0.529 \cdot P_{1422}$$

(2)

$$V_1 = 0.045 \cdot P_{2131} + 0.266 \cdot P_{2211} +$$
$$+0.430 \cdot P_{2311} + 0.462 \cdot P_{2321} + 0.998 \cdot P_{2411}.$$

This system of canonical variables testifies the correlation between the level of compliance with the organizational structure and indicators that characterize the efficiency of labor and financial resources and the availability and efficiency of information resources.

The second system of canonical variables explains 22.35% of the dispersion of variables characterizing IP; it is possible to explain 19.93% of the dispersion of the IBO indicators based on the equation of the second canonical model (3) and values of the indicators of innovation potential:

$$U_2 = 0.068 \cdot P_{1111} + 0.080 \cdot P_{1112} - 0.013 \cdot P_{1113} -$$
$$-0.066 \cdot P_{1114} + 0.016 \cdot P_{1115} - 0.118 \cdot P_{1116} +$$
$$+0.117 \cdot P_{1117} + 0.051 \cdot P_{1118} + 0.060 \cdot P_{1119} +$$
$$+0.085 \cdot P_{1110} + 0.342 \cdot P_{1121} + 0.283 \cdot P_{1122} +$$
$$+0.162 \cdot P_{1211} + 0.109 \cdot P_{1212} + 0.182 \cdot P_{1213} +$$
$$+0.142 \cdot P_{1214} + 0.211 \cdot P_{1215} + 0.248 \cdot P_{1221} -$$
$$-0.083 \cdot P_{1222} - 0.240 \cdot P_{1223} - 0.226 \cdot P_{1224} -$$
$$-0.035 \cdot P_{1311} + 0.143 \cdot P_{1312} - 0.038 \cdot P_{1313} -$$
$$-0.014 \cdot P_{1314} - 0.640 \cdot P_{1321} - 0.433 \cdot P_{1322} -$$
$$-0.527 \cdot P_{1323} + 0.017 \cdot P_{1411} + 0.198 \cdot P_{1412} +$$
$$+0.148 \cdot P_{1413} + 0.043 \cdot P_{1414} + 0.133 \cdot P_{1415} +$$
$$+0.296 \cdot P_{1416} + 0.139 \cdot P_{1421} - 0.537 \cdot P_{1422}$$

(3)

$$V_2 = -0.023 \cdot P_{2111} + 0.055 \cdot P_{2121} + 0.158 \cdot P_{2131} +$$
$$+0.193 \cdot P_{2211} - 0.850 \cdot P_{2311} - 0.879 \cdot P_{2321} + 0.054 \cdot P_{2411}.$$

The second system of canonical variables reveals a correlation between the internal rate of return and indicators that characterize the efficiency of the use of financial resources.

The third system of canonical variables explains 17.7% of variance of variables characterizing IP; it is possible to explain 13.42% of the dispersion of the IBO indicators based on the equation of the third canonical model (4) and values of the indicators of resource innovation potential:

$$
\begin{aligned}
U_3 = &-0.055 \cdot P_{1111} + 0.224 \cdot P_{1112} - 0.099 \cdot P_{1113} - \\
&-0.157 \cdot P_{1114} - 0.099 \cdot P_{1115} - 0.234 \cdot P_{1116} + \\
&+0.190 \cdot P_{1117} + 0.229 \cdot P_{1118} + 0.208 \cdot P_{1119} + \\
&+0.175 \cdot P_{1110} - 0.066 \cdot P_{1121} - 0.033 \cdot P_{1122} + \\
&+0.166 \cdot P_{1211} + 0.111 \cdot P_{1212} + 0.121 \cdot P_{1213} + \\
&+0.758 \cdot P_{1214} - 0.015 \cdot P_{1215} - 0.478 \cdot P_{1221} + \\
&+0.246 \cdot P_{1222} + 0.114 \cdot P_{1223} + 0.314 \cdot P_{1224} - \\
&-0.384 \cdot P_{1311} + 0.363 \cdot P_{1312} - 0.378 \cdot P_{1313} - \\
&-0.059 \cdot P_{1314} + 0.067 \cdot P_{1321} - 0.086 \cdot P_{1322} - \\
&-0.139 \cdot P_{1323} + 0.247 \cdot P_{1411} + 0.154 \cdot P_{1412} + \\
&+0.084 \cdot P_{1413} + 0.141 \cdot P_{1414} - 0.021 \cdot P_{1415} + \\
&+0.045 \cdot P_{1416} - 0.265 \cdot P_{1421} - 0.044 \cdot P_{1422}
\end{aligned} \quad (4)
$$

$$
\begin{aligned}
V_3 = &-0.869 \cdot P_{2111} + 0.274 \cdot P_{2121} + \\
&+0.637 \cdot P_{2131} + 0.014 \cdot P_{2211} - \\
&-0.056 \cdot P_{2311} - 0.023 \cdot P_{2321} - 0.008 \cdot P_{2411}.
\end{aligned}
$$

The third system of canonical variables testifies to the correlation between the property status and the indicators characterizing the availability of material resources.

In total, three significant systems of canonical variables explain about 65% of dispersion of the variables characterizing the IP, and about 59% of the dispersion of IBO indices. Due to high-value determinant levels of the canonical models (2-4), conclusion about statistically significant relationship between the variables is justified, but the generalized IBO index cannot be assessed on the basis of the IP (and vice versa) with a high degree of certainty. In order to detect the relationship between the indicators of the first level of decomposition, a regression analysis was performed on the basis of the information array of values of IP and IBO. The

multivariate linear models constructed as a result of regression analysis for the investigated factors are as follows:

$$
\left\{
\begin{aligned}
P_{2111} = &\, 2.756 + 0.069 P_{1111} + 0.230 P_{1114} + 0.058 P_{1115} + \\
&+0.060 P_{1116} - 0.582 P_{1117} - 0.549 P_{1118} + 0.088 P_{1119} + \\
&+0.408 P_{1110} - 0.030 P_{1211} - 0.117 P_{1213} - 0.149 P_{1214} + \\
&+0.117 P_{1221} - 0.234 P_{1222} + 0.221 P_{1224} + 0.256 P_{1311} + \\
&+0.782 P_{1313} - 0.573 P_{1314} - 0.132 P_{1321} + 0.002 P_{1411} - \\
&-3.002 P_{1415} + 0.011 P_{1421} - 0.064 P_{1422} + 0.147 P_{2121} - \\
&-0.182 P_{2131} - 0.032 P_{2211} + 0.913 P_{2411} \\[6pt]
P_{2121} = &\, 0.067 + 0.096 P_{1116} + 0.088 P_{1212} + 0.181 P_{1214} - \\
&-0.244 P_{1215+} 0.247 P_{1221} + 0.112 P_{1222} + 0.0998 P_{1311} + \\
&+0.231 P_{1312} - 0.082 P_{1313} + 0.031 P_{1314} + 0.193 P_{2131} \\[6pt]
P_{2131} = &\, 0.174 + 0.382 P_{1214} - 0.245 P_{1215} + 0.152 P_{1221} - \\
&-0.055 P_{1222} + 0.117 P_{1311} + 0.079 P_{1312} - 0.167 P_{1313} - \\
&-0.215 P_{1314} + 0.178 P_{2121} \\[6pt]
P_{2211} = &\, -0.1597 + 0.520 P_{1111} - 0.138 P_{1112} - \\
&-0.851 P_{1113} + 0.422 P_{1114} + 0.026 P_{1115} - 0.849 P_{1119} + \\
&+0.583 P_{1110} + 1.192 P_{1121} - 0.915 P_{1122} - 0.379 P_{1211} + \\
&+0.678 P_{1212} - 0.465 P_{1213} + 0.245 P_{1214} + 0.135 P_{1215} + \\
&+0.141 P_{1221} - 0.227 P_{1222-} 0.059 P_{1223} + 0.556 P_{1224} + \\
&+0.114 P_{1311} + 0.229 P_{1312} + 0.032 P_{1313} + 0.168 P_{1314} - \\
&-0.597 P_{1321} + 0.559 P_{1322} + 0.063 P_{1323} - 0.110 P_{2111} - \\
&-0.0002 P_{2121} - 0.149 P_{2131} \\[6pt]
P_{2311} = &\, 0.004 + 0.024 P_{1221} + 1.009 P_{2321} \\[6pt]
P_{2321} = &\, 0.001 + 0.014 P_{1112} - 0.020 P_{1221} + 0.951 P_{2311} \\[6pt]
P_{2411} = &\, -1.251 + 0.072 P_{1111} + 0.161 P_{1222} - \\
&-0.366 P_{1223} + 0.091 P_{1311} + 0.175 P_{1322} - 0.082 P_{1323} + \\
&+0.081 P_{1411} + 2.166 P_{1415} + 0.130 P_{1416+} 0.126 P_{1421} + \\
&+0.201 P_{1422}
\end{aligned}
\right. \quad (5)
$$

The constructed models are statistically significant, determination coefficient (DC) of linear multifactorial model of the fast liquidity ratio (P_{2111}) is 0.775, DC of the turnover rate of trade payables (P_{2121}) is 0.771, DC of the turnover rate of accounts receivable (P_{2131}) is 0.770, DC of operating leverage (P_{2211}) is 0.774, DC of the profitability of sales (P_{2311}) is 0.9595, DC of product profitability (P_{2321}) is 0.9596, DC of organizational structure compliance level (P_{2411}) is 0.9612.
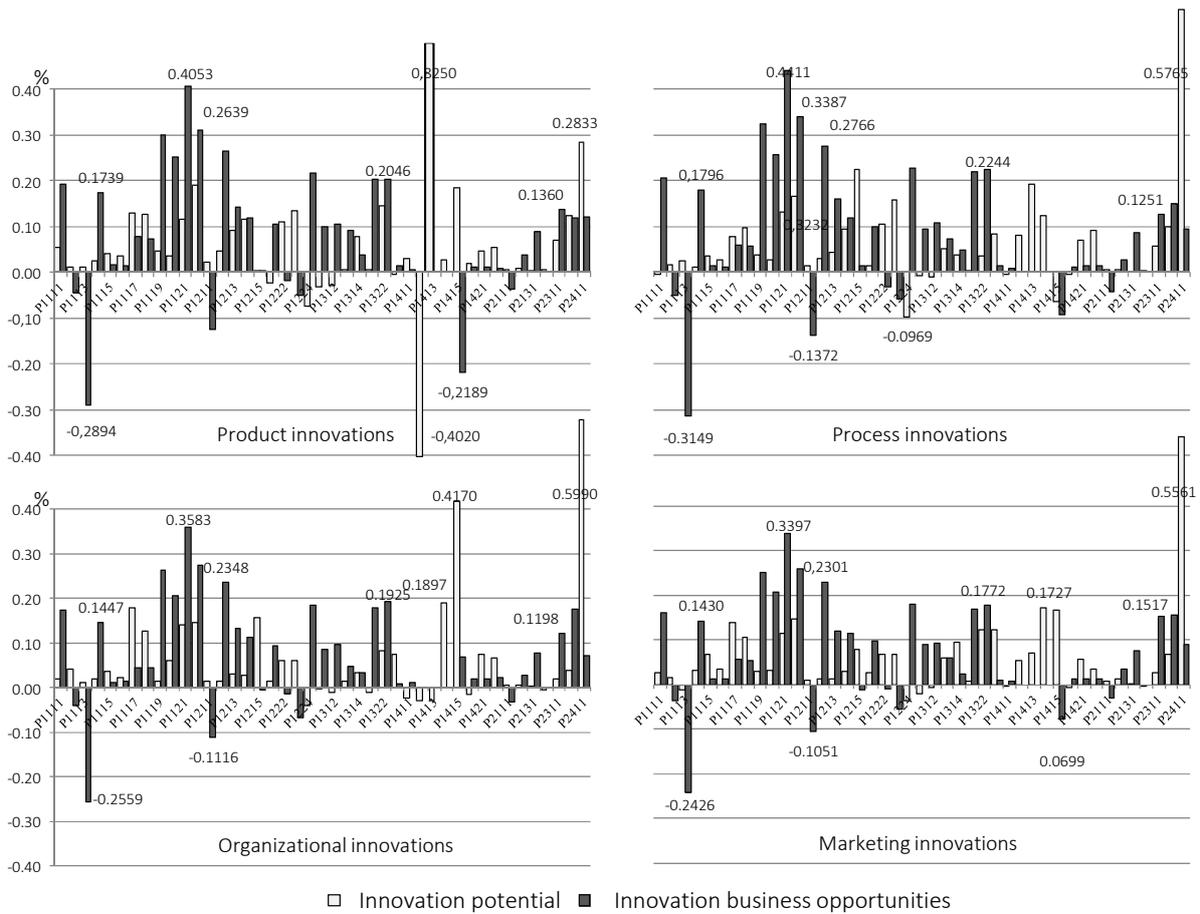
Figure 2. Graphic interpretation of mutual influence
of the factors of company's innovation capability

Constructed regressive multivariate models can become an objective analytical basis for the modeling of innovation capabilities, taking into account the mutual influence of factors. In the course of scientific research, change of innovation capability was forecasted taking into account the dynamics of the variables depending on each factor. The results of the carried out dynamic simulation on the example of the scenario of factor growth of 1% for one iteration are shown in Figure 2.

Figure 2 demonstrates, for example, that if a company introduces innovation projects aimed at 1% increase of productivity, it gains additionally positive dynamics of other factors related to labor productivity (P_{1121}), total positive impact of these factors on innovation potential is about 0.1477% (as for product innovations) and on innovative business opportunities is 0.4053% (0.1329% and 0.4411%, respectively, for process innovations, 0.1387% and 0.3583% for organizational innovations, 0.11132%

and 0.3397% for marketing innovations). The innovative projects aimed at increase of information productivity have the greatest interconnected effect, so that additional growth of innovative capacity for product innovations is 0.82% for each 1% increase of the efficiency of information resources.

4. DISCUSSION

As a result of the simulation, it has been found that the factors have a disproportionate interrelated effect on different types of innovations (for example, as a result of the introduction of innovative projects aimed at increasing the useful use of materials under the influence of the interconnections between factors, innovative capacity additionally increases with respect to product innovations by 0.0852%, processors – by 0.1074%, organizational – by 0.0995% and only 0.0032% – for marketing innovations).

When justifying managerial decisions on choosing innovation projects, it must also be taken into account that individual factors have a multi-directional, inter-related effect on innovation potential and innovative business opportunities. So, as a result of the conducted modeling, it has been established for example, that for product innovations:

1) innovative business opportunities broaden, but the level of innovation potential decreases in case of:

- the growth rate of personnel acceptance turnover ratio (P_{1112}), since this reduces the profitability of information resources and the stability of staff;

- the growth of the coefficient of stability of personnel (P_{1113}), since this reduces the share of employed workers in the average number of personnel;

- the growth of the coefficient of fixed assets suitability (P_{1211}) and simultaneous fall in the operating leverage (P_{2211});

- the growth of the return on raw material ratio (P_{1222}) is achieved by usage of cheaper inventories and changes in the structure of assets in the direction of increasing the share of less liquid assets;

- the growth of the coefficient of deficiency (P_{1223}) is not accompanied by the introduction of new, more effective fixed assets;

- the growth of the coefficient of information contradiction (P_{1416}) is achieved by decrease in the profitability of information resources and/ or share of R&D expenditures;

- the growth of the quick liquidity ratio (P_{2111}) is accompanied by a reduction in the operating leverage (P_{2211});

2) the level of innovation potential increases, but the innovative business opportunities are constrained by:

- the growth of the return on fixed capital ratio (P_{1221}), if it is achieved by a decrease of residual value of fixed assets during the accumulation of accrued depreciation and insufficient rates of fixed assets renewal;

- the growth of the coefficient of deficiency (P_{1223}), if it is caused only by changes in the structure of the cost of goods sold without the introduction of advanced production technologies that reduce the share of spoilage;

- the growth of the share of own working capital in equity (P_{1311}), if it is achieved only by changes in the structure of property at which the book value of fixed assets decreases in result of the systematic depreciation without a proportional renewal of fixed assets,

- the growth of the coefficient of autonomy (P_{1312}), if it is caused by decrease of book value of non-current assets and/or inventories required for a continuous and rhythmic production process while liabilities do not change their amount;

- the growth of the return on equity (P_{1323}), if it is caused by changes in the structure of equities (decrease of capital stock) without increase of income;

- the growth of the coefficient of information completeness (P_{1412}), if it is accompanied by a decrease in the rate of fixed assets renewal (P_{1212}), the coefficient of raw materials availability (P_{1215}), the share of own working capital in the total amount of working capital (P_{1314}), and / or decrease in the return on equity (P_{1323}).

The results of the conducted dynamic modeling of innovation capability also confirm the conclusion that the vectors of the interrelated effect differ in dependence with types of innovations, and this should also be taken into account when substantiating managerial decisions regarding the selection of innovative projects.

So, for organizational innovation, the decrease of innovation potential and increase of innovative business opportunities may be caused by:

- the increase of profitability of assets (P_{1321}), if it is achieved by reducing wage expenses,

depreciation and expenses for the formation and maintenance of the information base for decision-making and/or the reduction in the book value of fixed assets and inventories used in the production process, administrative or marketing activity;

- the increase in the information cost rate (P_{1411}), if it is not accompanied by increasing productivity and profitability of intellectual component of productive resources and increasing share of R&D expenditures;

- the increase in the coefficient of information security (P_{1413}), since the innovative activity of the personnel is constrained by the inaccessibility of information about the business;

- the increase in the share of R&D expenditures (P_{1415}) – in this case, the growth rate of R&D expenditures exceeds the rate of increase in productivity and profitability of information.

For process innovations, an increase in the coefficient of information contradiction (P_{1416}) (the ratio of independent evidence in favor of a decision taken to the total number of independent evidences) has the dissimulating effect both on the IP and on the IBO if it reduces the share of R&D expenditures and / or the profitability of information resources.

Unlike product innovations, innovative business opportunities for marketing innovations are constrained by the growth of the coefficient of stability of personnel (P_{1113}). Also, for marketing innovation projects, the raw materials availability (P_{1215}) is a constraining factor for innovative business opportunities and a motivating factor for innovation potential if, at the same time as it grows, the share of assets financed by own funds decreases and/or the turnover of accounts receivable and payable decreases.

To sum up, we may note that the growth of analyzed factors is accompanied by an increase in the level of integral indicators due to the synergistic change of other factors not taken into account by the static model of innovation capability.

Thus, the use of canonical analysis enables to quantify the synergistic effects of the mutual influence of factors within certain subsets of the indicators of innovation potential, innovative business opportunities and innovation system that characterize company's innovative capability to introduce innovations of distinct type. The proposed method gives an opportunity to implement cognitive approaches in the enterprise management system, which consist in the initial selection of indicators of the overall innovation capability of the economic entity.

CONCLUSION

As innovation processes should be, on the one hand, agreed with the main goals and objectives of other business processes of the enterprise, on the other hand, they are intended to perform certain tasks that are limited in time and space dimension, innovation activity management should be implemented as the project management using scenario modeling.

During the process of selecting the type of innovative implementations, the formation of a portfolio of innovative projects and determination of the volume and direction of innovation funding the criterion grating selection should be taken into account, providing transfer characteristics of the general state system of innovation management at the level defined now as desired, according to the introduction of some innovative projects in the period.

The selection of innovative projects generated by type of innovative transformations is based on the use of scenario modeling, taking into account the retrospective analysis of the dynamics direction of mutual influence between the sets of indicators that shape innovation in the ability of the enterprise. For initial assessment of company innovation capability the appropriate cognitive model should be used that allows to reveal mutual influence of the sets of indicators and the synergistic effect of a particular

type of innovation. This analytical model can be used for more in-depth analysis of innovative capacity by type of innovation, and to design changes in the implementation of the chosen innovative project.

Proposed guidelines for the formation of analytical framework for innovative companies capacity provide the basis for cognitive management tools of innovative activity cost optimization and in the future may be used for comparative analysis of innovation capability clusters domestic and foreign enterprises.

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