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METHODOLOGICAL APPROACHES TO THE EVALUATION AND ANALYSIS OF THE IMPACT OF INTERRELATED FACTORS ON THE BUSINESS INNOVATION CAPACITY

S. Labunska

The methodological fundamentals have been described and the methodological approaches to the selection for the commercialization of innovative projects of the generated portfolio by innovation type have been substantiated. Such a selection is suggested to be run on the basis of scenario modelling, given the retrospective analysis of the direction of the vectoral influence between the sets of indicators that form an overall integrated assessment of the innovation capacity of an enterprise. The results of calculations have been represented based on the developed models on the example of evaluation of scenarios of the changing factors that generate additional effects influencing the level of enterprise innovation capacity and innovative business opportunities.

Keywords: innovation, innovation potential, innovation capacity, competitiveness, evaluation, analysis.

МЕТОДОЛОГІЧНІ ПІДХОДИ ДО ОЦІНЮВАННЯ ТА АНАЛІЗУ ВПЛИВУ ВЗАЄМОПОВ'ЯЗАНИХ ФАКТОРІВ НА ІННОВАЦІЙНУ СПРОМОЖНІСТЬ ПІДПРИЄМСТВА

Лабунська С. В.

Розкрито методологічні основи та обґрунтовано методичні підходи до відбору для комерціалізації інноваційних проектів зі сформованого портфеля за видами інноваційних змін. Такий відбір запропоновано здійснювати на основі використання сценарного моделювання з урахуванням ретроспективного аналізу спрямування векторального впливу між множинами показників, що формують загальну інтегральну оцінку інноваційної спроможності підприємства. Наведено результати розрахунків за побудованими моделями на прикладі оцінювання сценаріїв зміни чинників, які породжують додаткові ефекти, що впливають на рівень інноваційного потенціалу та інноваційних бізнес-можливостей підприємства.

Ключові слова: інновації, інноваційний потенціал, інноваційна спроможність, конкурентоспроможність, оцінка, аналіз.

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МЕТОДОЛОГИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ И АНАЛИЗУ ВЛИЯНИЯ ВЗАИМОСВЯЗАННЫХ ФАКТОРОВ НА ИННОВАЦИОННУЮ СПОСОБНОСТЬ ПРЕДПРИЯТИЯ

Лабунская С. В.

Раскрыты методологические основы и обоснованы методические подходы к отбору для коммерциализации инновационных проектов сформированного портфеля по видам инновационных преобразований. Такой отбор предложено осуществлять на основе использования сценарного моделирования с учетом ретроспективного анализа направления векторального влияния между множествами показателей, формирующих общую интегральную оценку инновационной способности предприятия. Приведены результаты расчетов по построенным моделям на примере оценки сценариев изменения определенных факторов, вызывающих дополнительные эффекты, влияющие на уровень инновационного потенциала и инновационных бизнес-возможностей предприятия.

Ключевые слова: инновации, инновационный потенциал, инновационная способность, конкурентоспособность, оценка, анализ.

The intensive competition in the global market, growing opportunities, challenges and threats for business activities require active application of innovations, technological solutions, new financial instruments, timely justified management decisions to permit and secure best financial performance. In today's competitive market companies use innovations to improve their production processes and improve the quality of business administration.

Research on the content and practical application of innovation development theories, conducted by V. Heiets, M. Yermoshenko, V. Ponomarenko, S. Iliashenko, L. Fedulova, T. Lepeyko, has formed a fundamental basis for composition and further development of management approaches to the innovation activity of industrial enterprises in Ukraine. And one of the general conclusions drawn by the mentioned scholars is that the innovation potential as the ability of an enterprise to generate knowledge for the commercialization of creative ideas of a product, process, organizational and marketing innovation for intensive development is an impetus for success.

The objective of the research is development of a methodological approach to the evaluation, analysis and forecasting innovation capacity based on the revealed interrelated factors of impact on the innovation potential and business opportunities for innovation, that is crucial for practical implementation of an innovation management system.

Several years ago, Ukraine's performance in innovations in the Global Competitiveness Index (GCI) could be seen almost as a competitive advantage (63rd rank in 2009), in 2011 Ukraine gained the status of an efficiency driven economy and moved further in the way to the innovation driven one [1]. However, in 2012 the GCI moved Ukraine to 93rd place for this pillar, down by 22 scores within a year. This downturn was not typical of post-Soviet economies. For instance, Russia rose by 7 positions over 2012, whilst Kazakhstan (having outperformed Ukraine) rose by 19 scores, as a result, the gap between Ukraine and its peers widened significantly. In 2013 innovation factors increased to 81st position, but the impact direction changed: innovation factors were drivers for the aggregate Global Competitiveness Index up to 2012, but they became a disadvantage since 2012 (Fig. 1).

International evaluations, independent from those of the WEF, have also confirmed Ukraine's low place in innovation factors. For example, the Global Innovation Index 2013 (compiled by the INSEAD business school and the World Intellectual Property Organization) has placed Ukraine in 71st position out of 142, 8 positions down compared with 2012 [2]. Nevertheless, even with this score Ukraine is a leader amongst the medium-income nations. Yet another Global Innovation Index, compiled by the Boston Consulting Group (BCG) and the US National Associ-

ation of Manufacturers, evaluates business capacity to encourage development of innovations. This organization has placed Ukraine in the 64th position out of 110 nations.
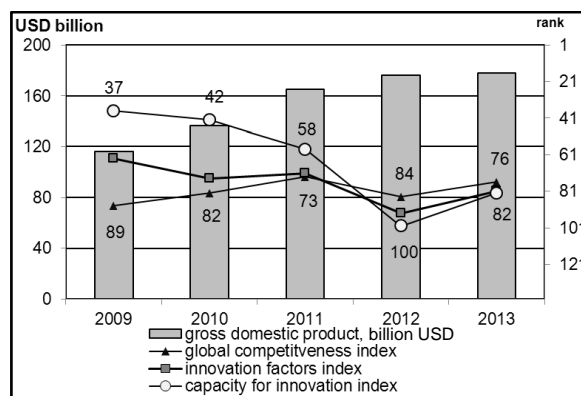

Figure 1. **Dynamics of the Global Competitiveness Index and its components**

Various organizations' rankings of Ukraine's innovations in the economy and business do not see the country as a leader. Moreover, the indices evaluating the innovations in business (those by the World Economic Forum and by the BCG) have not ranked Ukraine within the top 50, meaning that the country does not have a competitive advantage in the global perspective.

An insight analysis of the innovation factors index evaluated by the World Economic Forum [1] has revealed a sharp fall in Ukraine's capacity for innovations: in 2012 it dropped from 58th to 100th position out of 148 nations (Fig. 1), a slight increase to the 82nd rank in 2013 did not change the negative impact of the capacity for innovation on the overall innovation index.

An analysis of Ukraine's innovation in the GCI (Fig. 2) suggests that the downward trend is largely caused by a drop in scores for qualitative indicators: the capacity for innovation (82nd out of 144 nations, 29 scores down in comparison with 2011), university-industry collaboration (74th, down by 5 grades) and the quality of scientific research institutions (67th, down by 3 grades) [1]. Losing 23 positions, the indicator of the availability of scientists and engineers has also dropped noticeably now to 48th place, yet it still can be seen as a competitive advantage. Ukraine performs relatively well in the PCT (patent applications per capita) and occupies 52nd place globally. Nonetheless, Ukraine continues to lose all of its competitive advantage in the innovation pillar of the Global Competitiveness Index.

The survey conducted by the Foundation for Effective Governance in 2013 [2] shows that the regional businesses look rather optimistically at the capacity for innovation. The average score across 27 regions makes 4.03, which is comparable with Azerbaijan (35th in the world). This relatively high result is partly due to the disposition of the regional business relying more on its own R&D then on adoption and purchasing such skills. Large companies naturally have higher capacity for innovation (4.19 scores) than small enterprises (3.95) but the gap is not extremely significant. It should be noted that the executives assess business failures strongly and see them as valuable experience rather than something disgraceful (the average score of 5.07 out of 7). The firm-level technology absorption is evaluated highly, too (4.29). Considering this with the reasonably good assessment of the capacity for innovation, it signals that Ukrainian businesses have kept their innovation potential and can revive it if there is sufficient funding and favourable market conditions.
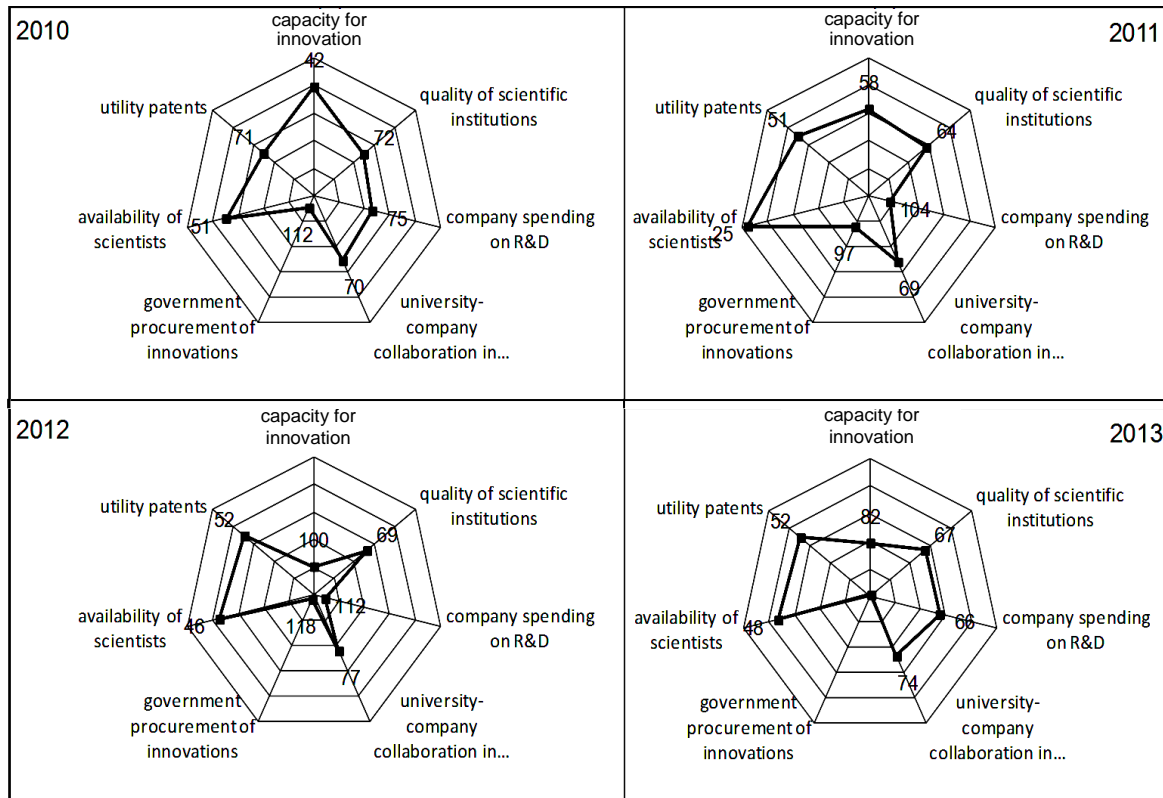

Figure 2. **Innovation factors pillars in the Global Competitiveness Index**

It is important to mention, that surveys conducted by the Foundation for Effective Governance as well as the World Economic Forum estimated innovation capacity indices based on experts' analysis mainly, so the results are applicable to the national economy level and hardly to a separate business unit. The methodical approaches based on accounting information suggested by the author [3] obtain advantages of precise evaluation and comparativeness within the industry.

As proposed in [3], several components are estimated during the evaluation of the innovation capacity of a business, including the innovation potential and business opportunities to innovate. The concept of the innovation potential may be crucial for rational framing the information base for evaluation. Namely prof. Lepeyko T. [4] argues that the innovative potential of an enterprise may be defined as the ability of a business entity to produce new high-tech products in conformity with market requirements (especially in the global market). Decrease in the innovation potential leads to deterioration of market positions, fall in sales and losses of opportunities for further development of an enterprise. Formation of the innovative capacity depends on the readiness of the enterprise production system to accept a particular innovation.

The information analytical base for innovation potential evaluation is composed of the following indicators [3]:

availability and effectiveness of labour resources (staff availability ratio (x_{1111}), staff recruitment ratio (x_{1112}), staff stability ratio (x_{1113}), staff discipline ratio (x_{1114}), wage motivation ratio (x_{1115}), staff training ratio (x_{1116}), high-qualified staff ratio (x_{1117}), middle-qualified staff ratio (x_{1118}), high-qualified staff recruitment ratio (x_{1119}), research personnel ratio (x_{1110}), labor productivity ratio (x_{1121}), staff research activity ratio (x_{1122}));

availability and effectiveness of material resources (fixed assets) suitability ratio (x_{1211}), new fixed assets ratio (x_{1212}), fixed assets growing value ratio (x_{1213}), fixed assets/assets total ratio (x_{1214}), raw materials availability ratio (x_{1215}), fixed assets productivity ratio (x_{1221}), raw materials productivity ratio (x_{1222}), efficiency of material usage ratio (x_{1223}), defective goods ratio (x_{1214});

availability and effectiveness of finance resources (owner's current assets/owner's assets ratio (x_{1311}), stockholders' equity/assets ratio (x_{1312}), inventory/owner's current assets ratio (x_{1313}), current assets/owner's assets ratio (x_{1314}), assets yield ratio (x_{1321}), invested stock yield ratio (x_{1322}), stockholders' equity yield ratio (x_{1323});

availability and effectiveness of information resources (information/staff ratio (x_{1411}); information completeness ratio (x_{1412}), information security ratio (x_{1413}), relevant information ratio (x_{1414}), information contradiction ratio (x_{1415}), R&D expenses/expenses total ratio (x_{1416}), information productivity (x_{1421}), information yield ratio (x_{1422}).

In order to reveal interrelations between first level decomposition factors, a regression analysis was conducted based on the assessed indices of the innovation potential and innovative business opportunities. Calculations of the regression analysis were carried out on the module "Multiple Regression" of Statistica 7.0, statistical sampling was composed of 81 enterprises. A revealed multifactor linear regression model for indicators of innovative business opportunities in evaluating the innovation capability is:

$$X_{2111} = 2.7555 + 0.069 \cdot X_{1111} + 0.2295 \cdot X_{1114} + 0.0581 \cdot X_{1115} + 0.0603 \cdot X_{1116} - 0.5822 \cdot X_{1117} - 0.5491 \cdot X_{1118} + 0.0877 \cdot$$
$$\cdot X_{1119} + 0.4082 \cdot X_{1110} - 0.0299 \cdot X_{1211} - 0.1165 \cdot X_{1213} - 0.1487 \cdot X_{1214} + 0.1173 \cdot X_{1221} - 0.2342 \cdot X_{1222} + 0.2212 \cdot$$
$$\cdot X_{1224} + 0.2561 \cdot X_{1311} + 0.7819 \cdot X_{1313} - 0.5732 \cdot X_{1314} - 0.1315 \cdot X_{1321} + 0.0023 \cdot X_{1411} - 3.0016 \cdot X_{1415} + 0.0112 \cdot$$
$$\cdot X_{1421} - 0.0642 \cdot X_{1422} + 0.1469 \cdot X_{2121} - 0.1817 \cdot X_{2131} - 0.0328 \cdot X_{2211} + 0.9134 \cdot X_{2411}$$

$$X_{2121} = 0.0668 + 0.0961 \cdot X_{1116} + 0.0876 \cdot X_{1212} + 0.1814 \cdot X_{1214} - 0.2438 \cdot X_{1215} + 0.2474 \cdot X_{1221} + 0.1116 \cdot X_{1222} + 0.0998 \cdot$$
$$\cdot X_{1311} + 0.2305 \cdot X_{1312} - 0.0819 \cdot X_{1313} + 0.031 \cdot X_{1314} + 0.1925 \cdot X_{2131}$$

$$X_{2131} = 0.1738 + 0.3818 \cdot X_{1214} - 0.2454 \cdot X_{1215} + 0.1518 \cdot X_{1221} - 0.0547 \cdot X_{1222} + 0.1172 \cdot X_{1311} + 0.0793 \cdot X_{1312} - 0.1672 \cdot$$
$$\cdot X_{1313} - 0.2152 \cdot X_{1314} + 0.1784 \cdot X_{2121}$$

$$X_{2211} = -0.1597 + 0.5201 \cdot X_{1111} - 0.1376 \cdot X_{1112} - 0.8512 \cdot X_{1113} + 0.4219 \cdot X_{1114} + 0.0259 \cdot X_{1115} - 0.8493 \cdot X_{1119} + 0.5828 \cdot \quad (1)$$
$$\cdot X_{1110} + 1.1921 \cdot X_{1121} - 0.9153 \cdot X_{1122} - 0.379 \cdot X_{1211} + 0.6782 \cdot X_{1212} - 0.4654 \cdot X_{1213} + 0.2445 \cdot X_{1214} + 0.1353 \cdot$$
$$\cdot X_{1215} + 0.1409 \cdot X_{1221} - 0.2271 \cdot X_{1222} - 0.059 \cdot X_{1223} + 0.5556 \cdot X_{1224} + 0.1135 \cdot X_{1311} + 0.2287 \cdot X_{1312} + 0.032 \cdot X_{1313} +$$
$$+ 0.1684 \cdot X_{1314} - 0.5965 \cdot X_{1321} + 0.5591 \cdot X_{1322} + 0.0628 \cdot X_{1323} - 0.1099 \cdot X_{2111} - 0.0002 \cdot X_{2121} - 0.1487 \cdot X_{2131}$$

$$X_{2311} = 0.0038 + 0.024 \cdot X_{1221} + 1.0093 \cdot X_{2321}$$
$$X_{2321} = 0.0013 + 0.0143 \cdot X_{1112} - 0.0204 \cdot X_{1221} + 0.9508 \cdot X_{2311}$$

$$X_{2411} = -1.2505 + 0.0718 \cdot X_{1111} + 0.1614 \cdot X_{1222} - 0.3659 \cdot X_{1223} + 0.0907 \cdot X_{1311} + 0.175 \cdot X_{1322} - 0.0821 \cdot X_{1323} + 0.081 \cdot$$
$$\cdot X_{1411} + 2.1658 \cdot X_{1415} + 0.1301 \cdot X_{1416} + 0.126 \cdot X_{1421} + 0.2012 \cdot X_{1422}$$

The constructed model is statistically significant, the coefficient of determination of the linear multivariable model of quick ratio (X_{2111}) estimated as 0.7754, sales/liabilities ratio (X_{2121}) estimated as 0.7712, sales/receivables ratio (X_{2131}) estimated as 0.7702, operating leverage (X_{2211}) estimated as 0.7738, sales yield ratio (X_{2311}) estimated as 0.9595, production yield ratio (X_{2321}) estimated as 0.9596, reliability level of organization structure (X_{2411}) estimated as 0.9612.

The suggested methodical approach applied to accounting information on the innovation activity of industrial enterprises in Ukraine revealed an interrelated complex impact of factors on the innovation capacity (Fig. 3).
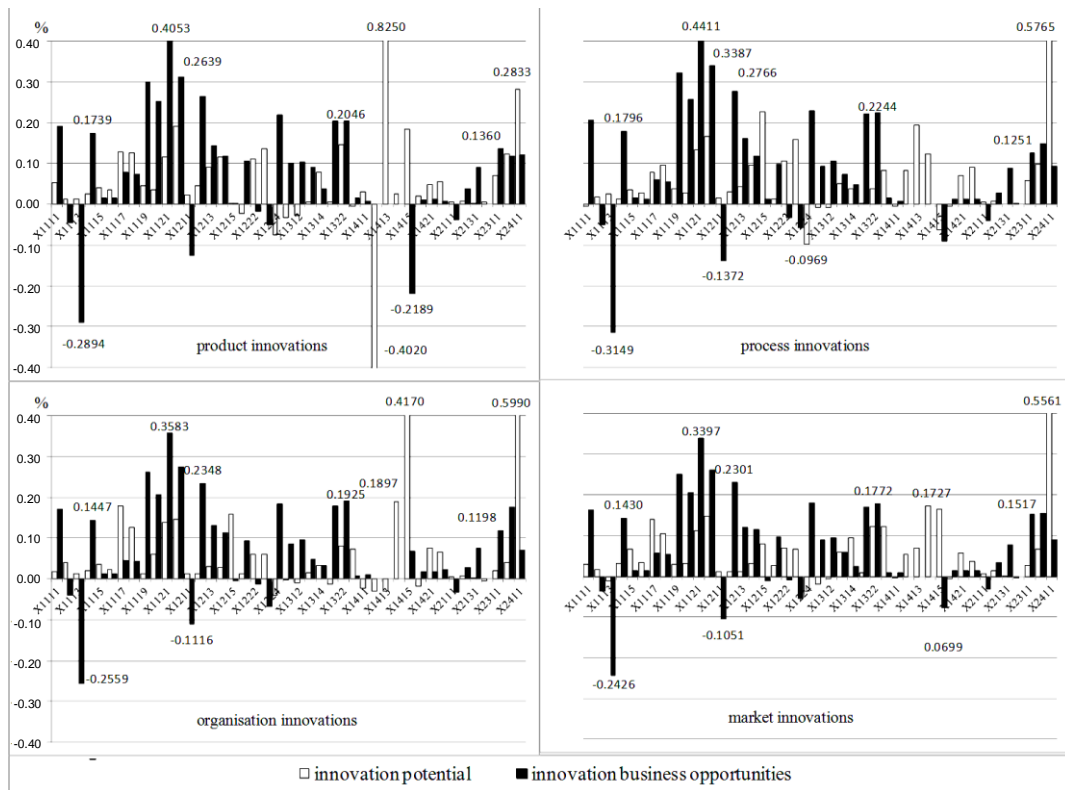

Figure 3. **Vectors of interrelated factors influence on the innovation capacity of enterprises**

The results of the conducted research shown in Fig. 3 revealed, for example, that if the introduction of innovative projects aimed at improving productivity enable companies to enhance productivity by 1 %, the surveyed companies achieve positive dynamics of other factors related to labor productivity (x_{1121}), their combined positive impact on the innovative capacity is on average 0.1147 % and on innovative business opportunities it is 0.4053 % for product innovations (0.1329 % and 0.4411 % for process innovations, 0.1387 % and 0.3583 % for organizational innovations, 0.1132 % and 0.3397 % for marketing innovations). Innovative projects aimed at improving the information security obtained the greatest effect of the interconnected impact (additional growth of the innovative capacity for product innovations makes 0.82 % for every 1 % increase in the coefficient of information security), information productivity (0.52 % for product innovations, 0.5382 % for process innovations, 0.5740 % for organizational innovations and 0.5798 % for marketing innovations), innovative activity (0.5019 %, 0.4765 %, 0.504 % and 0.485 %, respectively), and as the appropriateness of the organizational structure (0.4046 %, 0.6978 %, 0.6702 % and 0.6926 %).

The conducted dynamic simulations revealed that the factors have an interrelated disproportionate effect on different types of innovation (e.g. as a result of innovative projects aimed at increasing the efficiency of the material usage ratio under the influence of the relationships between the factors of the innovative capacity further average increases were observed: 0,0852 % for product innovation, 0.1074 % for process innovations, 0.0995 % for organizational innovations and 0.0032 % for marketing innovations).

The fact that certain factors have different effects on the interconnected innovative potential and innovative business opportunities must be noted in the process of managerial decisions substantiation when selecting innovation projects.

Thus, as a results of the dynamic simulation of the innovation capacity the following conclusions can be drawn as for product innovations:

1) factors that have a positive interrelated impact on the level of innovative business opportunities and a negative impact on the level of the innovation potential are:

growth in the staff recruitment ratio – because it decreases the stability of staff and information resources yield;

growth in the staff stability ratio – because it decreases the rate of newly hired employees;

growth in the fixed assets suitability ratio – if a simultaneously operating leverage is reduced;

growth in the raw materials productivity ratio – if it is achieved by reducing the cost of inventories and changes in the structure of assets towards a growing share of less liquid assets;

growth in the efficiency of material usage ratio – unless it is accompanied by new more efficient plant equipment;

growth in the information contradiction ratio – because it can be accompanied by a decrease in the proportion of R&D expenses and decreasing profitability of information resources;

growth in the quick ratio – if accompanied by a reduction of the operating leverage;

2) factors that have a positive impact on the level of innovation potential and a negative impact on the level of innovative business opportunities are:

growth in the fixed assets productivity ratio – if accompanied by reduction in the process of fixed assets renewing and decrease of their residual value as a result of accumulation of depreciation;

decrease in the defective goods ratio – if achieved only by changing the structure of cost of sales;

growth in the owner's current assets/owner's assets ratio – if achieved only by reducing the fixed assets book value;

growth in the stockholders' equity/assets ratio factor autonomy – if simultaneously the residual value of fixed assets and the book value of inventory necessary for a rhythmic manufacturing process decrease;

growth in the stockholders' equity yield ratio – if achieved by decrease of stockholders' equity components;

growth in the information completeness ratio – if accompanied by reduction in the process of fixed assets renewing, decrease in the raw materials availability ratio, the stockholders' equity/assets ratio and/or fall in the stockholders' equity yield ratio.

The results of the dynamic modeling of the innovation capacity also confirmed that the vectors of interrelated effects vary subject to an innovation type and this also should be considered for substantiation of administrative decisions on the innovation projects selection. Thus, organizational innovation factors that have a dissimulative impact on the innovation capacity and a stimulation effect on innovative business opportunities include:

growth in the assets yield ratio – if achieved by reduction of wages, depreciation, expenses for accumulation of information for decision-making, and/or by a decrease in the book value of fixed assets and inventories used in the production process, administrative or sales activities;

growth in the information/staff ratio – if not accompanied by an increasing share of R&D expenses, productivity and profitability of information resources;

growth in the information security ratio – as the unavailability of information can induce a decrease in the staff innovative activity.

growth in the share of R&D expenses – in the case the growth rate of R&D expenses exceeds the growth rate of productivity and profitability of information.

Innovation growth in the information contradiction ratio may lead to a decrease in the innovation potential and business opportunities for innovation if it is accompanied by a decreasing share of R&D expenses and/or the information yield ratio.

For marketing innovations the growth of the staff stability ratio may lead to a decrease in the innovation potential and business opportunities for innovation; the raw materials availability ratio shows a stimulation effect on the innovation potential and a dissimulative impact on business opportunities for innovation if at the same time the current assets/owner's assets ratio decreases and/or the turnover of payables and receivables decreases.

In general, factors of the innovation capacity have a positive correlated effect on the innovation potential and innovative business opportunities, so that the growth of factors is accompanied by increasing levels of integrated indicators caused by coherent changes in other factors that were not included in the innovation capacity static model.

Thus, the applied methods of the regression analysis confirmed interrelation between the innovation potential and innovation business opportunities that are components of the innovation capacity, so assessment, analysis and forecasting of the innovation capacity should be based on dynamic models, that make it possible to take into account the interrelated factors effect on the innovation activity and enhance reliability of the forecast. While justifying decisions upon selection of innovation projects it is necessary to take into consideration the fact that some factors have controversial interconnected effects. Thus, the simulation of an innovation project aimed to increase the stability of personnel by 15 % reveals an increase in the innovative capacity for product innovation by 0.15 % on static model application, but the approval of the innovation project must be based on the results of calculations on a dynamic model, proving the possibility of reducing the innovation capacity by 1.4 % as a result of this innovative project caused by negative changes in other factors (e.g. reduction of the innovative activity of staff, etc.).

So it is recommended to use integral criteria in the selection of innovation projects based on complex indicators of the innovation capacity, innovation potential and innovative business opportunities and additional basic criteria, based on the interconnected impact of factors of innovation capacity decomposition. A significant advantage of the suggested methodological approach to the evaluation, analysis and forecasting of the innovation capacity is a possibility to form an information base for a quantitative study of the managerial choice for implementing innovative projects. To increase the validity of the choice, management should also apply the proposed additional criteria; rational use of additional criteria requires a deep analysis of the effects of the innovation project and reflects the specificities of financial and economic activities of a particular company.

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ОБҐРУНТУВАННЯ ВИБОРУ КОНКУРЕНТНОЇ СТРАТЕГІЇ ПІДПРИЄМСТВА

Кіпа Д. В.

Розроблено методичний підхід до вибору конкурентної стратегії підприємства. Проаналізовано наявні методи вирішення багатокритеріальних завдань, серед яких: методи теорії нечітких множин, методи теорії корисності, методи векторної стратифікації і метод аналізу ієрархій Сааті. Обґрунтовано необхідність використання методу аналізу ієрархій для вибору конку-