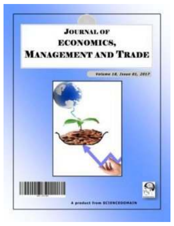

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Cognitive Analysis and Modeling of Innovation Potential

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Authors' contributions

This work was carried out in collaboration between all authors. Author SL designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author II designed the questionnaire, made the data collection. Author OP conducted the analysis and made the results interpretation. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The main aim of the research is to develop cognitive model for innovation potential evaluation.
Study Design: Empirical research of financial, statistic and management reports of enterprises dated 2012 and 2015, analysis of expert findings for the same periods.
Place and Duration of Study: Accounting Department of Simon Kuznets National University of Economics, between May 2016 and April 2017.
Methodology: Content analysis has been used as the primary method to reveal the nature of innovation potential. Research proceeds from the fact that enterprise innovative potential is the integral subsystem of its innovation capacity and consists of material, labor, financial and information resources. The inherent characteristics of innovative potential were captured by applying cognitive analysis and modeling methods.
Results: Based on the content analysis it was ground, that innovation potential is one of the main components of enterprise's innovation capacity, which is formed in the periods preceding the period of innovation implementation. As for empirical part of research, sample included 81 (based on data of the year 2012) and 93 (based on 2015 year) companies of engineering, metallurgy and chemical industry of four regions of Ukraine, expert analysis involved 27 top-managers. Developed cognitive

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map and method of evaluating of innovation potential allowed to reveal, that metallurgical enterprises have high innovation potential, however in modern realities of the Ukrainian economy and the world market situation, their innovative activity is restrained; the engineering companies have low innovation potential and hardly implement organizational innovations.

Conclusion: Cognitive methods of analysis and modeling of innovation potential allow to ensure accuracy of evaluation, which is achieved by combining quantitative data of financial reports and qualitative information of expert groups; comparability of results for enterprises of different industries and regions; possibility of quantitative generalization for conclusions at different levels of management.

Keywords: Cognitive analysis; cognitive modeling; innovation; innovation capacities; innovation potential; enterprise; decision-making; management.

1. INTRODUCTION

The effectiveness of the functioning of economic systems, among which the enterprise occupies the key place, is largely determined by how well their elements are coordinated and interact in the process of achieving the goal. The enterprise as an open dynamic system, is impacted by multi-directional socio-economic factors on the micro and macro levels, which determine the acceleration of the changes in external surroundings. In the context of the growing importance of the information component in the overall business potential, it becomes vital for management to identify and streamline the perception, accumulation and structuring of information, which is the basis for managerial decisions in innovation activity. Rapid and adequate processing of information flows and determining direct and indirect influence on signal indicators of innovation activity at all levels of enterprise management ensure the effectiveness of innovation capabilities management.

The importance of innovation capabilities is rooted in evolutionary economics [1]. The evolutionary scholars argue that the superior ability of certain enterprises to sustain innovation and create new knowledge leads to the development of organizational capabilities, consisting of critical competences and embedded routines. Company's innovative culture, combined with appropriate accumulated knowledge stocks, engenders the development of new products and new methods for doing business [1,2]. Although the evolutionary economics theory facilitates understanding of innovation phenomena, it is insufficient to explain all sides of intriguing process of changes in firm's innovation capability. In addition, there have been very little empirical researches aimed at uncovering components of firm's innovation capability. So, the problem of the paper is to examine empirically possibilities of quantitative assessment and analysis of innovation capability in dynamic.

The inherent nature of innovative capability limits possibilities and reduces the value of the results of standard analytical procedures. The intrinsic characteristic of firm's innovative capability are: the complexity of the structure (multilayered, hierarchical), formed by elements of innovative potential with weak interactions; The rapid dynamics, the complexity and unpredictability of its changes; consistent patterns of the interaction of parts and the whole (integrity, integrativity), of system hierarchical orderliness (communicative, hierarchical), of system feasibility (equifinality, necessary diversity, potential efficiency). The development of innovative capacity is accompanied by the solution of a multitude of poorly structured problems. These characteristics of innovation potential cause the necessity for applying cognitive analysis and modeling methods. So, the main aim of the paper is to develop cognitive model for innovation potential evaluation, that captures intrinsic nature of firm's innovative capability.

2. THEORETICAL BACKGROUND

The concept of innovative potential, as the property of the system, which ensures its growth through innovations, was introduced by Freeman [3], based on the theory of long waves of Kondratiev and the theoretical contribution of Schumpeter [4]. Schumpeter concludes that innovation potential is the main basis for the effectiveness of innovation processes. Despite the large number of scientific works on this issue in foreign and domestic scientific sources there is no unambiguous interpretation of the nature of firm's innovative potential. Based on the concept analysis of innovative potential definition [5,6], several conceptual approaches may be discussed.

On the one hand, the innovation potential is defined as availability of resources that enable company to engage in innovative activities. Innovator firm resources in turn lead to superior performance, particularly in highly competitive or challenging environments. The resource-based view [7,8,9] helps to explain how knowledge and resultant organizational capabilities are developed by innovative enterprises.

Such an approach is followed by Ansoff, Abalkin, Fatkhuddinov, Illiashenko, Trofilov and others [10]. Thus, in particular, Illiashenko [11] in his studies shows that the economic potential of the enterprise is a complex dynamic stochastic system, in which the personnel, production, innovation, and organizational and managerial potential can be distinguished.

Another interpretation of innovation potential is the functional and productive approach. Under this approach scholars consider innovation potential from the point of view of the company's ability to innovate and to obtain a positive result from innovations. This approach determines the dynamic component of the innovation process, which is quite significant during the selection and implementation of the innovation project, but in most cases it characterizes the criteria for selecting innovative projects or the effectiveness of their implementation.

The system-institutional approach to understanding the nature of innovation potential argues for combination of firm's innovative resources, structural and functional links between innovator and different institutional entities during commercialization of innovative products.

According to Goncharov [12] definition of innovation potential is related with the concept of enterprise production capacity, so decisions upon innovations depend on the products life cycle. Under competition, duration of products life cycle objectively decrease, determined by the interaction of two opposite trends; the first one is ambition to outstrip competitors in the production of new products and the second one is endeavor to maximize profits from already launched products.

The resource-based view is endorsed in Ukrainian legislation, so the Law of Ukraine "On Priority Areas of Science and Technology Development" interprets the country's innovative potential as the set of scientific, technological, financial, economic, industrial, social, cultural and educational recourses of the country necessary for the innovative development.

Innovation potential, in the sense of the resource-based view, is one of the main components of enterprise's innovation capacity, which is formed in the periods preceding the period of implementation of innovation projects. Summarizing the concept analisys, research will proceed from the fact that enterprise innovative potential is the integral subsystem of its innovation capacity and consists of material resources, labor resources, financial resources and information resources (including intangible assets).

Information is one of the most important resources for innovation activity, and the integration of individuals' specialized knowledge is the essence of organizational capabilities [1,7,13,14,15]. In this regard, the most important information resources are unique, inimitable, and immobile, reflecting the distinctive pathways of each innovative firm [7,14,16].

Consistent with other scholars we define innovation potential as an indicator and a strategic criterion for the effective management of innovative activity of business entities. Thus, the innovation potential of the enterprise is a multidirectional phenomenon: it is influenced by innovation activity management and varies depending on the result of the R&D. On the other hand, the innovation potential is in some way a prerequisite for innovations and sets financial, material, labor and information limits to innovation process.

The existence of innovative potential is indisputably necessary, but the availability of a specific resources does not in itself guarantee their effective use by the entity in innovation process because: firstly, the introduction of each particular type of innovation (process, product, organizational or marketing) requires a certain structure of innovation potential, secondly, the possibilities of attracting additional financial resources depend on both the financial state of the enterprise and financial market conditions, thirdly, innovation changes depend on the readiness of the management to percept ideas and introduce innovations, and fourthly innovation potential is affected by internal and external threats that vary according to the types of innovations.

Thus, the innovation potential of the enterprise should be considered as a systemic category characterized by synergy, endangerment, purposefulness, adaptability, communicative and alternative ways of functioning and development, as well as weak structuring.

3. METHODOLOGY

Scientific analysis and research of weakly structured systems yield from application of the method of cognitive modeling. Cognitive modeling of weakly structured systems is aimed at the development of formal models and methods that support the intellectual process of solving problems by taking into account in these models and methods of cognitive capabilities (perceptions, representations, cognition, understanding, explanation) of management subjects in solving administrative problems.

Cognitive modeling, which combines structural & system modeling and simulation, most fully and adequately reflects a real object in comparison with other types of mathematical modeling [17]. It stands out among other types of simulation with its openness for experts from various fields of science. This allows to construct mathematical models with easily interpreted in practice results. The purpose of cognitive modeling of weakly structured systems is to find out the mechanism of functioning of the system, forecasting the development of the system, its management, determining the possibilities of its adaptation to the external environment [18,19]. Cognitive modeling in the problems of analysis and management of weakly structured systems is the study of the functioning and development of weakly structured systems and situations by constructing a model of a weakly structured system (situation) on the basis of a cognitive map. In this model, the cognitive map reflects the idea of the problem, the main elements of the cognitive map are the constituent elements (basic factors, concepts) and causal relationships between them.

A cognitive map is represented in the form of a graph in which the vertices correspond to the constituent elements, and the edges are weights (on a certain scale), which reflect the strength and direction of the interaction between the constituents. The task of analyzing situations based on cognitive maps can be divided into two types: static and dynamic [20]. Static analysis or analysis of impacts is studying the structure of the cognitive map interrelationships, that allows to identify the structure of the system, to find the most significant constituent elements, and to evaluate their interactions. Investigation of the interaction of the constituent elements makes it possible to estimate the distribution of influence on the cognitive map, which changes their state (value). Dynamic analysis is the basis for generating possible scenarios for developing a situation in time (impulse modeling). The study reported here examines enterprise's innovation potential based on static cognitive analysis. Cognitive modeling of innovative potential of enterprise begins with solving the problem of identification of a cognitive map (Fig. 1):

Cognitive modeling of innovation potential allows to describe its structure, interaction and mutual influence of its components, the causal relationship between them, various processes occurring in it, their interaction with the external environment, to identify the impact of the external environment on the current situation, to predict the magnitude of innovation, and on this basis to justify the necessary management actions to solve problems that arise during innovation activity. The main purpose of the cognitive model (Fig. 1) is to help the expert in the process of cognition of enterprise innovation potential and, accordingly, solution of problem situations in complex weakly structured systems. The cognitive model explains which element or the relationship of elements must be influenced, with what force and in what direction, to achieve the set goal at the lowest cost.

Since the delimited components of innovation potential are determined by different measures, in order to generalize their estimation, the assessment conducted in comparison with the best indicator among the investigated enterprises, and the components (material (*MR*), financial (*FR*), labor (*LR*) and informational recourses (including intangible assets) (*IR*) are measured based on indices characterizing the availability and efficiency of the use of the specified resource in the enterprise Thus, the innovation potential can be determined as the integral indicator (*IP*), which is cognitive function of separate subsystems:

$$IP = f\,(a \cdot MR,\ b \cdot FR,\ c \cdot LR,\ d \cdot IR)$$

Where *a, b, c, d* - weighted coefficients of influence of each separate component on the level of innovation potential;

MR, FR, LR, IR - indicators of the level of each component.

The numerical values of the weighting factors for the determination of innovation potential during the study were estimated by expert questionnaire survey of knowledgeable specialists, taking into account their level of competence and consistency of experts' opinions.

Approbation of the proposed evaluation methodology was carried out by studying the financial and economic activity of the enterprises of engineering, metallurgy and chemical industry of four regions of Ukraine. In order to provide opportunities for analysis of changes in the innovation potential, calculations were made for two periods, the years 2012 and 2015. The number of investigated enterprises was 81 and 93 units, respectively. The subject composition of the studied population was carried out by the method of random numbers. The coverage rates amounted (in 2012 and 2015) to 65% for engineering (that means that in 2012 65 engineering companies were investigated from their total population of 98 companies), 90% for metallurgy (9 from 10 respectively) and 32% for chemical industry (7 from 22 respectively). Calculations and intermediate conclusions were separated by industries and aggregated for regions.

In view of the significant differences in the organization of corporate governance and decision-making mechanism for the management of innovation processes, the general and investigated samples were formed by large business units: Public and private joint-stock companies.

The information sources of the research on selected enterprises were financial and statistical statements, internal management reports, data of the expert survey, conducted by the method of questioning. The group of experts included representatives of top management, which are engaged in the assessment of resources and property status of the enterprise, managers of the strategic and operational planning department, heads of technological and technological development of the enterprise, marketing department (and / or logistics Systems) and delivery services, etc. In order to establish the optimal number of experts, specialists of financial-analytical, planning-economic and accounting services of the

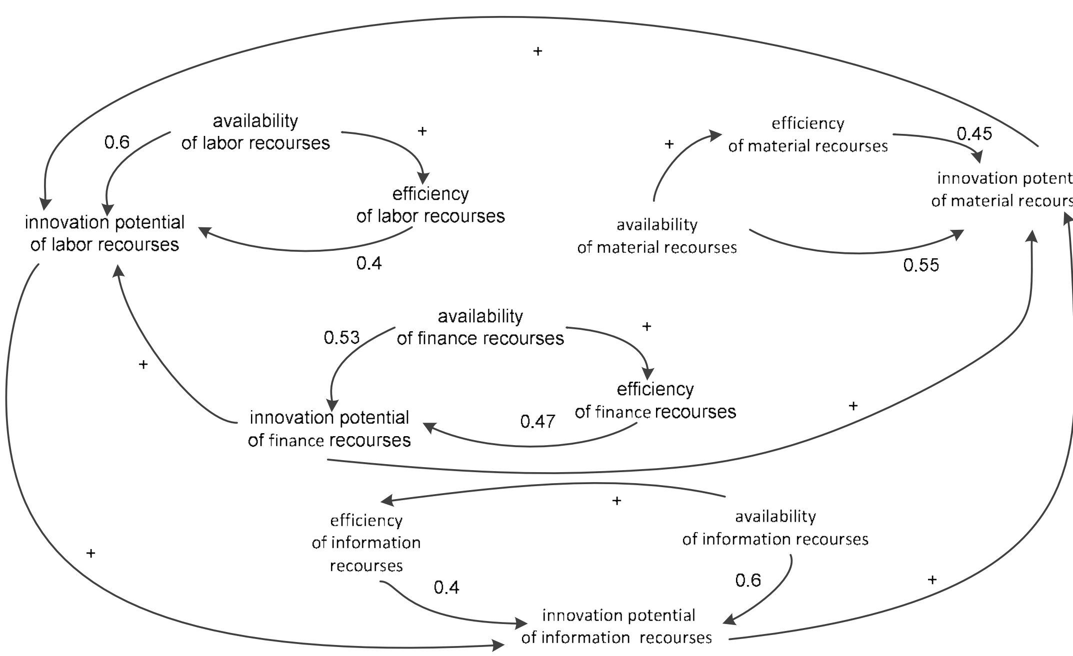

Fig. 1. A cognitive map representing enterprise innovation potential

investigated enterprises conducted self-assessment of competence on a scale from 2 to 5 points. Processing of the received data allowed obtaining a quantitative assessment of the competence of a potential expert. Surveys were conducted in accordance with the existing classification of innovations, namely: Product, process, organizational and marketing innovations.

4. RESULTS AND DISCUSSION

So, in order to form an information base for assessing the availability of labor resources, the following indicators were calculated and analyzed:

1) Coefficient of staffing, characterizing the ratio of the actual number of employees to the established staffing schedule. The average indicators reached 94.32% (engineering), 96.06% (metallurgy) and 92.29% (chemical industry); 42 of surveyed companies reported almost complete staffing; Only in 3 cases the number of actually employed is less than 50% of staffing schedule in result of the reorganization of enterprises.
2) The acceptance turnover ratio, which shows the share of the newly hired employees in personnel total number. The average indicators amounted 15.46% (engineering), 8.0% (metallurgy) and 12.43% (chemical industry). 29 enterprises recorded the value of this indicator higher than average.
3) The coefficient of stability of personnel, which shows the share of workers who have worked in the company for more than three years in personnel total number. The average calculated values of the indicator reached 70.54% (engineering), 84.01% (metallurgy) and 75.13% (chemical industry) and confirmed the high stability of personnel at Ukrainian companies. Stability of personnel has a double impact on the innovative potential of the enterprise. Increasing the continuous work experience at the enterprise leads to the accumulation of work experience in solving problems that arise during the operational activities, and therefore have a positive impact on the level of labor force potential. However, the growth of staff stability can lead to a reduction in the ability of staff to generate new progressive ideas or approaches to managerial and production decisions in the new environment.
4) The coefficient of labor discipline, which shows the rate of personnel absentees in the actual working time. The average indicators amounted 5,02% (engineering), 4,63% (metallurgy) and 1,59% (chemical industry). According to experts, this indicator should be used in assessing the innovative potential of the enterprise in terms of process innovations; for innovations of other types the coefficient of salary motivation is more preferable.
5) The coefficient of salary motivation, which shows the ratio of the average level salary of the company to the industry average salary. The calculated average indicators amounted to 0.8004 (engineering), 0.8063 (metallurgy) and 0.7076 (chemical industry). In general, 28.4% of the surveyed enterprises have an average salary higher than the industry average salary.
6) Coefficient of professional development, which shows the ratio of the number of workers who enhanced qualification in the referenced period to the personnel total number. The calculated average indicators amounted to 11.52% (engineering), 19.45% (metallurgy) and 6.98 (chemical industry). However, more than 24% of the enterprises did not carry out the training of workers at all.
7) Coefficient of intellectual level of personnel, which shows the share of highly skilled workers in the personnel total number. The average calculated values for industries were 21.42% (engineering), 21.18% (metallurgy) and 21.53% (chemical industry). However, over 65% of enterprises have a share of highly skilled workers below the average;
8) Coefficient of workers average level, which shows the average tariff rate of workers. The average calculated values for industries were: in engineering - 5,09, in metallurgy - 5,28, in chemical industry - 4,71. According to the expert group's findings, the coefficient of workers average level is used to assess the innovation potential of product and process innovations; for organizational and marketing innovations, the coefficient of intellectual level of personnel is more preferable;
9) The coefficient of recruitment of highly skilled personnel, which characterizes the share of highly skilled workers in personnel total number. The average calculated

values for industries amounted to 3.14% (engineering), 1.55% (metallurgy) and 2.38% (chemical industry). More than 38% of the surveyed enterprises have this coefficient higher than industry average.

10) the share of engineering and scientific workers in personnel total number. The average values for industries were estimated as 10.63% (engineering), 11.85% (metallurgy) and 10.83% (chemical industry).

The information base for assessing innovation potential by indicators that characterizes the efficiency of labor resources, according to the expert group's findings, consists of:

1) The labor productivity coefficient. The calculated average indicators amounted to EUR 0.24 (engineering), EUR 0.42 (metallurgy) and EUR 0.62 (chemical industry). Only 27% of the surveyed enterprises had labor productivity higher than the average industry.
2) The coefficient of innovative activity, that shows the number of inventions and rationalization proposals per employee. The coefficient of innovative activity in practice is influenced also by ability of personnel to cooperate in the networks. The calculated average values amounted to 0.25 (engineering), 0.50 (metallurgy) and 0.94 (chemical industry).

Table 1. The estimated benchmark values for labor resources component of innovation potential

Indicator	Equation	Year	Benchmark values by industries		
			Engineering	Metallurgy	Chemical industry
coefficient of staffing (x_{1111})	$\frac{actual\text{ number of employees}}{\text{schedule number of employees}}$	2012	1.0000	1.0000	1.0000
		2015	1.0000	1.0000	1.0000
acceptance turnover ratio (x_{1112})	$\frac{\text{number of newly hired employees}}{\text{personnel total}}$	2012	0.7200	0.2047	0.3404
		2015	0.2642	0.1044	0.2287
coefficient of stability of personnel (x_{1113})	$\frac{\text{number of employees who have worked in the company for more than three years}}{\text{personnel total number}}$	2012	1.0000	0.9735	0.9351
		2015	1.0000	0.9459	1.0000
coefficient of labor discipline (x_{1114})	$\frac{\text{personnel absentees time}}{\text{working time total}}$	2012	0.9900	0.9900	0.9800
		2015	1.0000	0.9956	1.0000
coefficient of salary motivation (x_{1115}),	$\frac{\text{company average level salary}}{\text{industry average salary}}$	2012	1.5500	1.1189	1.1928
		2015	2.6816	.5061	1.8089
coefficient of professional development (x_{1116})	$\frac{\text{number of workers who enhanced qualification}}{\text{personnel total}}$	2012	0.6564	0.6933	0.2412
		2015	0.1225	.9761	0.9838
coefficient of intellectual level of personnel (x_{1117})	$\frac{\text{number of highly skilled workers}}{\text{personnel total}}$	2012	0.7813	0.2732	0.3978
		2015	0.3899	0.3897	0.3900
coefficient of workers average level (x_{1118})	$\frac{\text{tariff rate total}}{\text{personnel total}}$	2012	5.9692	5.5705	4.8500
		2015	6.3562	.3323	6.3208
coefficient of recruitment of highly skilled personnel (x_{1119})	$\frac{\text{highly skilled workers}}{\text{personnel total}}$	2012	0.1250	0.0257	0.0521
		2015	0.0402	0.0364	0.0823
share of engineering and scientific workers in personnel total number (x_{1110})	$\frac{\text{engineering and scientific workers}}{\text{personnel total}}$	2012	0.4000	0.1639	0.2387
		2015	0.2339	0.2338	0.2159
labor productivity coefficient (x_{1121})	$\frac{\text{labor expenses}}{\text{cost og goods produced}}$	2012	57.2783	20.7376	69.9017
		2015	26.6019	19.0076	26.6019
coefficient of innovative activity (x_{1122})	$\frac{\text{number of inventions and rationalization proposals}}{\text{personnel total}}$	2012	2.0371	1.0722	5.2616
		2015	1.4463	1.1091	1.8118

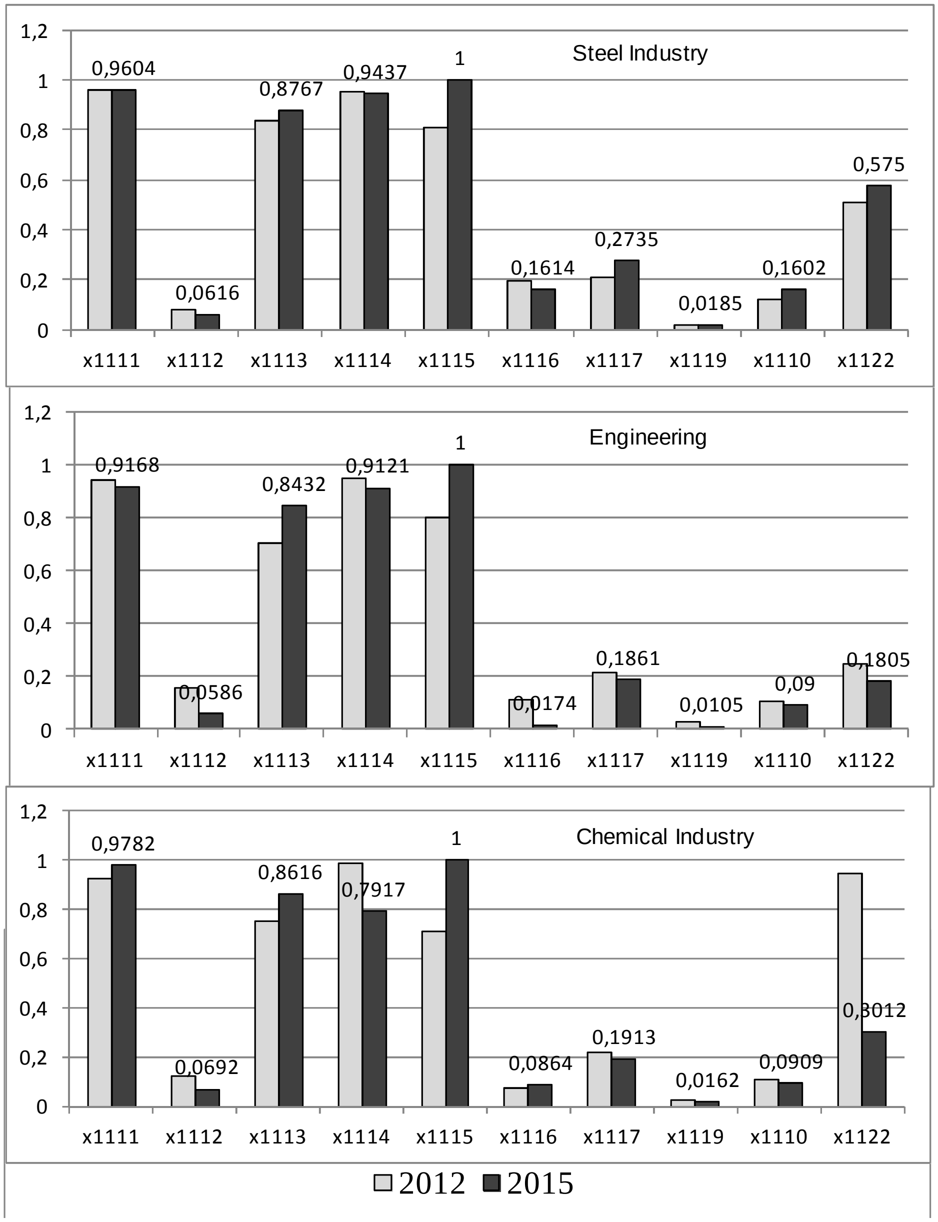

Fig. 2. Dynamics of average industry values of innovation potential indicators, characterizing the availability of labor resources

The standardization of the indicators calculated for each enterprise in the framework of the research was carried out using the benchmark values by industry (Table 1). The determination of the benchmark values was performed at the maximum value for the stimulant values and the minimum value for the disinfectant indicators.

The results of the analysis of indicators of innovation potential, characterizing availability and efficiency of labor resources are presented in Fig. 2 above.

In order to determine the reference vector of innovation potential by availability of material resources, following indices were calculated (Table 2):

1) The coefficient of fixed assets suitability, which shows the ratio of accrued depreciation to original value of fixed

assets. The calculated average values amounted to 49.68% (engineering), 46.01% (metallurgy) and 39.24% (chemical industry). According to companies' financial statements 40.63% of enterprises in the machine-building industry have level of fixed assets suitability more than 50%, and 18.75% of enterprises - more than 75%.

2) The coefficient of fixed assets renewal, which shows the share of purchased new fixed assets in their total cost. The calculated average values amounted to 5.97% (engineering), 6.55% (metallurgy) and 3.94% (chemical industry). Only 29% of the surveyed enterprises had the pace of updating fixed assets more than medium-sized. According to expert analysis, the coefficient of fixed assets renewal is used to assess innovation potential for product and process innovations, as well as the coefficient of fixed assets growth.
3) The coefficient of fixed assets growth, which characterizes the rate of growth (decrease) in the book value of fixed assets. The calculated average values amounted to 11.65% (engineering), 19.65% (metallurgy) and 5.11% (chemical industry). In the engineering sector, over 50% of enterprises had coefficients of fixed assets growth less than 1%.
4) The share of fixed assets in the total assets of enterprise. The calculated average values amounted to 32.52% (engineering), 56.38% (metallurgy) and 34.99% (chemical industry). Sector specificity of the investigated business entities should justify the high share of property, plant and equipment in assets, but the high degree of depreciation, which is observed in most cases, leads to distortion of the traditional structure of assets of an industrial enterprise. So positive conclusions based on the cost of fixed assets, which is less than 50% af total assets for industrial enterprises, may be contradictable.
5) Coefficient of raw materials availability, which shows the ratio of actually available materials to the cost of materials necessary for production program. The calculated average values reached to 83.41% (engineering), 87.95% (metallurgy) and 79.48% (chemical industry).

Table 2. The estimated benchmark values for material resources component of innovation potential

Indicator	Equation	Year	Benchmark values by industries		
			Engineering	Metallurgy	Chemical industry
coefficient of fixed assets suitability (x_{1211})	$\frac{\text{accumulated depreciation}}{\text{original value of fixed assets}}$	2012	1.0000	0.8251	0.5818
		2015	0.9466	0.6563	0.8937
coefficient of fixed assets renewal (x_{1212})	$\frac{\text{purchased new fixed assets}}{\text{residual value of fixed assets}}$	2012	0.8059	0.3389	0.0941
		2015	0.2628	0.0528	0.3957
coefficient of fixed assets growth (x_{1213})	$\frac{\text{residual value of fixed assets}}{\text{residual value of fixed assets in previous period}} - 1$	2012	1.2616	0.7282	0.1549
		2015	0.7177	0.07	0.8698
fixed assets share (x_{1214})	$\frac{\text{residual value of fixed assets}}{\text{total assets}}$	2012	0.7519	0.7919	0.7409
		2015	0.8081	0.5997	0.7823
coefficient of raw materials availability (x_{1215}),	$\frac{\text{actually available materials}}{\text{materials necessary for production program}}$	2012	1.0000	0.9500	0.9053
		2015	0.9367	0.95	0.931
return on fixed capital ratio (x_{1221})	$\frac{\text{sales}}{\text{residual value of fixed assets}}$	2012	13.9783	7.6447	9.4998
		2015	13.7518	7.9509	9.9648
return on raw material ratio (x_{1222})	$\frac{\text{sales}}{\text{raw material expenses}}$	2012	7.4436	3.2891	5.3876
		2015	8.0814	5.085	4.839
coefficient of deficiency (x_{12223})	$\frac{\text{cost of spoiled materials}}{\text{cost of goods sold}}$	2012	0.0100	0.0526	0.0276
		2015	0.01384	0.05868	0.02062

The assessment of innovative potential in component of material resources efficiency, according to the findings of expert analysis, was conducted on the following indicators:

1) return on fixed capital ratio, which shows sales per fixed assets book value. The calculated average values reached to 4,0853 (engineering), 2.7982 (metallurgy) and 5,0484 (chemical industry).
2) return on raw material ratio, which shows sales per raw material cost. The calculated average values reached to 2.1796 (engineering), 1.5566 (metallurgy) and 2.0499 (chemical industry). Sector specificity of financial and economic activity to a certain level can justify the high material content of the produced products; However, the revealed level of return on raw material ratio has negative impact on innovation capacity: more than 66% of enterprises have a share of material costs in the total cost of more than 50%, each 8th enterprise - more than 75%.
3) the coefficient of deficiency, which shows the portion of spoilage in the cost of sales. The calculated average values amounted to 4.54% (engineering), 9.63% (metallurgy) and 7.24% (chemical industry).

For evaluating the innovation potential, the analysis of financial resources availability was conducted based on the following indicators (Table 3):

1) The share of own working capital in equity; the calculated average values amounted to 0.228 (engineering), 0.0 (metallurgy) and 0.1737 (chemical industry). Of the total sample, more than 54% of enterprises did not have equity to form current assets.
2) The coefficient of autonomy; the calculated average values amounted to 0.3998 (mechanical engineering), 0.0 (metallurgy) and 0.22836 (chemical industry).
3) The coefficient of provision of stocks by own funds; the calculated average values amounted to 68.14% (engineering), 0% (metallurgy) and 60.68% (chemical industry).
4) The share of own working capital in the total amount of working capital. The calculated average values amounted to 19.05% (engineering), 0% (metallurgy) and 12.4% (chemical industry).

At this stage of approbation of the proposed methodology, it was found that in a number of cases (12% of the investigated enterprises) a high level of unprofitability caused a systematic accumulation of uncovered losses, which mathematically led to negative values of equity in the financial statements. This situation is especially resonant for the metallurgical industry of Ukraine. For such enterprises, the arithmetic calculation of financial stability indicators is unrepresentative.

Table 3. The estimated benchmark values for financial resources component of innovation potential

Indicator	Equation	Year	Benchmark values by industries		
			Engineering	Metallurgy	Chemical industry
share of own working capital in equity (x_{1311})	$\frac{\text{stockholders equity} - \text{fixed assets}}{\text{stockholders equity} + \text{liabilities}}$	2012	0.8509	0.000	0.8220
		2015	0.9413	1.000	0.7169
coefficient of autonomy (x_{1312})	$\frac{\text{stockholders equity}}{\text{stockholders equity} + \text{liabilities}}$	2012	0.9265	0.7760	0.7013
		2015	0.9752	0.7407	0.8610
coefficient of provision of stocks by own funds (x_{1313})	$\frac{\text{inventories}}{\text{stockholders equity}}$	2012	6.3045	0.0000	2.3045
		2015	4.3901	1.9797	3.535
share of own working capital in the total amount of working capital (x_{1314})	$\frac{\text{stockholders equity} - \text{fixed assets}}{\text{current assets}}$	2012	0.8312	0.000	0.5488
		2015	0.9589	0.5142	0.7895
profitability of assets (x_{1321}),	$\frac{\text{income}}{\text{total assets}}$	2012	0.1811	0.1599	0.0841
		2015	0.1774	0.0179	0.1133
profitability of invested capital (x_{1322})	$\frac{\text{income}}{\text{stockholders equity} + \text{long term liabilities}}$	2012	0.4803	3.7035	0.1059
		2015	0.4532	0.0213	0.1833
return on equity (x_{1323})	$\frac{\text{income}}{\text{stockholders equity}}$	2012	0.4803	3.7164	0.1631
		2015	0.4331	0.0241	0.1851

The information base for evaluating the innovation potential in component of financial resources efficiency, according to the findings of expert analysis consisted of the following indicators:

1) The profitability of assets; 40.74% of investigated enterprises declared losses during the analyzed period. The calculated average values for engineering companies amounted to 2.97% and 4.75%, excluding unprofitable enterprises, metallurgy - 5.23% and 9.42% respectively, chemical industry - 1.79% and 4.77%.
2) The profitability of invested capital; the calculated average values amounted to 5.98% (engineering), 51.39% (metallurgy) and 2.41% (chemical industry).
3) The return on equity, which shows income per equity capital. The calculated average values amounted to 7.39% (engineering), 104.95% (metallurgy) and 4.4% (chemical industry). It should be noted that high rates of return on equity were, in some cases, accompanied by a crisis financial state of enterprises, especially in metallurgy.

The availability of information resources to assess the innovative potential of enterprises, according to the findings of expert analysis, is characterized by the following indicators (Table 4):

1) The information cost rate; the calculated average values amounted to 0.3582 (engineering), 0.314 (metallurgy) and 0.3005 (chemical industry).
2) The coefficient of information completeness; the calculated average values amounted to 68.32% (engineering), 74.76% (metallurgy) and 72.86% (chemical industry).
3) The coefficient of information security; the calculated average values amounted to 3.6% (engineering), 4.94% (metallurgy) and 45.5% (chemical industry).
4) The coefficient of information accuracy; the calculated average values reached to 84.32% (engineering), 95.43% (metallurgy) and 90.09% (chemical industry).
5) The share of R&D expenditures; the calculated average values amounted to 0.25% (engineering), 0.58% (metallurgy) and 0.82% (chemical industry).

Table 4. The estimated benchmark values for information resources component of innovation potential

Indicator	Equation	Year	Benchmark values by industries		
			Engineering	Metallurgy	Chemical industry
information cost rate (x_{1411})	$\frac{\text{expenses for creating an information base for decision} - \text{making}}{\text{personnel total number}}$	2012	2.4399	0.4458	0.6732
		2015	1.6785	0.6685	0.7374
coefficient of information completeness (x_{1412})	$\frac{\text{information available to a decision maker}}{\text{information necessary to make a well} - \text{grounded decision}}$	2012	0.7465	0.8001	0.7776
		2015	0.7693	0.8001	0.7242
coefficient of information security (x_{1413})	$\frac{\text{expenses for the protection of information}}{\text{expenses for creating an information base}}$	2012	0.0478	0.0599	0.0557
		2015	0.054	0.0492	0.0417
coefficient of information accuracy (x_{1414})	$\frac{\text{relevant information}}{\text{information available to a decision maker}}$	2012	0.9942	0.9877	0.9863
		2015	0.9877	0.9831	0.9792
share of R&D expenditures (x_{1415}),	$\frac{\text{R\&}D\ expenses}{\text{total operating expenses}}$	2012	0.0121	0.0100	0.0657
		2015	0.0161	0.0128	0.0146
productivity of information (x_{1421})	$\frac{\text{cost of goods sold}}{\text{expenses for creating an information base for decision} - \text{making}}$	2012	3 332.4	4 999.8	12 922
		2015	1916.6	2803.1	3110.7
profitability of information (x_{1422})	$\frac{\text{income}}{\text{expenses for creating an information base for decision} - \text{making}}$	2012	1 051.1	834.96	64.502
		2015	149.58	297.49	85.543

The effectiveness of information resources for the purpose of innovation potential assessment, according to the expert survey findings, is characterized by the following indicators:

1) The productivity of information; the calculated average values reached to 863.88 (engineering), 2356.84 (metallurgy) and 2345.02 (chemical industry).
2) The profitability of information; the calculated average values reached to 52,5259 (engineering), 197,5546 (metallurgy) and 12,8553 (chemical industry).

For the purpose of determining the result for each investigated enterprise, the standardized values of the indicators were summed up on the basis of weighting factors pre-determined during the expert analysis.

The results of the evaluation of innovation potential according to the proposed methodology at the highest level of generalization are shown in Fig. 3.

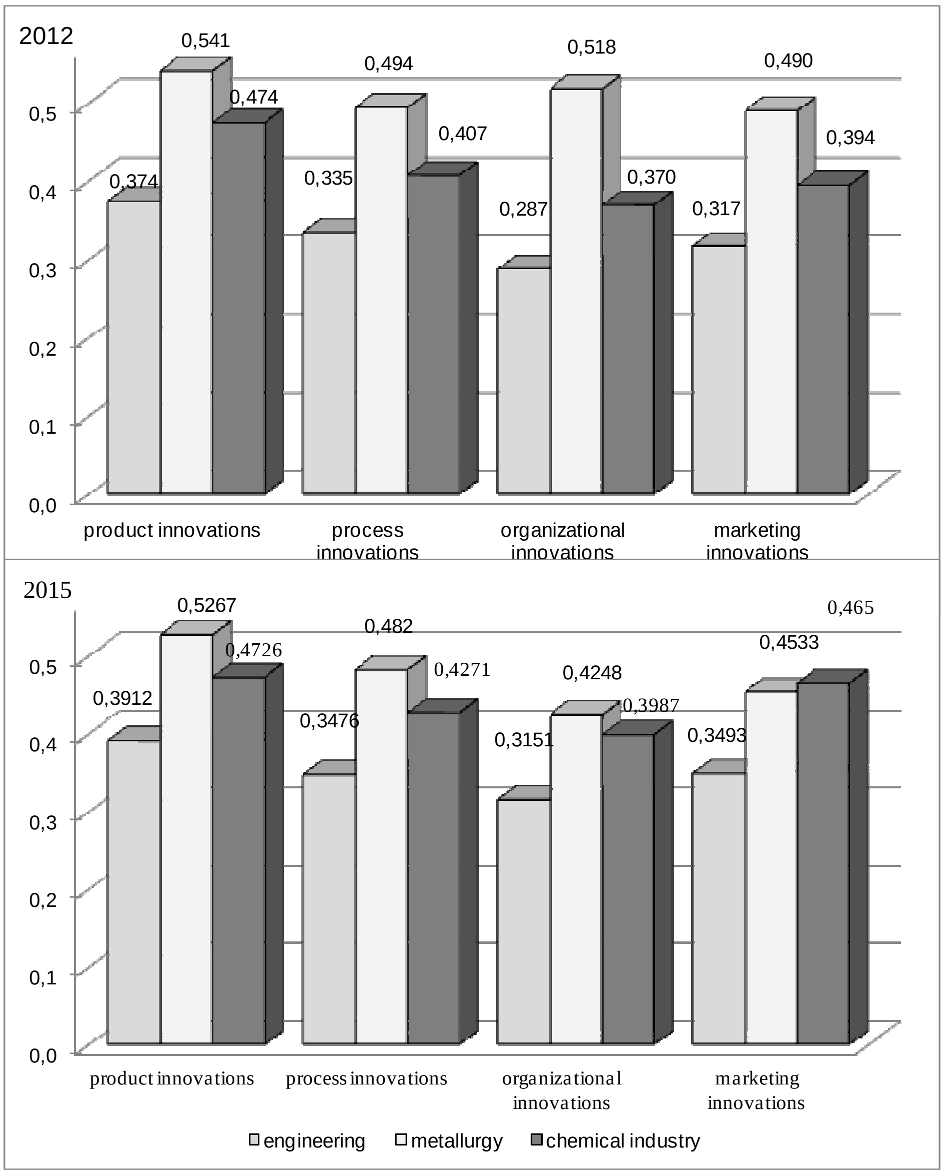

Fig. 3. Summarizing indicators of innovation potential by industries

Fig. 3 demonstrates that metallurgical enterprises have the highest innovation potential, these enterprises have the largest resource base for innovation, but in modern realities of the Ukrainian economy and the world market situation, the innovative activity of these metallurgical combines is restrained. The engineering companies have the lowest level of innovation potential, according to conducted analysis. Fig. 3 demonstrates that enterprises in the machine-building industry hardly implement organizational innovations, that embody reforms of the structural organization of production and management activities, changes organizational interrelations between the structural divisions of the enterprise, etc.

During the conducted assessment and analysis of the enterprises of the machine-building industry, no differences were found between the average levels of innovative potential of economic entities located in different regions of Ukraine: the average regional dispersion estimates are 0.0035%, 0.0028%, 0.0045% and 0.0051%, according to the types of innovations respectively.

For metallurgical enterprises, such regional consistency is not preserved (the average square variance of regional estimates is 0.1060%, 0.1120%, 0.2353% and 0.2656%, according to the types of innovations respectively), but the regional differences are not resonant. Significant regional disparities in the innovation potential of enterprises are inherent in the chemical industry.

A more in-depth analysis allows us to determine that the identified regional disproportions are caused by significant differences in innovation potential of companies-leaders and outsider companies.

5. CONCLUSION

The results of approbation of the proposed cognitive model for assessing the innovation potential of enterprises ground advantages of its use such as: complexity of evaluation, which is achieved by using quantitative data of financial and statistical reports and qualitative information of expert groups; comparability of results for enterprises of different industries and regions; possibility of quantitative generalization of results for substantiation of decisions and conclusions at different levels of management of economic entities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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