METHODICAL APPROACH TO THE MANAGEMENT OF INNOVATIVE DEVELOPMENT

The issue of innovative development is becoming increasingly important in terms of the spread of globalization. The formation of the phenomenon of "knowledge economy" indicates that the basis for the effective management of innovative development is the direct knowledge that contributes to the activation of innovative processes in society. Therefore there is a need to improve methods of innovative development taking into account current realities.

The researches of such scholars as M. Boyarsky [3], N. Chukhrai [11], P. Drucker [1], A. Grebeshkova [9], O. Iastremska [2, 13], A. Kyzym [2], T. Lepeyko [3], A. Malyarchuk [9], O. Melnychuk [7], A. Nalyvayko [9], V. Ponomarenko [2], A. Prosovych [11], B. Santo [6], B. Stadnyk [7], G. Starchenko [8], L. Shulgina [12], G. Vereshchagina [13], M. Yohny [7], B. Yukhimenko [12] and others are devoted to the issues of innovative development .

In a globalized economy and the integration of Ukraine into the European Union with a view to increase the efficiency of innovative development, the analysis of the Global Innovation Index (The Global Innovation Index), calculated according to the methodology of the international business school INSEAD, France seems reasonable [14]. A recent study for 2016 includes 128 countries, where Ukraine occupies the 56th place in the rating of innovation among others, the received index is 35.7 (according to a 100-points scale). In comparison with 2015 (the 64th place) the position of the country has improved significantly, indicating the increased efficiency of innovation. The rating leaders are Switzerland (66.3), Sweden (63.6) and the UK (61.9). Such post-Soviet countries as Estonia (the 24th place), Latvia (the 34th place), Lithuania (the 36th place), Russia (the 43^{d} place), Moldova (the 46th place) have much more better condition for developing innovation and Armenia (the 60th place), Georgia (the 64th place) and Azerbaijan (the 85th place) have much worse positions [14].

Doubtless for the development and innovation is the thesis that the success of the economy is connected with both the presence of innovative capacity and with its application [14]. The Global Innovation Index is composed of two groups of indicators: the available resources and the conditions for innovation (Innovation Input), including institutions, human capital and research; infrastructure; development of internal market; business development and practical results of innovation (Innovation Output), within which the development of technology and the knowledge economy are analyzed and the results of creativity [14]. Ukraine occupies the 76th

place (38.9 points) for the Innovation Input and the 40th place (32.5 points) on Innovation Output.

According to the information provided, the strengths of Ukraine in 2016 include: ease of starting a business, expenditure on education, gov't expenditure / pupil, secondary, tertiary enrolment, graduates in science & engineering, ease of getting credit, females employed w / advanced degrees, GERD financed by abroad, patents by origin / bn PPP $ GDP, utility models by origin / bn PPP $ GDP, ICT services exports, industrial designs by origin / bn PPP $ GDP.

The weakest elements that hinder the implementation and dissemination of innovation and reduce the efficiency of innovation are: political stability & safety, regulatory quality, rule of law, ease of resolving insolvency, government's online service, gross capital formation, GDP / unit of energy use, state of cluster development, FDI net inflows, growth rate of PPP $ GDP / worker, ICTs & business model creation. Therefore, to address these issues enterprises should take appropriate decisions that will both increase their innovation activity and also the introduction and spread of innovation.

The basis of the effective decision-making regarding innovative development is a quantitative assessment of its actual results. Therefore the methodological approach evaluating the effectiveness of innovative development, approved at 41 machine-building enterprises of Kharkov region is proposed. Let us consider in detail the contents of the stages of methodological approach.

Stage 1 − the separation of cluster-uniform groups of machine-building enterprises. The purpose of this phase is the distribution of the investigated entities into disjoint groups (clusters), ensuring maximum proximity (similarity) at selected characteristics between enterprises of one group and the maximum difference between the groups.

As a part of the implementation of this phase, the analysis of the literature on economic and mathematical modeling is made, a result of which indicates that one of the important conditions for building economic and mathematical models is homogeneity of initial set of statistical data.

Uniformity of data means that there is no strong break of trends and abnormal observations. When working with spatial data sets, often the cause of their heterogeneity is the presence of several groups of objects that are significantly different. The previous procedures of economic and mathematical models construction include grouping that provides problem solution. Statistical clustering involves separation of the universe of phenomena or objects into

homogeneous groups with individual characteristics. To get more persistent integration of data it is appropriate to use cluster analysis methods that concern to the methods of multivariate clustering and yield the outstanding groups of objects.

Significant advantages of cluster analysis over other statistical methods of grouping are: cluster analysis allows to separate objects according to one sign, and on the set of features; cluster analysis does not impose any restrictions on the type of the objects and allows us to consider a lot of output data of any nature; cluster analysis allows to examine a considerable amount of information and dramatically reduce, compress large amounts of socio-economic information, to make it compact and visible.

The main limitations of cluster analysis are the five requirements to be met by the raw data of the study: indicators should not correlate with each other; indicators should not contradict the theory of measurements; distribution of performance should be close to normal; performance must meet the requirement of "stability", defined as the absence of influence of random factors on their values; the sample must be homogeneous, i.e. not contain random "emissions".

The criteria for the implementation of clustering are the indicators characterizing the efficiency of the entity. Analysis of modern methodological approaches and guidelines for the financial analysis of companies shows that the efficiency of their operation in general is evaluated using ratios of profitability and resources turnover. The following parameters are proposed to be used for clustering:

return on assets − shows the amount of net income received by enterprises per one unit of value of its assets and determines the overall return of the use of property and capital of the company;

assets turnover − describes the intensity and rate of assets turnover and is defined as the ratio of net income from sales to the average for the period of an enterprise assets value; acts as an important indicator of business activity of a market participant.

In the process of selection and justification of clustering method, a comparative analysis of existing methodical set of tools is made. Thus, cluster analysis methods can be divided into two main groups: hierarchical (natural) and non-hierarchical (artificial). The feature of hierarchical method is that the number of clusters is not defined in advance, so this group of methods is called natural clustering. These methods are based on the assumption of the existence of cluster of different orders in the information space that build the full tree of inserted clusters. The advantage of this method is its visibility and the opportunity to get a detailed picture of the

structure of data. Disadvantages include limitation of information, the complexity of measuring the proximity of objects and inflexibility of obtained classifications.

However, it should be noted that for the large number of observations the hierarchical methods of cluster analysis are unsuitable. In such cases, the non-hierarchical methods that are the iterative methods of splitting the original population should be used. In the process of distribution the new clusters are formed as soon as the rule of stop is not fulfilled. Thus, non-hierarchical clustering means the division of the set of data into a number of separate clusters.

Consistent use of both clustering methods can reduce the negative impact of these deficiencies result and techniques to get the most reasonable clustering. That is why it is advisable to use natural methods of clustering to justify the number of clusters and methods of artificial clustering for more adequate distribution companies between clusters.

As a part of the cluster groups formation the direct allocation of disjoint homogeneous groups of machine-building enterprises is held.

The implementation of the next step involves the standardization of the input data set and determination of the number of cluster groups using natural methods of clustering that involves two procedures.

1. In order to meet the requirements of indicators used in cluster analysis the procedure of normalization and standardization of the original space that ensures the normal distribution law and allows to use the indicators with different measurement units is carried out. All the calculations are made in private Statistica 8.0, ensuring the accuracy of their conduct.

2. The allocation of the number of clusters using natural methods of clustering. Under the natural means of clustering , a series of algorithm of arranged data, the visualization of which is provided by means of graphs, is meant. Graph built during the implementation of hierarchical clustering algorithm is called dendrogram. Dendrogram represents the mutual relationships between the objects of a given set. To determine the number of clusters in a built dedrogram, the ratio of the lengths of connections between objects is calculated as follows:

1. Relations of dendrogram built on the set of units are arranged in decreasing order of their length.

2. The ratio between the lengths of neighboring connections is evaluated according to the following formula:

$$i_2 = \frac{d_1}{d_2}, i_3 = \frac{d_2}{d_3}, ..., i_{\varpi-1} = \frac{d_{\varpi-2}}{d_{\varpi-1}} \quad (1)$$

where d_1, d_2,… $d_{\varpi-1}$ − ordered links length,

i_1, i_2,… $i_{\varpi-1}$ − the ratio of the links length;

3. Searching of i_k, of the value for which the following ratio is performed:

$$i_k < i_{k+1} \text{ для } k = 2,3,...,\varpi - 1. \quad (2)$$

According to this ratio k clusters are considered as an optimal allocation.

Construction of dendrogram of machine-building enterprises under the study is performed using package Statistica 8.0. Fig. 1 shows the dendrogram of distribution of machine-building enterprises according to the homogeneous cluster groups.

According to the results of cluster analysis (Fig. 1) the calculations by formula are made (1):

$$i_2 = \frac{1,8}{1,45} = 1,24, i_3 = \frac{1,45}{1,35} = 1,07, i_4 = \frac{1,35}{0,9} = 1,5$$

Correlation (2) is performed for 3 clusters. Therefore it is advisable to distinguish three cluster groups of enterprises that will provide the homogeneity of enterprises in the middle cluster.

The next step is to use the artificial methods of clustering according to the management efficiency of an enterprise innovative development. Analysis of the literature led to the conclusion that the most common method is non-hierarchical clustering method of k-means. Popularity of this method lies in transparency and unambiguous algorithm results. The method of k-means refers to a group of iterative methods.

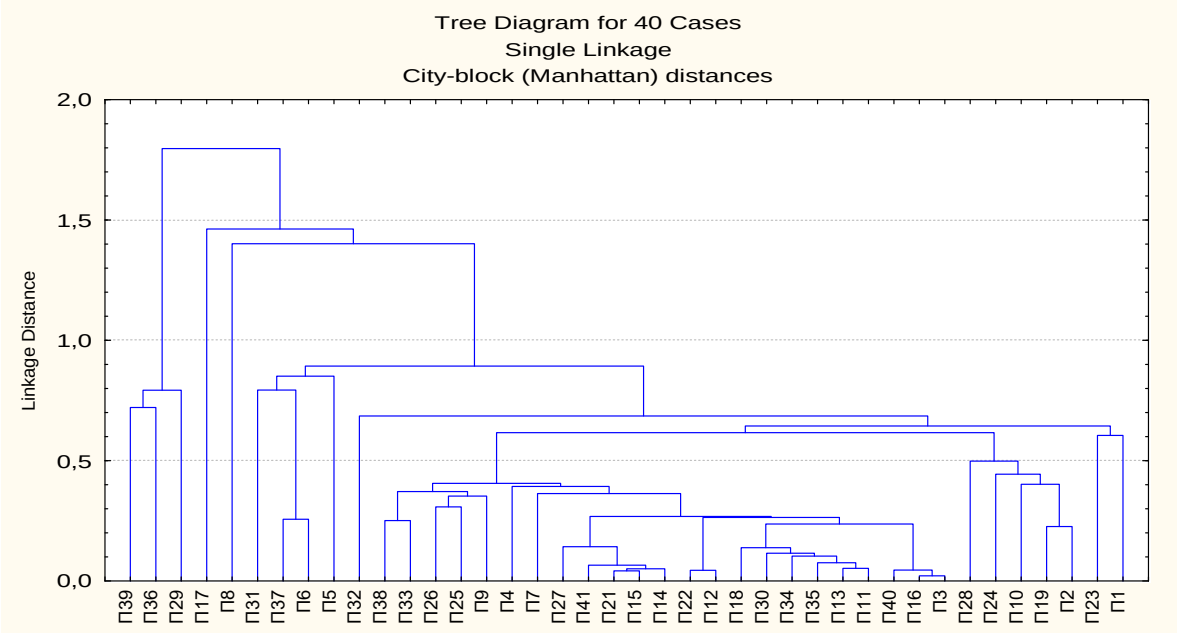

Fig. 1. Dendrogram of machine-building enterprises distribution

Based on the algorithm and using Statistica 8.0 selection of three cluster groups of enterprises for 4 years was conducted. The results are presented in Table. 1.

Table 1 – Composition of cluster groups for 2011-2014.

Cluster	2011	2012	2013	2014	Persistent core
1	П1,П4, П5, П10, П17, П23, П24, П26, П28, П29, П35, П36, П37, П40	П1, П4, П5, П17, П23, П26, П29, П36, П31, П39	П1, П29, П36, П39	П5, П6, П8 П17, П29, П31, П36, П37, П39	П29, П36
2	П8,П31	П3, П8	П4,П5,П6,П8,П10,П15,П19,П24,П28,П31,П32,П37, П38	П1, П2, П4, П9, П10, П14, П15, П19, П21, П24, П25, П26, П27, П28, П32, П41	–
3	П2, П3, П6, П7, П9, П11, П12, П13,П14, П15, П16, П18, П19, П21, П22, П25, П27, П30, П32, П33, П34, П38, П39, П41	П2, П6, П7,П9, П10, П11, П12, П13, П15, П16, П19, П18, П21, П22, П24, П25, П27, П28, П30, П33, П34, П35, П38, П39, П40, П41	П2, П3,П4,П7,П9, П11, П12, П13, П14, П16, П17, П18, П21, П22, П23, П25, П26, П27, П30, П33, П34, П35, П40, П41	П3, П7, П11, П12, П13, П16, П18, П22,П23, П30, П33, П34, П35, П38, П40	П7, П11, П12, П13, П16, П18, П22, П30, П33, П34, П41

From Table 1 it can be seen that the constant movement of enterprises from one cluster to another took place over this period. Only a third of companies did not change the cluster group during these 4 years. And the biggest differences in cluster groups took place in 2013. The resulting cluster groups for the period of 2013-2014 to a greater extent correspond to the real economic situation in the country and machine-building industry, so it is proposed for further calculations to use the homogeneous groups of 2014.

The adequacy of the results of cluster analysis is checked on the basis of discriminant analysis. Discriminant analysis is a multivariate statistical method that allows to determine the differences between two or more groups of similar objects on several variables simultaneously.

According to the results of calculations (Fig. 2) one can make a conclusion about the stability of obtained cluster groups i.e. clustering of enterprises in terms of the quality of their operation meets the existing regularities in a sample. The quality of clustering obtained is confirmed by out of the common value of the average estimates for indicators that form the basis of the grouping.

	Classification Matrix (дискриминантный 2013 Rows: Observed classifications Columns: Predicted classifications			
Group	Percent Correct	G2 p=,33333	G3 p=,33333	G1 p=,33333
G2	100,0000	16	0	0
G3	100,0000	0	16	0
G1	100,0000	0	0	9
Total	100,0000	16	16	9

Fig.2. The classification matrix.

According to the results of clustering, 3 groups of enterprises, the efficiency of innovative development of which can be characterized as follows, were formed:

cluster 1 − includes 9 enterprises, operation of which is characterized by the highest level of management efficiency of an enterprise innovative development. Thus, these peculiar entities have a maximum profitability and return on capital and property use, while keeping a high rate of assets turnover, indicating the efficient costs structure and in general characterizes the innovative development of an enterprise of a given cluster as a high one;

cluster 2 − includes 16 enterprises that are characterized by an average assets turnover rate and have the average level of profitability i.e. return on operational capital and assets. This situation indicates the insufficient use of existing innovative potential by the enterprises and provides the opportunity to determine the level of functioning of enterprises of this cluster as the average;

cluster 3 − includes 16 enterprises that have a low level of assets turnover and low or even zero profitability, indicating the poor quality of their operation. A significant proportion of enterprises of this cluster (40% of total sample under the study) confirms a deep systemic crisis in engineering and justifies the need to develop effective mechanisms for raising the level of innovation development of entities in this industry.

The main direction of the second stage of methodical approach to the management of innovative development of enterprises is to obtain an appropriate integrated assessment. When building a system of indicators evaluating the effectiveness of innovative development it is necessary to ensure the implementation of the following principles:

complexity − means that the evaluation of the effectiveness of innovative development management as a whole should combine the highlighted features the evaluation of group indicators with none of them to be excluded;

sufficiency – means that a set of indicators must reflect the necessary and sufficient information on the efficiency level of innovative development management;

dynamics − requires a retrospective evaluation over a definite period.

Accordingly, it is proposed in order to build a reasonable system of indicators to use informal methods of filtration – a comparative analysis of literature.

In conditions of a significant reduction of the competitiveness of domestic economy to ensure the effectiveness of innovative development management, an innovative potential of an enterprise, which determines the level of formation and efficiency of an enterprise innovative business opportunities [for generalized 2, 5, 6] plays an important role. Analysis of literature on the research of efficiency of an enterprise innovative activity [3, 7-13] allowed to distinguish the following groups of indicators: sale of innovative products - make it possible to estimate the share of innovative products (by their types) in an enterprise sales volume; implementation of innovations − determines the level of implementation of innovative equipment, technologies, etc. at an enterprise. Information support of an evaluation indices system development for selected groups is a statistical form of survey of innovation activities of industrial enterprises (Form № 1− innovation (annual)).

According to the structural and meaningful filling of the form and based on the analysis of the literature, it is advisable to develop a list of indicators evaluating the level of innovative potential of an enterprise that is presented in Table. 2.

Table 2 − List of indicators evaluating the level of innovative potential of an enterprise

Grouping Sign	Indicator	Symbol	Index Calculation Formula
1 Indices of innovative products sale	Ratio of sales of innovative products	x_{11}	The ratio of innovative products sale to the total sales
	The coefficient of innovative products (services) sale that are new for a particular market	x_{12}	The coefficient of innovative products (services) sale that are new for a particular market
	The ratio of innovative products (services) sale that are new to a particular market to the total sales	x_{13}	The coefficient of innovative product (service) sale, which is new only for the enterprise being analyzed
2. Indicators of innovations introduction	The coefficient of implementation of innovative machinery, equipment, appliances, apparatus, etc.	x_{21}	The ratio of a number of implemented innovative machinery, equipment, appliances, apparatus, etc. to the total number of implemented machinery, equipment, appliances, apparatus, etc.
	The coefficient of degree of technology novelty	x_{22}	The ratio of a number of innovative technologies to all new technologies in Ukraine

The next step is the calculation of the integral index of evaluation of the level of an enterprise innovative potential use. For the evaluation, the method of calculation of taxonomic index is proposed to be used. Calculations of integral index are made for each type of clusters (see Table 3).

Table 3 − The value of the integral index of innovative potential ($I_{VPt}^{іннов}$)

Enterprise	2010	2011	2012	2013
JSC "Electric machine"	0,34	0,36	0,36	0,36
JSC "FED"	0,25	0,28	0,23	0,22
ETK "ElKor"	0,22	0,21	0,15	0,15

For the integral index of the level of innovative potential of an enterprise it is proposed to use a verbal-numeric scale by Harrington, that can be grounded as follows: has a universal nature and is widely used for a qualitative gradation of quantitative criteria in assessing economic processes; is a common tool of transformation of qualitative characteristics of a probabilistic nature into quantitative ones; makes it possible to establish a degree of quality intensity of an enterprise inner potential use and economically adequate interpret the results; grading scale allows to get a balance between an accuracy of parameters` estimation and a validity of these estimates and the numerical values of the limit values of the Harrington scale obtained when analyzing and processing a large amount of statistical data [13].

The study proposes to undertake the following economic interpretation of the level of an enterprise innovative potential:

− Low level − is characterized by the insufficient level of innovative products sale and innovation, lack of interest of an enterprise management and staff in the implementation of innovations, etc.;

− Average level − indicates the presence of negative trends in an enterprise act6ivity that reduces the level of implementation of innovative products and innovations, occasional implementation of innovations, etc.;

− High level − reflects the ability of an enterprise to provide a sufficient level of implementation of innovative products and innovations, demonstrates an active innovative policy.

Taking into account the fact that the value of taxonomic index with which the help of which the level of an enterprise innovation potential is estimated, changes from 0 to 1, and in accordance with the values of gradation of verbal-numeric scale by Harrinhton [13], it is proposed to use the following scale of ranges of an enterprise innovative potential use (Table 4).

Table 4 − Scale of ranges of an enterprise innovative potential

The range of changes of the integral index of the level of an enterprise innovative potential use	The level of an enterprise innovative potential use
$0,00 \leq VP_t \leq 0,36$	Low
$0,36 < VP_t \leq 0,64$	Average
$0,64 < VP_t \leq 1$	High

The economic content of a certain level of innovative potential is presented in Table 5.

Table 5 − The economic content of a certain level of innovative potential

Level	The economic interpretation
Low	There is a condition at an enterprise when it has a good innovative potential, which is characterized by a high level of implementation of innovative products and innovations.
Average	There is a situation when an enterprise demonstrates a sufficient innovative potential, which is characterized by an average level of implementation of innovative products and innovations.
High	The situation in which an enterprise shows a low innovation potential, which is characterized by an average level of implementation of innovative products and innovations.

A set of managerial decisions depending on the innovation potential of an enterprise is presented in Table 6.

Table 6 –A set of managerial decisions based on the level of innovation potential use

Level	Managerial decisions depending on the level of innovation potential
Low	The choice of prospects for further growth of the level of innovative potential use, which will facilitate the search and introduction of new technologies, equipment and innovative products.
Average	The choice of prospects for further growth of the use of innovative capacity, which will encourage the implementation of new technologies and equipment, development of innovative products.
High	The choice of prospects for further preservation of the level of innovative capacity, which will promote the relevance of technologies and equipment used at an enterprise; continuous improvement of products through the use of new knowledge.

Thus, as a result of the research clustering of 41 machine-building enterprises of Kharkiv region was conducted; the range of changes of integrated evaluation values of an enterprise innovative potential was formed; an adequate economic interpretation that takes into account their substantial features in accordance with the objectives of the study was given; the diagnostics of innovative potential of a machine-building enterprise in terms of cluster homogeneous groups was held. The obtained results can serve as the basis for developing a set of decisions on the management of an enterprise innovative development.

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