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PECULIARITIES OF DIFFUSION OF INNOVATIONS IN THE REGIONS OF UKRAINE

Abstract. Article is devoted to analysis of the scientific, technical and innovative development of Ukraine for the purpose of identification of peculiarities of diffusion of innovations in the regions. Relevant issues of diffusion of innovations are generalized using results of the corresponding theoretical and practical studies, which were conducted in the countries with market economy and with the high level of information technology development. Peculiarities of diffusion of innovations in areas with different population density, scientific and business environments are considered. Indicators of scientific, technical and innovative development of the regions of Ukraine are analyzed using the method of principal components. Authors singled out from the general array of parameters specific indicators, which characterize the principal components of innovative development, among which there are levels of research activity, innovation activity, human and financial potential. Consolidation of regions depending on the level of indicators, which characterize the principal components of innovative development is performed. Correlation between the value of corresponding indicators and levels of urbanization and industrial development of the regions are clearly established.

Grouping of regions of Ukraine depending on the level of development of a human capital, amounts of funding of R&D and innovation activities, level of implementation of innovative products and technologies in production is performed. Need of increasing the availability of disaggregated statistics related to innovation activity of the enterprises and scientific institutions in Ukraine is proved. Ways of acceleration of diffusion of innovations and regional alignment of indicators of innovative development in Ukraine are defined, including: strengthening of the state innovation policy to foster development of regional and industry networks of exchange of the innovation experience, knowledge, open information on new developments and possibilities of financing of the innovation projects; support of creation in rural territories of partnership around the innovation projects to ensure SME greening and rapid implementation of the latest innovation processes.

Keywords: diffusion of innovations, innovations, scientific and technical development, innovation activity, state innovation and investment policy.

JEL Classification: O32, O38

Formulas: 0; fig.: 3; tabl.: 3; bibl.: 11.

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ОСОБЛИВОСТІ ПОШИРЕННЯ ІННОВАЦІЙ У РЕГІОНАХ УКРАЇНИ

Анотація. Досліджується науково-технічний та інноваційний розвиток України в контексті виявлення особливостей поширення інновацій у регіонах країни. Визначено сучасні проблеми поширення інновацій на основі узагальнення результатів теоретичних і прикладних досліджень, що проводились у країнах із високим рівнем соціально-економічного розвитку. Розглянуто особливості поширення інновацій у місцевостях із різною щільністю населення, а також різним науковим і бізнес-середовищем. Проаналізовано показники науково-технічного та інноваційного розвитку регіонів України методом головних компонент. Із загального масиву ознак виокремлено показники, що характеризують головні компоненти, серед яких: рівень активності науково-дослідної та інноваційної діяльності, а також людського і фінансового потенціалу. Здійснено об'єднання регіонів за рівнем ознак, що входять до складу головних компонент. Установлено взаємозв'язок позицій регіонів за вказаними показниками і показниками, що характеризують рівень їхньої урбанізації та промислового розвитку.

Здійснено групування регіонів України залежно від рівня розвитку людського капіталу, обсягів фінансування НДДКР та масштабів запровадження новітніх продуктів і технологій у виробництво. Обґрунтовано необхідність розширення зрізу даних державного статистичного обліку щодо інноваційної діяльності підприємств та організацій України. Запропоновано шляхи прискорення поширення інновацій та регіонального вирівнювання показників інноваційного розвитку в межах країни, серед яких: активізація державної інноваційної політики сприяння розбудові регіональних і галузевих мереж обміну інноваційним досвідом, знаннями, відкритою інформацією про нові розробки та можливості фінансування інноваційних проєктів, а також підтримка створення на сільських територіях партнерства навколо інноваційних ідей з метою підвищення продуктивності, удосконалення організації та обслуговування виробництва, забезпечення його екологізації та запровадження новітніх інноваційних процесів.

Ключові слова: поширення інновацій, нововведення, науково-технічний розвиток, інноваційна активність, державна інноваційно-інвестиційна політика.

Формул: 0; рис.: 3; табл.: 3; бібл.: 11.

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ОСОБЕННОСТИ РАСПРОСТРАНЕНИЯ ИННОВАЦИЙ В РЕГИОНАХ УКРАИНЫ

Аннотация. Определены современные проблемы распространения инноваций на основе результатов соответствующих исследований. Рассмотрены особенности распространения инноваций в местностях с разной плотностью населения, научной и бизнес-средой. Проанализированы показатели научно-технического и инновационного развития регионов Украины. Осуществлено объединение регионов по уровню активности научно-исследовательской и инновационной деятельности, а также развития человеческого и финансового потенциала. Установлена взаимосвязь позиций регионов по указанным показателям и показателям, характеризующим уровень их урбанизации и промышленного развития. Предложены пути ускорения распространения инноваций и регионального выравнивания показателей инновационного развития в Украине.

Ключевые слова: распространение инноваций, нововведения, научно-техническое развитие, инновационная активность, государственная инновационно-инвестиционная политика.

Формул: 0; рис.: 3, табл.: 3, библи.: 11.

Introduction. Implementation of new technologies and development of innovative products has driven the growth of national economy. Moreover, global environmental and social challenges require new production and organizational innovative solutions. Therefore, there is a need for effective state innovation policy which important task is an ensuring fast and uniform distribution of innovations among the regions of Ukraine.

Research background and purpose of the article. Issues of diffusion of innovations have been considered in the economic researches of Ph. Aghion, P. Howitt, W.Cohen, D. Levinthal, C. Edquist, P. Geroski, C. Hollifield, J. Donnermeyer, E. Rogers, R. Solow, P. Stoneman, T. Swan and others. Theoretical aspects of the innovative development have been investigated in scientific studies of I. Ansoff, Y. Bazhal, G. Birmann, V. Heyets, S.Ilyashenko, L. Kantorovich, B. Twiss, R. Foster, B. Shapiro, J. Schumpeter and others. At the moment there is a number of researches concerning issues of diffusion of innovations in business environments of different density and analysis of the regional aspects of innovative development (D. Sunding, D. Zilberman, C. Hollifield, J. Donnermeyer and others). However these issues only begin to fall within an area of interest of Ukrainian researchers. Therefore, research of regional aspects of diffusion of innovations in Ukraine using the methods of principal component, clustering and multidimensional scaling is especially relevant.

Results of research. Emergence of innovations, except for accidental inventions, connected with systematic activity of the enterprises and individuals with obligatory leverage of financial resources in order to achieve commercial effect [1]. Favorable for emergence of innovations environments are cities where the population has the high level of education and where observed high concentration of the companies, which use new technologies. However, among tasks of the state economic policy universal distribution of innovations is priority objective. For example, according to the Concept of development of rural territories, economic growth in the rural zone has to be provided through implementation of innovations in agrarian production.

As a rule, diffusion of innovations is described by a S-curve at the beginning of which there is a high resistance to changes. After overcoming this resistance there is a rapid diffusion of innovations to the further attenuation connected with exhaustion of potential of its development and loss of relevance [2]. Delays in transfer of the new technologies, even in case of their critical importance, connected with lack of information [3]. Diffusion of innovations is done via two channels (media and personal communications) and has the epidemic nature. At the same time, the assumption concerning perception of innovations by the enterprises at the time of obtaining information is adjusted by threshold model which take into account guidelines and scale of activity of enterprises. It is in fact more risky to spend time and resources, accepting innovations at an early stage when the performance level and profitability is uncertain. At the same time, it is easier for big companies to undertake risks as their business activity, products and the markets are more diversified.

Researches concerning features of economic actors, which affects the decision to invest in new technologies, demonstrate that experience, education, size of the company and risk level are important for the investment decision. Extensive experience and higher education increase adsorption, which is perception of benefits of innovations by the entrepreneur. Moreover, capability to finance innovations and to perceive risks depending on knowledge of rather effective use of innovations [4; 5], size of the company and its investment expectations.

Theoretical studies shows that there is no difference in diffusion of innovations in the rural zone compared with the areas with more dense scientific, educational and business environment [3]. Simultaneously, diffusion of innovations in the rural zone takes more time that is connected with individualism, closeness of a rural entrepreneurship and smaller opportunities concerning formation

of necessary communications [6]. Informatization promotes overcoming a problem of remoteness and isolation through establishment of necessary communications. However, for underpopulated areas expansion of networks and social communications in the innovation sphere remains complicated and expensive. Availability of institutions of higher education and infrastructure for R&D promotes development and implementation of new technologies. The low level of education, qualification and awareness in the rural zone and lack of opportunities to carrying out own research complicates emergence and distribution of innovations.

It is important that relevant researches of diffusion of innovations in the rural areas confirm the general results obtained earlier – rather slower diffusions in outlying areas compared to large cities [2]. Further influence of information technologies and Internet access did not change the general results of researches [7] and shows considerable differences in use of the latest knowledge in city and rural areas. The received results confirm a hypothesis that the speed of diffusion of innovations is affected not only by a possibility of an information access, but also by perception of innovations which is defined by knowledge of entrepreneurs, access to financing and openness to changes. In addition, nowadays such important factor as new communication networks in business environment, fast transfer of information from producers and suppliers, availability of specialized magazines and web portals, regular fairs and distribution of the international contacts becomes an integral part of system of dissemination of information for agricultural enterprises.

Despite of the fact that the institutional structure of Ukraine is homogeneous there are considerable differences in the innovative development of certain territories caused by urban saturation of regions, industry structure of regional economy and, respectively, level of economic development, which defines opportunities of technical retrofitting, technology updating and organizational optimization of production.

Table 1.
Principal components of scientific, technical and innovative development of Ukraine in 2017.

Number of components	Principal components variables	Loading (a >0,6)	General dispersion, %	Cumulative dispersion, %	Description of the principal components
1	κ_{11} – total funding of R&D and innovation activities per 1000 UAH of gross regional product; κ_{12} – number of organizations which carried out R&D per 1000 enterprises; κ_{13} – number of enterprises which implemented innovation processes per 1000 enterprises; κ_{14} – number of enterprises which implemented any forms of innovations per 1000 enterprises; κ_{15} – number of workers involved in R&D to total number of employees.	a=0,95 a=0,89 a=0,89 a=0,88 a=0,73	41,1960	41,1960	Level of research and innovation activity
2	κ_{21} – number of graduates with PhD and doctoral degrees per 10000 inhabitants; κ_{22} – number of universities with PhD and doctoral programs per 10000 inhabitants; κ_{23} – number of graduates with higher educational per 1000 inhabitants	a=0,98 a=0,97 a=0,94	19,6788	60,8748	Human potential of scientific, technical and innovative development
3	κ_{31} – gross regional product (million UAH) per enterprise.	a=0,75	14,3982	75,2730	Financial potential of scientific, technical and innovative development

Source: originally developed by the authors.

In this paper, we use the array of statistical data [8; 9] to analyze scientific, technical and innovative development of Ukraine in 2017. Using principal component analysis and “Statistica”

software package developed by StatSoft, we singled out from the general array of parameters specific indicators, which characterize the principal components of innovative development among which there are levels of research activity, innovation activity, human and financial potential (tab. 1). In order to obtaining a clear assessment of the principal components, we use orthogonal rotation (dispersion redistribution). Therefore principal components did not correlate with each other.

In addition, we studied regional differentiation using cluster analysis, which allows to single out groups of regions with similar levels of scientific, technical and innovative development (Fig. 1).

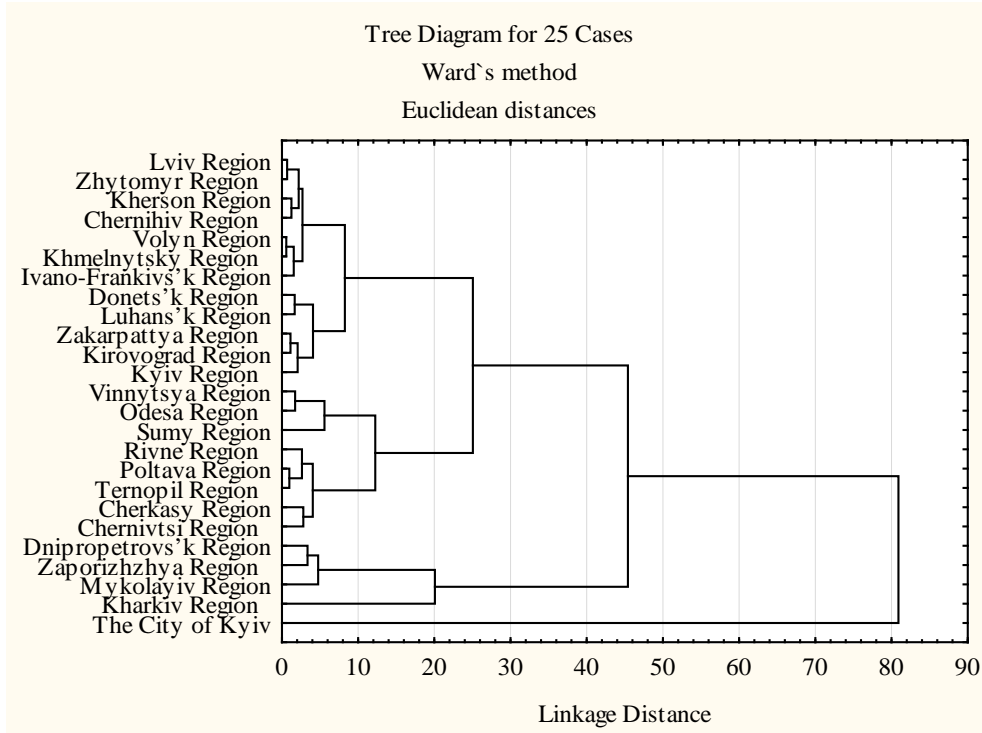


Fig. 1. Dendrogram of results of cluster analysis of Ukrainian regions depending on the level of scientific, technical and innovative development

Source: originally developed by the authors.

Diagram of consolidation of regions into clusters according to Ward's method was used to determinate quantity of clusters which regional structure is characterized by considerable differences in the level of scientific, technical and innovative development. According to the diagram (fig. 2) a total number of steps is $n=24$, number of a step on which took place the first considerable increase in distance from the previous consolidation of objects is $m=18$. Therefore, the number of essential consolidations into clusters is $m=6$.

The regional structure of clusters represented in table 2.

Table 2.

Structure of clusters derived by Ward's method

Cluster number	The number of objects in the cluster	The cluster's composition
1	12	Chernihiv Region, Dnipropetrovsk Region, Ivano-Frankivsk Region, Kherson Region, Khmelnytsky Region, Kirovograd Region, Kyiv Region, Luhans'k Region, Lviv Region, Volyn Region, Zaporizhzhya Region, Zhytomyr Region
2	3	Vinnytsya Region, Odesa Region, Sumy Region
3	5	Rivne Region, Poltava Region, Ternopil Region, Cherkasy Region, Chernivtsi Region
4	3	Donets'k Region, Zakarpattia Region, Mykolayiv Region
5	1	Kharkiv Region
6	1	The City of Kyiv

Source: originally developed by the authors.

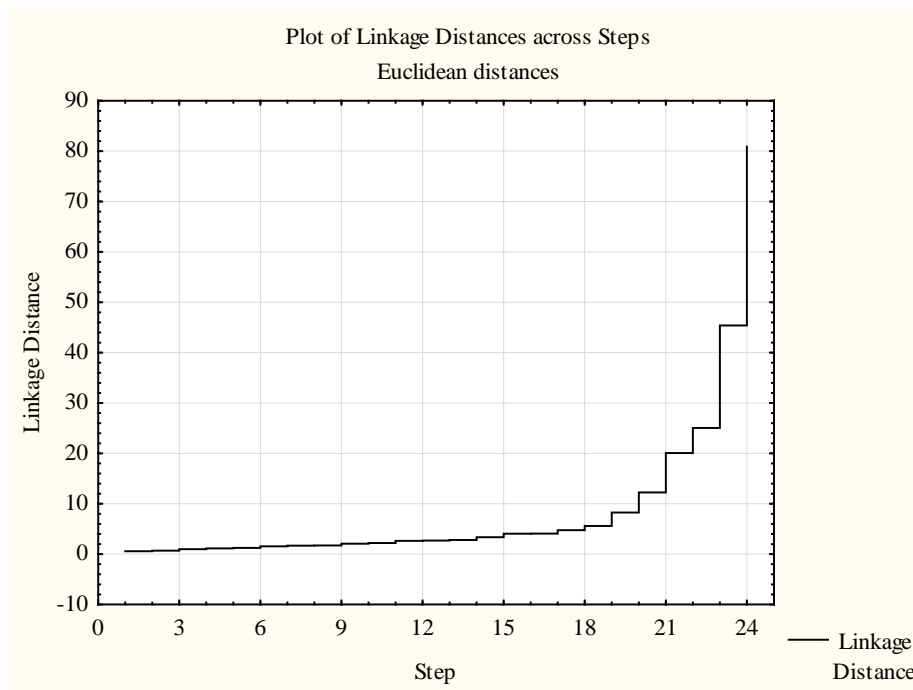


Fig. 2. Consolidation of regions into clusters according to Ward's method
Source: originally developed by the authors.

Performed analysis of human potential, financial potential and innovation activity of enterprises allowed to determine completely specified groups of regions (tab. 3) depending on the level of urban saturation and concentration of industrial and R&D activity.

Table 3

Mean values of variables in clusters derived by Ward's method

Cluster number	K ₁₁	K ₁₂	K ₁₃	K ₁₄	K ₁₅	K ₂₁	K ₂₂	K ₂₃	K ₃₁
1	1,032	0,328	0,243	0,330	1,160	0,649	0,037	4,109	0,906
2	2,766	0,465	0,352	0,432	4,597	1,870	0,093	10,082	0,873
3	1,403	0,348	0,276	0,404	1,529	0,834	0,045	7,596	0,894
4	8,237	0,393	0,296	0,415	5,608	0,886	0,065	7,840	1,105
5	16,526	1,010	0,404	0,587	13,322	3,097	0,232	13,908	0,788
6	11,051	1,246	0,242	0,362	32,056	8,495	0,750	32,614	1,882

Source: originally developed by the authors.

To form geometrical configuration of system of points which represent the analyzed regions on the plane (fig. 3) and obtain a matrix of paired comparisons of regions we apply method of multidimensional scaling to array of statistical data. Figure below demonstrate that regions with the prevailing rural population which economy substantially depends on the agricultural industry [10] is characterized by relatively low level of scientific, technical and innovative development.

Results of carried-out analysis shows shortcomings of the national system of statistical service of innovation activity. In particular, data on the total amount of expenditures on innovation activity, venture funding and state support of innovation development is incomplete. Moreover, data concerning the innovation activities of enterprises is limited to the sphere of industry. At the same time, deep and profound analysis of the innovation activity demands additional statistical data concerning number of SME, which develop and implement innovation technologies and number of SME, which applied third-party innovation technologies.

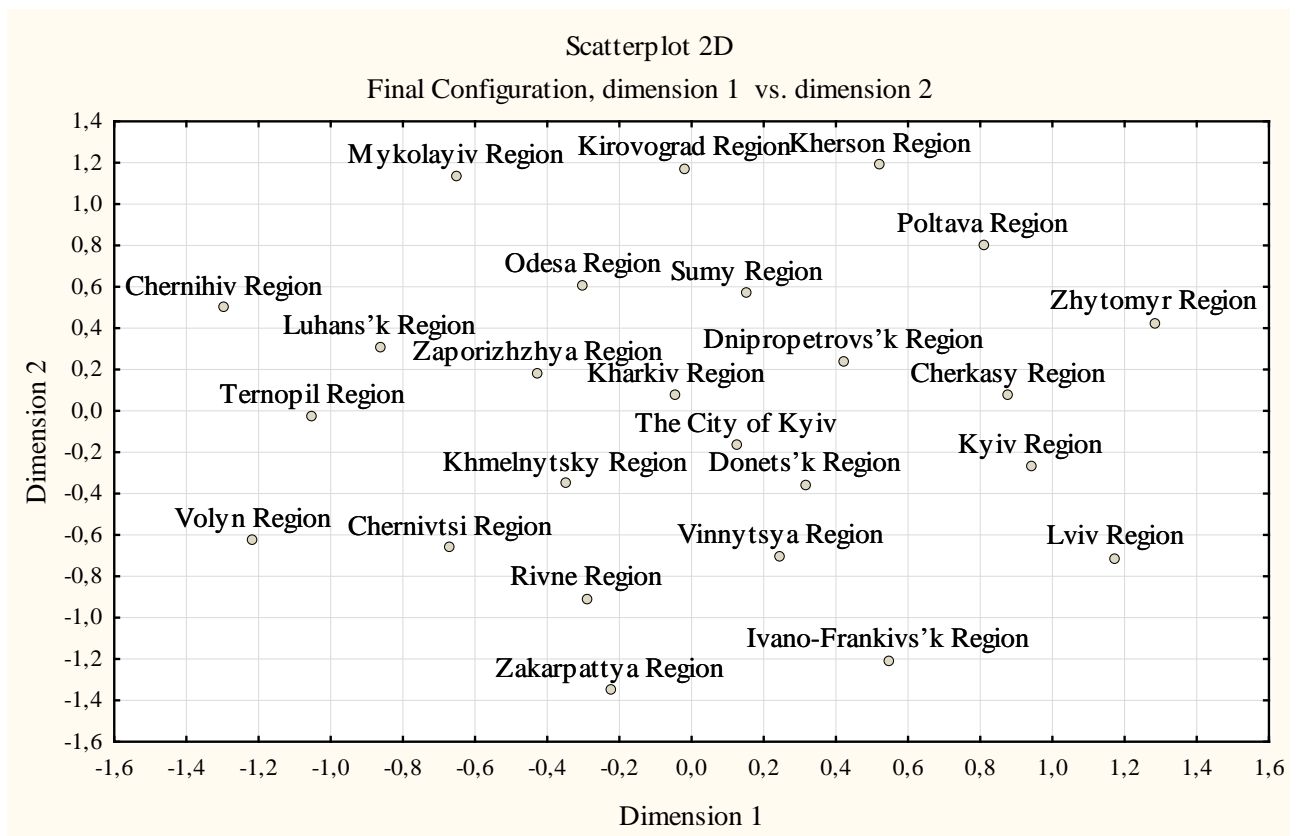


Fig. 3. Results of multidimensional scaling of Ukrainian regions
Source: originally developed by the authors.

In addition, there are several limitations concerning application of traditional methods to analysis of the innovative development of regional economy. Influence of total R&D expenditures on innovative development in fact can be as overestimated (as financial provision of the innovation process is not always directly connected with creation of innovations), and underestimated (in case of SME which usually do not carry out separate accounting of R&D expenditures).

In our opinion, number of patent applications better indicates the level of innovative development of economy, than aggregated R&D expenditures. However, the fact of patent grant does not mean that inventions will be immediately and successfully commercialized. Experience has shown that SME often have no resources and experience for patent research, patent application and IP rights enforcement. Therefore, SME cannot expect considerable profits from commercialization of their intellectual property through assignment or licensing of IP rights to third party. The extension of system of indicators of innovative development performed by OECD and Eurostat [11] accompanies the incorporation into the list of innovation enterprises not only those which implement new processes and products, but also those which apply new technologies, innovation market strategies or new organizational management systems.

In general, results of carried-out quantitative analysis as well as theoretical conclusions proved that dense environments of city agglomerations and industrial regions tends to be more innovative compared to rural areas. Therefore, in our opinion, state support should create favorable conditions for implementation of new products, processes and technologies by enterprises which face restrictions in the innovative development because of the small scale of activity. Of particular importance are programs of information, mentoring and coaching programs and also access to the international and domestic credit lines for SME.

Experience has shown that implementation of the innovation projects in the rural areas becomes complicated due to the lack of thought-over business plans because of deficit of the corresponding specialists. At the same time, big agricultural enterprises, for example grain holdings, that possess considerable human and financial resources, do not face problems, which are inherent

to small, and medium sized agricultural enterprises. Therefore, innovations in the rural areas appear to be available only for big agricultural holdings while farms demand opening of special state programs of financing and extensive network of mentor support.

Increase in availability and awareness of innovations are directly connected with accessibility of modern innovative infrastructure, including telecommunications, venture funds, industrial parks and business incubators. Moreover, innovation knowledge often goes beyond the formal instructions and standards. Dissemination of innovation knowledge carried out through exchange of experience and performed by movement of labor and informal personal contacts that is more common for urban environment or big enterprises which have ample opportunities in human capital management.

Areas with a high concentration of hi-tech companies become centers of training and employment of labor force with the high professional level of knowledge and skills while encourage innovation in the rural areas demands creation of favorable conditions for training and attracting qualified professionals. In our opinion, following factors can promote innovative development of rural economies: increase in education level, acceleration of knowledge sharing, facilitation of access to a skilled labor force in rural territories, financing of the corresponding innovative infrastructure, expansion of network of local colleges and providing a possibility of remote study which allows to slow down outflow of qualified employees from the rural areas.

It should be noted that the role of institutional framework of innovation activity grows in regions where peripheral areas with a low density of a business environment prevail. Institutional framework of innovation activity includes persons and organizations, which work at a permanent basis and provide assistance in managing the financial and organizational aspects of innovation development.

In the rural areas, even qualified and experienced entrepreneurs often are not inclined to invest in new technologies. Because effect of innovations in the form of improvement of business processes and labor organization often did not promote fast increase of company's profitability owing to high costs of service of innovative production lines and ERP systems or insufficient enterprise scale. Thus, in some regions only special state programs of support of innovative activity along with raising standards of production, quality of the products and ecological safety will stimulate entrepreneurs to implement technological innovations. At the same time, peculiarities of innovative technologies forms preconditions for its diffusion in the industries, which are closely connected with natural processes and provides additional benefits within the context of a long-term sustainable development as, for example, in organic production of agricultural products.

Higher cost of investment in new technologies in rural areas stems from higher transportation, information, service and transaction costs of innovative activity. Therefore, special state support and financing of innovative entrepreneurship in rural areas looks justified taking into account necessity of mechanization of the agricultural industry as a core precondition of national competitiveness and food security.

In our opinion, selection of innovative enterprises in order to provide its state support has to be based on need to increase efficiency of agricultural production without creation of additional barriers for non-state investment. Investment support of rural areas has to go both for increase in competitiveness of the agricultural industry, and for improvement of a business environment, providing cumulative effect which exceeds the total profit of certain innovative enterprises.

State can play a valuable role in promoting economic development of rural areas by providing financial support for innovative projects, which improve working conditions for farmers, provide social development of rural territories, decrease an outflow of qualified professionals from the rural areas, improve international image of the country as producer of environmentally friendly food. At the same time, state support programs should ensure that consistent innovation development of rural areas are focused towards potential profitability of innovative projects to support the competition among SME and to work within laws of market economy.

Conclusions. Summing up research it is necessary to notice that carried-out analysis proved uneven innovative development of Ukrainian regions, which differ in the level of human potential, aggregated R&D expenditures and effective implementation of innovative technologies. Though

each region includes territories with a high and low density of population, only industrial regions with high level of urbanization demonstrate long-term development of human and financial potential, high scientific and innovation activity. Therefore, according to necessity of innovative modernization of national economy, state economic policy has to provide financial support for SME, which create or implement innovation technologies and commercialize intellectual property at regional level.

State support of rural areas have to promote partnership among all stakeholders in undertaking innovative activity to increase economic performance and profitability of SME, develop environmentally friendly technologies, improve organization and management of product and process innovations. Special purpose public authorities should carry out estimation of innovation projects and provide support, financial provision, assistance and accompaniment of selected projects to promote cooperation between researchers, consultants and entrepreneurs. Acceleration of diffusion of innovations in the regions of Ukraine demands earmarked state funding of innovative activities in rural areas based on the principles of public-private partnership. Topicality of the issue of diffusion of innovations in Ukraine testify necessity of further theoretical and practical research of innovation activity of regional SME, which exert considerable impact on business environment and social development of regional economies.

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Стаття рекомендована до друку 10.09.2018

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The article is recommended for printing 10.09.2018

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