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ASSESSMENT OF IMPORTANCE OF ACADEMIC SOCIETY DEVELOPING SECTOR OF HIGH TECHNOLOGY

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Abstract. The author of the presented paper aims at discovering the main patterns of the development of the sector of high technology in the context of social, economic and technological progress in a context of internationalisation; to develop and prove the suggested methodology necessary to assess the importance of academic society in the process of the development of the sector of high technology. Main theories dedicated for the development of the sector of high technology are analysed here. Theoretical assumption to use human development index for the measurement of country's ability to develop the sector of high technology on example of EU is also discussed and examined here, too. As a result, the author determines main aspects defining the assessment of importance of academic society on industrial, business, national and international levels of the process of high technology development.

Keywords: academic society, globalisation, high technology development, human development index, innovative process, internationalisation, sector of high technology.

Jel classification: F14, F18, F21, F23, F47, O1, O14, O15.

1. Introduction

Nowadays, cooperation between main areas of education, research and innovation represents the reality, which currently has been determined by processes of economic globalisation, business internationalisation and general challenges, which have been faced by the whole world in the last few years due to financial crisis. The scientific problem is related to the abundance of the research papers dedicated to the search of new factors of economic growth, demonstrating the predominance of high-technology economy in the future economies. On the other hand, many scientists see the opportunity to transform national economies into competitive knowledge based systems, which assures economic and social welfare. In this case, the importance of science and education is undoubted.

Thus, the focus on the problem of the development of the sector of high technology highlighted the importance of the process and the implementation of the alternative methods of the economic development, while the applied theoretical models could meet new challenges and requirements determined by:

– development of a common cultural, social, economic and information environment on the global scale;

– priorities for creation of the knowledge society and the knowledge economy;

– possibilities to respond to the needs, on one hand, related to the development of the high technologies in the state, on the other hand, required for the development of both – business and academic sector;

– international competition and the increasing pace of innovation processes.

The object of the scientific research includes the process of development of the sector of high technology.

The goal of the paper is to develop a theoretical model based upon the application of the methodology of complex evaluation of the process of development of the sector of high technology, designated for economic solutions, revealing the importance of academic society.

Methodology of research includes the analysis of scientific literature, the systematic review of scientific statements and empirical research results, comparison and synthesis. The main method applied in the paper is of logical and analytical character based on the analysis of the current situation enabling setting the main theoretical guidelines for performance evaluation methodology developing the high technology sector. Empirical studies conducted on the basis of the systems approach performing the correlation and regression analysis, cluster analysis, multicriteria analysis.

2. Impact of the processes of internationalisation on the development of the sector of high technology

There are ongoing discussion on the concepts of internationalisation and globalisation in the scientific literature. Some authors believe there are identical concepts showing different levels of world economy unification (Enders 2004; Ball, Lindsay, Rose 2008), others argue that internationalisation processes should be treated as series of measures to achieve the degree of globalisation in a certain area (Leask 2009). Scientists dealing with processes of internationalisation identify globalisation as the biggest benefit. Globalisation has become a popular term in social sciences as symbol of new era of economic and social life, characterised by gradual dissapearance of importance of national cultures, national economies and national borders (Hirst, Thompson 1999). Other authors (Cornford, Navarra 2008) argue that globalisation is a complex phenomenon, which may have an impact on social aspects, firstly, on national level. This process may be explained by following reasons:

– first, an absence of common and broadly accepted model of global economy. It is not clear what globalisation theory differs from the applicable international economic theory;

– second, lack of evaluation of the impact of globalisation on economic processes. Changes are treated casually, on the basis of sector internationalisation model and processes with global market forces dominance;

– third, lack of retrospective historical analysis of current changes. Investigated processes may be described as unique and unprecedented.

Thus, the processes of globalisation are treated in a different ways. Some authors agree that processes of internationalisation have common goals with processes of globalisation, but the meaning of internationalisation should be understood in a narrow way as part of processes of international economic cooperation. P. Hirst and G. Thompson (1999) propose two concepts – globalisation and economic globalisation, where the last term does not include cultural and political aspects, but is limited by participation of national and international institutions supporting processes of internationalisation.

Summing up, authors (Hirst, Thompson 1999; Gao 2009; Kong Wing Chow, Ka Yiu Fung, Lam, Sami 2011; Li 2010) distinguish following features of internationalisation:

– *inevitability of the processes of internationalisation*. The authors believe that the present economic situation is not unexpected. Its creation was determined by international economic situation and interdependence of the countries (Park 2001; Salter 2009; Mayer, Ottaviano 2008; Longhi, Nijkamp 2007; Watt 2009).

– *emergence of multinational enterprises and corporations*. The authors highlight that relatively small number of transnational corporations may be explained by different areas local advantages, characterised by wide range of financial resources, natural resources, concentrationa of manufacturing and market potential (Gornitzka, Langfeldt 2008);

– *mobility of capital and labour force on the global scale*. At the same time it is noted that industrial regions are characterised by high concentration of foreign direct investment and labour force (Belitz, Edler, Grenzmann 2006; Tronti 2007);

– *concentration of economic activity in some regions.* Authors distinguish four main regions with high concentration of consumers, invesment, financial revenue and trade: European countries, North America, Japan and China (Solberg, Durrieu 2006; Gao 2009; Kong Wing Chow, Ka Yiu Fung, Lam, Sami 2011; Li 2010);

– *exceptional importance of influential regions supporting processes of internationalisation*. These regions of the world, relatively called G4, coordinate global economic policy on financial and other markets (Hirst, Thompson 1999).

Summing up the definitions of internationalisation processes it can be concluded that the processes of internationalisation can be seen as a strategy or policy, focused on promotion of mobility, development and innovation, moving beyond the borders of one country (Ackers 2008), involving aspects of international trade and foreign direct investment (Mayer, Ottaviano 2008).

Processes of internationalisation are important in the context of high technology development: the sector of high technology has become an important factor in international trade balance (Teichler 2004; McIntyre 2005; Marginson, van der

Wende 2007; Rudzki 1995; Passera 2004; LiPuma 2006; Mohrman, Ma, Baker 2008; Ackers 2008; Mayer, Ottaviano 2008).

Scientists analysing processes of internationalisation in a terms of technological development, note, that use of technology raises productivity in all sectors of economy (Welfens, Vogelsang 2008). The reasons are following:

– technology enhances cost optimisation and processes of activity coordination, and decreasing costs increase productivity (Bresnakan, Trajtenberg 1995);

– technology allows to offer new products or services to the market, emphasizing easy to use, time saving, quality and other advantages (Brynjolfsson, Dick, Smith 2010);

– technology leads to positive change not only internally, but also externally (*spillover-effects*), which promotes faster knowledge exchange (Roemer 1997);

– technology promotes experience, knowledge and technology exchange between different industries, which increases variety of production (Welfens, Vogelsang 2008).

The analysis of theoretical aspects highlights the high technology development as a key factor to combine the economy priorities and the interests of social classes worldwide.

Summing up the theoretical analysis of scientific sources, the majority of scientiests evaluates the process of deveopment of sector of high technology on different levels of the processes of internationalisation:

– national level, revealing inner opportunities based on the analysis of macroeconomic factors (Tvaronavičienė, Grybaitė, Korsakienė 2007; Tvaronavičius, Tvaronavičienė 2008; Lapinskienė, Tvaronavičienė 2009);

– regional level, showing synergy effect of cooperation between several countries developing the sector of high technology (Melnikas 2002);

– international level, analysing the common tendencies of the investigated process worldwide (Snitka 2002).

2.1. Problematic aspects of theoretical description of the high technology development

The concept of the sector of high technology and its development may be understood in the broad sence; however, the majority of the scientists distinguishs following features:

– short life cycle of the production on the market (Gardner, Johnson, Lee, Wilkinson 2000);

– difficulties implementing results of the sector of high technology in practice and the manufacturers risk (Gardner, Johnson, Lee, Wilkinson 2000);

– dependance on scientific and technological level (Sahadev, Jayachandran 2004);

– dependance on the current infrastructure (Sahadev, Jayachandran 2004).

The first concepts of the sector of high technology and the high technology development are discovered in the papers of Hymer (1960), Vernon (1966), Dunning (1977), Johanson and Vahne (1977). The above mentioned authors describe the sector of high technology as a specific type of industry, which depends on the processes of exchange in the international economy. Thus, U.S. Office of Technology Assessment in its edition *Technology, Innovation, and Regional Economic Development* (1984) provides one of the first definitions of the sector of high technology and defines it as industries, involved in the process of new product design, development and launch into the market applying scientific and technical knowledge.

The Organization of Economic Development and Cooperation (OECD) recognizes those high technology industry areas, where research and development are significant in promoting sales of final outputs such as: air industry, the pharmaceutical industry, computers and office equipment, communication tools, and the scientific (medical, precision measurement, optical) measures (Lioshky 2009). Similarly, the National Science Fundation of the United States of America indicates two main criteria necessary for development of high technology sector (National Science Foundation 2009):

– skilled labor force which is understood as occupational employment, and the percentage of particular occupations within industries change over time, reflecting upon the changes in employment growth, as well as the business structure;

– research intensity, where data is derived from studies of publicly traded companies is known as R&D dollars as a percent of total sales.

The other problem is related to the evaluation of the resuts of the sector of high technology. Thus, Gardner, Johnson, Lee, Wilkinson (2000) see the result of the sector of high technology as modern and innovative *production*, based on the research, scientific and technological application. On the other hand, according to Bozkaya, Romain, Potterie (2003) the sector of high technology is focused on the use of modern technologies in the process of manufacturing and service, where the functional performance requires the participation of highly-skilled labour force.

Summing up, the high technology development may be understood as a continuous process important for economic growth and social stability. The analysis of theoretical aspects highlights the high technology development as a key factor to combine the economy priorities and the interests of social classes worldwide.

2.2. Importance of academic society developing sector of high technology

The main theoretical models of high technology development were created over the last decade of the previous century. The most popular, Triple Helix Model of high technology, represents a spiral model of innovation that represents relationships at different points in the process of knowledge capitalization (Etzkowitz, Gulbrandsen, Levitt 2000; Etzkowitz 2002; Wessner 1999). The model consists on three autonomous helices and determines processes related to innovation and high technol-

ogy development by cooperation between the academic society, public institutions and the business sector.

Analysis of other theoretical models (Boyer, Arnalble, Barre 1999; Viale, Campodall'Orto 2000; Casas, Gortari, Santos 2000; Feinson 2003; Marton 2006; Steen, Liesch 2007; Longhi, Nijkamp 2007) has underlined that the essential assumption ensuring a successful development of the sector of high technology is related to the cooperation of industrial, business and academic areas on national level, and possible demerits may be compensated by stimulating enhancement of internationalisation processes, supporting mobility of two factors of production – labour force and capital – on international level.

Moreover, global, national, regional and local innovation systems (such as cluster of industries) with the support from the side of educational and training system are the main building blocks of the "New growth theory" (OECD 1999).

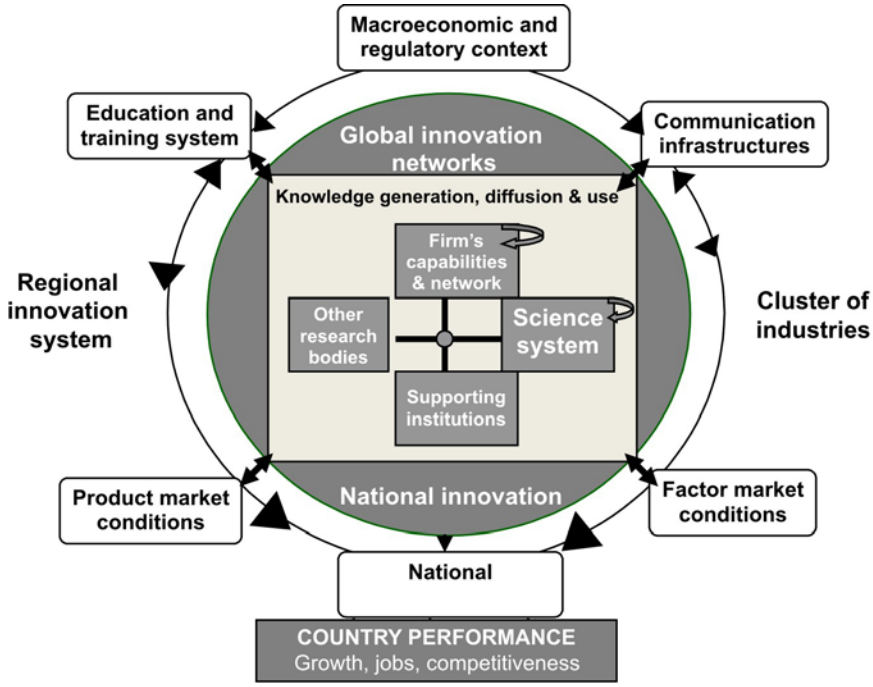

Fig. 1. Model of "New growth theory"
(Source: OECD, Managing National Innovation Systems, 1999)

"New growth theory" reflects the attempt to understand the role of knowledge and technology in driving productivity and economic growth. In this view the key elements are:

– investments in research and development;

– education and training;
– new managerial work structures.

The model of "New growth theory" shows the relationship between the main actors of knowledge-based economy, i.e. enterprises, universities, government and other public research institutions, and the variety of some specific factors such as the industry structure, the education and training system, the human resources and the labour market, the financial system, etc. Using the model, it is possible to identify the main building blocks of a "knowledge system". In this system, science, technology or innovations and industry are central but not sufficient to ensure economic growth, competitiveness and job creation. Therefore, the education and training system, human resources and the labour market, and the financial system all have a substantial impact on the performance of the chain 'Science-Technology-Industry'.

Summing up, many scientists see the opportunity to transform national economies into competitive knowledge based systems, which assures economic and social welfare. The role of science and education is undoubted. From this perspective, the performance of an economy depends not only on how the individual institutions perform, but also on how they interact with each other as elements of a collective system of knowledge creation. Such interactions between various institutions are possible within the well-developed educational and training system, which ensures the inter-connection between all three elements: science, technology and industry.

3. Research methodology

The theoretical analysis of the process of the development of the sector of high technology stresses that the cooperation between highly qualified labour force, academic area, business sector and institutions is the key to the successful innovative process in economy. In other words, the development of the sector of high technology is the result of complex set of relationships among actors in the system, which includes enterprises, universities and government.

An understanding of each element of the system can help identify leverage points for enhancing innovative performance and overall high technology development. It can assist the strongest and the weakest links within the process of the development if the sector of high technology. The methodology which seeks to evaluate the readiness of each element of the system dedicated for the enhancement of the development of the sector of high technology is the most valuable in the context of internationalisation involving the increasing mobility of highly skilled labour force and capital and, as the result, assimilation of conditions in order to develop the sector of high technology worldwide.

3.1. The measurement and assessment

The measurement and assessment of the development of the sector of high technology consist of two parts.

The first part is dedicated to the analysis of the impact of the combination of gross domestic product and human development index on country's readiness to develop the sector of high technology. The cluster analysis here is in use.

The second part is dedicated to reveal the main aspects defining the process of the development of the sector of high technology. The process of the development of the sector of high technology splits into four stages: 1) *industrial level*, characterised by the number of patents per mln. Inhabitants; 2) *business level*, characterised by the number of innovative enterprises in the country; 3) *national level*, characterised by the turnover of the sector of high technology; and 4) *international level*, focusing on the share of the sector of high technology in the world export. The methodology of variation of economic phenomena based of correlation analysis and dispersion calculation is in use here.

It is assumed, that attempts to link these aspects defining the process of the development of the sector of high technology will show that improved innovative capacity of enterprises in terms of products, patents and productivity contribute to the high performance of the country on international level in terms of world export of the sector of high technology (Ambrusevič 2012).

4. Results of empirical research

Performed comparative analysis of macroeconomic factors affecting the development of high technology sector has confirmed the idea of four levels of assessment: national (number of patents), business (number of innovative enterprises), industrial (turnover of production of high technology sector), international (share of export of the sector of high technology in the country‘s export) (Ambrusevič 2010).

Performed comparative analysis of sources, dedicated to the high technology sector development has justified the inclusion of economic freedom index and human development index into suggested methodology of evaluation of the development of the sector of high technology. Conducted correlation analysis of 169 world countries between gross domestic product per capita and human development index has shown, that choosen criteria are statistically correct and may be implemented in further analysis (correlation coeficient 0,6519) (Ambrusevič 2012).

Cluster analysis based on revealing the spaces of humen development index has identified four groups of countries in the European Union. Each group of country may be identified regarding the average, minimal and maximal value of gross domestic product per capita, common for all countries of the certain group. Regarding the results the first cluster includes Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Finland and Sweden; second – Czech Republic, Estonia, Cyprus, Hungary, Malta, Slovenia, Slo-

vakia, United Kingdom; third – Latvia, Lithuania, Poland, Portugal, Romania; fourth cluster – Bulgaria (Ambrusevič 2012).

The established clusters are being compared on four levels of assessment of high technology development: national (number of patents), business (number of innovative enterprises), industrial (turnover of production of high technology sector), international (share of export of the sector of high technology in the country's export).

Table 1. Evaluation of dependance of high technology sector development factors on clustering features

Index space	Number of countries	Number of patents per mln. inhabitants	Intergroup dispersions	Average number of innovative enterprises (%)	Intergroup dispersions	Average turnover of the sector of high technology (%)	Intergroup dispersions	Average of share of the sector of high technology in the world export, %	Intergroup dispersions
0,850–0,900	13	140,2	6357,28	18,82	31,02	3,82	10,51	1,87	4,49
0,800–0,849	8	21,76	660,71	13,13	13,11	3,09	9,78	0,94	3,53
0,750–0,799	5	3,67	6,36	8,02	5,56	1,16	0,15	0,08	0,004
0,700–0,749	1	1,45	0	8,30	0	0,82	0	0,02	0
General dispersion		7286,977		38,531		9,1147		3,7285	
Determination coefficient		0,5529		0,4849		0,1239		0,1395	
Empirical correlation ratio		0,7436		0,6963		0,3520		0,3735	

The calculation has shown that the variation of the index space have the greatest impact on the number of patents per mln. inhabitants, which defines the industrial level of the development of the sector of high technology (determination coefficient 0,5529), and the number of innovative enterprises, which defines business level of the development of the sector of high technology (determination coefficient 0,4849). Therefore, the research revealed that the variation of the index space is appropriate for predictions regarding two parameters characterizing the development of the sector of high technology in the European Union: the number of patents per mln. inhabitants (empirical correlation ratio 0,7436) and the number of the innovative enterprises (empirical correlation ratio 0,6963).

In order to establish alternative aspects, important for the evaluation of development of the sector of high technology, multicriteria analysis was in use.

Table 2. The comparison of EU countries' high technology sector factors (prepared by author)

Countries	a)	b)	c)	d)	e)	f)	g)	Relative signifi-cance	Rating
Weights	0,25	0,15	0,20	0,05	0,05	0,15	0,15		
Belgium	6263	2005	1,30	0,16	0,41	55 204	2212	0,0324153	11
Bulgaria	140	80	0,15	0,28	0,05	16 321	1093	0,0074113	23
Czech Republic	1955	774	0,98	0,29	0,26	47 729	1802	0,0220619	12
Denmark	5779	1790	1,65	0,18	0,70	44 878	1253	0,0338380	10
Germany	61 240	18 405	1,77	0,35	0,41	487 260	16915	0,1812858	1
Estonia	174	78	0,54	0,10	0,48	4741	266	0,0091223	21
Ireland	2501	995	0,88	0,09	0,35	17 660	827	0,0171468	15
Greece	1311	673	0,15	0,12	0,29	35 140	1546	0,0115372	19
Spain	13 342	11 141	0,71	0,22	0,33	188 978	8621	0,0710541	4
France	39 369	14 442	1,31	0,34	0,40	363 867	11084	0,1279755	2
Italy	16 831	9099	0,56	0,21	0,34	192 002	8723	0,0705180	5
Cyprus	70	65	0,10	0,12	0,19	1226	160	0,0035305	26
Latvia	126	68	0,21	0,15	0,27	6520	395	0,0059823	25
Lithuania	233	96	0,23	0,17	0,41	11 443	625	0,0079781	22
Luxem-bourg	591	142	1,36	0,22	0,05	4377	94	0,0150350	18
Hungary	977	329	0,49	0,23	0,23	25 971	1409	0,0132831	17
Malta	32	11	0,39	0,02	0,19	861	43	0,0046469	27
Nether-lands	9666	3990	1,03	0,22	0,45	96 861	3872	0,0437456	8
Austria	6946	1870	1,81	0,13	0,62	49 377	1423	0,0362975	9
Poland	1513	980	0,18	0,21	0,17	73 554	5269	0,0216966	13
Portugal	1921	1116	0,61	0,11	0,35	30 160	1118	0,0159731	16
Romania	653	435	0,22	0,18	0,13	30 802	2112	0,0113756	20
Slovenia	529	226	0,94	0,36	0,24	9793	374	0,0147863	14
Slovakia	252	150	0,18	0,16	0,11	15 028	804	0,0065149	24
Finland	6243	1730	2,51	0,29	0,65	58 257	1257	0,0430821	7
Sweden	12 063	2671	2,64	0,22	0,77	78 715	2105	0,0550521	6
United Kingdom	34 037	14 124	1,08	0,18	0,46	323 358	11626	0,1166542	3
Total								1,000000	

By using multicriteria evaluation following alternative criteria has been rised:

a) expenditure on research and development;
b) expenditure of national budget on social and economic needs;
c) share of expenditure on business enterprise sector (percentage of GDP);
d) share of expenditure on government sector (percentage of GDP);
e) share of expenditure on higher education sector (percentage of GDP);
f) research and development personnel;
g) human resources in science and technology.

Results of evaluation of the set of alternative criteria revealed that estimated countries rating coincids countries performance on international level by comparing countries share of high technology export in the world trade. This proves that set of criteria is appropriate for assessing processes of high technology development.

Table 3. Estimation of correlation between multiple indicators and attributes of evaluation

Criteria		Expenditure on R&D	Expenditure of national budget on social and economic needs	Share of expenditure on business enterprise sector (% of GDP)	Share of expenditure on government sector (% of GDP)	Share of expenditure on higher education sector (% of GDP)	Research and development personnel	Human resources in science and technology
Number of patents	r	0,9378	0,83093	0,360215	0,465149	0,208442	0,888236	0,850273
	t	13,506	7,467325	1,930685	2,627268	1,065618	9,667599	8,077209
Number of innovative enterprises, %	r	0,1566	0,018847	0,701205	0,056859	0,407077	0,045678	-0,07308
	t	0,7928	0,094253	4,917558	0,284756	2,228376	0,228630	-0,36635
Average turnover of the sector of high technology, % of GDP	r	0,1018	0,04728	0,439899	0,243444	0,290417	0,067754	0,013543
	t	0,5116	0,236662	2,449199	1,254975	1,51749	0,339550	0,067723
Average of share of the sector of high technology in the world export, %	r	0,9184	0,853343	0,376821	0,401527	0,269722	0,890322	0,84281
	t	11,606	8,183983	2,034044	2,192108	1,400518	9,776647	7,829729

$t_{stat..}$ = 2,0595

Combined use of factors, describing different stages of the process of high technology development, and set of alternative criteria, having impact on the market of high technology, may be in use by analysing importance of academic society for the investigated process. The established correlation shows that such aspects of academic research and development personnel and human resources in science and technology are important for industrial (number of patents) and international level (average share of the sector of high technology in the world export) of the process of development of the sector of high technology.

5. Conclusions

On the basis of empirical studies assessing countries potential developing high technology sector there is suggested to evaluate number of patents reflecting sec-

tor‘s capacity, number of innovative enterprises reflecting business capacity, turnover of high technology trade reflecting national capacity and share of high technology in national export representing international level of high technology development. The triple helix model, encouraging deeper cooperation between government, business sector and academic society, is being detalized with significant criteria, identified by the results of the method of multicriteria evaluation:

a) expenditure on research and development;
b) expenditure of national budget on social and economic needs;
c) share of expenditure on business enterprise sector (percentage of GDP);
d) share of expenditure on government sector (percentage of GDP);
e) share of expenditure on higher education sector (percentage of GDP);
f) research and development personnel;
g) human resources in science and technology.

Results of evaluation of set of criteria in the example of the European Union have revealed that established ranks of countries meet tendencies of high technology development on international level by analysing share of high technology sector in world export.

Combined use of factors, describing different stages of the process of high technology development, and set of alternative criteria, having impact on the market of high technology, may be in use by analysing importance of academic society for the investigated process. There is established, that academic research and development personnel and human resources in science and technology are important for industrial (number of patents) and international level (average share of the sector of high technology in the world export) of the process of development of the sector of high technology in the European Union.

Performed empirical evaluation of theoretical guidelines of the method assessing the process of the development of the sector of high technology on the example of the countries of European Union has shown that suggested methodology can be implemented in practice in comprehensive evaluation of the development of the sector of high technology in different countries and regions.

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