Research Paper

Internationalisation Processes Developing Sector of High Technology in the European Union: Cluster Analysis

NIKOLAJ AMBRUSEVIC

Corresponding author: nikamb@ism.lt

ISM University of Management and Economics, Lithuania

Henley Business School, University of Reading, United Kingdom

nikolajambrusevic.ambrusevic@henley.ac.uk

About the author

Nikolaj Ambrusevic is an experienced educator lecturing Marketing, Management, International Business and Economics. Nikolaj holds a PhD in Economics and has two Master's, in Business Administration and in International Law. He works as an Associate Professor at several higher education institutions in his home country, Lithuania, and is a visiting lecturer at Henley Business School at the University of Reading, United Kingdom. Previously, he worked for multinational and global market intelligence companies specializing in technology, automotive, travel, construction, oil & gas mining, and other industrial verticals across CEE & CIS countries. He is the author of multiple articles and proceedings at international conferences and investigates the internationalisation process of high technology development.

Abstract

The author of the paper aims at discovering the main patterns in order to evaluate the impact of the internationalisation process of high technology development in the context of social, economic and technological progress, and to develop and prove that the suggested methodology is necessary to assess the importance of specific social, economic and technological changes. Main theories explaining the development process of the high technology sector are analysed here. Theoretical suggestion is also discussed to use the combination of the human development index and other economical factors in order to measure a country's abilities in high technology sector development in EU. Cluster and multicriteria analyses are used for examination in this study, too. As a result, the author determines the main aspects defining the assessment of importance of certain processes of internationalisations on industrial, business, national and international levels of the process of high technology development.

Keywords: Internationalisation, High technology development, Human development index, Sector of high technology, Cluster analysis

Introduction

Many economists and scientists agree that the sector of high technology is the long term driver of economic growth, and national economies flourish when societies create conditions in which new sources of wealth and work are created. It is a well-known fact that innovative companies of the sector of high technology gain a larger market share, add more value and create more new jobs than other companies. Nowadays the major trends in high technology sector development may be characterised by increased scope of globalisation and, as result, information exchange, rapid scientific changes and diffusion of new technologies, forced by new customer preferences.

Despite the importance of the high technology development, the European Union is facing a big challenge here. When it comes to technological innovation, Europe is now lagging behind not only the US and Japan, but also China (Tsanova and Havenith, 2019). Thus, the clear understanding and evaluation of main trends related to the development of the sector of high technology and supporting international competition in innovation processes becomes extremely important.

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, and multicriteria analysis.

Meaning of the Internationalisation Process in the Globalised World

Regarding J. Enders (2004) the terms of '*internationalisation*' and '*globalisation*' became popular in the beginning of the last decade of the XX century. There is a heated debate on describing the processes of internationalisation and the concept of globalisation in scientific literature nowadays. According to some authors, these are identical concepts expressing varying degrees of unification of the world economy or its individual spheres (Enders, 2004; Ball, Lindsay and Rose, 2008). Other authors tend to differentiate the meanings and highlight that the processes of internationalisation must be treated as a set of measures to achieve the level of globalisation in a particular area (Leask, 2009).

Currently, the scientific literature is focused on the following aspects of internationalisation processes:

- internationalisation processes in the context of globalisation (Wach, 2014);
- implementation of measures to promote internationalisation processes;
- internationalisation processes in the context of technological advances;

- internationalisation processes that promote international trade;
- activities of multinational companies and their influence on internationalisation processes;
- activities of transnational organisations promoting the internationalisation of national markets.

Although the vast majority of scientists and economists in economic theory and practice agree on the inevitability of globalisation of the world economy (Park, 2001; Salter, 2009), the process of examining economic internationalisation reveals aspects that some authors assign to threats and challenges, and others - to natural forms of international economic cooperation. The main forms of economic internationalisation are being distinguished regarding two main criteria for their assessment:

- The involvement of public authorities in the global economy in a global context (Mayer and Ottaviano, 2008);
- The social nature of internationalisation processes as a result of international economic trends (Longhi and Nijkamp, 2007; Watt, 2009).

Impact of the Processes of Internationalisation on High Technology

Sector Development

High-tech issues attracted the attention of researchers five decades ago in order to find new ways to increase the competitiveness of globalised economy. The research of Hymer (1960), Vernon (1966), Dunning (1977) and Johanson & Vahne (1977) is significant for this period of time. The results of these studies allowed the sector of high technology to be defined as an industry whose development is characterised by an element of internationalisation and orientation towards international trade. Authors of subsequent research papers such as D'Avenie (1994), Roberts and Malone (1996), Carayannis, Rogers, Kurihara and Allbritton (1998), Loane (2005), Carter and Jones-Evans (2006), highlighted the most effective directions for high-tech development: industrial innovation and additional funding for its commercialisation.

The challenges and demands posed by internationalisation processes might be seen at different levels of the modern economy, and it is therefore appropriate to examine the development of the sector of high technology in three ways:

- On a global scale, where the impact of the sector of high technology affects all economic and social aspects, and its valuation is significant in predicting global trends;
- On an industrial level, while assessing the impact of the sector of high technology in different regions of the world;
- On a national level, when identifying the importance of the sector of high technology for a particular country.

Empirical Research Methodology: Cluster Analysis

The process of evaluation of the sector of high technology in an example of the European Union consist of two parts.

The first part is dedicated to the distinguishing main economic and social factors having impact on countries' performances developing sector of high technology. By using COPRAS multicriteria evaluation (Podvezko, 2011) following set of alternative criteria has been raised:

- a) expenditure on research and development (percentage of GDP);
- b) expenditure on social protection (percentage of GDP);
- c) share of GERD (Gross domestic expenditure on R&D) financed by business enterprise sector (percentage of GDP);
- d) share of GERD financed by government sector (percentage of GDP);
- e) share of GERD on higher education sector (percentage of GDP);
- f) research and development personnel (as percentage of total labour force);
- g) persons employed in science and technology (as percentage of active population).

The second part of the research is dedicated to reveal the impact of chosen economic and social criteria on 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 here: 1) *industrial level*, characterised by the number of community design applications to the EUIPO (European Union Intellectual Property Office) per mln. inhabitants; 2) *business level*, characterised by the number of innovative enterprises as a share of all enterprises in the country; 3) *national level*, characterised by the innovation turnover as a share of total turnover; and 4) *international level*, focused on the exports of medium- and high-technology products as a share of total product exports. The methodology of variation of economic phenomena based of correlation analysis and dispersion calculation is in use here.

It is assumed, that the complex evaluation of the aspects defining the process of the development of the sector of high technology will confirm that the improved innovative capacity in terms of patent applications, growing number of innovative enterprises and their productivity contributes to the high performance of a country on international level in terms of increasing exports of medium- and high-technology products.

Results of Empirical Research

Cluster analysis based on revealing the spaces of human development index has identified four groups of countries within the European Union.

Each group of the countries may be identified regarding the average level of the index and the value of Gross Domestic Product per capita.

Regarding the results the first cluster includes Ireland, Germany, Sweden, the Netherlands, Denmark,

Table 1 Clusters Based on HDI and Average GDP Per Capita Data

Country	Human Development Index	GDP per capita, USD
Ireland	0.938	78,785
Germany	0.936	52,559
Sweden	0.933	52,984
Netherlands	0.931	56,383
Denmark	0.929	52,121
United Kingdom	0.922	45,705
Finland	0.920	46,430
Belgium	0.916	48,245
Austria	0.908	52,137
Luxembourg	0.904	106,705
France	0.901	45,775
Slovenia	0.896	36,746
Spain	0.891	40,139
Czech Republic	0.888	37,371
Italy	0.880	39,637
Malta	0.878	45,606
Estonia	0.871	34,096
Greece	0.870	29,123
Cyprus	0.867	39,973
Poland	0.865	31,939
Lithuania	0.858	34,826
Slovakia	0.855	35,130
Latvia	0.847	29,901
Portugal	0.847	32,006
Hungary	0.838	31,903
Croatia	0.831	26,221
Bulgaria	0.813	23,156
Romania	0.811	26,447

Sources: United Nations Development Programme Human development report 2018, International Monetary Fund

the United Kingdom, Finland, Belgium, Austria, Luxembourg, and France; second – Slovenia, Spain, Czech Republic, Italy, Malta, Estonia, Greece, Cyprus, and Poland; third – Lithuania, Slovakia, Latvia, Portugal, and Hungary; fourth cluster – Croatia, Bulgaria, and Romania.

The calculation has shown that the results of the cluster analysis have the greatest impact on the number of innovative enterprises, which defines the business level of the development of the sector of high technology (determination coefficient 0.64). Therefore, the research revealed that the variation of the index space is appropriate for predictions regarding one parameter characterising the development of the sector of high

Table 2 Comparison of Clusters HDI and Average GDP per Capita Data

Cluster (number of countries)	HDI frames	Average GDP per capita, USD	Minimal GDP per capita, USD	Maximal GDP per capita, USD
1 (11)	0.922	57,984	45,705	106,705
2 (9)	0.878	37,181	29,123	45,606
3 (5)	0.849	32,753	29,901	35,130
4 (3)	0.818	25,275	23,156	26,447

Table 3 Evaluation of Dependence of High Technology Sector Development Factors on Cluster Features (Prepared by Author)

Cluster	Number of countries	Patents, average	Intergroup dispersion	Enterprises, average	Intergroup dispersion	Turnover, average	Intergroup dispersion	Export, average	Intergroup dispersion
1	11	56.55	2178.98	58.88	25.57	11.57	21.15	53.82	42.59
2	9	32.44	506.25	39.39	88.11	10.14	16.41	51.98	169.10
3	5	13.60	43.84	36.04	122.67	10.36	25.23	49.20	261.61
4	3	8.67	36.22	26.20	148.82	5.40	45.34	42.10	267.23
General dispersion		1370		214.24		26.16		158.90	
Determination coefficient		0.25		0.64		0.12		0.08	
Empirical correlation ratio		0.4978		0.8027		0.3505		0.2801	

technology in the European Union: the number of the innovative enterprises (empirical correlation ratio 0.8027).

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

where:

- expenditure on research and development (percentage of GDP);
- expenditure on social protection (percentage of GDP);
- share of GERD financed by business enterprise sector (percentage of GDP);
- share of GERD financed by government sector (percentage of GDP);
- share of GERD on higher education sector (percentage of GDP);

- f) research and development personnel (as percentage of total labour force);
 g) persons employed in science and technology (as percentage of active population).

Table 4 The Comparison of EU Countries' High Technology Sector Factors (Prepared by Author)

Countries	a)	b)	c)	d)	e)	f)	g)	Relative significance	Rating
Weights	0.25	0.15	0.20	0.05	0.05	0.15	0.15		
Belgium	2.49	19.6	58.6	22.5	2.0	1.67	22.4	0.0445567	6
Bulgaria	0.96	12.5	43.6	21.8	0.1	0.71	18.7	0.0301735	16
Czech Republic	1.93	12.0	39.5	35.6	0.8	1.33	25.2	0.0359149	12
Denmark	2.87	22.4	59.4	29.4	0.0	2.18	18.1	0.0517844	2
Germany	2.94	19.4	65.2	28.5	-	1.62	30.5	0.0528665	1
Estonia	1.49	13.0	48.2	37.6	0.3	0.91	25.5	0.0337873	15
Ireland	1.18	9.5	48.4	25.9	1.5	1.33	16.2	0.0295481	20
Greece	0.99	19.4	40.2	42.6	2.3	1.03	10.1	0.0267201	24
Spain	1.19	16.6	46.7	40.0	4.4	0.96	16.6	0.0295566	19
France	2.22	24.3	55.7	34.6	1.0	1.48	23.7	0.0440712	7
Croatia	0.84	14.3	42.9	41.4	4.8	0.65	13.1	0.0261226	25
Italy	1.29	20.9	52.1	35.2	0.9	1.15	17.6	0.0342141	14
Cyprus	0.50	13.0	34.9	41.1	4.6	0.36	14.1	0.0232173	26
Latvia	0.62	11.7	21.6	47.7	2.9	0.57	26.4	0.0222678	27
Lithuania	1.04	11.2	39.0	39.2	2.4	0.82	23.9	0.0267586	23
Luxembourg	1.24	18.4	47.1	47.7	1.6	1.86	32.2	0.0385340	10
Hungary	1.36	14.0	56.4	26.2	-	0.89	19.1	0.0351460	13
Malta	0.77	11.3	54.5	33.4	1.3	0.66	26.6	0.0282824	21
Netherlands	2.03	15.9	52.0	31.3	0.1	1.57	20.2	0.0410174	9
Austria	3.09	20.5	53.1	30.4	0.0	1.76	25.6	0.0513535	3
Poland	1.00	16.4	53.1	38.9	2.4	0.85	20.8	0.0296218	18
Portugal	1.27	17.4	44.4	42.6	3.7	1.11	16.2	0.0297631	17
Romania	0.49	11.7	49.4	39.6	1.1	0.37	6.7	0.0201952	28
Slovenia	2.20	16.2	69.2	20.2	0.4	1.46	17.3	0.0439611	8
Slovakia	1.18	14.5	46.2	41.0	1.9	0.70	18.1	0.0277851	22
Finland	2.75	24.9	57.0	28.9	0.4	1.86	20.1	0.0495332	5
Sweden	3.25	20.2	61.0	28.3	0.9	1.69	24.9	0.0509485	4
United Kingdom	1.69	15.2	51.8	26.3	1.4	1.32	22.4	0.0364340	11
Total								1,000000	

Table 5 Comparison of EU Countries High Technology Sector Development Criteria

Criteria of high technology sector development	Community design applications to the EUIPO per million population		Number of innovative enterprises as a share of all enterprises (%)		Innovation turnover as a share of total turnover (%)		Exports of medium- and high-technology products as a share of total product exports (%)	
	result	place	result	place	result	place	result	place
Belgium	33	11	64.2	3	7.6	17	48.8	18
Bulgaria	17	19-21	26.1	24	4.8	26	32.1	27
Czech Republic	21	17	42.0	17	14.6	6	64.9	5
Denmark	80	3	49.5	13	7.0	18	48.3	20
Germany	40	9	67.0	1	13.3	7	68.0	3
Estonia	29	13	26.5	23	10.5	13	44.0	21
Ireland	16	22	61.0	4	18.1	3	52.6	14
Greece	6	26-27	51.0	12	12.8	8	22.5	28
Spain	20	18	36.4	21	15.9	4	48.4	19
France	25	15-16	56.4	7	15.0	5	59.2	7
Croatia	6	26-27	39.7	20	4.9	25	39.3	23
Italy	30	12	48.7	14	10.1	14	52.6	13
Cyprus	17	19-21	41.8	18	4.5	27	59.6	6
Latvia	25	15-16	25.5	26	5.3	24	35.1	26
Lithuania	10	23	43.3	16	8.6	16	35.3	25
Luxembourg	194	1	65.1	2	6.5	20-21	50.6	15
Hungary	7	25	25.6	25	12.5	9	70.3	1
Malta	89	2	41.2	19	4.1	28	70.1	2
Netherlands	45	7	55.3	8-9	10.8	12	48.9	17
Austria	50	6	59.5	6	12.0	11	57.8	9
Poland	39	10	21.0	27	6.4	22	49.6	16
Portugal	17	19-21	54.0	11	6.3	23	37.7	24
Romania	3	28	12.8	28	6.5	20-21	54.9	12
Slovenia	41	8	45.9	15	12.4	10	56.1	10
Slovakia	9	24	31.8	22	19.1	2	67.6	4
Finland	54	5	55.3	8-9	9.3	15	43.7	22
Sweden	58	4	54.2	10	6.9	19	55.1	11
United Kingdom	27	14	60.2	5	20.8	1	59.0	8

Source: Conducted by author based Science, Research and Innovation performance of the EU, 2018.

Results of evaluation of the set of economic and social criteria revealed that estimated countries rating coincides countries performance in human development index rating. This makes possible that set of criteria is appropriate for assessing the impact on combination of economic and social factors on processes of high

technology development.

The impact of established economic and social factors was compared on four levels of assessment of high technology development: industrial (number of community design applications to the EUIPO per million population), business (number of innovative enterprises as a share of all enterprises), national (innovative turnover as a share of total turnover), international (exports medium- and high-technology products as a share of total product exports). Resulting matrix facilitates decision making process of choosing appropriate funding structure in order to improve country's performance on different stages of high technology development.

Table 6 estimates the reliability for five selected economic and social factors included in the final analysis. As the result, the number of community design applications to the EUIPO per million population (industrial approach of high technology sector development) has statistically significant relations with the research and development personnel and the number of persons employed in science and technology; similarly, number of innovative enterprises as a share of all enterprises (business approach) has statistically significant relations with the research and development personnel, and with the expenditure on research and development and the expenditure on social protection; only one significant factor was established for the exports of medium- and high-technology products as a share of total product exports (international approach) the share of GERD financed by business enterprise. There is important to note that the innovation turnover as a share of total turnover representing national approach in the process of high technology sector's development has no significant correlations with the established economic and social factors.

Table 6 Estimation of Correlation between Multiple Indicators and Attributes of Evaluation

Criteria		a)	b)	c)	d)	e)	f)	g)
Community design applications to the EUIPO per million population	r	0.2445	0.2999	0.2498	0.0879	-0.2339	0.5318	0.5799
	t	1.2859	1.6029	1.3153	0.4502	1.2266	3.2022	3.6293
Number of innovative enterprises as a share of all enterprises (%)	r	0.6047	0.5316	0.3666	-0.2790	-0.1408	0.7598	0.3627
	t	3.8715	3.2007	2.0094	1.4814	0.7251	5.9595	1.9847
Innovation turnover as a share of total turnover (%)	r	0.2175	0.0466	0.1896	-0.2358	-0.2055	0.2141	0.0122
	t	1.1364	0.2381	0.9845	1.2372	1.0705	1.1179	0.0622
Exports of medium- and high-technology products as a share of total product exports (%)	r	0.2446	-0.0328	0.4575	-0.2829	-0.3130	0.0992	0.28849
	t	1.2863	0.1675	2.6237	1.5041	1.6806	0.5083	1.5364

$$t_{stat.} = 2.0555$$

Conclusions

Overview of theoretical statements and analysis of conducted scientific research confirmed the idea of four levels of assessment: industrial (community design applications to the EUIPO per million population), business (number of innovative enterprises as a share of all enterprises), national (innovation turnover as a share of total turnover), international (exports of medium- and high-technology products as a share of total product exports).

Results of evaluation of the set of economic and social criteria revealed that the estimated rating for those countries coincides their performance in human development. This makes it possible that the set of criteria is appropriate for assessing the impact on the combination of economic and social factors on processes of high technology development:

- a) expenditure on research and development (percentage of GDP);
- b) expenditure on social protection (percentage of GDP);
- c) share of GERD financed by business enterprise sector (percentage of GDP);
- d) share of GERD financed by government sector (percentage of GDP);
- e) share of GERD on higher education sector (percentage of GDP);
- f) research and development personnel (as percentage of total labour force);
- g) persons employed in science and technology (as percentage of active population).

As a result, the number of community design applications to the EUIPO per million population (industrial approach of high technology sector development) has statistically significant relations with the research and development personnel and the number of persons employed in science and technology; similarly, the number of innovative enterprises as a share of all enterprises (business approach) has statistically significant relations with the research and development personnel, and with the expenditure on research and development and the expenditure on social protection; only one significant factor was established for the exports of medium- and high-technology products as a share of total product exports (international approach) the share of GERD financed by business enterprise.

Empirical evaluation of the theoretical guidelines, suggested as a method to assess the development process of the high technology sector of the European Union countries, has confirmed its validity for comprehensive evaluation of the development process of the high technology sector in different countries and regions worldwide.

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