Modeling the Influence of Cluster Components on the Economic Development of a Territory

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Abstract **–The article examines the clusters with research centers/institutions as a core. The cluster model has been developed on the basis of the modified theory of "growth poles", taking into account the main provisions of the theory of "structures with direct and indirect relations". Based on a survey among representatives of science, business and government, calculated are the values of indicators of economic expectations of return on invested capital in basic and applied research. An economic and mathematical model has been developed and the dependence between GDP volumes and the level of research funding have been established. It is proved that in the conditions of the Ukrainian economy, research centers/institutions should be the center of the cluster and the start component of regional economic development.**

Keywords **– Cluster, science, business, government, development.**

1. Introduction

The study on the effectiveness of the formation and functioning of cluster systems is based on different theoretical provisions. Depending on the objectives of the research, as a rule, the following provisions are distinguished: "growth poles", "structures with direct and indirect relations", "agglomeration economy, "economic geography", "urbanization and regional economy", "national innovation system", "regional science", "industrial areas and social structures".

The results of the study presented in the article are based on a modified theory of "growth poles" Parr, taking into account the main directions of the theory of "structures with direct and indirect relations"[1]. At the same time, the cluster is considered as a dynamic, interrelated system of "the level of development of research - economic expectations/economic activity of business - institutional constraints". The resultant indicator of the functioning of the cluster is the dynamics of GDP/GRP. In practical context, the task is to form a new concept of the region's business climate based on the effective use of the component of the economic potential of regional socio-economic systems. The level of investment in basic and applied research is considered as one of the "growth poles" that complies with the main provisions stated in documents of the European Research Area (ERA) [2].

2. Literature review

The concept of the cluster was studied by the representatives of the neoclassical economic school. Alfred Marshall in his book "Principles of economics" determined the positive effect of the concentration of specialized industries in a particular area [3]. Companies that manufacture certain products were grouped by geography. In his study, Marshal concluded that the analyzed companies were linked by three main factors. These are a pool of work force, specialized suppliers and easy access to knowledge and information, and are known under the term of "Marshallian Trinity" [4].

Porter interprets the concept of a cluster as 'groups of companies and institutions co-located in a specific geographic region and linked by interdependencies in providing a related group of products and/or services' [5], [6],[7].

The definition of clusters is built on three key pillars [8]. The first pillar is geography. Clusters include companies by geographic proximity, which form clusters at the macro, regional or city levels.

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The second pillar is value creation. Clusters include enterprises of various industries. Companies manufacture products or provide services in order to meet the needs of consumers and make a profit [9], [10], [11]. The third pillar is business environment. The business environment represents the interaction and cooperation of government officials, small businesses, educational and research institutions and regional innovation system) [12], [13], [14].

The cluster is a strategic component of regional and national development policy. This is confirmed by the following provisions: new methods of competition appear inside the cluster. Accordingly, the competition contributes to the creation of innovation; clusters create conditions for the formation of innovative systems at the macro, regional and local levels; clusters contribute to the creation of more efficient mechanism of cooperation between the government and business; existence of enterprises of various industries in the cluster accelerates the creation of competitive advantages by investing in technology, infrastructure and education; relations inside the cluster ensure the development of outsourcing; internal competition contributes to the expansion of the cluster [15],[16],[17]. Formation and development of cluster provide integral advantages: improve the competitiveness of the economy; activate innovation and real coordination of the interests of authorities, business, science, and education at the local, regional and national level [18]. Cluster success factors are as follows: common goals, strategic thinking, team work for innovation, network co-operation [19].

Formation of a cluster can be a consequence of the so-called cluster initiative. Cluster initiative can occur at three levels: national, regional and local [20]. Cluster is a system that can be formed at the level of a state, a region and a city. It includes companies that manufacture products, government agencies, educational and research institutions [21].

3. Methods

The article highlights three stages of research. At the first stage, a correlation and regression analysis was carried out between the GDP components. The use of correlation and regression analysis for designing the economic development models was carried out by such authors Zakharkina, L et al. [22]. That is, dependence was established between investment in science, business and government at the state level.

Correlation and regression analysis of GDP and economic sentiment indicator became the second stage of the research based on the Methodology for calculating indicators of business expectations in accordance with the requirements of the expanded Special Data Dissemination Standard of the International Monetary Fund [23].

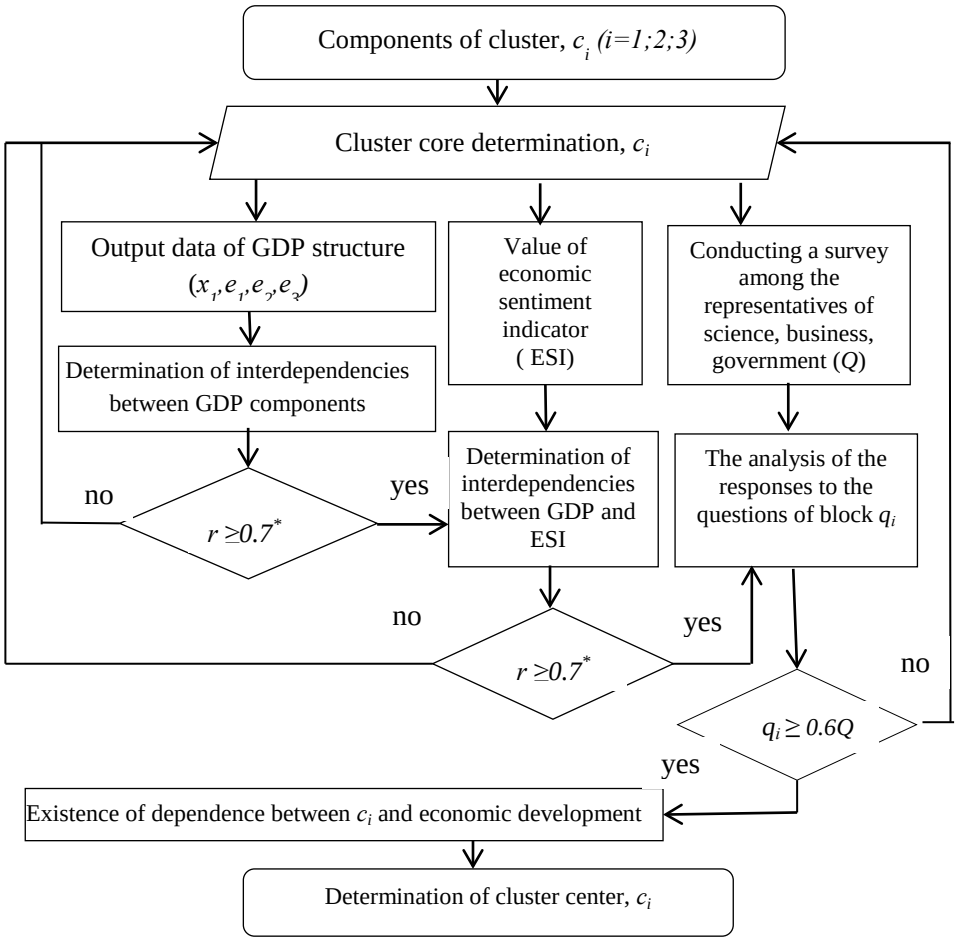
The cluster model of economic development within the city was used by Yang et al.,; Zhao J. et al. [24], [25]. The third stage was a survey among representatives of the city, as a local cluster. For this purpose, we used the method of interviewing while conducting a survey among the representatives of business, government and science within the cluster under study. The method of interviewing suggested by Telizhenko & Halynska,; Hu C. et al., was adapted to our study [26], [27]. The purpose of the survey is to determine the expectations of business activity and the role of science in economic development. According to the results of the study, the main expectation is science and it is the investments in research that contribute to the most efficient economic development of clusters of all levels.

Taking into account that we consider the cluster as a synergy of science, business and government, the article gives the results of the analysis of the interaction of these three components, and their influence on the development of the territory.

We believe that trends in the interaction of science, business and government at the national level are also inherent at the local level (region, city or particular territory where the cluster is formed). Analysis of the publications on the formation and financial development of clusters has shown that the determination of the cluster core should be a precondition. In particular, it is necessary to determine what component will be in the center of cluster formation in territorial development. Science, government or any field of business can be such a component [28], [29]. Figure 1. shows algorithm of cluster core determination.

We suggest considering the development of the cluster on the basis of determining the effect of investment in research (x_1). These researches are aimed at the implementation of new (technological, organizational, methodological, managerial, etc.) projects in business (e_1). This in turn will increase the effectiveness of business (e_2) and will contribute to the growth of investment in research from business (x_2).

In addition, the social rating and the effectiveness of the government (e_3) will increase in the territory. And this in turn will increase the amount of tax revenue. These taxes will be used for the development of infrastructure and the further costs of research incurred by the government (x_3).



*Notes: *) assessment scale of the strength of Chaddok's stochastic dependence is used for the assessment of the closeness of the interdependence between the values. According to this scale: if r ≥0.7- the dependence is close*

Figure 1. Algorithm of cluster core determination (Compiled by the authors)

Leal C. states «Intellectual capital is changing into a momentous issue for a firm's long-term profit and performance within the knowledge-based economy as a lot of corporations determine their core competence as invisible assets instead of visible assets» [30]. Taking into account the fact that the effect of the implementation of research takes a long period from the moment of development to the moment of obtaining the result, then in Figure 2. the dotted arrows indicate the effectiveness of future periods e'_1, e'_2 , e'_3.

At the same time, each new circle will increase the financial flows in the analyzed area more and more. In our opinion, such development is possible if science is the start component.

The synergistic interaction of science, business and government based on the cluster approach gives us a reason to consider the effectiveness of the development of the territory (E') as an arithmetic progression of investment in scientific research x_1 (Formula 1).

$$\begin{cases} E'_{t_0+t} = f(E_{t_0}) \\ E_{t_0} = f(x_1, x_2, x_3, e_1, e_2, e_3) \\ e_1 = \lim_{x\to\infty} \sum_{i=1}^{3} x_i \\ e_2 = e_1 + f(e_1) \\ e_3 = e_2 + f(e_2) \end{cases} \quad (1)$$

where E'_{t_0+t} – the effectiveness of development of the territory in the future period of time *t* in relation to the year the cluster was formed t_0 ; E_{t_0}– the effectiveness of development of the territory during the first period (year) of cluster formation t_0; x_1 – investment in research, which consist of self-financing at the expense of scientists and scientific organizations, funds of business enterprises and financial support of the government, USD.; x_2 – investment from enterprises and business organizations in research, USD.; x_3 – the costs of

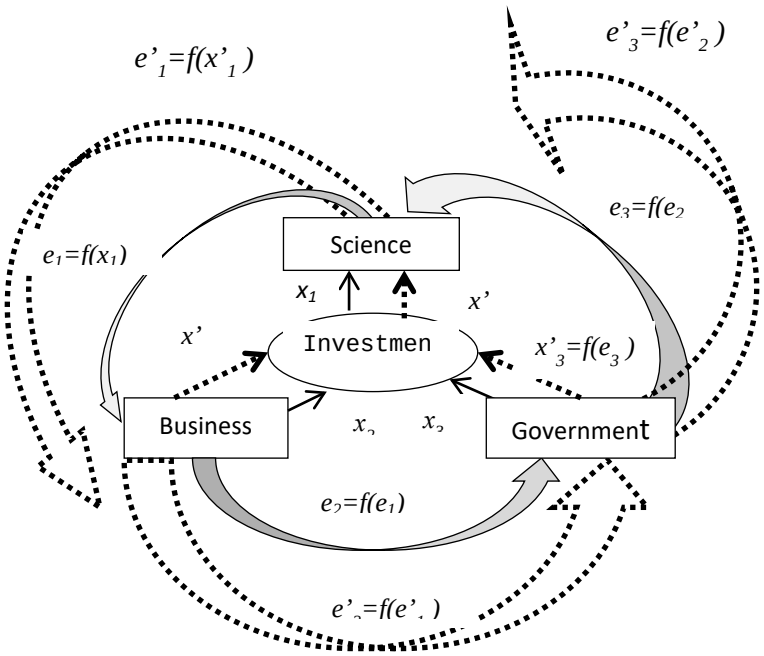


Figure 2. The scheme of the interaction and movements of investment based on the cluster approach (Compiled by the authors)

research incurred by the government, USD.; e_1 – effectiveness of research results (development of new technologies for business); e_2 – effectiveness of business activity due to the implementation of new technologies (making a profit of manufacturing non-resource-intensive, environmentally friendly and competitive products, budget replenishment with tax revenues); e_3 –the effectiveness of the results of the activities of the government (redistribution of financial revenues for the development of the infrastructure of the territory and further scientific funding).

4. Results

At the first stage, we define the GDP components, which characterize the economic development of the cluster components shown in Figure 2. Statistics data for Ukraine for 2012-2016 (in dollars) were used to determine the GPD components (x1, e1, e2, e3). Since the GDP indicator is an indicator of the country's economic development, we consider that the trend towards changes in GDP during the period under study is directly proportional to the trend of economic development of local levels (region, city). Therefore, based on the country's GDP and the GDP components, we will conduct a correlation and regression analysis on the dependence between the costs of science (x_1) and the effectiveness of business and government (e_1, e_2, e_3). The relevant components of GDP, which characterize this interaction, are shown in Table 1.

Table 1. GDP structure in Ukraine for the years 2012-2016 both in dollars

Indicator	Volume by year, (million USD)				
	2012	2013	2014	2015	2016
GDP (E)	175781	183310	131805	90615	93270
Taxes (e_3)	21785	22208	17016	14425	14428
Volume of goods turnover[1] (e_2)	312451	297445	226998	146817	151743
Gross profit from scientific and technical activities[1] (e_1)	1763	1933	1287	1150	1375
Costs of research conducting and developments[1] (x_1)	1135	1235	791	502	450

Notes: [1] Compiled by author based on State Statistics Service of Ukraine [23],[31].

The results were obtained based on the correlation and regression analysis (Table 2.). The results of the analysis indicate the existence of a correlation relation between studied components. The correlation coefficients r are greater than 0.85 and are close to 1. This indicates a high degree of direct linear relation between GDP components during the observation period. The determination coefficient shows that the variation of Y is caused by the

variation of X by 76-99% for the studied components of GDP.

Table 2. The results of the assessment of the interdependence of GDP volume and its components in Ukraine for the years 2012-2016

Studied dependence Y=f(X)	The results of correlation and regression analysis		
	Equation of pairwise linear regression	Linear correlation coefficient, r	Determination coefficient, r^2
$E=f(e_3)$	$E=-70293.9+ 11.4e_3$	0.994	0.989
$e_3=f(e_2)$	$e_3=7014.2+ 0.08e_2$	0.984	0.968
$e_2=f(e_1)$	$e_2=0.7+ 205.4e_1$	0.873	0.763
$e_1=f(x_1)$	$e_1=814.4 +0.8 x_1$	0.899	0.808
$E=f(x_1)$	$E=34134.5+122.5x_1$	0.996	0.993
$E=f(e_2)$	$E=8276.3+ 0.5e_2$	0.990	0.981

Thus, the costs of science influence the formation of the GDP. To confirm this, Figure 3. shows a comparison of GDP and research costs in the EU countries. It is obvious from Figure 3. that the high economic development of a country and the GDP are directly proportional to the amount of research costs.

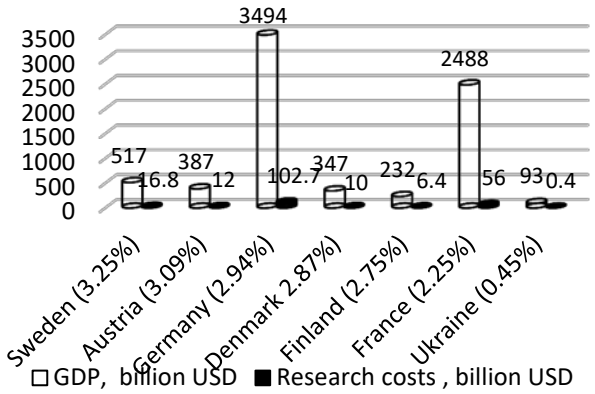


Figure 3. Comparison of volumes of GDP and research costs in Ukraine and the EU countries for 2016 (in dollars and percentage terms) (Compiled by authors on the basis of World GDP -2016) [23],[31].

But, it is well known, that the effectiveness of investment in science has a long-term effect. Therefore, there is a need to analyze not only the actual indicators, but also the expected indicators.

The second stage. We have analyzed the interdependencies between the volume of GDP and the expected growth in business activity, which is a necessary condition for the economic development of the territory. To analyze the growth of business activity, we used the Economic Sentiment Indicator (ESI), which is calculated in accordance with the Methodology for calculating indicators of business expectations in accordance with the requirements of the expanded Special Data Dissemination Standard of the International Monetary Fund. The essence of the methodology is as follows: while determining individual indicators of business expectations, the results of survey are used. This survey is to obtain the opinions of companies' managers not to collect statistics data. That is, it is a tool for the study of economic phenomena, taking into account the subjective views of market agents.

The main indicators of business expectations, which are calculated in the EU member states, are as follows: industrial confidence indicator, construction confidence indicator, retail trade confidence indicator, services confidence indicator, consumer confidence indicator and economic sentiment indicator.

When using statistics data on the expectations of enterprises regarding the prospects for the development of their business activity, the difference between the proportion of respondents who provided answers like "increase" and "decrease" should be additionally calculated for each of the indicators. This difference is called "balance" and allows to answer each question with one number with a "+" or "-" sign. This value indicates which trend will prevail in the dynamics of each indicator (Table 3.).

Linear correlation coefficient indicates that there is a high degree of colligation between the GDP and economic sentiment indicator according to the Chaddock scale (r =0.739). Consumer confidence indicator s_5 has very high degree of colligation with GDP (r=0.907) when analyzing the components and economic sentiment indicator. And construction confidence indicator s_1 has low degree of colligation with GDP (r =0.406).

While conducting a multifactorial correlation and regression analysis, we obtained that GDP is 89% dependent on consumer behavior, especially in the service sector. This is indicated by the multiple determination coefficient r_2 = 0.889 while analyzing the simultaneous consideration of the influence of s_4 and s_5 on GDP. GDP is 97% dependent on simultaneous consideration of s_3, s_4 and s_5 (r_2 = 0.974). And GDP is 100% dependent on simultaneous consideration of s_1, s_2, s_3, s_4 and s_5 (r^2 = 1). Coefficients of multiple correlation r from 0.9 to 1 indicate very high degree of colligation between the indicators.

At the third stage of our study, we conducted a survey among respondents at the local level, i.e. city level. The foundations of the economic development of a city as a cluster are formed under condition of cluster property, which consists in close interaction of its components. We divided the respondents into three groups: representatives of business, science and government. Total amount of distributed questionnaires is 60 (20 per each group), 47 were received back (Q = 47). Accordingly, by groups: 14 of business structures representatives, 13 of science field respondents, and 20 of public servants representatives. That is, 29% of surveyed respondents were the representatives of business,

28% were the representatives of science and 44% - public service (Table 4.).

Table 3. The results of the correlation and regression analysis of GDP volumes and the economic sentiment indicator for Ukraine for 2017 and the beginning of 2018

Period under study and indicators	Real GDP, (E) million USD	Economic sentiment indicator (ESI), % (s)	Components of economic sentiment indicator (s_i, i=1…5)				
			Construction confidence indicator s1	Industrial confidence indicator s2	Retail trade confidence indicator s3	Services confidence indicator s4	Consumer confidence s5
1st quarter of 2017	21792	81.7	-26.5	-7.1	-1	-14.7	-28.9
2nd quarter of 2017	25373	91.9	-25.9	-5.5	2.7	-8	-28.4
3rd quarter of 2017	31678	103.6	-23.6	-3.2	5.7	-3.7	-25.8
4th quarter of 2017	31929	100.4	-24.4	-4.5	12	-6.3	-27
1st quarter of 2018	26734	108.8	-19.7	-2.6	5.3	-5	-28.3
2nd quarter of 2018	30697	104	-21.5	-3.9	5.3	-5	-27.1
Equation of pairwise linear regression E=f(s_i)		E= -1918 +304s	E=43064 +636s_1	E=35611 +1696s_2	E=23977 +811s_3	E=34132 +856s_4	E=116476 +3206s_5
Linear correlation coefficient, r		0.739	0.406	0.680	0.847	0.837	0.907
Determination coefficient, r^2		0.547	0.165	0.463	0.718	0.701	0.823
Linear multifactorial regression model E=f(ns_i)		-				E=92470+385s_4+2236s_5	
		-			E=78821+385s_3+188s_4+1862s_5		
		-		E= 74910-465s_2+373s_3+401s_4+1739s_5			
		-	E=97462+661s_1-1946s_2+374s_3+570s_4+2186s_5				
Coefficient of multiple correlation, r		-				0.943	
		-			0.987		
		-		0.989			
		-	1				
Coefficient of multiple determination, r^2		-				0.889	
		-			0.974		
		-		0.978			
		-	1				

Compiled by authors on the basis of sources: Real GDP & Economic sentiment indicator [23]

Regarding the issue on what influences the increase in tax revenue, 40% of respondents believe that this is business development due to an increase in good turnover and the number of jobs. 34% of respondents believe that this is the influence of government through changing the tax system. 15% of respondents note that this is the development of science, through the development of new technologies. And 11% of respondents could not choose the answer. They noted that the development of all components would be the most effective.

We also analyzed the opinion of respondents by each group separately. The respondents of the business sector stated that the basis of the territorial development is business processes (50%) and investment in research - 43%. The business - structures (64%) are the most interested in the development of science. And 71% of respondents of this group noted the dependence of GDP on investments in science.

75% of respondents of government group noted that the basis for territorial development is strengthening the state administrative apparatus and 25% of respondents answered that it is investment in scientific activities. Government authorities (55%) are the most interested in the development of science. And 85% of respondents of this group noted the dependence of GDP on increasing the scientific activities funding.

Growth in business activity is expected primarily in the public administration sector. This is confirmed by 53% of respondents. And it is precisely its strengthening that will be a precondition for territorial development (51% of respondents confirmed this thesis).

Table 4. The results of a survey among the representatives of business, science and government

Questions	Answers
What do you consider the basis of territorial development?(q_1)	Development of business processes – 21%
	Investment in research – 28%
	Strengthening the state administrative apparatus – 51%
Where do you expect the greatest growth in business activity in the coming years? (q_2)	In business – 38%
	In science – 9%
	In public administration – 53%
The most interested party in the development of science in a particular territory is (q_3):	Public administration – 34%
	Enterprises (business - structures) – 45%
	Consumers – 21%
Does GDP depend on investment in science? (q_4)	Yes – 79%
	No – 19%
	Other – 2%

That is, business is the most interested in the development of science in a certain territory (45%). And 79% of respondents consider that the development of economic growth depends on investment in research. That is, the basis for the development of the cluster is financing of the scientific component. The results of the third stage of the study (at the city level) once more confirmed that the center of the cluster is precisely the science.

5. Conclusion

The dependence between research funding and the level of economic development has been established. In particular, the structure of GDP shows the highest correlation relation between the costs of research and GDP (R = 0.996). The modeling of cluster components shows that in the conditions of the Ukrainian economy, GDP is expected to increase by 0.013% with an increase in total capital investment in applied and basic research by 1%. This demonstrates a lack of effectiveness during the implementation of applied research results.

Analysis of economic sentiments and expectations in the business environment showed that real GDP growth depends on business confidence indicators. The greatest weight (40%) of the economic sentiment indicator has industrial confidence indicator. Thus, reducing the balance in terms of industrial confidence indicator by 4-5 points reduces the real GDP by an average of 1206 million dollars. This negative trend requires the state to develop a mechanism to stimulate business activity, which leads to attracting investment in applied science from the business.

In general, the results of the study indicate the need to create a holistic concept of regional cluster forming. And the research centers, research universities, scientific laboratories, technology parks, etc. are the core of this cluster.

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