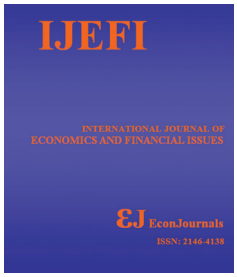

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Factors of the Effective Development of the St. Petersburg Instrument Engineering Cluster

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ABSTRACT

The study analyzed the effectiveness of the cluster policy in the field of instrument engineering. Based on the study of theoretical and practical provisions, the identification of the main problems of the development of cluster projects was made; the concept of knowledge transfer was discussed and its relevance for the implementation of the cluster policy in the field of instrument engineering was determined; the methodology for assessing the effectiveness of the cluster policy was analyzed; the factors of the effectiveness of the development of the instrument engineering cluster were evaluated on the basis of the multiple correlation analysis. The study resulted in a direct correlation between the dynamics of the development of the instrument engineering cluster of St. Petersburg and the wages of employees of the enterprises in the cluster.

Keywords: Industrial Cluster, Instrument Engineering, Cluster Policy, Effectiveness, Development, St. Petersburg
JEL Classifications: O25, O31

1. INTRODUCTION

The Chairman of the Government of the Russian Federation approved a list of 25 clusters in different regions in August 2012 as part of support of the formation of cluster policy in Russia, after a competitive selection of the pilot programs of development of innovative territorial clusters. International experience was partially used in the selection of innovative clusters, in terms of the procedures of evaluation and composition of criteria for selecting projects. The selection of innovative clusters took place in two stages and was largely consistent with existing international practice.

As already noted, the fundamental document prescribing the scope of cluster policy in Russia is a concept of long-term social and economic development of the Russian Federation through to 2020. Apart from it, the following documents form the basis of the regulatory framework:

- Government Resolution dated March 6, 2013 No. 188 "On approval of rules of distribution and provision of subsidies from the federal budget to the budgets of the subjects of the Russian Federation for the implementation of activities under the programs of development of pilot innovative territorial clusters" (Government Resolution "On approval of rules…");
- Order No. 457 dated August 13, 2013 "On approval of the level of co-financing of expenditure obligations of the subjects of the Russian Federation at the expense of subsidies from the federal budget for the implementation of programs of the development of pilot innovative regional clusters in 2013" (Order of the Ministry Economic Development of Russia "On approval of the level…").

To get an idea about the development of innovative industrial projects in the Russian Federation, the topic of introduction of programs to support the development of 25 innovative territorial clusters requires a detailed study with a multi-faceted approach. Several typical problem areas have been identified in this paper, on the basis of the general review.

As one of the Russian daily columnists rightly noted, the news of the approval of a list of innovative regional clusters by the Prime Minister had not become central to the news agencies, it was

not paid much attention by the mass media (Tarasenko, 2012). However, it should have been – at least because the innovative future of Russia depends largely on the functioning of clusters and industrial agglomerations (Resolution of the St. Petersburg Government "On the Concept…"; Babkin, 2014; Babkin and Khvatova, 2011; Vertakova et al., 2015; Lizunov, 2010; Popov and Plotnikov, 2012; Nikolova et al., 2015; Ilin and Anisiforov, 2014). It is hard to disagree with this statement, but you should consider the fact that currently it is almost impossible to monitor the implementation and development of the pilot projects. Consequently, one of the most obvious problems of the state cluster policy is of information nature.

It is worth noting that one of the advantages of the cluster approach is that it is possible to solve the problem of limited investment resources to ensure innovation, because international experience shows that such projects raise more and more investment, including foreign (Decree of the Government of the Russian Federation "On approval of the concept…"). Collecting the necessary information plays an important role with the intention to invest in a certain project, and it is vital to maximize its disclosure in certain areas. In the context of the current situation, initial and, most importantly, publicly available information on ongoing cluster projects is missing for potential investors.

It not an easy task to obtain objective conclusions based on the results of measures for implementation of the programs, but there are well-developed methods and practical experience in the world practice to solve such problems. The European Commission widely uses involvement of independent experts for monitoring and evaluation of programs. However, this method is quite expensive, so it is usually applied selectively (Resolution of the Government of the Russian "Federation Federal Target Program…"). Due to this, the need emerges to develop a system of evaluating the effectiveness of the implementation of cluster programs at the local level. An integral part of implementation of such projects is the task of evaluating how well the means or resources of the program are converted into measures. In other words, one of the most important components of the process of development of the cluster pilot projects is to find results/costs ratio. Therefore, one of the significant shortcomings of the legal framework is the lack of guidelines for evaluating the effectiveness of implementation of the approved cluster pilot projects.

To consider the feasibility of placing a pilot cluster in a particular region, for example in St. Petersburg (Order of the Ministry Economic Development of Russia "On approval of the list; Order of the Ministry of Energy of the Russian Federation "On approval of the Strategy; European Cluster Observatory; Kudryavtseva and Utkina, 2014), the most likely cores of the cluster groups of the subjects of the Russian Federation were identified. In other words, it is necessary to find out the existence of such enterprises in the regions where pilot projects are implemented, which refer to the sector of the cluster being implemented.

The study used data from the European Cluster Observatory (ECO) (United Interagency Information and Statistical System; Methods of Assessing the Efficiency and Effectiveness of the Program; Kudryavtseva and Zhabin, 2014; Babkin and Kudryavtseva, 2015b), which uses "from above" approach to identify clusters, assuming the search of spatial localization of productions focused on specific economic activities. Cluster analysis, in accordance with the methodology proposed by the ECO, involves studying the statistics of employment of cluster groups and its analysis on various parameters. In other words, a quantitative indicator of employment in the clusters of the defined sectors was taken as the basis to identify significant industrial clusters in the regions in which the pilot cluster projects are implemented.

The results of the study showed that the sector in which a particular cluster pilot project is implemented is not commercially important in all regions. This situation comes down to one of the most polemical issues in relation to the formation of clusters, namely the question of the possibility of their artificial creation. This refers, first and foremost, to the state intervention which corrects the natural course of the process (Economic Portal). The common point of view among the experts is that the formation of clusters is a purely natural process, and the state intervention is useless and even harmful. The only thing that the state can and should do is to create conditions for the independent emergence of clusters and maintain the conditions for those already naturally formed. Moreover, the experience of the USSR and "scientific-industrial complexes" and "territorial production cooperatives" existing at the time has shown that the planning system and sectoral principle of economic management imposed severe restrictions on their activities. For example, the choice of supplier was often determined not by the interests of the enterprise, but by the order "from above." As a result, component parts being produced in the region were imported from other republics. The main difference between a cluster and the territorial production complex is that the cluster best takes the market mechanism into account; it can be effective only when it is created on the initiative from the bottom, when the enterprises come to the need to join into the cluster to improve their competitiveness (Association of Innovative Regions of Russia).

The first studies conducted by Marshall and the later studies of Rosenblum, Krugman and others have shown the advantages of joining into clusters (Marshall, 2008):

- Intensity of the labor reserves because of the geographical concentration of firms in one sector;
- Availability of appropriate materials and other resources (intangible assets, consulting services, etc.) at a lower price; and
- Intensity of the exchange of knowledge between the firms and institutions in the cluster.

It must be admitted that spatial proximity is a necessary but not sufficient condition. What contributes to the productivity of innovative cluster agglomerations? It is important to understand the consequences of proximity, complementarity of knowledge and multiple information exchange for the effectiveness of such associations. While the first two benefits (also known as local externalities) have an indirect impact on the innovative activity of the enterprise, the third has a direct effect on innovation orientation of personnel and firms concentrated in the cluster.

Dissemination of knowledge is one of the explanations for the increased speed of innovation development in the clusters; many managers and scholars have recognized knowledge as a key source of competitive advantage. Knowledge is a potentially important resource for organizations because they can have valuable, rare, unique and not interchangeable characteristics, especially if it is so-called implicit knowledge.

Michael Polanyi first introduced the concept of implicit knowledge in the middle of the 20th century (1985). He classified knowledge into two types: Explicit (obvious, formalized) knowledge and implicit (tacit, non-formalized). He defined the explicit knowledge as a kind of codified knowledge, which is transferred through official ordered languages. Nonaka et al. describe explicit knowledge as something that can be implemented in the form of code or in a language and as a result can be relatively easily put into words, stored, processed and passed on to someone else (Nataeva and Kudryavtseva, 2015; Nonaka and Takeuchi, 2011; Popov and Plotnikov, 2012; Porter, 2005; Polanyi, 1985; Cook and Cook, 2004; Fallah and Sherwat, 2004). This is a public and most widespread form of knowledge that can be found in books, magazines, media, television, online, etc. It represents a variety of data, scientific formulas, guidance, descriptions, etc. The patent is one example of the explicit knowledge.

Polanyi (1985) defines implicit knowledge as "constantly being in the full knowledge of the human mind and body." The implicit knowledge is related to the context in which it is presented and to its own interpretation by the individual. In other words, the implicit knowledge is personal and hardly formalized – its roots lie in the actions, procedures, attitudes, values, emotions, experiences, etc. It is a less familiar, non-traditional form of knowledge. It is the knowledge that we do not realize; it is acquired through the exchange of experience, observation, imitation. According to Kikoski, implicit knowledge embodies the human education, his or her natural talent, experience and judgment (Kikoski and Kikoski, 2004). For example, the implicit knowledge of an experienced venture capitalist tells him or her which of the two business plans is more suitable for investment.

Explicit and implicit types of knowledge are complementary. There is a constant exchange and transformation between them. Competitive advantage will be achieved only if the company values the existing store of non-formalized knowledge, which is difficult to formulate and pass on, while explicit knowledge can be known or passed on to others.

An important aspect is the degree of the transfer of any knowledge to a particular person, group, or all members of the organization. The management should address this process in their activities and take action if necessary. Howells (1996) notes that the intuition based on formalized knowledge plays an important role in the innovation process that shows that most of the knowledge, which is important for a job or an improvement of a particular product, a process or a technology, is silent. It is important to note that the exchange of implicit knowledge can be only at the individual level, while the exchange of explicit knowledge can be at the individual, organizational level, and even at the national level.

Sharing implicit knowledge at the individual level can be an intentional transfer of information or unintentional abundance. Abundance of implicit knowledge can both help and disturb a company or even a country. For example, when companies place their research and development (R and D) centers in the innovation cluster, they can benefit from gaining new knowledge formed in result of the socialization of their employees in a group with others. However, involuntary transfer of knowledge from own employees to other companies in the group can occur with the same results. In this case, though socialization is due to a corporate decision, the actual exchange of implicit knowledge is carried out by employees of neighboring firms and can only happen through them. Similarly, the firms take measures for the internal interaction by arranging workshops, parties and other events that promote sharing knowledge between employees. In Japan, where implicit knowledge is of great value, Honda is an example of socialization, arranging meetings for "brainstorming" – informal meetings to discuss the detailed ways to solve complex problems arising in the development of new products. The meetings are held in holiday houses, any employee of the company interested in the project can attend such a meeting; importance is not attached to qualification or status in the course of the discussion. The participants drink sake, enjoy their meal and bathe in the hot springs during the discussion. These meetings are not just a forum for constructive dialogue, but also a form of dissemination of experience. This form of work is especially effective in the dissemination of implicit knowledge and making prospects (Nonaka and Takeuchi, 2011).

Geographical proximity in the transfer of knowledge between the companies in the cluster allows to interact directly with customers, suppliers, partners, competitors, as well as educational and research institutions. Direct interaction helps a person to gain knowledge from the outside, where the knowledge in most cases is non-codified. Technological clusters also allow an individual to absorb the collective tacit knowledge "embedded" in the socio-cultural dimension of the cluster. Being part of the innovation cluster, implicit knowledge also increases due to close control of emerging technologies, identifying common problems and their solutions in the industry.

The transfer of implicit knowledge is highly dependent on the difference between "face to face" contact and "at arm's length" contact. The proximity of the two partners is a key factor for the degree of transfer of non-formalized knowledge. Most of tacit knowledge is transferred through body language or physical demonstration of skills, and therefore the use of information and communication technologies for its transfer is only partially possible. Nonaka argues that since the implicit knowledge cannot be fully transferred in the formal language, its electronic storage can hardly be the case, and even if so, it will lead to loss of knowledge (Nonaka and Takeuchi, 2011). Therefore, it can be concluded that the transfer of non-formalized knowledge requires personal and informal communication.

The process of the transfer of knowledge assumes the arrangement of the knowledge flow from the source to the receiver (Porter, 2005). To make implicit knowledge transferable, the source must first formulate and make this knowledge explicit. This process

is called externalization. The source then makes a decision who to share this knowledge with. This process is called transfer of knowledge. Knowledge can be shared both unintentionally and intentionally with others. It is important to note that the more codified the knowledge, the less control over the process of exchange a person has, because the process of the transfer is facilitated. This does not mean that non-codified knowledge is devoid of leakage probability: It is possible, but not as often and not so easy. For example, a situation is the following: Someone has visited a person's workplace, watching as the person was doing his or her job, etc. However, it does not necessarily mean that the guest will extract some information from the observations just because he was there. This study also depends on the ability of the recipient to absorb that knowledge. Assume two different persons may stumble on the same information. One person linked this information to the other that he or she has, and used it in an innovative way in result. At that time, the other person just missed that information and was unable to use it in this way.

According to Van Baalen et al., any form of formalized knowledge assumes the existence of implicit knowledge, which, in turn, cannot be so easily formulated (Van Baalen et al., 2005). As a consequence, the transfer of innovative knowledge (which is often implicit) between employees, organizations, etc. will become problematic.

There is a concept of so-called "stickiness" of knowledge. The concept of "stickiness" includes three objects: A source of knowledge, a recipient of knowledge and context. When the source and the recipient of knowledge work in one context and engage in the same practice, "stickiness" will be relatively low, while the transfer of knowledge itself will be more difficult and costly than when the source and the receiver operate in different contexts and engage in different practices.

Sources may also be reluctant to share their knowledge due to the fear of losing ownership, privileged position or superiority. Reflecting on the topic of internal stickiness of the knowledge transfer, Szulanski (2003) identified three significant barriers sufficient to destroy the transfer of the tacit knowledge. First is the uncertainty and ambiguity of the implicit knowledge that must be transmitted. It plays an important role when neither the sender nor the recipient can find enough matches or comparisons with the reception and transfer of such knowledge. Also, this is closely related to the second barrier – The lack of ability to absorb knowledge, which occurs when the receiver is not able to cope with the uncertainty and thus increases the probability of an unsuccessful transfer. The third obstacle is related to the mitigation of transfer of knowledge with hindered relations between the sender and the recipient.

Another barrier, though having a lesser impact, is the lack of motivation among the sender and the recipient. The unreliability of the sender, who can slow down the transfer of knowledge, also takes place. In addition, there is a widespread view that the refusal to share information and implement knowledge transfer is often the result of neglecting human factors and putting excessive emphasis on information and communication solutions. Emotional factors, such as power, trust, likes and dislikes played an important role in the transfer of implicit knowledge (Polanyi, 1985).

Possibility of exchange also depends on the company's social culture. Enterprise culture significantly affects the transfer: A condition for the specified purpose is to provide a climate of openness and trust. During the transfer of implicit knowledge, communication problems may arise, since many companies focus on specialized activities. The higher the degree of specialization, the higher the insulation and the more narrow the prospects. The organizational structure often prevents the exchange of implicit knowledge through the establishment of mismanagement. In addition, unclear objectives and unclear incentives can also prevent the transfer. Finally, the physical layout of offices may act as a barrier because it may disturb and obstruct communication between the employees (Nataeva and Kudryavtseva, 2015; Kikoski and Kikoski, 2004).

Thus, implicit knowledge plays an important role in all stages of the innovation process. Obviously, in its early stages (generation and disclosure of the idea), the role of non-formalized knowledge is the highest. In addition, an intuitive restriction of the available alternatives before the stage of the real trial run causes the effect of accelerating the innovation process. This shows that with appropriate management of implicit knowledge, the next task will be to have a flexible solution, and that at all stages of the innovation process (from idea emergence to entering market), the proper transfer of implicit knowledge is of great importance for the success of innovation. Western managers are used to working with formalized knowledge – knowledge that is codified, "sliced and diced," i.e., arranged in paper and electronic documents stored in databases and knowledge bases. Perhaps, it is time to shift the focus to working with non-formalized knowledge, while not denying the importance and practical use of formalized knowledge. Takeuchi said in one of his reflections: "Western companies want to see everything in a formalized manner – operational objectives, financial returns. They need to learn to understand the value of what remains hidden, unspoken and ambiguous." But understanding and implementation in the West of the control methods implemented by Eastern cultures should take a long time, and this theory in modern realities of the approach to the conduct of economic and business activity is a concept among other methods.

The aim of the study is to test the hypothesis that the factor of the state economic policy of the effective development of innovation clusters is an investment in human capital, which ensures transfer of innovative knowledge within the cluster. The study was conducted on the example of the instrument engineering cluster of St. Petersburg.

2. METHODOLOGY

The developed program of the development of the cluster of information technology, radio electronics, instrument engineering, communications, and information telecommunications of St. Petersburg includes a point called "Procedure and criteria of evaluation of the effectiveness of the implementation of program measures." However, the criterion is the achievement of the target

indicators of performance, distributed by periods of time. The target values of effectiveness and development of the innovative territorial cluster and their target values are presented in Table 1. 2013 was reviewed in this study in order to consider the evaluation of the effectiveness of the cluster activities.

Accounting and annual statements of the enterprises included in the core of the instrument engineering cluster were analyzed to determine the target indicators of the program effectiveness (Babkin and Kudryavtseva, 2015a). The forms of financial statements posted on the official websites of the enterprises on the Internet and on the corporate information disclosure servers were used as initial data. Since the open accounting information by its legal nature is applicable to enterprises with the legal form of "open joint-stock company," the overall conclusions drawn from the analysis are applicable only to these enterprises and do not refer to the problems of small enterprises with the legal form of "limited liability company" and "closed joint-stock company."

The obtained information allowed to determine actual increase in the target values of effectiveness of implementation of the cluster development programs. The calculation was made by comparing the actual results achieved for each indicator in 2013 with those of enterprises' activity in 2012. The final difference between the target indicators was represented as a percentage. The results are shown in Table 2.

The decline of values in comparison with 2012 was due to a sharp increase of R and D income in 2012. This significant growth allowed to generate the necessary scientific and technical foundation for the development of enterprise production. The decline of revenues is due to an increase of the share of production orders in the structure of business revenues and a decrease of science revenues. A large-scale launch of new production capacities created in 2011-2012 also took place in 2013.

The development program, in addition to the evaluation of the effectiveness of the cluster measures applied above, also mentioned the evaluation of the following indicators in the direction "Development of IT technology:"

- Number of IT companies in the cluster operating in the international market of goods and services, combined export earnings;
- Share of the domestic software and IT equipment (developed by the participating organizations of the cluster) used in Russia in various sectors;
- Growth of the educational capacity and qualification of personnel structure of IT specialists of the cluster, the number of trained specialists in short supply sectors;
- Reduction of IT staff deficit in St. Petersburg;
- Growth of the average salary of IT specialists.

The results of evaluation of some indicators in the direction "Development of IT technology" are presented in Table 3.

We have proposed to use regression analysis to determine factors of evaluation of the effectiveness of the cluster policy in the field of instrument engineering in St. Petersburg. We propose to use

Table 1: Indicators of effectiveness and their target values

Target values of effectiveness and development of the innovative territorial cluster	2013 (%)
Growth of average wages of participating organizations, % to previous year	3
Growth of investment costs of participating organizations, net of the cost of acquisition of land, construction of buildings and structures, and supply of utilities, % to previous year	5
Growth of output per worker in participating organizations, % to previous year	5
Growth of total revenues of participating organizations, % to previous year	3

Table 2: Actual increase in the values of effectiveness for 2013, compared with 2012

Target values of effectiveness and development of the innovative territorial cluster	Actual increase (%)
Growth of average wages of participating organizations, % to previous year	4
Growth of investment costs of participating organizations, net of the cost of acquisition of land, construction of buildings and structures, and supply of utilities, % to previous year	−11
Growth of output per worker in participating organizations, % to previous year	−9.6
Growth of total revenues of participating organizations, % to previous year	−8

Table 3: Actual increase in target values in the direction "Development of IT technology"

Target values in the direction "Development of IT technology"	Actual increase (%)
Number of IT companies in the cluster operating in the international market of goods and services	0
Share of the domestic software and IT equipment (developed by the participating organizations of the cluster) used in Russia in various sectors	1
Reduction of IT staff deficit in St. Petersburg	Acute shortage persists
Growth of the average salary of IT specialists	30

indicators of the value of fixed assets, average wage level, level of employment in the region, as well as budget investment as the criteria of effectiveness of the clusters functioning. These indicators are expected to correlate with the profitability of the sector or with the volume of output. Choice of the latter will be based on whether the state finances the industry in such an amount that ensures its immediate development and helps increase profits. In other words, state investment was chosen as a central parameter of effectiveness.

Identification of the amount of state investment in fixed assets and the determination of its significance will base on the calculation of the share of state investment in the total value of fixed assets of the enterprises in the instrument engineering sector. All data presented in Tables 4-7 were collected and

aggregated for St. Petersburg from the unified interdepartmental information and statistical system (United Interagency Information and Statistical System). Table 5 shows the total value of state investments in fixed assets in Russia from 1998 to 2014.

Table 5 shows the dynamics of the total investment in fixed assets from the state budget in St. Petersburg over the years.

Table 6 reflects the dynamics of the total investment in fixed assets from the state budget in the sector of instrument engineering, radio electronics, communications, information and telecommunications. It is based on the data from the state statistics committee, which reflect the dynamics of investment by economic activity, according to NACE classification. After analyzing the industry, it was decided to use the data by the following activities for the study (Babkin and Kudryavtseva, 2015a):

- Production of machinery and equipment;
- Production of electrical, electronic and optical equipment;
- Production of electronic components, instruments for radio, television and communications; and
- Production of medical devices, measuring means, monitoring, control and testing; optical devices, photo and film equipment; watches.

In order to determine whether the state can influence the development of the sector and its profitability through investment from the budget, it is necessary to determine the share of this investment in the total amount of fixed assets of enterprises in this sector. Table 7 shows the dynamics of the availability of fixed assets in a given sector at the full reported value.

After finding the required data, we need to find out what proportion of state investment they make in the total value of fixed assets of

Table 4: Investment in the Russian Federation from 1998 to 2014, billion rubles

Year	Investment	Budget investment
1998	319.6	61.1
1999	582.2	99.2
2000	1053.7	232.1
2001	1335.8	272.9
2002	1455.7	289.6
2003	1824.9	358.0
2004	2246.8	401.0
2005	2893.2	589.2
2006	3809.0	769.2
2007	5217.2	1119.0
2008	6705.5	1404.7
2009	6040.8	1324.1
2010	6625.0	1294.9
2011	8445.2	1622.0
2012	9595.7	1712.9
2013	10,065.7	1916.3
2014	9852.9	1598.3

Table 5: Investment in fixed assets from the state budget in St. Petersburg from 1998 to 2014, billion rubles

Year	Budget investment	Budget investment in St. Petersburg
1998	61.1	2.5
1999	99.2	4.2
2000	232.1	9.3
2001	272.9	11.5
2002	289.6	12.5
2003	358.0	15.0
2004	401.0	16.9
2005	589.2	25.0
2006	769.2	32.3
2007	1119.0	47.0
2008	1404.7	59.0
2009	1324.1	56.4
2010	1294.9	54.8
2011	1622.0	68.1
2012	1712.9	71.9
2013	1916.3	80.5
2014	1598.3	68.7

Table 6: Investment in fixed assets from the state budget in St. Petersburg, aimed at the development of the sector of instrument engineering, radio electronics, communications, information and telecommunications, 1998 to 2014

Year	Budget investment in St. Petersburg, billion rubles	Budget investment in St. Petersburg on the devlopment of the sector under study
1998	2.5	38.2
1999	4.2	63.4
2000	9.3	140.2
2001	11.5	171.6
2002	12.5	186.8
2003	15.0	222.5
2004	16.9	256.6
2005	25.0	375.6
2006	32.3	484.6
2007	47.0	709.7
2008	59.0	890.9
2009	56.4	846.1
2010	54.8	816.1
2011	68.1	1,021.9
2012	71.9	1,079.1
2013	80.5	1,223.4
2014	68.7	1,037.8

Table 7: Dynamics of the availability of fixed assets in the sector of instrument engineering, radio electronics, communications, information and telecommunications in St. Petersburg, million rubles

Year	Value of fixed assets at the year-end
1998	19,392.7
1999	22,619.6
2000	26,757.4
2001	30,961.4
2002	36,099.8
2003	42,295.2
2004	48,972.6
2005	55,766.5
2006	64,632.6
2007	78,492.4
2008	91,961.3
2009	106,521.2
2010	122,416.1
2011	136,016.2
2012	151,119.5
2013	174,359.9
2014	197,026.7

enterprises in this sector in St. Petersburg. The results are shown in Table 8.

Table 8 shows that the share of state budget investments in the total value of fixed assets is small and <1%. There has been a positive trend until 2008 inclusive and the recession since 2009. This can be explained by the deterioration of the economic situation in the country generated by a fall in oil prices and tax revenues. The funds were directed to crisis response measures to support the economy and deficiency payments.

Thus, the state does not actively invest in the sector under study, and therefore does not directly influence its development, as well as profits. In other words, it only helps to maintain the infrastructure that ensures the production process, but not the margins, profits, etc. This is why the output volume rather than sector profitability will be used to build regression models between the indicators as a resultant.

3. RESULTS

The study of the multiple correlation suggests evaluating the impact of two or more factors on the resultant of interest for the researcher. This paper evaluates the impact of several factors on the volume of output in the sector of radio electronics and instrument engineering in St. Petersburg by years from 1998 to 2014. The initial data for the analysis are presented in Figure 1.

Notation agreed in the table: Resultant (dependent variable) Y – Volume of output, mln rub. The following factors were chosen: X_1 – Volume of investment in the sector from the state budget (mln rub); X_2 – Value of fixed assets at the year-end of enterprises in St. Petersburg in the sector (mln rub); X_3 – Average wage in the sector in St. Petersburg (rub); X_4 – Level of employment in St. Petersburg (in percent).

The first step in the analysis is the construction of the correlation matrix for the purpose of sound selection of the factors to be included in the regression equation: Identifying factors that insignificantly influence the result and collinear factors (Figure 2).

The resulting matrix contains paired coefficients of correlation of the output volume and each of the analyzed factors, as well as coefficients that evaluate the degree of closeness of the ratio of correlation between the factors. The values in the cells where the elements intersect, the relationship between which is significant, are marked in red. There are two figures in each cell: The upper is the correlation coefficient, the lower is the level of significance.

As can be seen from the matrix data, there are no factors that insignificantly influence the results in the model under study.

Next we need to study the data of the correlation matrix for the existence of collinear factors, i.e. the factors with a strong linear relationship between them. They are all factors under study, because coefficients of correlation between them are close to unity. Accordingly, we rule out the factors from the model with the correlation coefficient with the lower result. Thus, there are two factors in the model: X_1 (volume of investment in the sector from the state budget) and X_3 (average wage in the sector in St. Petersburg). We build a regression equation with the selected factors (Figure 3).

Table 8: Calculation of the share of state investment in the total value of fixed assets, million rubles

Year	Budget investment in St. Petersburg	Value of fixed assets at the year-end	Share, %
1998	38.2	19,392.7	0.196981
1999	63.4	22,619.6	0.280288
2000	140.2	26,757.4	0.523967
2001	171.6	30,961.4	0.554239
2002	186.8	36,099.8	0.517454
2003	222.5	42,295.2	0.526064
2004	256.6	48,972.6	0.523966
2005	375.6	55,766.5	0.673523
2006	484.6	64,632.6	0.749776
2007	709.7	78,492.4	0.904164
2008	890.9	91,961.3	0.968777
2009	846.1	106,521.2	0.794302
2010	816.1	122,416.1	0.666661
2011	1021.9	136,016.2	0.751308
2012	1079.1	151,119.5	0.714071
2013	1223.4	174,359.9	0.701652
2014	1037.8	197,026.7	0.526731

Figure 1: Initial data

	1 X1 (Inv)	2 X2 (OPF)	3 X3 (Sal)	4 X4 (Lev)	5 Y
1998	38,21	19392,71	1819,10	58,7	4716,52
1999	63,36	22619,58	1979,70	60,1	5713,88
2000	140,21	26757,43	2897,01	61,5	6601,98
2001	171,62	30961,36	4126,08	63,3	7906,56
2002	186,80	36099,81	5707,17	65,7	9225,86
2003	222,53	42295,16	7277,38	64,4	10983,17
2004	256,61	48972,57	8658,07	66,6	12199,05
2005	375,62	55766,51	11077,72	68	15135,29
2006	484,62	64632,60	14086,65	70,1	17199,20
2007	709,67	78492,42	17806,83	71,9	22893,22
2008	890,86	91961,34	22362,89	71,4	26913,27
2009	846,10	106521,21	24470,91	70,5	22790,49
2010	816,14	122416,06	27618,13	70,3	30204,83
2011	1021,86	136016,17	30214,82	71,4	36144,68
2012	1079,13	151119,49	33175,15	72,8	39258,60
2013	1223,37	174359,90	37569,71	71,3	40674,17
2014	1037,78	197026,68	37556,77	71,9	39617,81

Figure 2: Matrix of pairwise correlation coefficients

Variable	Correlations (1 in Workbook1) Marked correlations are significant at p < ,05000 N=17 (Casewise deletion of missing data)				
	X1 (Inv)	X2 (OPF)	X3 (Sal)	X4 (Lev)	Y
X1 (Inv)	1,0000	,9506	,9834	,8985	,9813
	p= ---	p=,000	p=,000	p=,000	p=,000
X2 (OPF)	,9506	1,0000	,9886	,8150	,9777
	p=,000	p= ---	p=,000	p=,000	p=,000
X3 (Sal)	,9834	,9886	1,0000	,8661	,9911
	p=,000	p=,000	p= ---	p=,000	p=,000
X4 (Lev)	,8985	,8150	,8661	1,0000	,8704
	p=,000	p=,000	p=,000	p= ---	p=,000
Y	,9813	,9777	,9911	,8704	1,0000
	p=,000	p=,000	p=,000	p=,000	p= ---

The regression equation will be as follows:

$$\bar{Y} = 3377.683 + 6.414X_1 + 0.795X_3$$

The coefficient of determination is:

$R^2 = 0.98366091$.

Despite the selection of factors, the X_1 factor parameter is statistically insignificant in the regression equation. If the exception of such a factor does not significantly reduce the coefficient of determination, it is necessary to carry out this procedure. Therefore, we build a new equation including only factor X_3 (Figure 4).

In result, we obtain a single-factor model with the coefficient of determination slightly changed relative to the initial level and lack of insignificant parameters. The equation is generally statistically significant. In this case, it can be concluded that the variation in the volume of output of the sector of radio electronics and instrument engineering in St. Petersburg is largely (98.23%) explained by the variation of the average monthly wage of workers in the sector. The volume of output given the constraints of the argument values can be calculated by the regression equation:

$$\bar{Y} = 3586.267 + 0.996X_3$$

Thus, the above analysis of the multiple correlation has shown that the wage of workers in the enterprises of the cluster core directly influences the volume of output in the sector of instrument engineering and radio electronics, and is one of the most important factors influencing the result. In other words, it can be argued with a certain probability that if wages increase slightly, the volume of output will respectively grow at a slower pace, and therefore it is necessary to look for ways to increase wages by increasing labor productivity and attractiveness of cluster professions in the labor market in order to increase the volume of output.

This result coincides with the criterion of the effectiveness of the cluster development program and confirms the importance of human capital, which was considered in the framework of the concept of knowledge transfer.

Therefore, the hypothesis was confirmed that human capital, which provides innovative knowledge transfer within the cluster on the example of the cluster of instrument engineering in St. Petersburg, is the factor of state economic policy of effective development of innovative clusters.

Figure 3: Parameters of the multiple regression equation with selected factors

	Regression Summary for Dependent Variable: Y (1 in Workbook R= ,99179681 R?= ,98366091 Adjusted R?= ,98132675 F(2,14)=421,42 p<,00000 Std.Error of estimate: 1762,3					
N=17	Beta	Std.Err. of Beta	B	Std.Err. of B	t(14)	p-level
Intercept			3377,683	747,8316	4,516636	0,000484
X1 (Inv)	0,202831	0,188140	6,414	5,9494	1,078089	0,299220
X3 (Sal)	0,791653	0,188140	0,795	0,1890	4,207794	0,000877

Figure 4: Multiple regression equation with factor X_3

	Regression Summary for Dependent Variable: Y (1 in Workbook R= ,99111273 R?= ,98230444 Adjusted R?= ,98112474 F(1,15)=832,67 p<,00000 Std.Error of estimate: 1771,8					
N=17	Beta	Std.Err. of Beta	B	Std.Err. of B	t(15)	p-level
Intercept			3586,267	726,2677	4,93794	0,000179
X3 (Sal)	0,991113	0,034347	0,996	0,0345	28,85603	0,000000

4. CONCLUSION

As can be seen from the above, the state should form cluster policy in the field of instrument engineering taking into account that the main factor influencing the growth of output in the sector is wages. The cluster under study is innovative, and the process of knowledge transfer is fundamentally important to it. Based on these conclusions, it is necessary to invest in human capital and the creation of a common industrial and research cluster infrastructure that will facilitate the transfer of non-formalized knowledge in order to improve the effectiveness of the cluster policy.

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