



## **Modeling of Human Potential Parameters in the Context of Innovation and Technological Development of the Country: Case of Asia-pacific Countries**

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### **ABSTRACT**

In this study, human capital is considered as a key factor for the innovative development of the country. The authors proposed an empirical model of the impact of human development on innovation and technological development of the country. Due to the high differentiation of the Asia-pacific region, classification of countries, which was taken into account later when constructing the regression model, was carried out by defining the object of study indicators.

**Keywords:** Asia-pacific Region, Human Capital, Innovations, Patents, Econometric Modeling

**JEL Classifications:** O, O15

### **1. INTRODUCTION**

In 60-80 years of the last century, there was a tendency to the emergence of the new economic growth theories (Lucas, Becker, Schultz) proving that the main factor of the economic growth was a human capital. The level of the society development is determined not only by the dominant types of economies, but also by the established hierarchy of values and interests, and the population characteristics, which is "human capital." The human capital involves the abilities, knowledge, and skills of employees, which give them the opportunity to operate in an economic environment. Investing in human capital tends to lead to higher productivity and increased production efficiency. A practice has shown that an increase in human capital through education, better health care and nutrition, affects economic growth, especially in the countries (regions) with low incomes and limited human capabilities.

McCullosh clearly defined human resources as the capital (McCullosh 1870. p. 57). In addition, he pointed out the close analogy between the common and human capital, considering

that investment in human resources should have turnover rates consistent with the turnover rate of other investments plus the normal rate of turnover determined by the market interest rate during possible life of an individual (McCullosh, 1870. p. 67). In our view, it was an attempt to quantify the human capital.

Senior suggested that human resources can be treated as capital; nonetheless, in this capacity, he took skills and acquired abilities, but not the person (Senior, 1939. p. 68-69). On occasion, however, he treated human resources as capital with maintenance costs invested in person with the expectation of receiving benefits in the future. He argued that there is a slight difference between the arguments about the value of a slave and the values of a free man. The principal difference is that a free man sells himself for a certain period and for a certain relation, while the slave is sold on all his life.

Macleod considered the "producing" person as the fixed capital. From his point of view if this person isn't productive, he or she isn't subject to the economic analysis (Macleod, 1881. p. 134, 205-206, 213).

The Marginalists adhere to the following considerations about the nature of human capital. Von Thunen noted the reluctance of some economists to assess human resources in money, this reluctance, he said, "... arises the lack of clarity and confusion of concepts in one of the important areas of the political economy. Moreover, it may seem that the freedom and dignity of the people could be successfully provided, if they were subject to the laws of capital" (Thunen, 1875. p. 3). Von Thunen assumed that many social institutes could be cancelled if expenses which increase labor productivity, were considered in the analytical scheme of the human capital. The capitalized value of these expenses, besides, has to be included as a part in the aggregated stock of the capital (Thunen, 1875, p. 1-10).

Walras included all human resources in the capital. And the value or the price of these human resources, Walras said, is defined like other capital goods (Walras, 1954. p. 40, 214-216). He argued that the pure theory, "inherent in complete abstraction from the consideration of fairness and practicality," and urged, "to consider human resources solely in terms of exchange value" (Walras, 1954. p. 271).

At the beginning of the XX century, the neoclassic Marshall admitted that estimates of the capitalized cost of the person can be useful, and considered them in an explicit form by the method of capitalization of net earnings (consumption subtracted from earnings before capitalization) he rejected this notion as "unrealistic" because human resources are not sold on the market (Marshall, 1959. p. 469-470, 705-706).

The human resources were included in the definition of the capital by Fisher. Capital, as he claimed, is, "a useful intended material object," and, therefore, as human beings possess this characteristic, the sequence in reasoning demands their inclusion in the concept of the capital (Fisher, 1897. p. 201-202; 1927. p. 51-52, 68). However, the skill of an individual isn't the capital, it is an additive to the individual. Fisher pointed that there is trained individual who is to be included in the concept of capital (Fisher, 1965. p. 12-13).

According to Huebner, the human capital can have the same scientific interpretation as the usual capital has. Its operational definition can be received "by capitalization of human life cost through bonds, giving them a life annuity (for this labor) and negotiability (as to a credit source), considering them by the principle of providing and using a method of depreciation funds for the implementation of the considered object, if only the person has prospect of future business activity, and his family has obligations to block the existing risk of uncertainty of duration of human life." (Huebner, 1914. p. 18-19).

Some authors used estimates of the capital cost of the person as an assessment of losses in World War I (Guyot, 1914; Crammond, 1915; Bogart, 1919). "The person is the capital," told Guyot, "and society have to be interested in the reduction of death not only on humanitarian, but also for the economic reasons." (Guyot, 1914. p. 1197). Bogart claimed that the assessment of the monetary cost of the human lives lost in war is "method of doubtful statistical relevance," nevertheless, he considered that only the monetary

assessment of these lives lost in war can help to realize their enormous economic importance (Bogart, 1919. p. 269).

Boag considered a question of, whether it is correctly or not "to include in estimates of reduction of the capital, as costs of war, losses of human lives (Boag, 1916. p. 7)." He drew a conclusion that it is correct, as there is a close analogy between "material and human" the capital. Moreover, Boag has formulated some important issues relating to evaluation of the human capital. The first issue stated that the method of assessment should depend on the purposes for which the evaluation will be used. The second issue proposed that it is necessary to be careful in carrying out calculations for articles both for human, and for the usual capital. And, the third issue pointed that interference of costs of the usual and human capital should be taken into account.

Schutz substantiated the following thesis, "If education affects the production, which is important for the economy, therefore, it is a form of capital" (Shultz, 1973. p. 50), and as "a form of capital is education, it is called 'human' because it becomes part of the person, and the capital is due to the fact that the future is a source of satisfaction or future earnings, or both together" (Shultz, 1979. p. 13). Becker examined this concept in a broad sense, "Human capital is formed at the expense of investment in human, among which there are education, training in the workplace, health care costs, migration and search for information on prices and incomes" (Becker, 1962. p. 14).

Ben-Porath defines human capital as the "fund, whose function is a production of labor services in conventional units, and which in its quality is similar to any car as the representative of the material capital" (Ben-Porath, 1967. p. 352). Dolan under the human capital understands "the capital in the form of intelligence obtained through formal training or education, or through practical experience" (Dolan and Lindsey, 1992). Fischer, giving his definition of this category, relates to capital's ability to generate income, as well as innate abilities, education and the acquired qualification.

Currently, innovation is one of the mechanisms to ensure the country's economic growth. These innovations lead to the renewal of markets, quality improvement and expansions of the range of goods and services, creation of new manufacture methods, marketing, and management efficiency. Providing quality growth is possible under specific conditions which would enhance and strengthen the innovative component. The influence of innovation on the development of national economies has become the impetus for the development of the developed countries of the complex of measures aimed at elaboration of innovation. Indeed, progress in the field of innovation can only be achieved by a person, his abilities, and opportunities.

As Eminov fairly marked in his study dedicated to the assessment of the innovative aspects of economic growth: "The providing of quality growth is possible under specific conditions which would enhance and strengthen the innovative component" (Eminov, 2012). The influence of innovation on the development of national economies has become the impetus for the development

of the developed countries of the complex of measures aimed at elaboration of innovation. In particular, Eminov noted: "Today countries have a task to improve the quality of economic growth, to become the countries that provide such growth not only due to primary industries and their exports but also due to the high technology factors, to form the economy of innovation type, and to make innovation a key factor in economic growth" (Eminov, 2012). The achievement of these goals is certainly not possible without human development since the human being is a key factor in ensuring the innovative development of the country.

Thus, the purpose of the study is to model the relationship of indicators of human potential in the context of the innovative development of the country.

The identification of factors that have a significant impact on the innovative development of the country is determined by the need to develop strategies encouraging innovation in the economy. As Shtertser noted in his study, dedicated to the detection of determinants of region's innovation activity that the innovative activity consists of three integrated successive stages (Shtertser, 2010):

- Invention - The development of new scientific and technical ideas and solutions
- Innovation - Introduction of the invention into production and on the market
- Diffusion - The spread of innovations in time and space.

Moreover, it should be noted that quantitative evaluation of volumes and effectiveness of innovative development is quite difficult due to the limited statistical information at the regional and country aspects. The main measure of innovation activity in the foreign economic literature is the number of patent applications, and for comparison, in some Russian studies the used indicator is the number of innovative enterprises. Thus, the selection of indicators as a measure of innovative activity is the choice of the researcher.

## 2. METHODS

In this study, we agree with the views of foreign researchers, because patents to more accurately reflect the state of the research sector, as the main source of new knowledge and innovation, than the number of active, innovative enterprises. Exactly the number of submitted patent applications reflects the effectiveness of the active, innovative enterprises. Certainly, the innovative activity of enterprise has an impact on the innovative development of the country and its regions and is predetermined by a vast number of factors.

Selection of factors that have an influence on the innovative development of the country was conducted with the help of regression analysis methods. As the basic model was chosen a model with a fixed error, because the selection is not random, and there is a possibility of having a strong correlation between the individual characteristics of the country and the regressors.

The regression equation was estimated for 41 countries of the Asia-pacific region in the period 2008-2013 (246 observations). The

selection did not include North Korea, Nauru, Tuvalu, Marshall Islands and Palau in the absence of data of a number of indicators. The information base for the study was the statistics from World Bank base.

As the dependent variable characterizing the innovative activity of the country in the real research was used the number of the submitted applications for patents from residents and nonresidents calculated on 100 thousand population (Patent).

The following indicators were considered as the regressors:

- Gross indicator of coverage of the population by the higher education, in percentage (*EDU\_H*). This indicator that reflects the level of education of the population is a characteristic of the human potential.
- Gross domestic product (GDP) per capita, on PPP in the international dollars (*GDPpc*). This index reflects the socio-economic development of the country.
- Public expenditure on education in the percentage of GDP (*EDU\_GDP*). The indicator reflects the socio-economic development of the country.
- Expenses on research and development, as a percentage of GDP (*RgD*). The indicator reflects the funding of research and development.
- Imports of high-tech products as a percentage of imports of goods (*IMP\_HT*). The indicator characterizes the impact of foreign trade activities on innovation and technological development of the country.
- Engineers in research and development sector, on 1 million people (*TECH\_RgD*). The indicator reflects the quality of human potential.
- Researchers in research and development sector, on 1 million people (*RES\_RgD*). The indicator reflects the quality of human potential.
- The coefficient of demographic loading, a number of people at the age of 0-14 and 65+ on 100 people at the age of 15-64 (*TDR*). This is an indicator of human potential for the characteristic of age structure of the population.
- The public and private expenditures on health care, as a percentage of GDP (*HEALTH\_GDP*). The indicator characterizes the development of human development as every person needs different events directed to the maintenance of health.
- The expected life expectancy at the birth, years (*LEB*). The indicator characterizes human potential.
- Direct foreign investments, pure outflow, as a percentage of GDP (*INV\_OUT*). The indicator reflects the investment attractiveness of the country.
- The unemployment rate, as a percentage (*U\_EMPL*). This is an indicator for the characteristic of human potential.
- Export of hi-tech goods, the percentage of industrial export (*EX\_HT*). The indicator characterizes the influence of foreign economic activity on the innovative and technological development of the country.
- Direct foreign investments, pure inflow, as a percentage GDP (*INV\_IN*). The indicator reflects investment attractiveness of the country.
- Information and communication services. The protected

Internet services, on 1 million people (*IT\_SERV*). The indicator characterizes access for the person to information resources.

- Articles in scientific and technical journals, quantity (*SAJ*). The indicator reflects the quality of human potential.
- Internet users, on 100 people (*IT\_US*). The indicator characterizes access for the person to information resources.

As previously noted, the approbation of the regression model is conducted according to the Asia-pacific region. Obviously, there is a fairly high degree of differentiation both in terms of characterizing the socio-economic development and in terms of innovation and technological development in the Asia-pacific region. In this study, it is supposed to divide Asia-pacific countries into homogeneous groups on all indicators described above.

Based on the proposed set of indicators characterizing the level of innovation and technological development of the country, it is implemented a multi-dimensional grouping of countries in the Asia-pacific region, which was conducted with the use of IBM SPSS Statistics package for hierarchical scheme by Ward’s method, the criterion of association, which is the metric of the city (city-block [Manhattan] distances).

As a result of the cluster analysis, the Asia-pacific countries will be divided into homogeneous groups according to the level of innovation development. In this regard, it seems appropriate the introduction to model a dummy variable, which will take into account the specificities of each country. We will present the specification of countries (countries belonging to a particular cluster) by binary attributes (Figure 1).

Taking into the consideration the information above, the basic regression model has the form (Formula 1):

$$\text{Patent}_i = \alpha + \beta_1 + \text{EDU}_H + \beta_2 + \text{GDPpc} + \beta_3 + \text{EDU}_GDP + \beta_4 + \text{RgD} + \beta_5 + \text{IMP}_HT + \beta_6 + \text{TECH}_RgD + \beta_7 + \text{RES}_RgD + \beta_8 - \text{TDR} + \beta_9 + \text{HEALTH}_GDP + \beta_{10} + \text{LEB} + \beta_{11} - \text{INV}_OUT + \beta_{12} - \text{U}_EMPL + \beta_{13} + \text{EX}_HT + \beta_{14} + \text{INV}_IN + \beta_{15} + \text{IT}_SERV + \beta_{16} + \text{SAJ} + \beta_{17} + \text{IT}_US + \mu_1 \text{CI}_A + \mu_2 \text{CI}_B + \mu_3 \text{CI}_C + \xi_i \quad (1)$$

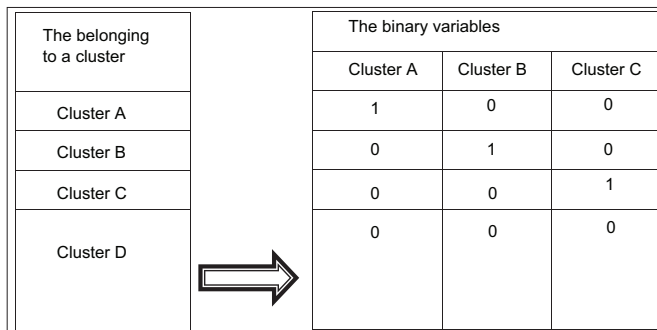
Where  $\alpha, \beta, \mu$  - The parameters of the equation;  $\xi_i$  - Residue; symbols with the variables indicate the direction of the relation.

### 3. RESULTS

On the basis of earlier offered set of indicators of innovative development, the multi-dimensional group of Asia-pacific countries for 2008-2013 was released. The results are presented in Table 1.

In 2013 cluster A included 12 Asian-pacific countries (29% of the total). The main characteristic of the countries that are included in this cluster is a low level of innovative development. This is evidenced by the low number of submitted applications for patents on average for 100 thousand populations, a number of articles in scientific magazines, and also and also the low number of engineers and researchers in research and development sector (mainly due to

**Figure 1:** Replacing the qualitative parameters of the regression model by binary attributes



**Table 1: The grouping of Asia-pacific countries by results of a clustering in 2008 and 2013**

Results of clustering at the beginning of the study period (2008)	Results of clustering at the end of the study period (2013)
<b>Cluster A</b> Guatemala, Tonga, Cambodia, Vanuatu, Samoa, Papua New Guinea, Solomon Islands, Timor-Leste, Micronesia	Peru, Ecuador, El Salvador, Panama, Colombia, Indonesia, Fiji, India, Mongolia, Chile, South Africa, Brunei Darussalam
<b>Cluster B</b> Macau, Mexico, Thailand, Costa Rica, Malaysia, China, the Philippines, Brunei Darussalam	Vietnam, Mexico, Thailand, Costa Rica, Malaysia, Philippines, China, Macau, Russia, Brazil
<b>Cluster C</b> Nicaragua, El Salvador, Vietnam, Honduras, Indonesia, Fiji, Mongolia, Peru, Ecuador, Colombia, Panama, Brazil, Chile, India, South Africa, Russian Federation	Solomon Islands, Timor-Leste, Honduras, Nicaragua, Cambodia, Micronesia, Guatemala, Tonga, Vanuatu, Samoa, Papua New Guinea
<b>Cluster D</b> Australia, Canada, New Zealand, South Korea, Japan, Singapore, Hong Kong, USA	Australia, Canada, New Zealand, South Korea, Japan, Singapore, Hong Kong, USA

Source: Calculated by authors based on following data (World Bank, The official site of Federal State Statistics Service of the Russian Federation, IMF, UNSD)

Chile, India and South Africa). As for the indicators characterizing human development, in this group of the countries it is possible to note average values in comparison with other clusters of indicators of GDP per capita, the gross coverage of the population with higher education (the average for the group is about 38%), life expectancy at birth an average of 72.7 years in the group.

During 2008-2013, the structure of cluster A had qualitative changes: According to the results of 2008 the group consisted of 16 countries; for the considered period, the Russian Federation, Vietnam and Brazil, having improved their ratings on the part of indicators that characterizes the innovative development, moved to the group of counties of cluster B. Herewith, the negative tendency of decrease of innovation activity indicators was noted in Brunei Darussalam (the number of the submitted applications for patents for the considered period decreased from 19.7 to 2.6 units [on

100 thousand population]), and also, the reduction was observed in terms of publication activity.

According to the end of 2013, the cluster B included ten countries of Asia-pacific countries (24% of the total). The countries of this group hold “middle” position comparing with the countries of other clusters. The countries of cluster B have ones of the highest values of GDP per capita and on average it has 27843 in PPP in international dollars. In 2013 in countries of this group, there was a high proportion of high-tech import, and it was on average 16.5% of the import of all goods (mainly due to the Philippines, Malaysia, and China). Herewith, and a high proportion of high-tech export was observed, and it was on average 24.5% of manufactured export, mainly due to the Philippines. As for indicators of human development, average life expectancy at the birth made 75 years, for support of education and health care were allocated on average on 4, 6 and 5, 7% of GDP, respectively. In cluster B, the average coverage of higher education was about 44%.

According to the end of 2013, the cluster C included 11 countries of Asia-pacific countries (26,8% of the total). The countries of this cluster are significantly different from all other clusters in the level of innovation development, as well as human development indicators. In this group, the lowest indicators of innovative activity of the population are noted (the number of the submitted patent applications was on average 0.747 on 100 thousand people of the population; the number of publications in scientific magazines was also at the lowest level in comparison with other clusters). This group has the lowest coverage of the population by the higher education (on the average 13.7%), and the lowest number of researchers and engineers in research and development sector. In the countries of the cluster C, there is the highest unemployment rate (on the average - 10.5%) relative to other clusters as well as the lowest rate of GDP per capita - 4084.9 PPP in international dollars. For the considered period the structure of a cluster increased. Two more countries could have joined the cluster - Nicaragua and Honduras, that, compared with other countries have failed to achieve the necessary to move to more prosperous cluster growth rates of certain parameters describing the level of innovation and the development of human potential.

In 2013, cluster D included eight countries of Asia-pacific countries (19.5% of the total). This cluster is formed by the leading countries in terms of innovative development and human development. In the countries of this group the indicator of average GDP per capita amounted to 48,054.53 in PPP in international dollars, and this indicates a relatively high level of socio-economic development of countries. Indicators of human development also are in the countries of this cluster at the high level: Coverage of the population with higher education on the average over the countries

of the group was 68%; on average on 100 thousand people of the population fall 819 and 4945.7 engineers and researchers in research and development sector, respectively. A number of publications in scientific journals at the end of 2013 amounted to an average of 43,233.6. In the countries of this group, it was on average 192 of 100 thousand people of the population of the submitted patents. All this certainly shows the high rates of innovation activity in the countries that are included in this cluster, as well as high rates of human development. For the considered period the structure of this cluster didn't change.

The results of a clustering show the great extent of differentiation of Asia-pacific countries as on the level of innovative development, and the level of human development. It is caused by a number of factors: Geographical position of the countries, climatic conditions, development of economy and labor market, demographic and social characteristics. In the context of innovations and opportunities of the person for therealization of the innovative ideas the USA, Japan, South Korea and other countries of a cluster of D are the most attractive.

Based on the above information, the regression model that describes the reciprocity of the factors that determines the innovative development in the context of human development was constructed. As a result, the correlation analysis revealed the strongly correlated factors. The presence of a linear relationship between the independent factors in the regression model leads to one of the major obstacles to the effective application of multiple regression analysis - Multicollinearity. To eliminate multicollinearity effect and to reduce the dimension of the baseline the factorial analysis by method main a component in the program SPSS was implemented in this study (Table 2).

Table 2 shows that own values of the first three principal components exceed a value of one so that they are retained for further analysis. Herewith, they explain 75.737% of the dispersion of initial signs. To determine the composition of the main components, and also to identify the correlation factors and principal components we construct a matrix of factor loadings. The sign of the factor loadings determines the direction of the connection (Table 3).

Table 3 shows that the first principal component includes indicators that reflect the level of human development: Gross indicator of coverage of the population the higher education; GDP per capita; costs of research and development; engineers in research and development sector; researchers in research and development sector; coefficient of demographic load of working-age population; the expected life expectancy at the birth; direct foreign investments (pure outflow); direct foreign investments (pure inflow); Internet users.

**Table 2: The value of the principal components and a share of the explained dispersion of signs**

The number of the component	The identification of the main component	The proper value of the principal component	The proportion of explained dispersion, %	The cumulative share of the explained dispersion, %
1	$F_1$	5.869	41.714	41.714
2	$F_2$	2.551	20.642	62.356
3	$F_3$	1.394	13.381	75.737

Source: Calculated by the authors

**Table 3: The matrix of factorial loadings main components**

Indicators	Component		
	$F_1$	$F_2$	$F_3$
<i>EDU_H</i>	0.771	0.225	0.144
<i>GDPpc</i>	0.718	0.057	-0.224
<i>EDU_GDP</i>	0.038	0.030	0.947
<i>RgD</i>	0.730	0.351	0.028
<i>IMP_HT</i>	0.242	0.750	-0.183
<i>TECH_RgD</i>	0.852	0.150	0.154
<i>RES_RgD</i>	0.819	0.207	0.093
<i>TDR</i>	-0.685	-0.020	0.084
<i>HEALTH_GDP</i>	0.107	0.443	0.592
<i>LEB</i>	0.715	0.147	-0.052
<i>INV_OUT</i>	0.716	0.021	-0.145
<i>U_EMPL</i>	-0.038	-0.050	-0.946
<i>EX_HT</i>	0.140	0.923	0.067
<i>INV_IN</i>	0.863	-0.097	0.079
<i>IT_SERV</i>	0.063	0.710	0.018
<i>SAJ</i>	0.278	0.807	-0.016
<i>IT_US</i>	0.909	0.170	0.018

Source: Calculated by the authors

Conventionally, the first component ( $F1$ ) may be called a “human factor:” GDP per capita reflects the level of material well-being, the gross coverage with higher education - literacy level, life expectancy at birth - the level of social well-being. Herewith, it should also be noted that these figures are included in the integral index - Human Development Index, according to the UN methodology. The structure of this indicator also includes indicators characterizing the number of specialists in research and development sector. The coefficient of demographic loading reflects the level of aging of the population, and also apopulation in working-age with the saved-up potential level. Direct foreign investments also play a special role in the formation of human opportunities because purposeful capital investments to various spheres and branches promote the improvement of the welfare of the population. The vast majority of indicators related to the first principal component of the direct correlation, i.e., at the increase in values of these indicators, according to calculations, a component changes the value towards increase, except for coefficient of demographic loading that tells about the decrease in value components with a growth of this indicator. The proportion of the variation of the first principal component was 41.714%.

The composition of the second principal component ( $F2$ ), the proportion of the variation which was 20.642%, includes indicators characterizing the innovative development of the country, so let's call it “Innovation potential factor:” Import of high-tech goods; export of high-tech goods; information and communication services; the protected Internet servers in calculation on 1 million people of the population; articles in scientific and technical journals. Indicators included in the second principal component has a direct correlation, indicating the increase in  $F2$  with the growth of the factors causing it.

The structure of the third principal component ( $F3$ ) includes: Public spending on education, total health expenditure, unemployment rate. The share of  $F3$  variation was 13.381%. Indicators of the third principal component, for the most part, can be described as factors that contribute to (obstructive) the development of

**Table 4: Matrix of pair coefficients of correlation between an integrated indicator of intensity and factors**

Factors	Patent	$F_1$	$F_2$	$F_3$
Patent	1.000	0.563	0.366	0.207
$F_1$	0.563	1.000	0.000	0.000
$F_2$	0.366	0.000	1.000	0.000
$F_3$	0.207	0.000	0.000	1.000

Source: Calculated by the authors

capacities (potency) of a person, which certainly have a positive effect on the level of innovation development. Public expenditure on education and health care costs have a positive correlation with the component; unemployment rate - negative. At the same time, measures to reduce unemployment and reduce tensions on the labor market, carried out by the state in a given country, of course, affect the rate of economic growth, which will lead to improving the level and quality of life in the country and, sure, will have favorable effect on the development of human capabilities and innovative thinking. All of the above will have a significant impact on the long-term and the level of innovation development of the country.

Thus, the study identified three common factors: The “human factor,” which characterizes the well-being of people (population) and the realization of its potential; “factor of innovative potential,” which describes the results of innovation activity in the country; “factor of human capabilities realization” describes the potential for personal fulfillment, as well as potential threats, hindering prosperous human development. It should be noted that the largest proportion of variation goes to the factor of human potential that tells about a bigger contribution of this component in the general variation of signs. This once again proves the fact that only the human factor can provide long-term sustainable innovation and technological development of any country.

Furthermore, the designation of the relationship between the development of innovative and derived factors is considered appropriate in this study (Table 4). As it was mentioned earlier, as a productive indicator was chosen the following indicator: The number of the submitted applications for patents from residents and nonresidents calculated on 100 thousand population (Patent).

As it can be seen from the Table 4, the relationship between the resulting index and the factors is direct, and the factor of human potential has the greatest impact on a number of the submitted applications for patents (the coefficient of correlation was 0.563). The factors are not correlated among themselves.

We will construct a regression model of the dependence of a productive indicator from the allocated factors (Formula 2). The regression model included the fictitious variables allowing to consider country belonging to a certain cluster.

$$y = 144.4 + 12.6F_1 + 8.8F_2 + 2.0F_3 - 112.5Cl_A - 111.8Cl_B - 92.1Cl_C \quad (2)$$

We will present confidential intervals of estimates of parameters of the regression equation (Table 5).

**Table 5: Confidential intervals for estimates of parameters of the regression equation**

Variables	Values of the parameters	Confidence interval	
		Lower bound	Upper bound
Constant	144.4	129.1	169.7
$F_1$	12.6	7.3	17.9
$F_2$	8.8	4.2	13.4
$F_3$	2.0	0.9	5.6
$CI_A$	-112.5	-142.9	-108.6
$CI_B$	-111.8	-140.1	-107.2
$CI_C$	-92.1	-120.4	-81.6

All parameters of the regression equation are significant at the 1% level of significance. Therefore, the model is adequate to the original data. Fischer’s F-criterion also showed the statistical importance of coefficient of determination ( $R^2 = 0.716$ ) at 1% level. The distribution of residuals indicates on the absence of heteroscedasticity in Figure 2.

In general, the regression model is considered to be an adequate source data as the coefficient of determination took value is not <50%. Thus, in 71.6% of cases, the change of the considered factors leads to a change in a number of patent applications in the country. All factors entered regression model with the signs which do not contradict reality. The constant  $\alpha = 144.4$  gives the predicted value of a dependent variable at the value of all factorial signs entering this model.

It should be noted that dependence of number of the submitted applications for patents from factors for the countries of each cluster will be described by the following equations:

For the countries of cluster A:  $y = 144.4 + 12.6F_1 + 8.8F_2 + 2.0F_3 - 112.5CI_A$

For the countries of cluster B:  $y = 144.4 + 12.6F_1 + 8.8F_2 + 2.0F_3 - 111.8CI_B$

For the countries of cluster C:  $y = 144.4 + 12.6F_1 + 8.8F_2 + 2.0F_3 - 92.1CI_C$

For the countries of cluster D:  $y = 144.4 + 12.6F_1 + 8.8F_2 + 2.0F_3$

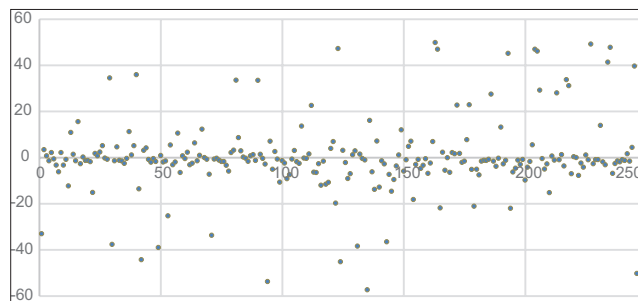
Further, we will give a visualization of results of research. In Figure 3 the empirical and simulated values of a number of the submitted applications for patents are given in the countries of a cluster A according to the results of 2013.

From Figures 3-6 it is visible that the model is adequate to the initial data, and the main tendency doesn’t contradict reality. In addition, relative deviations of the simulated values of a productive indicator from empirical data are presented on the graphs. The constructed model can be also used for the prediction of key indicators and identification of the main tendency of a productive indicator.

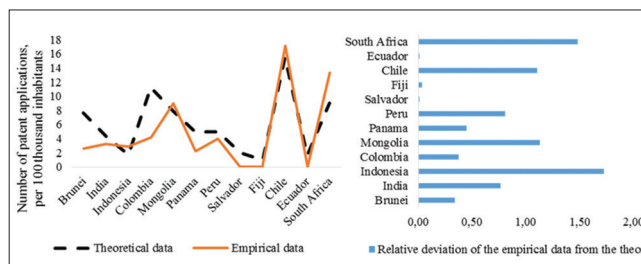
### 4. CONCLUSIONS

Thus, during research, the empirical model of the interrelation of innovative development from various factors was constructed.

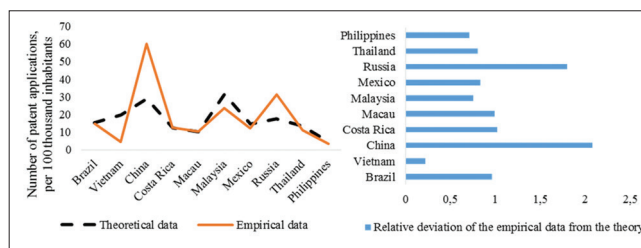
**Figure 2:** The distribution of residuals of the regression model



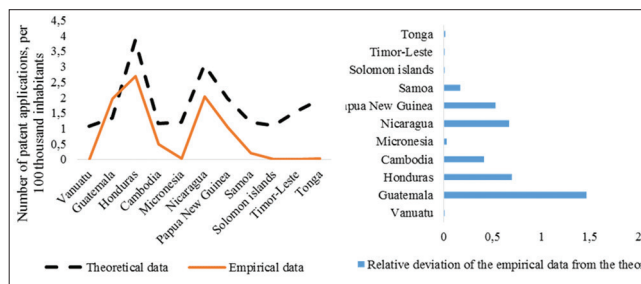
**Figure 3:** Number of the submitted applications for patents in the countries of a cluster A at the end of 2013



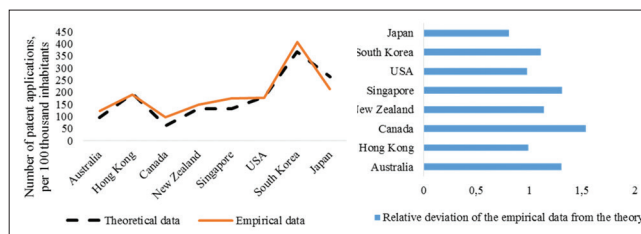
**Figure 4:** Number of the submitted applications for patents in the countries of a cluster B at the end of 2013



**Figure 5:** Number of the submitted applications for patents in the countries of a cluster C at the end of 2013



**Figure 6:** Number of the submitted applications for patents in the countries of a cluster D at the end of 2013



Indicators, their qualitative characteristics, the direction of communication are described, the basic model of assessment is offered. For the accounting of a factor of differentiation of the countries on a number of the indicators reflecting economic and innovative development, the clustering of the countries is carried out, and homogeneous groups are formed. Ultimately, the authors built a regression model that allows assessing the factors that influence innovation and technological development of the country. To eliminate the effect of multicollinearity, as well as to reduce the dimension of the initial indicators he factorial analysis by method main a component is realized in this research. Furthermore, the three major components were distinguished and their structure determined. Thus, the real research allowed to define quantitatively and qualitatively influence of a human factor in the innovative development of the countries of the Asia-pacific region taking into account their specific features.

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