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A Model of Regional Economic Space Modernization

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Abstract:

The paper presents a toolkit for regional modernization processes evaluation. A regression model derived allows for identification of the key factors that determine interrelation between regional development parameters.

The model application to the case of Tyumen region indicated a high extent of stability of spatial interaction patterns and a high degree of conservatism in the economy's structure due to the key role played by labor among other factors of output.

The model showed that the region's industrial component is highly dependent on the demographic factor, which means low innovation potential. Policy implication of the model provides a measure for necessary public interventions in innovation segment to compensate for the increasing innovation gap.

The interventions include incentives and stimuli to speed-up regional innovation dynamics, as well as the development strategy revision to introduce spatial economics concept, to prioritize modernization and to change traditional patterns of social and economic development.

Keywords*: Pegional development, economic space, modernization, economic model.*

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1. Introduction

Amid the Russian economy core transformation process an emphasis is to be made on regional-level changes and possible ways to deliver them. In the context of the uniform economic space theory a region should be considered as an integral spatial formation, often large in size, which is the biggest taxonomic unit in the system of territorial division. A region then is a domain where natural, geographical, economic, social, ethno-demographic and other processes interact. Therefore, transformation of economic space is possible only through modernization.

Contemporary conditions impose new requirements to public administration regarding modernization process strategy and tactics. Regional systems are in a transformation phase, which in turn requires the search for new paradigms that are adequate and actual. Thus, the new methodology is needed to revise regional socio-economic processes and to provide a holistic view of the patterns and interrelations, significant in terms of social and economic development and determinant to the modernization performance.

Since the second half of the 19th century, modernization paradigm is aimed at researching various aspects of transition to "new conditions" of life. Typically, the focus of research is the nature and factors of economic space transformation on different levels and their influence on institutes, norms and values. Besides, a modernization process study facilitates discovery of population behavior pattern considering time-and-space characteristics, which is also an advantage of the methodology.

Still, there are few studies covering modernization processes results on a regional level. In this regard, our study aimed to develop a toolkit for regional modernization processes assessment. The research hypothesis: economic space structure of a region depends on the nature of production processes held within the territory. A regional socio-economic space study was held then to determine and evaluate regional modernization processes.

2. Literature review

The theory of modernization was initially introduced to describe the Western European processes of transition from agrarian society to industrial society. Modernization was thought to be a process that covered different aspects of life: from economy to culture. Durkheim meant modernization the transition from mechanical to organic solidarity; Weber saw it as a shift from value-based to objective-based activity. Later, modernization was treated as a global process of displacing traditional local types by universal forms of modernity: Charlton and Andras defined modernization as "the tendency for growth in the adaptive complexity and efficiency of the social systems", given the modern societies are based upon growth and the expectation of growth, both economic and

"cognitive" (Charlton and Andras, 2003). In other words, modernization is a versatile process in which communities in a certain territory face a gradual or rapid change in traditional economic, social, political and cultural institutions.

Contemporary reminiscences may be found in Totonto (2017) regarding humanitarian aspects of modernization. This change over time entails or causes the emergence of fundamentally new institutions. In a broader sense, modernization is the process of substitution or destruction of traditional groups, institutions, norms and values by a new society. Up-to-date interpretation of modernization defines it as a special stage in the development of mankind, which is characterized by transition to a new type of society that is adequate to modern standards and requirements, and which grants the increase of quality of live resulting from the development of individuals' personal characteristics.

Modernization theory evolution can be divided into several stages, that changed each other along with the changes of economic development paradigms (Zedgenizova and Ignatyeva, 2017). Still, one tier of theories tries to explain the reasons of modernization, that are democratization, bureaucratization and internationalization according to Flora and Alber (1981). Another tier of modernization theory entails many approaches differentiated regarding various spheres of societies' life. Usually they are interdisciplinary in nature and cover various aspects of regional development. Thus, the paradigm has evolved from a generalized theoretical model into a ramified and empirically diverse structure. Evidence can be found in various domains of economic sciences, as well as the others. Modernization regarding quality of life is described, for example, in Martyshenko (2016), human capital development matters raised in Akhmetshin *et al.* (2018) infrastructure development and innovation issues of modernization discussed in Dunayev (2017).

Various aspects of spatial development are studied using the modernization paradigm, usually based on a comparative-historical approach. Phases of spatial transformation and rules of social development can be found in Black (1975) and Rostow (1960). A significant contribution to the study of development problems with an emphasis on global exogenous factors of the transformation process was made by Cardoso and Faletto (1979) and Wallerstein (1987).

The new industrialization is a promising model of regional economic space modernization of the old industrial regions and is a combination of reindustrialization (elimination of the consequences of deindustrialization) and neo-industrialization (creation of qualitatively new productive forces of the Technotronic level, interconnected in the system of automated machines). The new industrialization allows to create a new economic system, the basis of the structure of which will be the high-tech manufacturing sector, the achievements of the third and fourth industrial revolutions and the results of the fifth and sixth technological structures (Silin and Animitsa, 2017; Akopova and Przhedetskava, 2016).

It should be noted that, starting from the second half of the 19th century, the modernization paradigm is aimed at studying various aspects of transition to "new conditions" of life activity. Typically, the focus of research is the nature and factors of the transformation of economic space at different levels and their impact on institutions, norms and values.

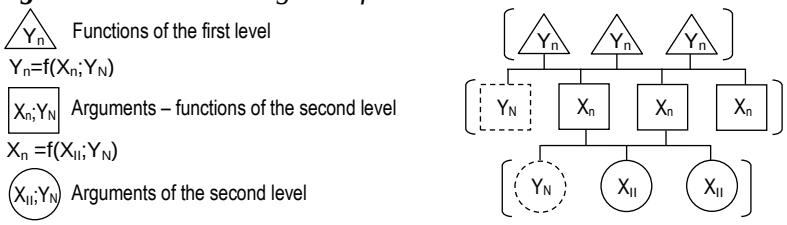
Thus, modernization is a complex global and complex process that takes place in all key spheres of life and involves improving the architecture of the existing way of life and the system of management. Its regional connotations require deeper research to determine explanatory models.

3. Methodology

Modernization processes' valuation requires a model to identify the nature of relationship between parameters of regional development. To derive the model, we took the following sequence of research activities:

1. Data set collection to run preliminary analysis and modeling considering the constraints and requirements regarding its quality and reliability of sources.
2. Identification of dependent and independent variables. This process was based on the results of an earlier research held using the method of directed graphs.
3. Selection of the set of independent variables, which was a several-step procedure: a) pairwise correlations of dependent and the whole set of independent variables were estimated to select arguments with the most statistically significant correlation ratios with respect to the modeled indicator; b) the selected indicators were multicollinearity-checked to exclude the mutual influence of two or more variables on the function; c) arguments that had not been included in any of the functions were analyzed to take them into account in the dynamics of other arguments. As a result, a three-level rotational model was formed (Figure 1).

Figure 1. *Structural diagram of the three-level rotational model*



4. Data set preparation for subsequent modeling procedures: ensuring the continuity of time series, eliminating the outliers and white-noise components, data scaling and, where necessary, smoothing time series. Details of the approach can be found in Ekimova *et al.* (2017).
5. Selection of a proper function describing dynamics of a given variable, using the curve fit method and nonlinear estimation. The set of tested functions included

linear, exponential, power, logarithmic, parabolic, logistic and other S-shaped curves, Johnson's function, trigonometric and other cyclic functions. Selection criteria were determination coefficient (R-squared), as well as the goal-specific path of a given social and/or economic process.
6. Generalized representation of a proper function.
7. Estimation of regression coefficients for each model.
8. Model's quality and goodness of fit evaluation (according to R-squared and Fischer criterion).
9. Regression coefficients' evaluation (Student's t-test and p-level).
10. Analysis of the estimated function and residual values.
11. Estimation of the discrepancy between actual data ad estimates.
12. Integration of the equations into the system.
To verify the model, a β-model was constructed. It was based only on the dependencies existing between the functions of the first level. Results section provides the description of the research steps' results.

4. Results and discussion

The first stage of modeling procedure resulted into a data set of indicators describing the progress of regional modernization (Table 1).

Table 1. *Regional modernization processes' characteristics (indicators)*

Identifier	**Indicator name**	**Identifier**	**Indicator name**	**Identifier**	**Indicator name**
Y1	Gross regional product, per capita	X7	Density of roads with a hard surface	X13	Rate of natural increase
X2	Index of industrial output	Y8	Average per capita income	X14	Rate of migration increase
X3	Index of agricultural output	X9	Average nominal wage	X15	Life expectancy at birth
Y4	Fixed capital investments, per capita	X10	Ratio of income of 10% most and 10% least prosperous population	X16	Infant mortality rate
X5	Depreciation of fixed assets	X11	Unemployment rate, by ILO methodology	Y17	Emissions into the atmosphere
X6	Density of railways	X12	Registered unemployment	X18	Reforestation

To build the model we took Tyumen region data from 1998 to 2016 (19 years). Earlier periods (before crisis of 1998 and currency denomination in 1997) were different in scale or in patterns of economic processes' dynamics. In this regard, the

1998 crisis can be considered as a starting point for analysis. In addition, according to some indicators, reliable statistical data were not available until 1998.

The indicators in Table 1 were divided into dependent functions (denoted by Y) and independent ones (denoted by X). The distribution of functions and arguments is performed in accordance with the data obtained from the previously constructed directed graph (Polyakova and Simarova, 2014). The dependent variables were denoted those that have shown the greatest impact on the regional socio-economic system.

Before the model was built, we ran an analysis of the main system-forming parameters, which were GRP per capita, investment in fixed capital per capita, individual income and level of emissions to the atmosphere. Their dynamics estimates included GRP and investment accelerator and multiplier, as well as income and emission elasticity to GPR change (see methods in Table 2).

Table 2. *Indicators for assessing the backbone modernization parameters*

Indicator	**Calculation procedure**
Accelerator	GRP per capita / fixed capital investment per capita
Multiplier	relative increase in GRP per capita / relative increase in fixed capital investment per capita
Coefficients of elasticity	Average growth rate of average per capita income of the population / average growth rate of GRP per capita
	The average growth rate of air pollutant emissions from the stationary sources / average GRP growth rate per capita

Following the procedure described above, we analyzed multicollinearity to exclude the mutual influence of the arguments on the same dependent variable. Also, the nature of the indicators was considered, as was the coverage of an indicator by analysis. Thus, for example, it was discovered that the index of industrial output had no significant effect on any dependent variable, while some arguments were strongly dependent on it. This required the model rotation. Similarly, rigid and reliable relationships between certain functions were established, which determined the rotation of some of them to the level of arguments. At the same time, the existence of significant interrelations between certain arguments caused the rotation of some of them to the level of sub-arguments. The final arrangement of functions and arguments included in the model is presented in Table 3 (note: the "x" symbol denotes the arguments to be included in the corresponding function).

The data preparation consisted in scaling the initial values to bring them to the dimension of one-two-digit numbers. We took natural logarithms of the initial levels, since it allowed to smooth series efficiently and keep an emphasis on a proper trend, if there was any.

Table 3. *Generalized model structure*

		Arguments												
		X2	X5	X7	X11	X13	X14	X15	X16	X18	Y1	Y4	Y9	Y10
Functions	Y1											x		
	Y4				x			x						
	Y8		x	x							x			
	Y17				x								x	

Thus, an analysis of per capita GRP dynamics discovered its linear nature, however, the following remark was pertinent: in the analyzed period, according to the visual representation, there was obviously a logistic dependence that had been investigated and rejected: from the development point of view, the expected and desirable GRP trend was the upwards one exceeding the population growth; yet, logistic curve presumes GRP stabilization, which was undesirable proceeding from the principles of normative and genetic forecasting models.

The indicator of per capita investment had similar dynamics compared with GRP, which could be explained by strong causality relation between them. Situational damping of investment was interpreted as a temporary decline in regional investment, caused by the impact of the global financial crisis of 2008. Consequently, in the economic-mathematical description of investment, we found necessary to use growth models, since before the crisis (during 2000-2007) investment grew steadily and rapidly.

Per capita income was found to have a logarithmic pattern of growth, which was characterized by a gradual slowdown in growth rates. Further dynamics was expected to be smoothly-upwards considering the increasing natural growth rates and then expected slowdown in wages' growth. Thus, the logarithmic function taken as basis was quite in line with the reality, as well as with short and medium-term prospects of income growth: the financial crisis slowed down the growth rate of wages, which directly affected the average per capita monetary income.

The volume of emissions of pollutants into the atmosphere was described by nonlinear logistic dependence. Emissions growth was expected to keep on decreasing to finally achieve stabilization. However, in the medium and long-term perspective, a significant reduction in emissions in Tyumen region, given the existing structure of industry and the technologies, seemed hardly possible. Thus, the downward dynamics of this indicator, as required by sustainable development goals, was found plausible only when significant results of modernization processes are achieved.

Considering the latter factors, trends and constraints, the generalized model was drafted as follows (1):

$$\begin{cases} Y1 = a_1 Y4 + b_1 \\ Y4 = a_2 + X11 + b_2 X15 + c_2 \\ Y8 = a_3 ln(b_3 X5 + c_3 X7 + d_3) \\ Y17 = \frac{1}{1+a_4 e^{b_4 X11 + c_4 Y9}} \end{cases} \quad (1)$$

where a, b, c, d were the regression coefficients; Y1 – GRP per capita; Y4 – Fixed capital investment per capita; X11 – Unemployment rate by ILO methodology; X15 – Life expectancy at birth; Y8 – Average per capita income; X5 – Depreciation of fixed assets; X7 – Density of automobile roads; Y17 – Emissions in the atmosphere; Y9 – Average nominal wage.

Parameter estimates were calculated using "Nonlinear Estimation" tool of 'Statistica' software package to derive the following equation (2):

$$\begin{cases} Y1 = 0{,}6902 Y4 + 0{,}7192 \\ Y4 = -0{,}0314 X11 + 1{,}6162 X15 - 4{,}4721 \\ Y8 = 36{,}0339 \ln(0{,}1841 X5 + 0{,}0708 X7 + 0.1643 Y1) \\ Y17 = \frac{1}{1-0{,}9188 e^{-0{,}00516 X11 - 0{,}7611 Y9}} \end{cases} \quad (2)$$

The model quality was evaluated according to the criteria described above. Thus, the value of determination coefficient of specific equations exceeds 94%, that indicates a high statistical significance of the described dependences. Similar conclusions were made upon F-test analysis results. The statistical significance of regression coefficients was also confirmed by satisfactory p-level values (a level of statistical significance) not exceeding the threshold value of 5%. This allowed to conclude that the dependencies obtained were non-stochastic in their nature.

Testing the model in retrospective data (reverse verification or back-testing) proved that the estimates' average relative deviations from the actual fall within a range 0.16% to 2.12%. At the same time, for the entire multiple of pairs (96 actual values vs. their model estimates) only 2 deviations exceeded 5% measure. The analysis of the residuals, the spread of which obeys the law of normal distribution in 96% of cases, confirmed the high reliability and statistical significance of the model derived. Thus, the generated system of equations adequately reflects the dynamics of the investigated variables, which allowed us to conclude that it was possible to use it to study the modernization processes in a region.

Prospects for further research lie in the domain of constructing forecast scenarios of the basic indicators' development. We derived forecasts and described scenario conditions for the variables included in the model as factors. The model, using the forecast data of variables, can be used to describe future pace of economic development and decide if the modernization process fits and meets the expectations of main stakeholders.

Several theoretical and empiric results can be drawn upon the model analysis and testing applied to other regions' data:

1. The current model of economic development relies significantly on the block of factors that are treated by political economy theory as "labor" that indicates the dominance of labor-intensive production in the structure of output.
2. The interrelations and regularities that have developed in the economic space of the region are stable, reflecting a high degree of conservatism in the economic structure. This proves the need for modernization reforms and indicates the potential complexity of their implementation. The refraction of the existing tendencies will require great effort and will face internal resistance.
3. Economy of the region is an industrial type economy. Such an indicator as agricultural output does not have a significant impact on the dynamics of the region's economic development. Moreover, the industrial component is highly dependent on the demographic factor, which allows to speak of its low innovative orientation, yet innovations act as the driving force of regional development. This thesis is postulated and reinforced in numerous scientific theories, and the importance of innovation is emphasized in several known studies. At the same time, their practical implementation does not meet modern requirements. The current system of public administration in economic sphere is based on a strategy of adaptation: it used traditional methods of management aimed to respond to changes in the global hydrocarbons market. This undermines regional competitiveness in the long term. Since modernization of regional economic space may promote the quality of life, the governments' task is to develop effective tools, means and infrastructure that facilitate regions' transition to an innovative development path.

It is necessary to create appropriate conditions, primarily of an institutional nature, to stimulate the development of the regional economy in a specified vector. One such key condition is a comfortable "smart" regulatory environment (the system of norms defining the conditions of business), that is formed with a regional peculiarity. In particular, regulatory norms should take into account and promote the competent spatial placement of advanced industries that can ensure the formation of continuous chains of education-science-technology-production-market (Rakmeeva, 2018).

Planting innovation into a region's modernization framework, especially in the regions of new development or industrial regions, is usually associated with organizational transformations aimed at achieving financial and economic goals, since the main criterion for innovation efficiency is profitability growth. Such transformations can be considered as a change in the parameters of business processes.

It is undoubled that the process of regional economies' modernization requires a complex and diverse toolkit, which considers various aspects of enterprises' functioning. This puts forward the need for a scientific rationalization of the

approach to designing enterprise management systems based on the definition of the structural elements of administration model. Therefore, we assume that introduction of the program-based approach will ensure the effective implementation of innovation as a key precondition for modernizing a region's economy. The latter, in turn, will lead to an improvement in the quality of life of the population.

5. Conclusion

Economic modeling of development process in the Russian regions in terms of GRP functionality proved the importance of investment and of several population-dependent factors. Thus, regional economic space transformations are much likely to become successful if the following provisions re met:

1) To level-up the existing gap between innovation development indicators of the Russian regions and the developed countries it is necessary to ensure innovation activities' pace ahead of global rates.
2) Innovation activity should be supported by a combination of accumulated capital and intellectual resources, as well as by a certain level of efficiency of their use, combined to the increase of individuals' entrepreneurial initiatives level.
3) Priorities in industrial development should be based on high-tech and knowledge-intensive industries, as well as on the introduction of advanced technologies.

The latter conclusions confirm the thesis about the necessity of state stimulation of innovation activity in the region and necessitate the development of new priorities in the management of modernization processes, the abandonment of the classical and well-established understanding of a number of patterns of regional dynamics.

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