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SUBSTANTIATION OF MODELS FOR FORECASTING THE REGIONAL SOCIAL AND ECONOMIC RURAL DEVELOPMENT

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ABSTRACT

The areas of application of mathematical and statistical methods for determining the prognostic model of rural development on the example of all Ukraine taking into account the economic, social and environmental component are explored in this article. Econometric modelling is the basis of the research methodology in this work. As a tool for analysis, a specific system of evaluation of selected indicators and their correlation and regression processing is applied. The results showed that the most influential factors for the level of development of rural territories of Ukraine are ten among the 60 indicators, grouped by the three components. They characterize the economic, social and environmental component and determine some impact on the functioning of the country's territorial system as a whole. The mathematical expression of the prognostic model of rural development is established using the regression analysis.

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A set of measures for regulation of rural development is developed on the basis of these results, which envisages the implementation of measures in the areas of software, normative and legal support. It is expected that this study will help public authorities make more effective decisions on addressing key issues of social and economic processes in rural areas of individual regions, Ukraine as a whole and other countries.

Keywords: model, correlation and regression analysis, forecasting, social and economic development, regulatory measures, rural areas.

1. INTRODUCTION

Predicting trends and the level of development of rural areas of Ukraine is an important element of scientific knowledge of the problem. It allows understanding more deeply the mechanisms of development of a certain range of processes over time, to reveal the nature of the relationships between the factors of influence on the economic, social and environmental components, to substantiate the directions of their optimization. We consider it necessary to clearly substantiate the methodological apparatus that most satisfies the task of the study in the context of forecasting calculations of rural development, allows to make the most approximate to the reality of forecasts based on extrapolation of indicators of past periods and taking into account the interrelations between different factors.

In this regard, the construction of a multifactor regression model allows for the most complete consideration of patterns and trends, and the selection of diversified factor indicators and to reveal the complex impact of economic, social and environmental factors on rural development. In addition, this model allows us to predict the impact of a change in one of the factors on the value of the resultant indicator, i.e. the value of the integrated development assessment.

2. LITERATURE REVIEW

The issues of theoretical and methodological support, determination of strategic directions of development of rural territories, substantiation of tools for forecasting social and economic parameters of functioning of territorial communities are devoted to the scientific works of many scientists.

In particular, a number of scholars describe the methodology for conducting statistical evaluations for economic research (FESHCHUR; BARVINSKYI; KICHOR, 2001), pointing to the importance of studying the factors behind the result. Other scholars (RUSKA, 2012;

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TOPTUNOVA; VASYLIEVA; KLOVANIK, 2008) have established sufficient significance of one- and multivariate correlation and regression analysis in the study of economic phenomena. One of the ways to achieve the strategic goals of economic systems development is to use econometric forecasting models (IVASHCHUK, 2008; RUSKA, 2012).

As a rule, the theoretical bases of application of estimation of the current state, influence of a certain set of factors and planning of development of economic systems are covered in their works.

Some authors propose to apply the method of mathematical and statistical evaluation of territorial development by separate components: employment and development of agricultural production (NIVIEVSKYI; CRAMON-TAUBADEL, 2006); household development (PSHYK-KOVALSKA, 2008); functioning of rural territories under self-government (ZVIERIAKOV; KOVALOV; SMENTYNA, 2017); within general country development planning (HORBULIN;, KACHYNSKYI, 2010).

Nevertheless, the works do not take into account the complexity of the problems and the importance of forecasting the development of rural territories by economic, social and environmental components and determining for each organizational and economic measures of influence.

The purpose of the article is to substantiate directions of formation of prognostic model of development of rural territories in Ukraine and proposing of necessary measures for solving economic, social and environmental problems of their functioning.

3. METHODOLOGY (DATA AND METHODOLOGY)

In addition to a number of general scientific methods of economic research, it was used in the course of the research as the basic systematic approach (in revealing the nature of rural territories and peculiarities of their functioning); economic and statistical analysis (in assessing the current state of rural development); econometric modelling (identification of the influence of factors on the level of rural development); abstraction and formalization (to substantiate the determinants of rural development, theoretical generalization and formulation of conclusions).

The research methodology involved considering the factor of forecasting as an integral element of the social and economic development of rural areas, where the process of determining organizational and economic security plays a key role.

4. RESULTS AND DISCUSSIONS

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4.1. Contents of the methodology for forecasting rural development

Prediction of social and economic development objective is to identify opportunities to fully customized qualitative and rural settings and calculate their significance. We selected 60 indicators for the three blocks of assessment of the state and development of rural areas for this purpose. The mathematical expression of the model formed with the purpose of predicting the development of rural territories, we have shown using formula (1):

$$G = f(X, Y, Z), \quad (1)$$

In this model, G – is an independent variable (the resultant regression equation is Y), X, Y and Z – dependent variables (factors – X) affecting level and variation.

In general, the proposed model with a consistent reflection of its components determines the dependence of the state and level of rural development on factors of economic, social and environmental nature, which is a logical conclusion given that the empirical studies indicate that there is a link between these groups of indicators. The peculiarity of the presented model is that it is a simplified expression of real processes, which, however, can serve as an important tool for determining and predicting the effect of a change in a factor or their totality on the state of the system under study.

Thus, we tried to reflect the impact of each of the groups and subgroups of factors of economic, social and environmental nature in the process of developing the model by selecting such a set that allows the most complete and accurate description of the studied processes and the general state of rural development. The influence of the remaining elements not taken into account in the model is expressed by the so-called error of approximation (ε), which gives the formula 1 the following form:

$$y = f(x_1, x_2, x_3 \dots) + \varepsilon, \quad (2)$$

where ε – a random component that explains the influence of other factors not known in the model and unknown factors.

The following circumstances make it advisable to introduce a number of conditions into the proposed model:

a) The spatial nature of the aggregate of data determines the dependence of the change of the effective indicator on the territorial features and conditions;

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b) The main condition for selecting the factors characterizing the result is the inclusion of the maximum possible number of significant factors of each group to the model;
c) Determining the state of development of rural areas as an effective indicator of the integral coefficient.

In the given equation y is a dependent (endogenous) variable whose value is formed on the basis of the interaction of independent (exogenous) factors.

The method of constructing the correlation and regression model is reduced to the following algorithm:

1) the formation of the purpose of the model;

2) choice of the method of model realization;

3) selection of model parameters;

4) setting conditions and restrictions;

5) selection of endogenous and exogenous variables;

6) checking the existence and closeness of relationships between factors;

7) construction of regression model, formation of regression equation;

8) check the reliability of the model

The results of the correlation and regression model can be used both to explain and modelling changes in the performance indicator, based on the change in factors, and to predict the change in the indicator over time.

The basic model calculations are performed using the program of STATISTICA (data analysis software system), version 6, manufactured by StatSoft, Inc. (2003). Advantages of application of the program are the wide toolkit of statistical methods and techniques, convenience of conducting calculations and reliability of the obtained results.

The working hypothesis of the study assumes the existence of the influence of economic, social and environmental factors that determine the level of development of rural areas on the indicator, which is a form of the final manifestation of this development – an integrated index of development by three components (X, Y and Z).

Conducting a correlation analysis of the data showed that there are some links between rural development indicators. The selection of the factor characteristics of the model in the

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classical sense involves the selection of indicators with the highest level of correlation. However, in our case there are a number of limitations:

– the presence of a clear structure of factors requires their uniform display in the model, which necessitates the inclusion of one factor from each group;

– given the large number of factors that can be included in the model, we can work not only with those that have the highest level of correlation with the score, but also with those that have medium and weak links.

Therefore, we selected a number of indicators for regression analysis, which as far as possible; satisfy the conditions of model (1) and the general algorithm for modelling the level of rural development by the method of sorting the most likely variants and combinations of factors. Table 1 shows the correlation matrix of the selected set of factors, which includes their optimal (10 out of 13 possible) numbers.

Table 1: Correlation matrix of the main indicators of rural development in Ukraine

Indicators		x_{24}	x_{31}	y_{17}	y_{26}	y_{34}	y_{41}	y_{54}	z_{12}	z_{22}	z_{31}	**y**
		x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	
x_{24}	x_1	1,000	0,121	0,097	0,223	-0,114	0,259	-0,213	0,226	-0,226	-0,351	**0,178**
x_{31}	x_2	0,121	1,000	-0,022	0,238	-0,526	-0,198	-0,400	-0,216	-0,018	0,080	**-0,103**
y_{17}	x_3	0,097	-0,022	1,000	-0,084	-0,161	0,054	0,276	0,339	-0,363	-0,150	**0,243**
y_{26}	x_4	0,223	0,238	-0,084	1,000	-0,205	0,024	-0,331	-0,065	-0,004	0,038	**-0,277**
y_{34}	x_5	-0,114	-0,526	-0,161	-0,205	1,000	0,380	0,047	-0,234	0,317	0,358	**-0,438**
y_{41}	x_6	0,259	-0,198	0,054	0,024	0,380	1,000	-0,284	-0,171	0,152	0,316	**-0,177**
y_{54}	x_7	-0,213	-0,400	0,276	-0,331	0,047	-0,284	1,000	0,248	-0,127	-0,332	**0,422**
z_{12}	x_8	0,226	-0,216	0,339	-0,065	-0,234	-0,171	0,248	1,000	-0,689	-0,474	**0,827**
z_{22}	x_9	-0,226	-0,018	-0,363	-0,004	0,317	0,152	-0,127	-0,689	1,000	0,302	**-0,659**
z_{31}	x_{10}	-0,351	0,080	-0,150	0,038	0,358	0,316	-0,332	-0,474	0,302	1,000	**-0,678**
y		**0,178**	**-0,103**	**0,243**	**-0,277**	**-0,438**	**-0,177**	**0,422**	**0,827**	**-0,659**	**-0,678**	**1,000**

Source: author's calculations.

As we can see, the variable attributes are characterized by varying degrees of correlative connection with the performance indicator (y), which ranges from 0.103 to 0.827. The low level of correlation in our case is reasonable and appropriate, given the large number of factors of the model. The set of factors included in the model is quite complex and characterizes different aspects of rural development, in particular:

Index x24 is the index of agricultural production that allows to trace the temporal and spatial tendencies of economic growth of the base-forming branch of rural territories, which will consequently influence the motivation for further investment in real sectors of the economy, including innovations; the change in the level of profitability of rural population and

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rational use of natural resources. That is, the intensification of the development of the agricultural sector of the economy will determine the positive signals for investment in the technical and technological support of production; it will create the preconditions for increasing productivity and profitability of employees, and will also create limiting factors for the environment.

Index x31 is the capital investment for one person – partly reflects the causal component of the increase in entrepreneurial activity and economic growth of the real sector; it is characterized by an inverse correlation with the resulting indicator, which is explained by the uneven spatial distribution of investments within Ukraine for the benefit of regions with lower levels of rural development;

Index y17 presents the demographic burden on the population aged 15 to 64 that has a slightly higher level of correlation with the resultant indicator than the previous indicators. It is explained by the importance of demographic factors of rural development and the isolation of the human being as a central object of manifestation of economic, social and environmental characteristics of development. It is characterized by a high degree of correlation with the share of the population with average per capita cash income per month below the subsistence level, reflects the demographic component of social processes in rural areas;

Index y26 presents the share of economically active people with higher education. It indicates the intellectual level of development of the national economy, indicates a close correlation with such indicators as the agricultural production index and capital investment per person. It reflects an inverse relationship with the resultant indicator, which is explained by the low level of education of the economically active population of rural areas;

Index y34 presents the share of persons employed in the real (material production and trade services) sector of the economy. It indicates a high dependence of the level of development of the national economy on traditional, raw material industries, as well as the limited choice of employment directions in the country's labour market. It is characterized by a high degree of correlation with the share of economically active persons with full tertiary education, capital investments per person. It reflects the inverse relationship with the resultant indicator, which is explained by the limited opportunities for diversification of the development of economic activity in rural areas;

Index y41 presents rural settlements located more than 5 km to the council – characterizing the degree of accessibility of rural population to economic and social

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infrastructure, the ability to provide economic and social needs in the centres of territorial communities. The inverse correlation connection with the resultant indicator results from the deterioration of the social and economic infrastructure at a distance from the administrative centres of rural areas. It should be borne in mind that in the context of community mergers into larger administrative entities, the distance of other settlements to the centres of territorial communities will only increase;

Index y54 presents the share of the population with average per capita cash income per month below the subsistence minimum. It reflects the economic and motivational components of rural labour application; it is also characterized by a direct dependence on the resultant indicator, which is explained by the causal link between increasing levels of development and reducing rural development. It displays a close correlation with almost all selected indicators;

Index z12 is a waste pollution coefficient of the I-III classes. It characterizes the environmental component of human economic activity and social behaviour. The indicator acts as a stimulant, i.e. its high value means a better level of hazardous waste management. The close correlation with the resulting indicator indicates a significant technogenic influence on rural development, which is also confirmed by close correlation with indicators such as the agricultural product index and capital per capita;

Index z22 is the proportion of polluted return water discharged into surface water bodies. It allows tracing the effects of economic activity on the pollution of rural water resources as one of the major determinants of human life. It is characterized by an inverse dependence with the resultant index, which is explained by the negative impact of excessive economic human interference on the environment;

Index z31 is a coefficient of load factor for pollutant emissions into the air. It allows determining the effects of economic activity on air pollution as one of the main factors of human activity, in particular in rural areas. It is characterized by an inverse dependence with the resultant index, which is explained by the negative impact of excessive economic interference on the environment.

The result of the correlation and regression analysis is to construct a regression equation, which in the general case has the following form:

$$y = a + b_1x_1 + b_2x_2 + b_2x_2 + b_3x_3 + b_4x_4 + b_mx_m*, \quad (3)$$

** Note. It was created by the author based on [362, p. 120].*

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where y – dependent or predicted variable (score) (resulting index); x1 – independent variable; a – a free member of the equation; b1 – is the coefficients of the conditionally pure regression, m is the number of independent variables.

Substituting the above given indicators (see Table 1) into formula (3), the regression equation will look like:

$$y = a+b_1x_1+b_2x_2+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6+b_7x_7+b_8x_8+b_9x_9+b_{10}x_{10}, \quad (4)$$

where y – integrated rural development index; a – a free member of the equation; b1 is a coefficient of conditionally pure regression; x1 - agricultural production index (x24); x2 – capital investment for one person (x31); x3 – demographic burden on the population aged 15–64 (y17); x4 – share of economically active persons with complete higher education (y26); x5 – share of employed in real (material production and trade services) sector of economy (y34); x6 – rural settlements more than 5 km from the council (y41); x7 – share of the population with average per capita cash income per month below the subsistence minimum (y54); x8 is the coefficient of pollution of waste of I-III classes (z12); x9 is the proportion of contaminated return water discharged into surface water bodies (z22); x10 is the coefficient of load for pollutant emissions into the air (z31).

It should be noted that the proposed set of factors is the result of a complete search of all empirically substantiated combinations of factors and an estimation of all regression models formed by them for the sake of significance and reliability., The proposed list of factors meets the following condition given the above conditions and constraints: it includes the maximum reasonable number of factors that, with a small exception, characterize each group of economic, social and environmental factors and collectively form an adequate and meaningful model for rural development.

Given the large number of factors used and the close and average correlation between them, an important condition for forming a selection of model factors is the absence of multicollinearity between them, which could distort the results of the regression analysis and significantly reduce the significance of the model.

We calculated the variance and deflection coefficient for the secondary regressions (2) of each of the exogenous factors included in the model to test for multicollinearity.

$$VIF=1/(1-R^2) \quad (5)$$

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The values of the calculated coefficients for each of the received variables are below the acceptable level (VIF<3). Accordingly, the phenomena of multicollinearity in the proposed model are not detected; all the factors can be included into the model.

The total expression of the results of the regression analysis, the determination of the regression coefficients (bi), β-coefficients, elasticity coefficients (ε) and the formation of the regression equation are shown in Table 2.

Table 2: Results of regression analysis of rural development in Ukraine

Factors		β-coefficient	Change in accordance with the value of β-coefficient	Coefficient of regression b_1	t – Student's criteria (t_{crit}=2.056)	p-level	Coefficient of elasticity
Free member				1,371477	8,08152	0,000001	
x_{24}	x_1	-0,109360	0,051223	-0,002180	-2,13499	0,049666	-0,1094
x_{31}	x_2	0,116096	0,057484	0,004347	2,01962	0,061660	0,1161
y_{17}	x_3	-0,203943	0,045347	-0,000417	-4,49733	0,000426	-0,2039
y_{26}	x_4	-0,231341	0,042928	-0,005351	-5,38906	0,000075	-0,2313
y_{34}	x_5	-0,283279	0,056505	-0,009373	-5,01336	0,000154	-0,2833
y_{41}	x_6	0,299277	0,051430	0,166541	5,81910	0,000034	0,2993
y_{54}	x_7	0,248324	0,052996	0,004894	4,68571	0,000293	0,2483
z_{12}	x_8	0,565111	0,062348	0,136967	9,06381	0,000000	0,5651
z_{22}	x_9	-0,190337	0,057000	-0,001108	-3,33925	0,004483	-0,1903
z_{31}	x_{10}	-0,332965	0,056227	-0,003277	-5,92185	0,000028	-0,3330
y							
Regression equation		**$y=1,371-0,0022x_{24}+0,0043x_{31}-0,0004y_{17}-0,0053y_{26}-0,0094y_{34}+0,1665y_{41}+0,0049y_{54}+0,1370z_{12}-0,0011z_{22}-0,0033z_{31}$**					

Note. * It is a factor characterized by a t-criterion value below the critical level.

As we can see, with the exception of x31, all other factors have a sufficient level of significance for the model (tfact <tcrit) at a confidence interval of 0.05. Accordingly, the casualty of their relationship is less than 5%. This is also evidenced by the p-level value (below the confidence interval level – 0.05).

Concerning index x31, we see that the p-level is 0.062. This indicates the possibility of including this indicator to the model, provided that the threshold of the confidence interval is slightly reduced to 0.07. That is, a slight deterioration in the quality of the model forecast by 2% allows us to supplement the set of model factors with an important indicator of the economic group.

On this basis, we opted for the addition of the model with the aforementioned indicator, with the condition that the confidence interval threshold is reduced to 0.07. Substantiating our

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choice, we will note the positive influence of the mentioned factor on the level of development of rural territories of Ukraine.

That is, it exists, but, given the temporal and spatial variability of the values of the indicators, it may acquire signs of a parabolic or other kind of curve. On the other hand, the identified trends in the behaviour of individual indicators of the studied model indicate the existence of factor traits that in a particular period or territory are characterized by enhanced effect on the productive trait.

4.2. Practical aspects of the prognostic model application

It is necessary to formulate new conceptual approaches to take into account the balance of interests of economic, social and environmental components based on the identified links and behavior model of predictive imperatives of the future state of rural areas, as well as to develop an appropriate development strategy to achieve the maximum value of the integral index and equalization of temporal and spatial imbalances.

We propose to apply a set of measures for regulation of rural development based on the results of the regression model and its interpretation, which implies the implementation of measures in the areas of software, normative and legal support (Table 3).

Table 3: Structuring of rural development regulation of measures based on regression model

Factor	Program measures	Legal and normative measures
x_{31}	Increasing the volume of investment into agriculture, business and infrastructure	Creating preferential conditions for investing in agriculture and rural development
x_{24}	Improvement of conditions of interaction of agricultural enterprises with territorial communities	Definition of principles and formation of legal framework for programmatic interaction of rural communities and agricultural enterprises
y_{41}	Provision of access of rural population to administrative and infrastructure services, especially in settlements which, as a result of administrative reform, lose certain functions of local self-government	Establishment of limit distances to administrative and infrastructure service centers, approval of the list of services and requirements for their provision
y_{54}	Increasing the rural population's opportunities for employment and entrepreneurship, increasing the level of social security for the rural population	Establishment of a reasonable level of subsistence level for the rural population, establishment of an institute for stimulating economic activity in rural areas
y_{34}	Increasing the level of diversification of rural employment by stimulating the development of services and IT	Creating preferential conditions for rural entrepreneurship in services and IT
y_{26}	Increase in the share of rural residents who live and work in the village after receiving higher education, involvement in living and working in the village of urban residents	Approval of the list of occupations and categories of IHE entrants obliged to work in rural by determined term, the formation of provisions on co-payments for employees of certain professions

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y_{17}	Increasing the number of children born in rural areas, creating additional motivators for youth living in rural areas	Establishment of a supplement for young people for living in rural areas, creating the conditions for buying housing in rural areas and bringing up children
z_{12}	Reduction of production volumes of wastes of I-III classes due to their replacement with safe materials; Improvement of the level of safety of storage and disposal of waste of I-III classes	Clarification of norms of production and management of waste of I-III classes in accordance with the achievements of STP and specificity of rural territories (proximity to residential areas, zones of agricultural production)
z_{31}	Reduction of dangerous atmospheric emissions due to technological changes in production or improvement of the state of emission filtration	Clarification of emission standards into ambient air, depending on the type and conditions of production, as well as the specifics of rural areas
z_{22}	Reducing the amount of polluted backwater discharged into surface water by improving production technologies or filtration systems	Clarification of standards and reduction of the list of permits for pollution of return water discharged into surface water bodies depending on the type and conditions of production, as well as the specifics of rural areas

Note. It is developed by the author.

We propose to include programmatic actions into existing programs and strategies as well as in the stage of formation. Their main purpose is to specify the goals and problems, the solution of which is necessary to improve one or another parameter of the state of rural territories.

A number of actions outside the scientific research are necessary for full implementation of the proposed measures, in particular: public discussion of proposals, determining the degree of financial and administrative support for their implementation, coordination of proposals regarding rural areas with other areas of public life, etc.

5. CONCLUSIONS AND RECOMMENDATIONS

The data suggests that the main constraints on rural development are negative demographic trends, low levels of education, and environmental pollution. Accordingly, it is advisable to develop an up-to-date regulatory concept and integrated rural development strategy that would reduce the negative impact on the human environment and exploit the strengths of each component of development.

The author's position involves the study of the most significant cause and effect relationships between factors and consequences using the economic and mathematical tools for predicting rural development. In our case, the set of factor traits includes a large number of parameters that are in practice complementary or, conversely, mutually exclusive. This necessitates complex mathematical calculations to determine the relationships of influence that

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will be fairly conventional in the calculations and will not be amenable to the logic of economic knowledge and processes.

From an economic point of view, the development of rural areas needs to be reviewed in the context of three main components: economic, social and environmental. On the basis of this, specific organizational and economic measures will be proposed to address topical issues of territorial development.

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