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ROAD INFRASTRUCTURE MANAGEMENT SYSTEM IN THE REPUBLIC OF MOLDOVA: THE CORRELATION BETWEEN ALLOCATED FINANCIAL RESOURCES AND ROAD QUALITY

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Abstract

The scientific work represents a research regarding the significant importance of performance-based road management in economic activity. In this sense, the authors have carried out a concrete estimation of some indicators that influence development and economic growth by ensuring the implementation of road management, carried out with the identification of elements of progress in order to review the way of efficient use of resources. Investments in transport networks ensure the increase of invested capital compared to that achieved in other fields of activity, based on direct and indirect effects, resulting from cost savings by attracting the necessary resources for the creation of modern road infrastructures. The progressive management of road is based on performance, both programming and the implementation of their maintenance and operational activities, determined in accordance with the defined performance indicators. The scientific methods used are: analysis and synthesis, induction and deduction, critical analysis of materials, etc. The main results obtained from the investigations refer to the assessment of the indicators regarding the effective management of road by applying the performance of progress in view of user access to qualitative public roads.

Keywords*: management, transport networks, public roads, quality, modern infrastructure, performance*

1. Introduction

The generating factor for growth and economic emancipation for the development of a society is the existence of modern and qualitative road networks, capable of ensuring commercial links at national level between various regions, but also internationally, thus contributing to the intensification of relations between states, connecting localities to the national network transport, thus facilitating the free movement of citizens and increasing mobility. Road management establishes and implements road infrastructure policy through predetermined and systematic activities, so as to ensure a performance and the achievement of the required quality of the road infrastructure.

2. The degree of investigation of the problem at present, the purpose of the research

The importance and topicality of the research topic can also be argued by the fact that roads are part of the national transport system. These are land communication paths that must meet certain conditions, such as:

- maximum safety, especially for passenger transport;
- speed, i.e. high traffic speed;
- mobility and access to all interesting places;
- regularity and punctuality, regardless of atmospheric conditions;
- large transport capacity along the entire route;
- economic, both in terms of initial investment and operating expenses.

With reference to our object of study, 3 determinants are stipulated in the specialized literature:

1. The road infrastructure, which is defined as part of the road construction consisting of earthworks, their consolidation and protection works, including works of art (bridges, viaducts, tunnels, etc.), which support the road superstructure and transmit to the ground requests from traffic and from the forces loading the construction.
2. Infrastructure – all the elements of a construction that support its useful part, connect it to the ground and transmit to it the forces that load the construction
3. Road infrastructure - the set of constructions, installations and equipment that support road traffic [4, 5].

The common definition of the notion of road, according to the DEX, is "land communication path, consisting of a narrow and continuous strip of beaten, cobbled, paved or asphalted land" [5].

From the studied literature, we find that one of the first researchers who analyzed the scientific determinant "road" is Prof. S. Tripp. in his work "Road traffic and its control". Tripp mentions that there are 2 major missions of roads: first, roads are the main conduit of traffic and second - roads serve the everyday activity of communities. He classifies roads into 3 categories: *arterial, sub-arterial and local or minor roads* [11].

Arterial roads are "roads in which everything but non-motorized traffic is included", sub-arterial roads are "roads open to all types of traffic and motor traffic must predominate"; local or minor roads are "roads intended for local traffic only, roads will be predominantly intended for the needs of passengers and pedestrians" [4].

At the same time, Stephen Marshall, a professor at the University of Westminster, in his publication A First Theoretical Approach to Classification of Arterial Streets, mentions that „There are countless ways to describe and classify roads. We can classify by form, by function, by use or provision, by their significance” [8].

Thus, from examining the diversity of classification systems found in the literature, it is evident that there is no single classification of road types. For example, roads can be classified as:

- by the type of property and the subjects that ensure their management,
- depending on the traffic (volume, composition),

- by network role (location and connectivity),
- by physical form – dimensions, alignment, etc.,
- as an urban function,
- according to people's activities on the roads.

Efficient road management must be regarded as a system, which is extremely important for the development of quality transport networks and represents a process of maintaining and modernizing road networks that allows their continuous use by traffic, efficiently and safe. From the analysis of specialized literature, we identify that the notion of *system represents a scientific determinant used over time*. Thus, the DEX defines the system as "an ensemble of elements (principles, rules, forces, etc.) dependent on each other and forming an organized whole, which puts order in a field of theoretical thinking, regulates the classification of material in a field of natural sciences or makes a practical activity work for its intended purpose [5].

Alexandru Surdu in his work *General theory of systems* makes a detailed analysis of the evolution of the notion of system. In this paper, the author mentions that "although it seems difficult to argue that there are historical elements worth mentioning in a general systems theory, there are nevertheless interesting issues that have been debated since antiquity and that are directly related to the topic under discussion" [10]. From this work there is evidence that the evolution of the notion of system begins in the works of the Greek philosophers Aristotle, Plato, etc. But still, we consider this scientific determinant to be relatively new. The founder of the general systems theory is the biologist Ludwig von Berthalanffy, who in 1968 proposed this theory as "a tool that could be shared by many different sciences" [7]. Starting with this theory, the notion of system also began to be used in management.

Thus, with the development of the management concept, the system is initially treated as a working method, a way of organizing a process, an operation. Currently, it is known that the management system represents that ensemble, all interconnected elements, through which the actual management process is executed, in order to achieve the defined goals.

Respectively, in order to define a system in any field, we must determine the elements that are a component part of the type of activity, and at the same time, we must determine those links or rather those existing connections between the elements of the process and at the same time, let's not forget to determine its objectives.

The purpose of the research: Following these investigations, the authors propose in this study to carry out an analysis on the management of road infrastructure, based on the combination of result indicators (quality) and inputs (allocation of financial resources) by the nature of the influence of the model parameters, which describe the dependence between effort and effect.

3. Applied methods and materials

The authors in their research used methods of empirical synthesis approached from the economic perspective of road infrastructure development with the set of processed qualitative data, centred on comparative analysis of econometric regression models. Using in this sense the observation and case study for the evaluation of public roads in correlation with the resources intended for the development of this field.

4. The obtained results and discussions

4.1. Implementation of performance-based management

In the new European approaches regarding the realization of constructions/rehabilitation of public roads, economic operators in construction must adopt, implement and maintain a high-performing Quality Management System, as a component part of the unit's general management system, through which they orient themselves and coordinates the unit's activity in terms of quality.

Quality assurance management is a main component of the quality system in the construction of public roads and represents a significant side of the management system of economic operators in construction. Quality management establishes and in fact transposes the quality policy through pre-established and systematic activities, thus still preventing non-quality, ensuring the achievement of the required quality and providing confidence in the capacity of the unit.

Within the new European approaches to construction / rehabilitation of public roads, economic operators in construction must adopt, implement and maintain an efficient Quality Management System, as a component part of the overall management system of the unit, which guides and coordinates the activity of the unit in terms of quality.

Quality is a notion with a very wide use, which makes it extremely difficult to make its definition from a scientific point of view. An older definition states - the set of properties of a product or service that gives it the ability to meet expressed or implied needs. Other informal definitions mention: - prevention is cheaper than repair; - or it is cheaper to do everything right from the beginning; - quality is the minimum cost that a product imposes on society.

The construction quality of roads is defined and regulated by law no. 721 of 02.02.1996 entitled “Law on quality in constructions”. The provisions of this law apply to constructions of any category and their related installations, regardless of the type of property or destination, including rehabilitation, capital repair of public roads, hereinafter referred to as constructions, as well as their modernization, modification, transformation and consolidation works.

Construction quality means a set of properties that must be possessed by an object to be put into operation, which meets the modern requirements for its construction, operation and economy.

The quality of the construction of the installation, of the infrastructure network, depends on the quality of the project, the quality of the construction materials, constructions, semi-finished products, parts and the quality of the construction and installation works.

Results-based or performance-based resource management was actually recommended by the Hoover Commission of the United States in 1949. In the 1950s and 1960s, many countries, including the United States, began evaluating institutions with the help of performance indicators not on how much they spent, but on what they actually produced. In the end, these systems did not deliver the expected results because they were too rigid to account for uncertainty and unpredictability and because they failed to identify the limits of formal systems that influence people's behaviour.

As a result, performance measurement declined in popularity in the late 1970s and mid-1980s, but has seen a renaissance in the last 30 years as a result of changing economic environments as well as citizens' ever-increasing demands for quality infrastructure. Thus, the strongest trend to improve performance is to use resources through performance-based management and reporting. Australia and New Zealand were the first countries to implement performance management based on performance indicators in the late 1980s, followed by Canada Denmark, Finland, France, Sweden, the United Kingdom and the United States in the early 1990s. In the late 1990s - in the early 2000s we find Austria, Germany and Switzerland.

Governments have introduced performance-based management for four main reasons:

- to improve efficiency;
- to improve decision-making;
- to transparently improve accountability;
- to make savings.

Some countries have focused on only one or two of these goals, while others have embraced all four, with the aim of introducing performance-based financial resource management and the responsibility of the legislature and citizens. Australia, Denmark, the Netherlands, New Zealand, the United Kingdom and the United States are pursuing this approach.

In countries such as the United States, ministries have developed strategic plans that include performance targets. Others have adopted performance contracts, for example, between a ministry and a subordinate institution. The purpose of these contracts or agreements is to facilitate a greater understanding and strengthen bargaining power within the public sector.

This approach has the advantage that it tends to clarify the responsibility of each party to the contract or agreement, informally particularly on the performance in the allocation of resources as well as the specification of sanctions and rewards.

There have been different approaches to implementing performance management. Some countries - for example Australia, the Netherlands, New Zealand, and the United Kingdom have implemented the top-down approach, others, such as Finland, have adopted a bottom-up and ad hoc approach in which institutions are free to develop their own methods based on performance and with little interventions on behalf of top bodies.

The main goal is to move from an input-based system to a results-based system. This can be achieved by a clear definition of the objectives and methods to be followed.

Therefore, there are higher demands for results but at the same time a greater freedom is granted regarding the methods used to obtain them. But the central point is responsibility, who and how is responsible for the results.

O a stronger emphasis on accountability allows the limitation, even the exclusion, of the daily controls of the superior organs. It is therefore important to develop appropriate means of measurement that fully ensure the obligation to be accountable, with the aim of both promoting greater operational freedom and effective strategic control.

In the Republic of Moldova, the management of resources in the field of road management focuses on the results to be obtained from the activities planned / carried out by the authorities / institutions, by establishing performance indicators in program budgeting.

Program performance is a method of presenting and substantiating budgets, based on programs with goals, objectives and indicators to evaluate their performance at all stages of management. Also, efficient program management is an efficient road management tool, which ensures the setting of priorities and decision-making on the allocation of resources necessary for the rehabilitation and modernization of roads. It is also based on the allocation of resources in programs according to the planning and setting of priorities, emphasizing the connections between the allocated budgetary resources and the results to be achieved, through the activities financed by these resources. It is a tool to strengthen the increased responsibility of public authorities / institutions in the process of spending the resources allocated to the maintenance and rehabilitation of road infrastructure and achieving progressive performance.

For the field of roads, financial means were used for the implementation of the Program "Development of transport and road management", Subprogram "Development of roads". The sub-program included maintenance, repair and rehabilitation activities of national and local public roads, road condition monitoring, as well as actions to increase road safety. The objectives of the subprogram were implemented by the State Enterprise "State Road Administration", the total length of national roads being 3336 km, and local roads - 5475 km.

4.2. Analysis of the multiple regression model

Next we will make a case study of a multiple regression model, so that we can observe the connection and dependence of financial resources used for maintenance and rehabilitation of roads in Moldova depending on the four road conditions, namely: good, mediocre, bad and very bad.

Table 1. Initial data

Year	Resources used for road maintenance and rehabilitation, mil. lei	Good condition IRI (2 - 4), %	Mediocre condition IRI (4 - 6), %	Bad condition IRI (6 - 8), %	Very bad condition (IRI > 8), %
	y	x_1	x_2	x_3	x_4
2009	416.4	9.8	29.6	40.7	19.9
2010	421.8	19.7	36.7	27.1	16.5
2012	1137.5	31.8	41.1	19.3	7.8
2013	1162.7	41.26	37.99	14.93	5.82
2014	2044.4	35.87	77.51	17.05	8.32
2015	1153.1	25.19	37.81	16.89	8.54
2016	1120.3	15.8	31.67	24.93	15.2
2017	1104.5	17.65	30.43	23.21	12.39
2018	874.3	16.83	29.3	23.98	14.63
2019	1597.1	14.75	25.7	25.8	21.23
2020	2100.9	17.81	23.09	25.88	20.92
2021	1977.8	42.72	24.59	18.8	13.86

Identification of variables

The multifactorial model for our problem is defined by the following relation:

$$y = f(x_1, x_2, x_3, , x_4) + \varepsilon \text{ , (1)}$$

where:

x_1, x_2, x_3, x_4 are exogenous, independent or cause variables;

y is the endogenous, dependent, or effect variable;

$\varepsilon(\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4)$ is the residual, ally, disruptive, or error variable;

$f(x_1, x_2, x_3, x_4)$ is the regression function with which the values of the variable *y* will be estimated.

The general form of the multifactorial model for the given problem is presented as follows:

$$y_t = c_1 + c_2x_{1t} + c_3x_{2t} + c_4x_{3t} + c_5x_{4t} \text{ , (2)}$$

where $= \overline{1,12}$; 12 is the number of terms of the statistical series, in our case the number of years for which the data were collected.

In this study we have the following variables:

y - Resources used for road maintenance and rehabilitation, unit of measurement - million lei;

x_1 – *Good road condition IRI (2 - 4)*, unit of measurement - % from the road length;

x_2 - *Mediocre condition of the roads IRI (4 - 6)*, unit of measurement - % from the road length;

x_3 - *Bad condition of the roads IRI (6 - 8)*, unit of measurement - % from the road length;

x_4 – *Very bad condition of the roads IRI (> 8)*, unit of measurement - % from the road length.

Regression coefficients c_1, c_2, c_3 and c_4 measure the influence of each of the 12 factorial characteristics on the result *y*.

The system of equations is obtained:

$$\begin{cases} c_1 + c_2x_{11} + c_3x_{12} + c_4x_{13} + \varepsilon_1 = y_1 \\ c_1 + c_2x_{21} + c_3x_{22} + c_4x_{23} + \varepsilon_2 = y_2 \\ c_1 + c_2x_{31} + c_3x_{32} + c_4x_{33} + \varepsilon_3 = y_3 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ c_1 + c_2x_{12,1} + c_3x_{12,2} + c_4x_{12,3} + \varepsilon_{12} = y_{12} \end{cases}$$

Estimation of the c_1 free term shows the level of the endogenous variable when all the influence variables x_1, x_2, x_3, x_4 have a zero value. Estimation of parameters c_1, c_2, c_3 and c_4 shows how much the endogenous variable varies when the exogenous variable corresponding to that parameter varies by one unit, provided that all other variables are constant.

The sign and value of the parameters c_1, c_2, c_3 and c_4 are used to describe the interdependence between the dependent variable y and the independent ones x_1, x_2, x_3 și x_4 and x_4.

Econometric description

The econometric description of the connection between the four variables y, x_1, x_2, x_3, x_4 can be made with the help of five models:

I. The unifactorial model: $\boldsymbol{y = f(x_1) + \varepsilon_1}$ explains the variation of *y* on the variable x_1, or the variation of the *Financial resources used for road maintenance and rehabilitation* depending on the *Percentage of the length of roads in good condition.*

II. The unifactorial model: $\boldsymbol{y = f(x_2) + \varepsilon_2}$ explains the variation of *y* on the variable x_2, or the variation of the *Financial resources used for road maintenance and rehabilitation* depending on the *Percentage of the length of roads in mediocre condition.*

III. The unifactorial model: $\boldsymbol{y = f(x_3) + \varepsilon_3}$ explains the variation of *y* on the variable x_3, or the variation of the *Financial resources used for road maintenance and rehabilitation* depending on the *Percentage of the length of roads in bad condition*.

IV. The unifactorial model: $\boldsymbol{y = f(x_4) + \varepsilon_4}$ explains the variation of *y* on the variable x_4, or the variation of the *Financial resources used for road maintenance and rehabilitation* depending on the *Percentage of the length of roads in a very bad condition*.

V. The unifactorial model: $\boldsymbol{y = f(x_1, x_2, x_3, x_4) + \varepsilon_5}$ explains the variation of *y* on the variable x_1, x_2, x_3, x_4, or the variation of the *Financial resources used for road maintenance and rehabilitation* depending on the *Total length of roads regardless of their condition.*

The identification of regression functions for unifactorial models is done using the graphical representation of the endogenous variable according to the exogenous variables (correlation graphs - Figures 1, 3, 5 and 7) performed in Excel and ANOVA tests performed in EViews (Figures 2, 4, and 6):

The unifactorial model: $\boldsymbol{y = f(x_1) + \varepsilon_1}$

or

$$\boldsymbol{Resources = f\ (\%\ \ of\ the\ length\ of\ roads\ in\ good\ condition) + other\ influencing\ factors}$$

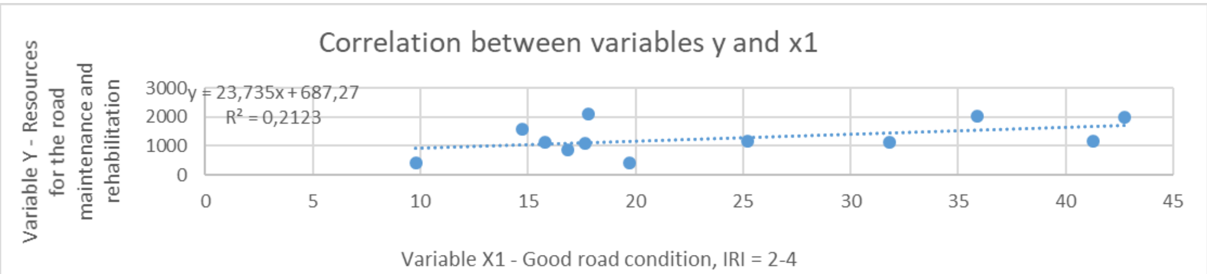
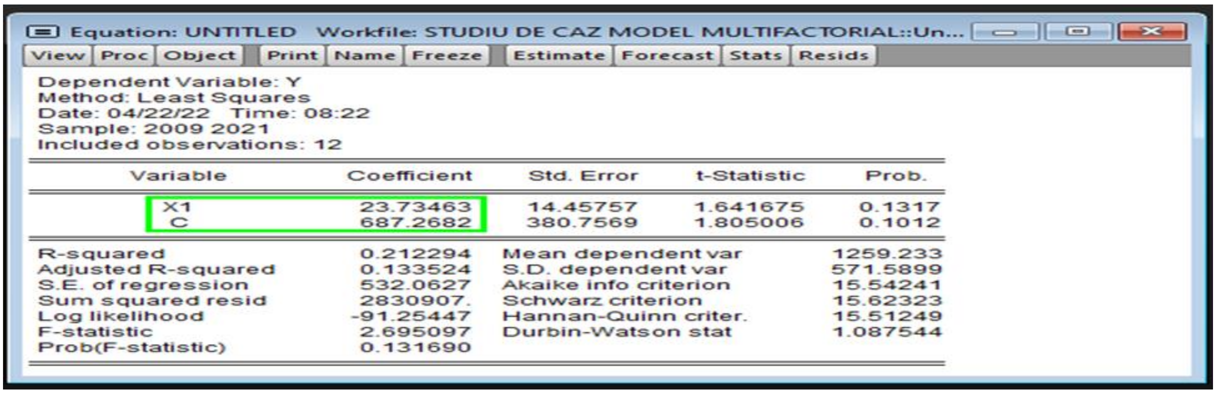


Figure 1. Graph of the correlation between the variable y and x1, or between the *Money resources used for road maintenance and rehabilitation* and % of the *length of roads in good condition*

Interpretation of Figure 1: it is observed that with the increase of the variable x_1 the variable *y* also increases, this means that the connection between them is direct. That is, the higher the percentage of road lengths in good condition, the greater the resources for their maintenance and vice versa, the worse the condition of roads will be, the lower the financial resources for their rehabilitation.



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Dependent Variable: Y
Method: Least Squares
Date: 04/22/22 Time: 08:22
Sample: 2009 2021
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X1	23.73463	14.45757	1.641675	0.1317
C	687.2682	380.7569	1.805006	0.1012

R-squared	0.212294	Mean dependent var	1259.233
Adjusted R-squared	0.133524	S.D. dependent var	571.5899
S.E. of regression	532.0627	Akaike info criterion	15.54241
Sum squared resid	2830907.	Schwarz criterion	15.62323
Log likelihood	-91.25447	Hannan-Quinn criter.	15.51249
F-statistic	2.695097	Durbin-Watson stat	1.087544
Prob(F-statistic)	0.131690		

Figure 2. ANOVA results for the unifactorial model $\boldsymbol{y = f(x_1) + \varepsilon_1}$

Interpretation of Figure 2: Regression equation is $y = 687{,}268 + 23{,}735 \cdot x_1$, the same as in the graph from Figure 1. If the length of roads in good condition would decrease by 1%, the resources allocated for their maintenance and rehabilitation would decrease by 23.735 million lei. The coefficient R-squared = 0.2123 is very small and close to zero, which indicates a very weak link between these two variables. Only 21.23% of the variation of financial resources is influenced by the percentage of roads in good condition.

Unifactorial model: $\boldsymbol{y = f(x_2) + \varepsilon_2}$

or

$$\boldsymbol{Resources = f(\%\ of\ the\ road\ length\ in\ mediocre\ condition) + other\ influencing\ factors}$$

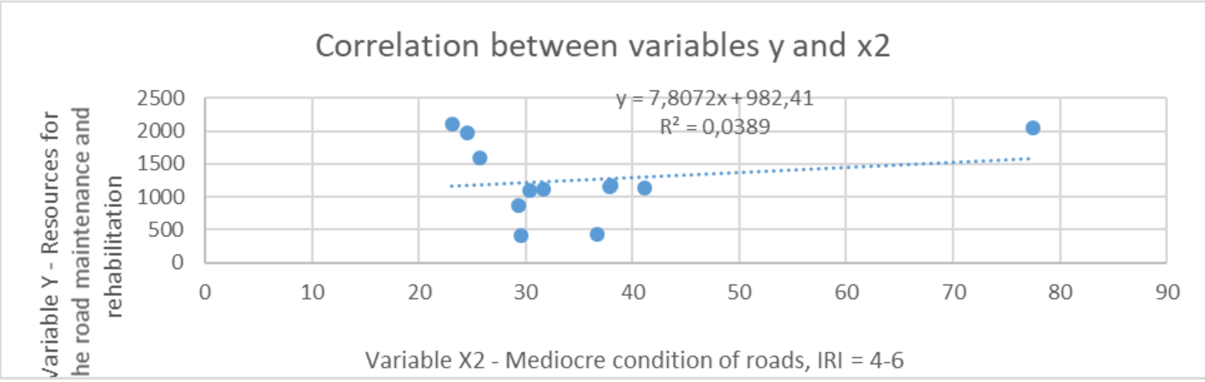
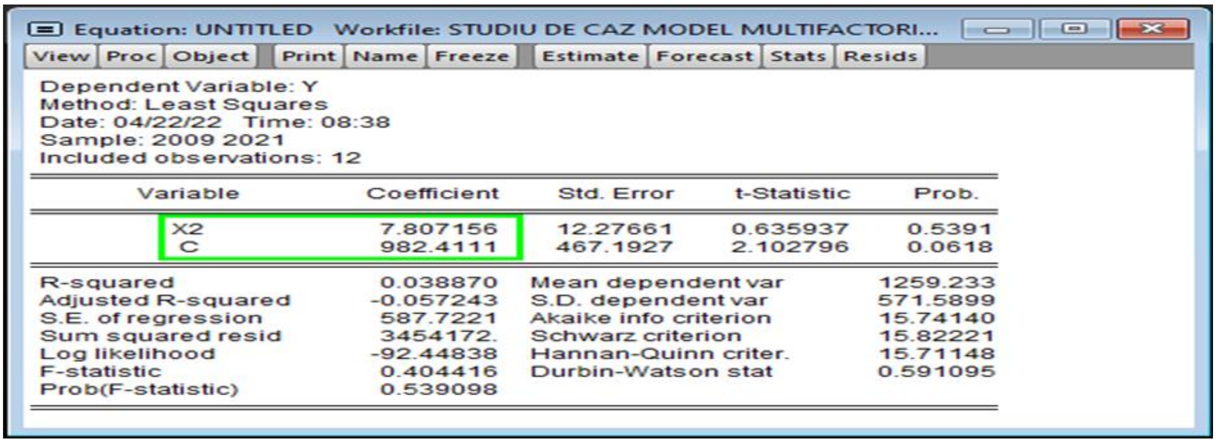


Figure 3. Graph of the correlation between the variable *y* and *x*2, or between the *Money resources used for road maintenance and rehabilitation* and % of the *length of roads in mediocre condition*

Interpretation of Figure 3 it is observed that with the increase of the variable x_2 the variable y also increases, this means that the connection between them is direct. That is, the higher the percentage of the length of roads in mediocre condition, the higher the resources for their maintenance and vice versa, the more the mediocre condition of the roads will deteriorate, the lower the financial resources for their rehabilitation.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Dependent Variable: Y
Method: Least Squares
Date: 04/22/22 Time: 08:38
Sample: 2009 2021
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X2	7.807156	12.27661	0.635937	0.5391
C	982.4111	467.1927	2.102796	0.0618

R-squared	0.038870	Mean dependent var	1259.233
Adjusted R-squared	-0.057243	S.D. dependent var	571.5899
S.E. of regression	587.7221	Akaike info criterion	15.74140
Sum squared resid	3454172.	Schwarz criterion	15.82221
Log likelihood	-92.44838	Hannan-Quinn criter.	15.71148
F-statistic	0.404416	Durbin-Watson stat	0.591095
Prob(F-statistic)	0.539098		

Figure 4. ANOVA results for the unifactorial model $\boldsymbol{y = f(x_2) + \varepsilon_2}$

Interpretation of Figure 4: Regression equation is $y = 982{,}411 + 7{,}807 \cdot x_2$, the same as in the graph from Figure 3. If the length of roads in mediocre condition would decrease by 1%, the resources allocated for their maintenance and rehabilitation would decrease by 7.807

million lei. The coefficient R-squared = 0.0389 is extremely small and close to zero, which indicates a significantly weak link between these two variables. Only 3.89% of the variation of financial resources is influenced by the percentage of mediocre roads.

Unifactorial model: $\boldsymbol{y = f(x_3) + \varepsilon_3}$
or

$$\boldsymbol{Resources = f(\%\ of\ the\ road\ length\ in\ bad\ condition) + other\ influencing\ factors}$$

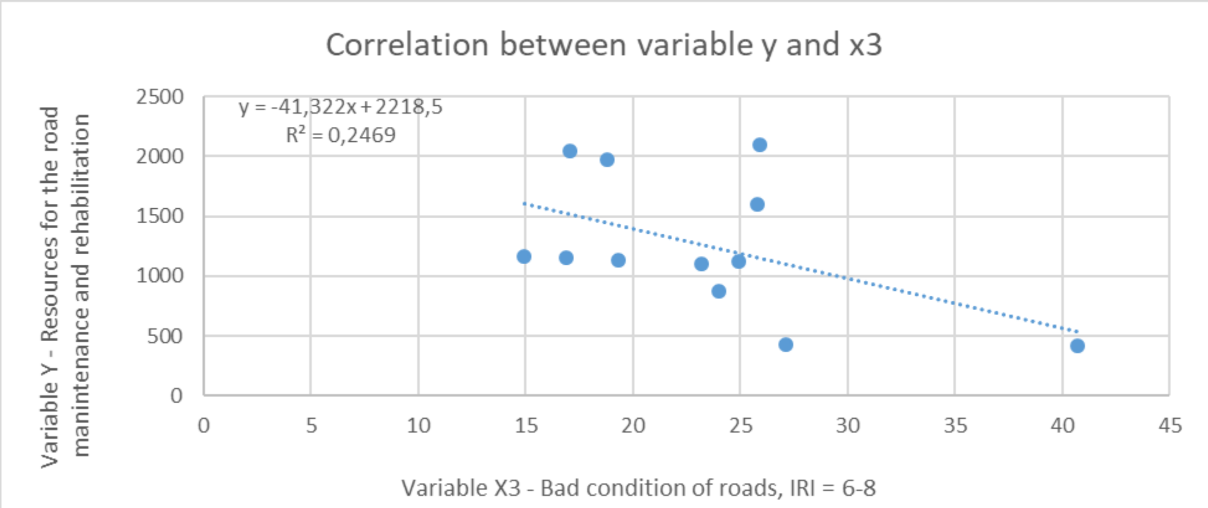
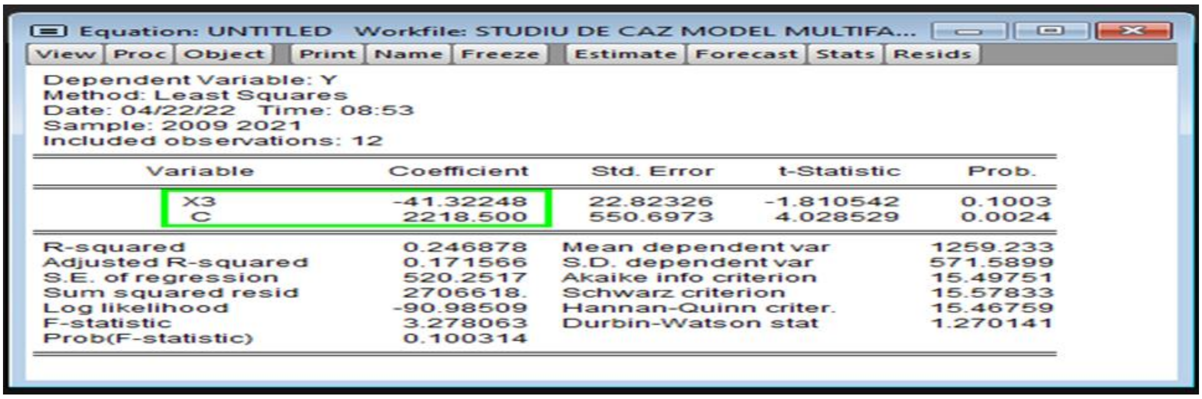


Figure 5. Graph of the correlation between the variable *y* and *x*3, or beteen the *Money resources used for road maintenance and rehabilitation* and % of the *length of roads in bad condition*

Interpretation of Figure 5: it is observed that with the increase of the variable x_3, the variable y decreases, this means that the connection between them is inverse. That is, the lower the percentage of the length of roads in poor condition, the higher the resources for their maintenance and vice versa, the worse the condition of the roads, the lower the financial resources for their rehabilitation.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Dependent Variable: Y
Method: Least Squares
Date: 04/22/22 Time: 08:53
Sample: 2009 2021
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X3	-41.32248	22.82326	-1.810542	0.1003
C	2218.500	550.6973	4.028529	0.0024

R-squared	0.246878	Mean dependent var	1259.233
Adjusted R-squared	0.171566	S.D. dependent var	571.5899
S.E. of regression	520.2517	Akaike info criterion	15.49751
Sum squared resid	2706618.	Schwarz criterion	15.57833
Log likelihood	-90.98509	Hannan-Quinn criter.	15.46759
F-statistic	3.278063	Durbin-Watson stat	1.270141
Prob(F-statistic)	0.100314		

Figure 6. ANOVA results for the unifactorial model $\boldsymbol{y = f(x_3) + \varepsilon_3}$

Interpretation of Figure 6: Regression equation is $y = 2218{,}5 - 41{,}322 \cdot x_3$, the same as in the graph from Figure 5. If the length of roads in poor condition would increase by 1%, the resources allocated for their maintenance and rehabilitation would decrease by 41.322 million lei. The coefficient R-squared = 0.2469 is very small and close to zero, which indicates a very weak link between these two variables. Only 24.69% of the variation of financial resources is influenced by the percentage of roads in poor condition.

Unifactorial model: $\boldsymbol{y = f(x_4) + \varepsilon_4}$
or

$$\boldsymbol{Resources = f(\%\ of\ the\ lengh\ of\ roads\ in\ a\ very\ bad\ condition) + other\ influencing\ factors}$$

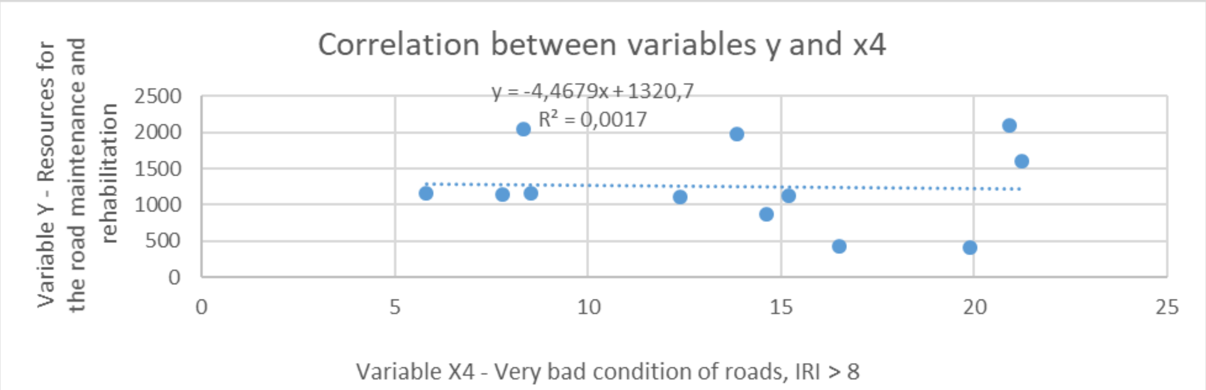


Figure 7. Graph of the correlation between the variable *y* and x_4, or between the *Money resources used for road maintenance and rehabilitation* and % of the *length of roads in a very bad condition*

Interpretation of Figure 7: it is observed that with the increase of the variable x_4, the variable y decreases slowly, this means that the connection between them is inverse. That is, the lower the percentage of the length of roads in very poor condition, the higher the resources for their maintenance and vice versa, the worse the condition of the roads will be, the lower the financial resources will be in order to rehabilitate them.

Forecast and confidence interval for 2022

We make the punctual forecast, assuming that the condition of the roads will change as follows: the good condition would reach a value of 40% (it will decrease by 2.72% compared to 2021), the mediocre condition - 20% (it will decrease by 4, 59% compared to 2021), poor condition - 23% (will increase by 4.2% compared to 2021), very bad condition - 17% (will increase by 3.14% compared to 2021). In other words, the general condition of the roads will worsen. Let's see how this influences the money reserves for the maintenance and rehabilitation of roads in the Republic of Moldova.

$$y_{2022} = 214{,}495 + 23{,}908 \cdot 40 + 13{,}873 \cdot 20 - 81{,}581 \cdot 23 + 135{,}948 \cdot 17 = 1883{,}022\ mil.lei$$

Conclusion: In 2021, the financial resources had a value of 1977.8 million lei. Given that, in 2022, the condition of the roads will deteriorate by the percentages assumed above, the monetary resources would reach a value of approximately 1883,022, which means an increase of 94.788 million lei or 4.79% compared to year 2021.

Usually, the prediction of the phenomenon y if the values of the factorial variables x_1, x_2, x_3, x_4 are known for the moment $(n + v)$ is done on the basis of a confidence interval:

$$\hat{y}_{2022} - t_{crit.} \cdot \sigma_y \leq y_{2022} \leq \hat{y}_{2022} + t_{crit.} \cdot \sigma_y$$

$$t_{crit.} = t_{0,05,12} = 2,365 \quad and \quad \sigma_y = 547,256$$
$$1883,022 - 2,365 \cdot 547,256 \leq y_{2022} \leq 1883,022 - 2,365 \cdot 547,256$$
$$588,762 \leq y_{2022} \leq 3177,281$$

Interpretation: If there are negative changes in the condition of roads in the Republic of Moldova, with the values assumed above, in 2022 is expected a value of resources used for road maintenance and rehabilitation between 588.762 and 3177.281 million lei.

Elimination of insignificant variables and the shape of the model obtained after each estimation iteration

A verification of the significance of the obtained parameters can be performed by the following comparisons:

- If $|t_{stat}| \leq 1$ than the coefficient is statistically *insignificant*;
- If $1 < |t_{stat}| \leq 2$, the coefficient is *relatively significant*. In this case it is recommended to use the Student distribution table;
- If $2 < |t_{stat}| \leq 3$, the coefficient is *significant*. This affirmation is guaranteed for (n – p – 1) > 20 and α ≥ 0,05;
- If $|t_{stat}| > 3$, the coefficient is *very significant*. The probability of error in this case, in a sufficient number of observations, does not exceed 0.001.

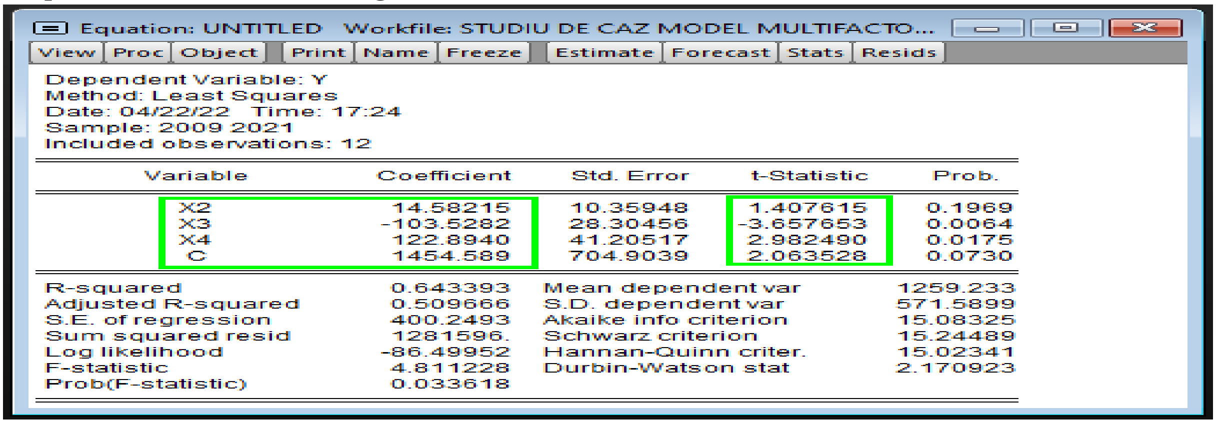
In this case we can say the following, at a significance threshold of α = 0,05:

Table 2

	Coefficients	***t Stat***	$\|t_{stat}\|$	***Significance of the coefficient***
Intercept	214.495131	0.189059728	0,19	-
X Variable 1	23.90775121	1.355212566	1,35	relatively significant
X Variable 2	13.87291137	1.405452385	1,41	relatively significant
X Variable 3	-81.58056104	-2.595978242	2,6	significant
X Variable 4	135.9477122	3.367373117	3,37	very significant

But to remove from the model any of the variables, which are insignificant, we will apply the step-by-step elimination method as follows: we first eliminate an insignificant variable that has the lowest value of $|t_{stat}|$, in this case the variable X_1. By removing it from the model, we analyze the newly obtained model. We repeat the steps until we get only significant variables in the model.

Step 1 – elimination of the significant relative variable X_1


Equation: UNTITLED Workfile: STUDIU DE CAZ MODEL MULTIFACTO...

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: Y
Method: Least Squares
Date: 04/22/22 Time: 17:24
Sample: 2009 2021
Included observations: 12

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X2	14.58215	10.35948	1.407615	0.1969
X3	-103.5282	28.30456	-3.657653	0.0064
X4	122.8940	41.20517	2.982490	0.0175
C	1454.589	704.9039	2.063528	0.0730

R-squared	0.643393	Mean dependent var	1259.233
Adjusted R-squared	0.509666	S.D. dependent var	571.5899
S.E. of regression	400.2493	Akaike info criterion	15.08325
Sum squared resid	1281596.	Schwarz criterion	15.24489
Log likelihood	-86.49952	Hannan-Quinn criter.	15.02341
F-statistic	4.811228	Durbin-Watson stat	2.170923
Prob(F-statistic)	0.033618		

Figure 8. ANOVA test of model $y = f(x_2, x_3, x_4)$

Table 3

	Coefficients	***t Stat***	$\lvert t_{stat} \rvert$	***Significance of the coefficient***
Intercept	1454.589	2.063528	2,06	-
X Variable 2	14.58215	1.407615	1,41	relatively significant
X Variable 3	-103.5282	-3.657653	3,66	relatively significant
X Variable 4	122.8940	2.982490	2,98	significant

Step 2 – elimination of the significant relative variable X_2

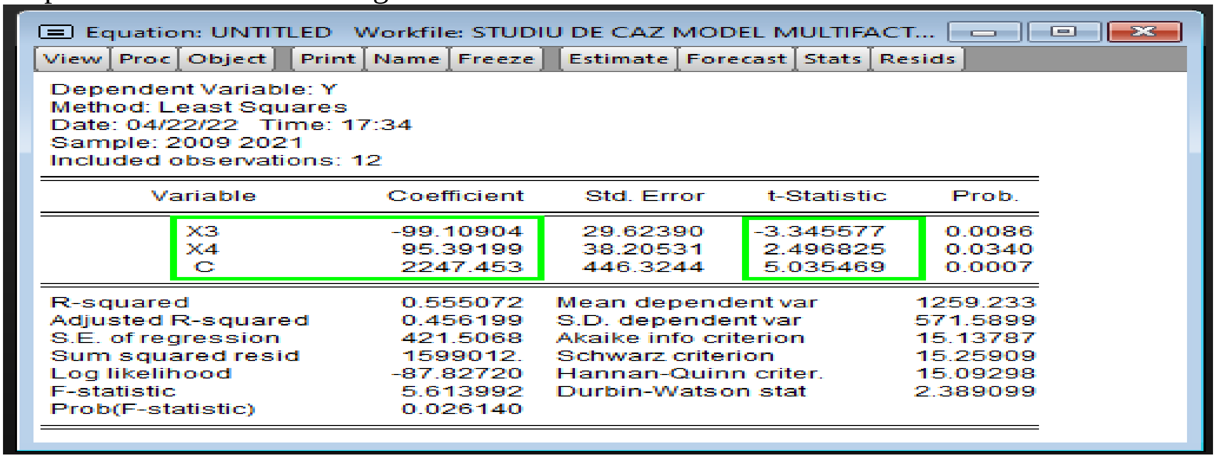


Figure 9. ANOVA test of model $y = f(x_3, x_4)$

Table 4

	Coefficients	***t Stat***	$\lvert t_{stat} \rvert$	***Significance of the coefficient***
Intercept	c_1 = 2247.453	5.035469	5,04	-
X Variable 3	c_2 = -99.10904	-3.345577	3,35	very significant
X Variable 4	c_3 = 95.39199	2.496825	2,5	significant

Thus, we obtained the final model in which all parameters are significant.

$$\boldsymbol{y = 2247{,}453 - 99{,}109 \cdot x_3 + 95{,}392 \cdot x_4}$$

Forecast for 2022 *in the light of this model.*

Suppose that the poor condition of the roads will reach a value of 20% (an increase of 1.2% compared to 2021) and respectively the very poor condition will reach 16% (an increase of 2.14% compared to the year 2021).

$$y_{2021} = 2247{,}453 - 99{,}109 \cdot 18{,}8 + 95{,}392 \cdot 13{,}86 = 1706{,}337$$
$$y_{2022} = 2247{,}453 - 99{,}109 \cdot 20 + 95{,}392 \cdot 16 = 1791{,}545$$
$$\boldsymbol{y_{2022} - y_{2021} = 1791{,}545 - 1706{,}337 = 85{,}208}$$

In conclusion, if the bad and very bad roads deteriorated even more, with the values assumed above, this would imply an increase of the monetary resources destined for the rehabilitation of the roads by 85.208 million lei.

We will test the significance of the parameters of this model for a significance threshold α = 0,05 with the help of the Student test ($t_{tab}(0{,}5; 12 - 2 - 1) = t_{tab}(0{,}5; 9) = 2{,}262$):

Zero hypothesis H_0: “The parameter estimators do not differ significantly from zero”

The alternative hypothesis H_1: “The parameter estimators differ significantly from zero”

We compare the tabular value with the calculated values and the following situations result:

- ✓ As $\left|t_{calc.}^{c_1}\right| \approx 5{,}04 > t_{tab}(0{,}5;9) = 2{,}262$ the H_0 zero hypothesis is rejected and the H_1 alternative hypothesis is accepted, thus the estimator c_1 differs significantly from zero.
- ✓ As $\left|t_{calc.}^{c_2}\right| \approx 3{,}35 > t_{tab}(0{,}5;9) = 2{,}262$ the H_0 zero hypothesis is rejected and the H_1 alternative hypothesis is accepted, thus the estimator c_2 differs significantly from zero.
- ✓ As $\left|t_{calc.}^{c_2}\right| \approx 2{,}5 > t_{tab}(0{,}5;9) = 2{,}262$ the H_0 zero hypothesis is rejected and the H_1 alternative hypothesis is accepted, thus the estimator c_3 differs significantly from zero.

We will test the significance of this model using the Fischer test (F test), formulating the two hypotheses:
Zero hypothesis H_0 -” The model obtained is not statistically significant”
The alternative hypothesis H_1 -” The model obtained is not statistically significant”
In figure 21 the correlation coefficient is $R^2 = 0{,}5551$.

$$F_{calc} = \frac{R^2}{1-R^2} \cdot \frac{n-k-1}{k} = \frac{0{,}5551}{1-0{,}5551} \cdot \frac{12-2-1}{2} = \frac{4{,}9959}{0{,}4449} = 11{,}23$$

As $F_{calc} = 11{,}23 \geq F_{\alpha,v_1,v_2} = 4{,}26$, the model is considered significant.

Conclusion: This model is suitable for forecasting the financial resources to be allocated in the coming years, depending on the negative change of roads that are in bad and very bad condition.

5. Conclusions

It is concluded that in the Republic of Moldova the challenge is to review the performance of requirements and indicators set by developed countries around the world. In addition, performance-based road maintenance and rehabilitation management is closely linked to the selection of appropriate performance indicators with successful progress, as it is the most modern approach to obtaining sustainable funding for road infrastructure maintenance and operation.

In order to ensure the quality of the road infrastructure, the level of performance of the management of their administration must be high enough. Road degradation causes discomfort, additional costs and waste of time. The correlation of the efficiency criteria with the criteria of capitalization of the economic resources requires a differentiated treatment of the roads and an efficient distribution of the resources.

The quality management system of the pavement of the roadway is the most important part of the management of road maintenance and modernization. The fundamental goal of a road management system is to obtain the best possible solution for the available funds and to provide quality roads to users with a high degree of comfortable and economical satisfaction. This can be achieved by comparing investment alternatives, coordinating design, construction, maintenance and evaluation activities, and the efficient use of existing field practices and knowledge.

The quality management system of the road infrastructure must carry out comparative cost estimates and economic evaluations for different options regarding maintenance, rehabilitation works, for a certain project, a group of road sectors or for the whole network. Improving the road infrastructure management system and safety conditions by efficiently amplifying the implementation of complex reform programs and large-scale investment promotion campaigns intensifies the development of transport networks by providing users with quality roads.

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Rezumat

Lucrarea științifică reprezintă o cercetare privitor la importanța semnificativă a managementului calității drumurilor, bazat pe performanță, în activitatea economică. În acest sens, autorii au efectuat o estimare concretă a unor indicatori care influențează dezvoltarea și creșterea economică prin asigurarea implementării managementului de calitate a drumurilor, realizat cu identificarea elementelor de progres în vederea revizuirii modului de utilizare eficientă a resurselor. Investițiile în rețelele de transport asigură creșterea capitalului investit față de cel realizat în alte domenii de activitate, în baza unor efecte directe și indirecte, care rezultă din economisirea de costuri prin atragerea resurselor necesare pentru realizarea unor infrastructuri moderne de drumuri. Managementul progresiv al calității drumurilor este bazat pe performanță atât programare cât și punerea în aplicare a activităților de întreținere a acestora și operaționale, determinate în mod corespunzător indicatorilor de performanță definiți. Metodele științifice utilizate sânt: analiza și sinteza, inducția și deducția, *analiza critică a materialelor, etc. Principalele rezultate obținute în urma investigațiilor se referă la aprecierea indicatorilor privind managementul eficient al calității drumurilor prin aplicarea performanțelor de progres în vederea accesului utilizatorilor, la drumuri publice calitative.*

***Cuvinte-cheie**: sistem, management, drumuri publice, calitate, infrastructură, resurse financiare*

Аннотация

Научная работа представляет собой исследование значимости управления качеством дорог, основанного на эффективности, в экономической деятельности. В этом смысле авторами была проведена конкретная оценка некоторых показателей, влияющих на развитие и экономический рост, путем обеспечения внедрения управления качеством дорог, проведенная с выявлением элементов прогресса с целью пересмотра способа эффективного использования ресурсов. Инвестиции в транспортные сети обеспечивают прирост вложенного капитала по сравнению с достигнутым в других сферах деятельности на основе прямых и косвенных эффектов, возникающих в результате экономии средств за счет привлечения необходимых ресурсов для создания современных дорожных инфраструктур. Прогрессивное управление качеством дорог основано на эффективности, как программирования, так и реализации их содержания и эксплуатационной деятельности, определяемой в соответствии с установленными показателями эффективности. В исследовании использованы научные методы: анализ и синтез, индукция и дедукция, критический анализ материалов и т. д. Основные результаты, полученные в результате исследований, относятся к оценке показателей эффективного управления качеством дорог путем применения показателей прогресса в просмотр доступа пользователей к качественным автомобильным дорогам общего пользования.

***Ключевые слова**: система, управление, дороги общего пользования, качество, инфраструктура, финансовые ресурсы*

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