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MATHEMATICAL MODELING OF TOURISM DEVELOPMENT IN TERRITORIAL COMMUNITIES

In this paper, the problems of development of associations of territorial communities in the tourism direction of economic development are considered.

The object of research is the improvement of territorial communities on the example of Ukraine. One of the most problematic places is the lack of funds for the development of existing large tourist complexes and the creation of new ones.

The study uses the idea that tourism development has a direct stimulating effect on the development of a number of important economic sectors. The use of a mathematical apparatus is also considered, which allows to analyze the main factors influencing the development of the tourism industry of territorial communities. A comprehensive solution of economic, social and environmental issues of sustainable tourism development is impossible without the development of mathematical models and supporting tools that allow predicting the main indicators of sustainable tourism development. The paper considers PLS-PM modeling using such internal consistency criteria as Cronbach's Alpha coefficient, Dillon-Goldstein coefficient ρ, model reliability, mean variance. The purpose of the PLS-PM model is to obtain estimates of latent variables for further forecasting procedures for the development of the system. The processes taking place in the tourism industry are characterized by a complex interaction of economic, environmental and social factors. Their influence should be taken into account for the implementation of the sustainable tourism development strategy. The analysis of the model was also carried out with the help of a single coefficient of quality of the correspondence of the data model, which characterizes the quality of the internal and external models of the system.

Thanks to the listed tools, the statement is formed that the regulation of key factors of the tourism sector of the economic sector can have a positive impact on the development of national culture and economy in the united territorial communities. The created mathematical model clearly forms the conclusion that the development of tourism in local communities can become the engine of their sustainable economic development, given the available regional conditions.

Keywords: *united territorial community, mathematical model of the tourist complex, PLS-PM methodology, sustainable development.*

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1. Introduction

Tourism is considered to be one of the major income activity supplements for many countries. In particular, for a number of countries tourism is exclusively the main source of income.

In recent years, the development of tourism as an activity has reached a significant leap and continues to grow. This is explained by the fact that thanks to tourism, the development of national culture and economy is growing, a significant number of jobs are provided, and the income of micro- and macroeconomics is growing. Among the significant advantages of tourism are such as GDP growth, the possibility of building it on the existing infrastructure with its further development to stimulate local trade and the development of other large industries, etc.

Consideration of tourism as an object of scientific research has been actively developed over the past decades. Despite this, it is possible to see a still growing trend towards considering tourism issues, a combination of business ideas and technically economically feasible implementations of these ideas.

Real tourism is of considerable interest in its development as one of the leading links in economic activity. On the example of Ukraine, it is possible to see that the percentage of development of this promising economic branch does not exceed 2 % of Ukraine's GDP. This is significantly lower than similar indicators of the world economy, where this indicator averages 10 % of GDP [1]. Since Ukraine has significant historical, geographical, natural, economic, socio-demographic prerequisites for the development of

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tourism, the low statistics of GDP from tourism indicates the existence of a number of problems in the implementation of tourism improvement. Among such problems are the lack of advertising for domestic tourism, the lack of funds to build existing large tourist complexes or create new ones, the relatively low quality of the variety of tourist services, and the development of infrastructure near tourist complexes. All this requires certain financial investments. These investments can be formed by united territorial communities, which themselves, at the expense of their own resources; can ensure the vital activity and viability of their territories.

2. The object of research and its technological audit

The object of research is the improvement of territorial communities on the example of Ukraine. *The subject of research* is a mathematical model for the development of tourism of united territorial communities (UTC). It is tourism that acts as a catalyst for economic growth, providing a stimulating effect on the development of such sectors of the economy as hotel business, catering, consulting services, sports and entertainment activities, construction, etc.

3. The aim and objectives of research

The aim of research is to build a mathematical model for the development of tourism in territorial communities. This will help create better conditions for economic growth and improve the quality of life for people.

To achieve the aim, the research process is divided into the following steps:

1. Select and justify the mathematical apparatus that allows to analyze the main factors influencing the development of the tourism industry of territorial communities.
2. Perform an analysis of the output obtained by substituting real data of the tourism sector into the constructed model.

4. Research of existing solutions to the problem

Among the world's leading concepts for the development of the tourism industry, the concept of sustainable development occupies a special place. In particular, in [2] conceptual clarifications are given regarding the sustainable development of tourism and the importance of cooperation for its growth is substantiated. At the same time, [3] explores the relationship between regional economic development and the practice of sustainable tourism. In [4], a new approach to the analysis of tourism and the environment is proposed by developing a theoretical general equilibrium model that considers the integration of the environment into the economic system from the point of view of tourism. As it is possible to see, the theoretical aspects of the concept of sustainable development of tourism have been analyzed in sufficient detail in scientific papers, but there is a clear lack of serious research on the mathematical modeling of the tourism system, taking into account the influence of the spheres of society (economic, environmental, social) on its development.

In [5], the problems of domestic tourism are considered and a model of a multilevel structural equation is proposed to study the factors influencing income structures, households, and regional consumption patterns.

The influence of e-commerce on the competitiveness of the tourism industry based on an optimized neural network model for the analysis and forecasting of tourism data was studied in [6]. To improve the model, it is planned to conduct an analysis of household impact on travel using deep learning.

A comprehensive study of tourist arrivals in Albania was carried out in [7], where the logistic and Gompertz models were used, which are mainly used to estimate the growth of scarce resources.

In [8], the role of tourism in shaping the fundamental foundations of development in developing economies is studied, focusing on the example of Pakistan. The main limitation of this study is the minimum sample size.

Many studies have focused on modeling tourism development based on an innovative approach. In particular, [9] substantiates the model of innovative tourism clusters as a factor in increasing the competitiveness of regions and the country as a whole. And in [10, 11] the problems of managing competitive organizations based on the use of innovative methods, the formation of mechanisms for ensuring and evaluating the innovative development of enterprises are considered. However, despite its promise and a significant number of scientific developments on the introduction of innovative approaches to the development of the tourism sector, they have not yet been sufficiently studied.

The above problems of tourism development are solved by the implementation of models for the formation and development of the tourism business in each individual territorial community based on a systematic approach. That is why the formation of new approaches to the construction of new and correction of existing methods for modeling models of objects in the field of tourism services is a promising and important problem of high priority.

5. Methods of research

In the course of the study, PLS-PM modeling was carried out using such internal consistency criteria as Cronbach's Alpha coefficient, Dillon-Goldstein's coefficient ρ, model reliability, average variance.

PLS-PM is a tool for modeling relationships between latent (implicit) variables [12]. The PLS-PM technique is designed to analyze high-dimensional data in a poorly structured environment. Also, the analysis of the model was carried out by means of a single coefficient of quality of the correspondence of the data model.

6. Research results

The regional tourism industry is an example of a complex economic system for which PLS-PM methods are appropriate. The concept of sustainable development is a modern trend in the development of the tourism industry. Sustainable tourism is tourism that meets the needs of today's tourists without compromising the needs of future generations of the local population. The processes taking place in the industry are characterized by a complex interaction of economic, environmental and social factors, the influence of which must be taken into account in order to implement a strategy for the sustainable development of tourism.

For clarity, PLS-PM modeling will be carried out using the example of the territorial communities of the Zakarpattia region (Ukraine).

Table 1 shows the indicators of sustainable development of tourism that affect the Zakarpattia region.

Table 1

Indicators of sustainable development of tourism in the Zakarpattia region

Factor	Indicator
Tourism	Number of tourists
	Health care institutions
	Sanatorium and health resorts
	Number of passengers
Social comfort	Number of higher education institutions
	Number of doctors
	Duration of job search, months
	Housing stock, million m^2
Ecology	Emissions of pollutants into the atmosphere, thousand tons
	Area of destruction of forest plantations
	Waste disposed, thousand tons
	Used fuel reserves, thousand tons
Economy	Cash income per person, USD
	Turnover of enterprises, million USD
	Investments in industry, thousand USD
	Differentiation of the standard of living of the population

The input data for modeling are presented using the resources of the Main Department of Statistics in the Zakarpattia region [13], which presents specific data for a given region during 2007–2017, presented in Table 2.

Formally, the conditions for setting a simulation using PLS-PM can be written as follows: let X be a block consisting of p variables and n observations. It can be presented in the form of a matrix:

$$X = \begin{pmatrix} x_{11} & x_{12} & \ldots & x_{1p} \\ x_{21} & x_{22} & \ldots & x_{2p} \\ \ldots & \ldots & \ldots & \ldots \\ x_{n1} & x_{n2} & \ldots & x_{np1} \end{pmatrix}.$$

The array X can be divided into blocks s: X_1, X_2,..., X_s. Each block of variables X_j ($j=1, 2,..., s$) is associated with a generalized variable LV_j ($j=1, 2,..., s$), which is an abstract concept (non-material and dimensionless). The estimate of this latent variable is denoted by the formula:

$$\widehat{LV_j} = Y_j, \ (j = 1, 2, ..., s).$$

In the model under consideration, the relationships that arise between variables can be divided into two types:

1. Relationships that arise between generalized variables for the corresponding blocks of indicators X_j ($j=1, 2,..., s$) form the so-called «external model».
2. Relationships that arise between generalized variables (these relationships form an internal model).

The input model of the study («Blocks-Indicators») is shown in Fig. 1. Latent variables are presented in the form of circles, and explicit variables, which are indicators from the Table 1 contained in rectangular figures. The relationship of latent variables is the inner part of the system model, respectively; the relationship of latent variables with explicit ones is the outer part of the model.

Table 2

Input data for specific model indicators

	Year	Number of tourists	Health care institutions	Sanatorium and health resorts	Number of passengers
Tourism	2007	72970	72	66	62.7
	2008	76965	71	58	66
	2009	56320	71	56	57
	2010	52080	70	56	49.8
	2011	21773	60	55	46.4
	2012	20180	58	57	45.2
	2013	19892	54	56	43
	2014	11625	54	58	41
	2015	10656	53	55	42.8
	2016	11601	52	45	37.3
	2017	14652	47	42	34.1
	Year	Number of higher education institutions	Number of doctors	Number of doctors	Housing stock, million m^2
Social comfort	2007	14	5100	6	27.2
	2008	14	5100	6	27.8
	2009	14	5100	5	28
	2010	11	5200	5	28.3
	2011	11	5300	1	29
	2012	11	5200	4	29.4
	2013	10	5200	4	29.6
	2014	10	5100	3	30.1
	2015	8	5000	3	30.4
	2016	8	4900	3	30.6
	2017	9	4900	2	31
	Year	Emissions of pollutants into the atmosphere, thousand tons	Area of destruction of forest plantations	Waste disposed, thousand tons	Used fuel reserves, thousand tons
Ecology	2007	88.2	1283	1600	90.2
	2008	91.3	1476	1100	92.4
	2009	87.6	1567	700	97.7
	2010	87.3	1744	1300	100.3
	2011	89.4	1882	11800	104.8
	2012	72.1	2138	7100	107.5
	2013	69.1	1424	5700	115.8
	2014	60.5	2019	56600	97.3
	2015	54.2	2288	900	81.5
	2016	4.9	2156	300	70.3
	2017	3.2	987	200	67.3
	Year	Cash income per person, USD	Turnover of enterprises, million USD	Investments in industry, thousand USD	Differentiation of the standard of living of the population
Economy	2007	244.13	1486.02	1356.76	401.6
	2008	322.15	1841.79	467.33	210.1
	2009	325.48	1587.1	1310.58	273.9
	2010	423.32	2256.78	2420.51	488.5
	2011	500.08	337.99	1044.55	142.4
	2012	573.03	2903.31	1092.3	161.6
	2013	597.64	371.72	834.22	122.8
	2014	776.92	426.91	552.54	78
	2015	739.05	466.67	751.02	96.8
	2016	685.48	2232.79	819.94	54.1
	2017	767.74	2151.57	874.99	2.5

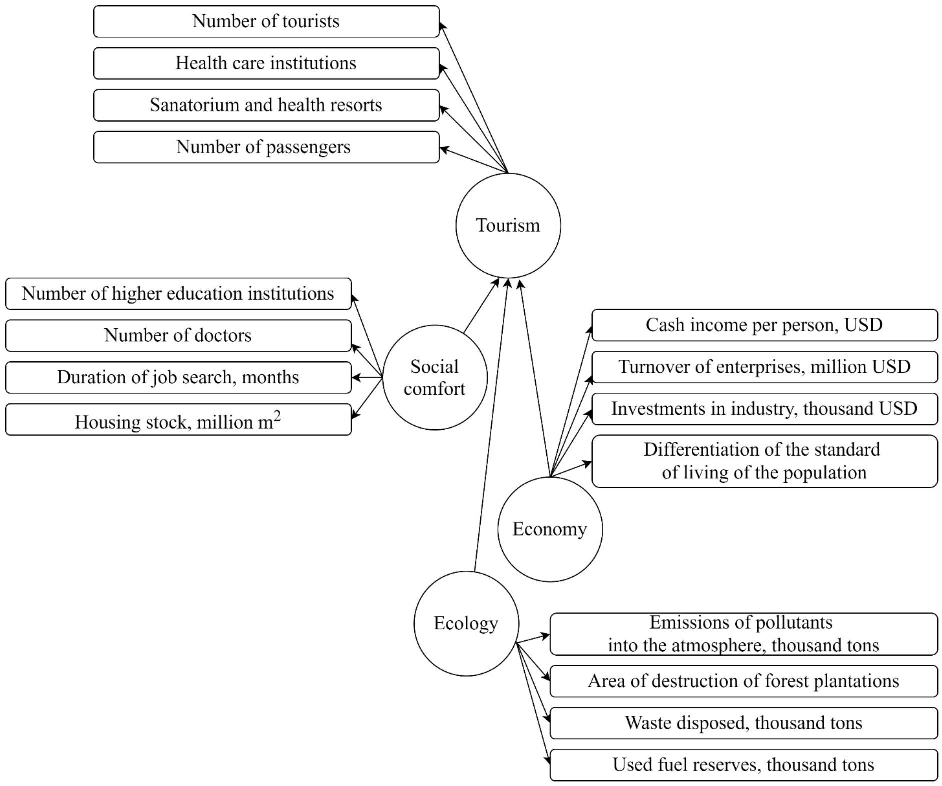

Fig. 1. Graphical model of sustainable development of tourism of territorial communities of the Zakarpattia region

The next step is to present the internal and external models of the system in an analytical form. The internal model can be written as an equation:

$$LV_{tourism} = \beta_0 + \beta_1 LV_{soc.com.} + \beta_2 LV_{ecology} + \\ + \beta_3 LV_{economy} + error_{tourism},$$

where $LV_{tourism}$, $LV_{soc.\ comf.}$, $LV_{ecology}$, $LV_{economy}$ – latent variables; β_1, β_2, β_3 – weight coefficients, i. e. coefficients of strength and direction of connections between latent variables; β_0 – free term; $error_{tourism}$ – random deviation of the model.

The external model looks like this:

$$\begin{cases} X_{heal.car.inst} = \\ = \lambda_{0\,heal.car.inst} + \lambda_{1\,heal.car.inst.} LV_{tourism} + error_{heal.car.inst.}, \\ X_{numb.tourists} = \\ = \lambda_{0\,numb.tourists} + \lambda_{1\,numb.tourists} LV_{tourism} + error_{numb.tourists}, \\ X_{hous.stock} = \\ = \lambda_{0\,hous.stock} + \lambda_{1\,hous.stock} LV_{soc.comfort} + error_{hous.stock}, \\ X_{numb.doctors} = \\ = \lambda_{0\,numb.doctors} + \lambda_{1\,numb.doctors} LV_{soc.comfort} + error_{numb.doctors}, \\ X_{emissions} = \\ = \lambda_{0\,emissions} + \lambda_{1\,emissions} LV_{ecology} + error_{emissions}, \\ X_{fuel.reserves} = \\ = \lambda_{0\,fuel.reserves} + \lambda_{1\,fuel.reserves} LV_{ecology} + error_{fuel.reserves}, \\ X_{invest.} = \\ = \lambda_{0\,invest.} + \lambda_{1\,invest.} LV_{economy} + error_{invest.}, \\ X_{diff.stand.liv} = \\ = \lambda_{0\,dif.stand.liv} + \lambda_{1\,dif.stand.liv} LV_{economy} + error_{dif.stand.liv}, \end{cases}$$

where $X_{heal.car.inst}$, $X_{numbtourists}$, ..., $X_{dif.stand.liv}$ – explicit variables; λ_0 – free members; λ_1 – load factors; $error_{hea.car.inst}$, $error_{numb.tourists}$, ..., $error_{dif.stamd.liv}$ – residual terms.

In the method of modeling weight coefficients using the least squares method, such a concept as the estimate of a latent variable is introduced, which is a linear combination of the corresponding explicit variables and is denoted as Y_i:

$$\widehat{LV}_j = Y_j = \sum\nolimits_k w_{jk} X_{jk}.$$

In our model, estimates of latent variables can be represented as the following system of equations:

$$\begin{cases} \widehat{LV}_{tourism} = Y_{tourism} = \\ = w_{h.c.i.} X_{h.c.i.} + w_{n.t.} X_{n.t.} + w_{n.p.} X_{n.p.} + w_{s.h.r.} X_{s.h.r.}, \\ \widehat{LV}_{soc.comf.} = Y_{soc.comf.} = \\ = w_{n.h.e.i.} X_{n.h.e.i.} + w_{n.d.} X_{n.d.} + w_{d.j.s.} X_{d.j.s.} + w_{h.s.} X_{h.s.}, \\ \widehat{LV}_{ecol.} = Y_{ecol.} = \\ = w_{e.p.a.} X_{e.p.a.} + w_{e.p.a.} X_{e.p.a.} + w_{e.p.a.} X_{e.p.a.} + w_{e.p.a.} X_{e.p.a.}, \\ \widehat{LV}_{econ.} = Y_{econ.} = \\ = w_{i.i.} X_{i.i.} + w_{c.i.p.p.} X_{c.i.p.p.} + w_{d.s.l.} X_{d.s.l.} + w_{t.e.} X_{t.e.}, \end{cases}$$

where $w_{h.c.i.}$, $w_{n.t.}$, ..., $w_{t.e.}$ – external scales of the model.

The first stage of modeling consists in calculating the weights to obtain the values of the estimates of the latent variables. This step is an iterative process. At the first step, let's set the initial value of w_{jk} weights. Let the initial value be equal to one, then get a system of the form:

$$\begin{cases} \tilde{w}_1 = (\tilde{w}_{11} = 1,\ \tilde{w}_{12} = 1,\ \tilde{w}_{13} = 1,\ \tilde{w}_{14} = 1), \\ \tilde{w}_2 = (\tilde{w}_{21} = 1,\ \tilde{w}_{22} = 1,\ \tilde{w}_{23} = 1,\ \tilde{w}_{24} = 1), \\ \tilde{w}_1 = (\tilde{w}_{31} = 1,\ \tilde{w}_{32} = 1,\ \tilde{w}_{33} = 1,\ \tilde{w}_{34} = 1), \\ \tilde{w}_1 = (\tilde{w}_{41} = 1,\ \tilde{w}_{42} = 1,\ \tilde{w}_{43} = 1,\ \tilde{w}_{44} = 1). \end{cases} \quad (1)$$

The tilde sign (~) indicates that the weights are arbitrary. Based on the given values, let's calculate the values of latent variables using the formula:

$$Y_k \propto X_k \tilde{w}_k, \quad (2)$$

where $k=1, 2, 3, 4$ (number of indicators).

For the developed model, let's obtain the system:

$$\begin{cases} Y_1 \propto 1X_{11} + 1X_{12} + 1X_{13} + 1X_{14}, \\ Y_2 \propto 1X_{21} + 1X_{22} + 1X_{23} + 1X_{24}, \\ Y_3 \propto 1X_{31} + 1X_{32} + 1X_{33} + 1X_{34}, \\ Y_4 \propto 1X_{41} + 1X_{42} + 1X_{43} + 1X_{44}. \end{cases} \quad (3)$$

The proportional sign is used instead of the equal sign, since in this case there is a dependence of the Y variables on the X variables, but there is no equality between the left and right parts of the expressions due to the approximate conditional values of the external weights.

At the second step, let's turn to the study of the internal model. The main goal at this stage is to enumerate the value of estimates of latent variables using an internal model. That is, it is necessary to calculate the value of latent variables Z_j based on linear combinations of estimates of other variables associated with LV_j, as indicated in the formula:

$$Z_j = \sum\nolimits_{i \leftrightarrow j} e_{ij} Y_i, \quad (4)$$

where e_{ij} – internal weights, which can be calculated using the formula:

$$e_{ij} = \begin{Bmatrix} cor(Y_j, Y_i),\ i \leftrightarrow j \\ 0,\ i \not\leftrightarrow j \end{Bmatrix}, \quad (5)$$

where $cor(Y_j, Y_i)$ – correlation coefficient between Y_i and Y_j.

The double arrow indicates that the scores Y_i are summed only for those latent variables LV_i that are associated with the j-th latent variable.

Thus, internal weights characterize the strength of relationships between latent variables.

The third step is to recalculate the external weights. To recalculate the values of external weights for the reflective type of the block of the external model, let's use the formula:

$$\tilde{w}_{jk} = \left(Y_j' Y_j\right)^{-1} Y_j' X_{jk}. \quad (6)$$

The recalculation of the values of external weights for the formative type of the block of the external model is carried out according to the formula:

$$\tilde{w}_{jk} = \left(X_j' X_j\right)^{-1} X_j' Y_j. \quad (7)$$

At each stage of the iterative process, let's calculate the degree of convergence of the external weights. That is, the external weights in step S are compared with the weights in the previous step (S–1).

In any case, the degree of convergence is considered sufficient when the following condition is met:

$$\left| w_{jk}^{S-1} - w_{jk}^{S} \right| < 10^{-5}. \quad (8)$$

So, let's move on to the PLS-PM analysis, which consists of the following steps:

1. Checking the internal and external consistency in the blocks.
2. Checking cross-correlations of block variables with latent variables of other blocks.
3. Checking the internal model.
4. Checking the properties of the model.

The first step is to check internal consistency. For this check, let's use the following criteria [14]:

– *Cronbach's Alpha coefficient* – reliability factor used to check the reliability of calculation results. The value of X_i denotes the assessment of element i, and $X=(X_1+X_2+...+X_k)$ denotes the sum of all indicators, consisting of k factors. The covariance between X_i and X_j is known as δ_{ij}, $\left(\delta_i^2 = \delta_{ii}\right)$, denotes the variance of δ_{ij}, $\left(\delta_i^2 = \delta_{ii}\right)$ denotes the variance of X, consists of elemental variances and elemental covariances:

$$\delta_X^2 = \sum_{i=1}^{k}\sum_{j=1}^{k} \delta_{ij} = \sum_{i=1}^{k} \delta_i^2 + \sum_{i=1}^{k}\sum_{j \neq i}^{k} \delta_{ij}.$$

The formula for determining the Cronbach's Alpha coefficient is:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \delta_i^2}{\delta_X^2}\right).$$

– *Dillon-Goldstein's coefficient* ρ is a robustness indicator based on model loadings rather than correlations observed between explicit variables in the dataset:

$$\rho = \frac{\left(\sum_{p=1}^{P_q} \lambda_{pq}\right)^2}{\left(\sum_{p=1}^{P_q} \lambda_{pq}\right)^2 + \sum_{p=1}^{P_q} (1 - \lambda_{pq}^2)},$$

where p – observation; P_q – indicators belonging to the latent variable block; λ – loads calculated as a correlation coefficient between latent (Y_p) and explicit (X_{pq}) variables according to the formula:

$$\lambda_{pq} = cor\left(X_{pq}, Y_p\right).$$

– *Reliability of the model.* Allows to see complete information about the reliability of the characteristic and model parameters. Calculated according to the formula:

$$CR = \frac{\left(\sum_{i=1}^{n} \lambda_i\right)^2}{\left(\sum_{i=1}^{n} \lambda_i\right)^2 + \sum_{i=1}^{n} \delta_i},$$

where λ – load factor for each element i; n – the number of indicators for the latent variable; δ – deviation of the model for each element i.

– *Average variance.* Allows to measure how far random valuesare distributed from their average, calculated by the formula:

$$\delta_{av.}^2 = \frac{\left(\sum_{i=1}^{n} y_i - \left(\frac{\sum_{i=1}^{n} y_i}{n}\right)\right)^2}{n},$$

where y_i – weight value for each indicator.

Table 3 shows the results of calculations of internal consistency in blocks for the first iteration.

From Table 3 it can be seen that the «Tourism» block has a satisfactory value of the coefficients with a difference from the others: «Social comfort», «Economy» and «Ecology», which have poor internal consistency, because they do not satisfy the condition that $\alpha > 0.7$.

Fig. 2 shows the correlation coefficients of explicit and latent variables. In the «Ecology» block, two variables («Area of destruction of forest plantations», «Waste disposed») have a negative correlation indicator in accordance with the latent variable. In the «Economy» block there is also an indicator with a negative correlation («Cash income per person»). It should be noted that a negative correlation score results in block mismatches.

Let's get rid of the negative indicators and list the coefficients. The result of the recalculation is given in Table 4.

The correlation scheme after the removal of negative indicators is shown in Fig. 3.

After the modification, it is possible to see that the Cronbach's Alpha coefficient does not satisfy the consistency criterion for «Social Comfort» and «Economy», because the condition is not met for all latent variables, where $\alpha > 0.7$.

Therefore, for the latent variables «Social comfort», «Economy», let's remove such indicators, the weights of which are less than 0.6 (it is possible iteratively increase this number, for example, first take 0.1, then 0.2, etc.). After recalculating the coefficients, let's obtain the result shown in Table 5.

So, it is possible to see that all the consistency criteria satisfy the necessary conditions ($\alpha > 0.7$, $\rho > 0.7$, $CR > 0.6$, $AVE > 0.5$).

Fig. 4 shows correlation schemes.

Table 3

Checking internal consistency in blocks (iteration 1)

Factor	Cronbach's Alpha coefficient, α	Coefficient ρ	Model reliability (*CR*)	Average variance (*AVE*)
Tourism	0.720	0.906	0.837	0.620
Social comfort	0.552	0.780	0.738	0.471
Economy	–0.314	0.955	0.281	0.573
Ecology	0.549	0.810	0.479	0.410

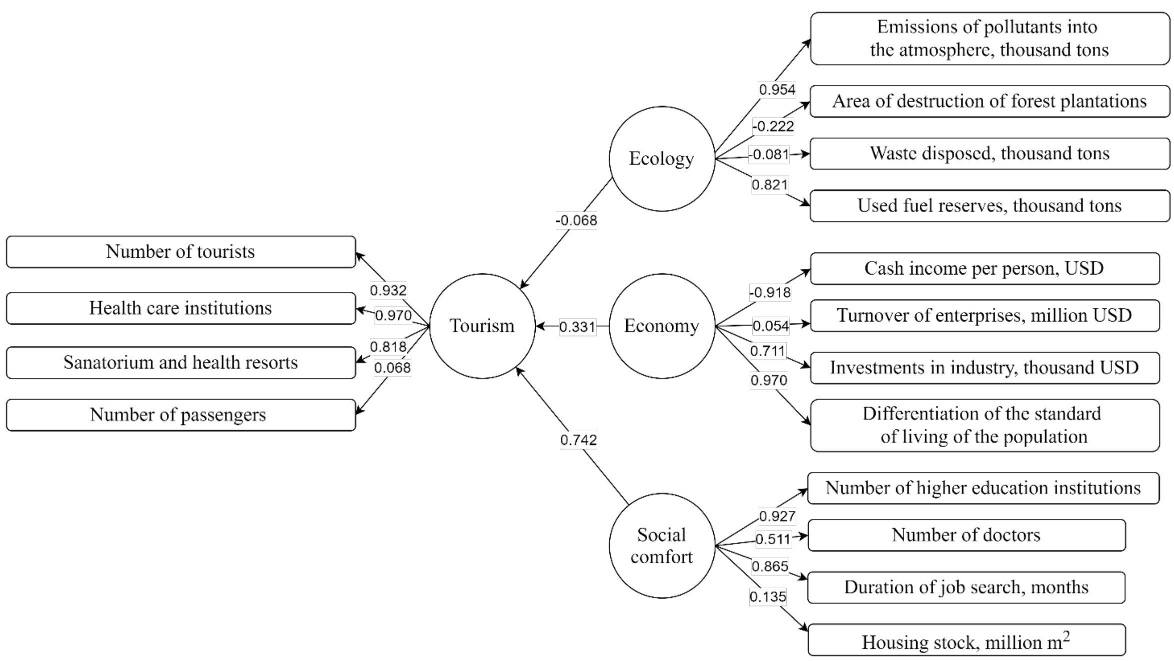

Fig. 2. Load factors in the external model

Table 4

Checking internal consistency in blocks (iteration 2)

Factor	Cronbach's Alpha coefficient, α	Coefficient ρ	Model reliability (*CR*)	Average variance (*AVE*)
Tourism	0.720	0.901	0.837	0.620
Social comfort	0.552	0.775	0.738	0.472
Economy	0.552	1.246	0.741	0.572
Ecology	0.866	1.221	0.930	0.870

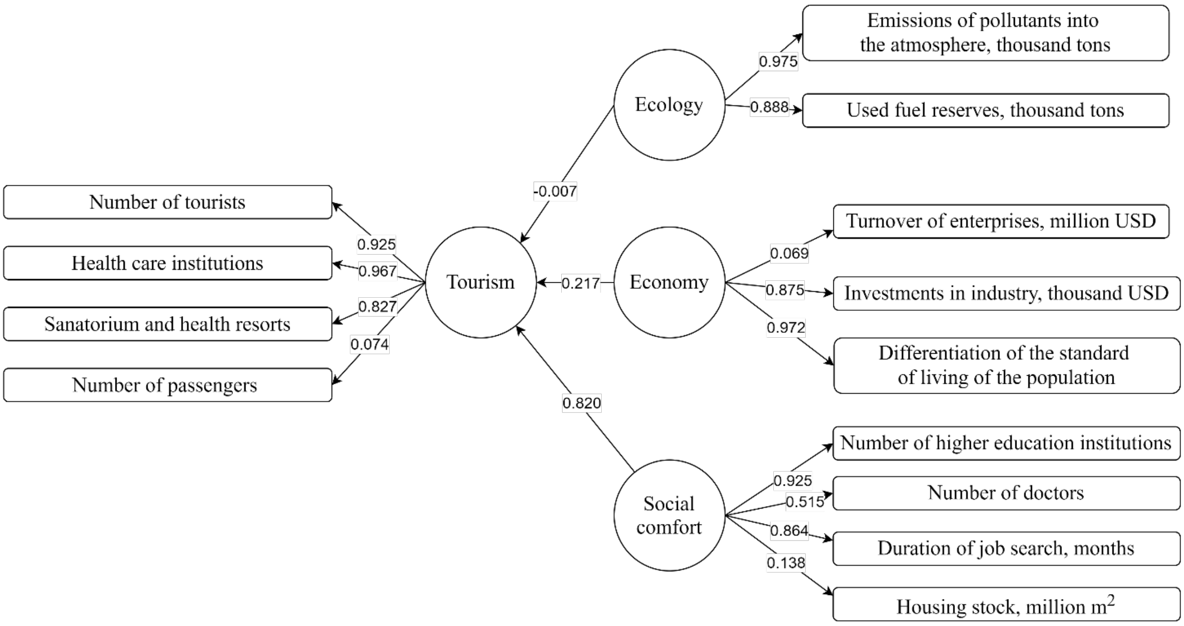

Fig. 3. Load factors in the outer model after iteration 2

Table 5

Checking internal consistency in blocks (iteration 3)

Factor	Cronbach's Alpha coefficient, α	Coefficient ρ	Model reliability (*CR*)	Average variance (*AVE*)
Tourism	0.720	0.906	0.837	0.621
Social comfort	0.834	0.840	0.923	0.857
Economy	0.851	1.278	0.921	0.855
Ecology	0.866	1.236	0.930	0.869

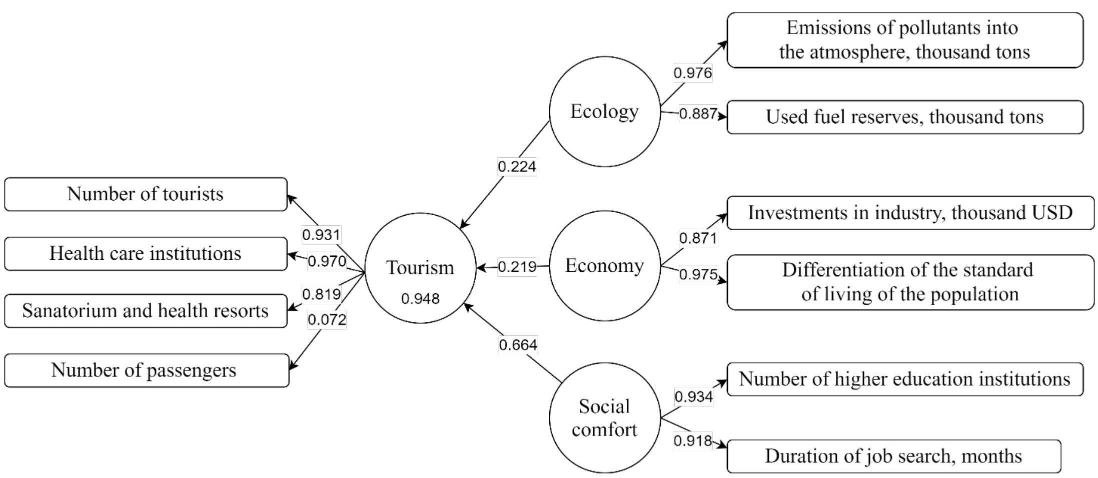

Fig. 4. Load factors in the external model after iteration 4

Let's move on to the next step – cross-correlations. Table 6 shows the coefficients of the external model.

Let's recall that variables are considered significant if the load factor satisfies the condition $w_j > 0.7$. Based on the results of the check, the variable «Number of passengers carried» should be excluded from the model. After excluding this indicator, let's obtain the following form of cross-overload coefficients, which is shown in Table 7.

Table 7 shows the summary statistics of the structural model. It can be seen that the strength of the links of all explicit variables with latent variables is at a sufficient level to consider that all variables are «loyal» to their blocks (latent variables).

Let's list the coefficients of internal consistency in blocks after deleting the indicator «Number of passengers carried». The result is shown in Table 8.

Let's move on to the next stage – checking the quality of the internal model.

Fig. 5 is a graphical representation of the internal model with the specified weight values.

Table 6

Values of cross load factors

Indicator	Tourism	Social comfort	Ecology	Economy
Number of tourists	0.931	X	X	X
Health care institutions	0.970	X	X	X
Sanatorium and health resorts	0.819	X	X	X
Number of passengers	0.072	X	X	X
Number of higher education institutions	X	0.934	X	X
Duration of job search, months	X	0.918	X	X
Emissions of pollutants into the atmosphere, thousand tons	X	X	0.976	X
Used fuel reserves, thousand tons	X	X	0.887	X
Investments in industry, thousand USD	X	X	X	0.871
Differentiation of the standard of living of the population	X	X	X	0.975

Table 7

Meaning of cross-load factors after modification

Indicator	Tourism	Social comfort	Ecology	Economy
Number of tourists	0.932	X	X	X
Health care institutions	0.969	X	X	X
Sanatorium and health resorts	0.819	X	X	X
Number of higher education institutions	X	0.934	X	X
Duration of job search, months	X	0.918	X	X
Emissions of pollutants into the atmosphere, thousand tons	X	X	0.975	X
Used fuel reserves, thousand tons	X	X	0.888	X
Investments in industry, thousand USD	X	X	X	0.870
Differentiation of the standard of living of the population	X	X	X	0.976

Table 8

Checking internal consistency in the deletion blocks of the «Number of passengers» indicator

Factor	Cronbach's Alpha coefficient, α	Coefficient ρ	Model reliability (*CR*)	Average variance (*AVE*)
Tourism	0.892	0.906	0.934	0.826
Social comfort	0.834	0.840	0.923	0.857
Economy	0.851	1.287	0.921	0.854
Ecology	0.866	1.225	0.930	0.870

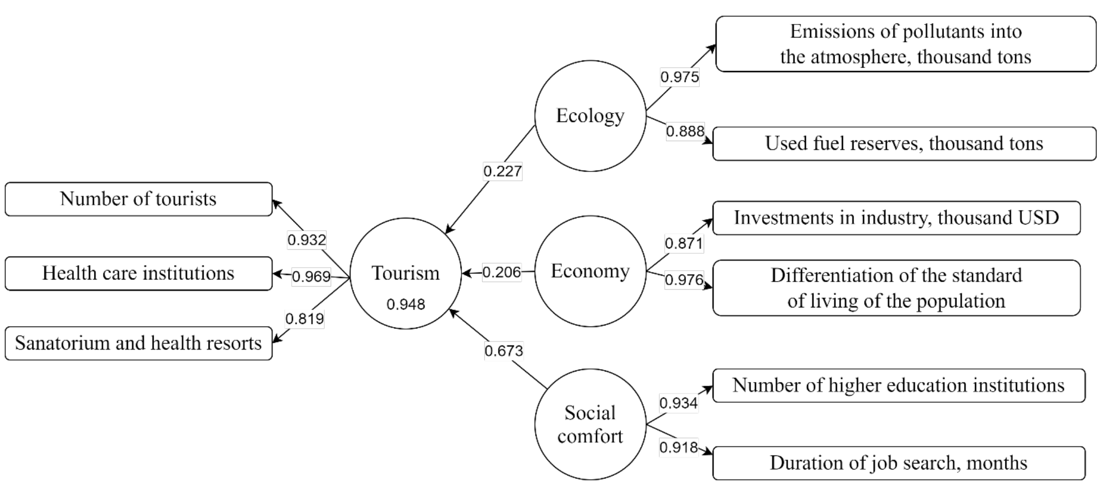

Fig. 5. The final model of sustainable tourism development of the territorial communities of the Zakarpattia region

Let's determine the coefficient of determination R^2, which indicates how much the obtained observations confirm the model.

The formula for calculating the coefficient of determination:

$$R^2 = 1 - \frac{\delta^2}{\delta_y^2}, \quad (9)$$

where δ^2 – average dispersion.

For this model, the coefficient of determination is 0.948 for the target block Tourism ($R^2 > 80$ %). The tabular model reliability parameter for all blocks is more than 50 %, which positively characterizes the model under study. The last column contains an indicator that characterizes the value of the average variance of block indicators. The AVE index for all blocks exceeds 50 %, therefore, according to this criterion, the internal model is also considered satisfactory.

The fourth stage is the calculation of a single data model fit quality factor – GoF (Goodness-of-Fit). The coefficient characterizes the quality of both the internal model of the system and the external one. The reliability of the model is considered high if the GoF coefficient exceeds 70 %. Formula for calculating GoF:

$$GoF = \sqrt{\overline{AVE} \cdot R^2}, \quad (10)$$

where

$$\overline{AVE} = \frac{AVE_{tourism} + AVE_{soc.comfort} + AVE_{ecology} + AVE_{economy}}{4}.$$

For the model studied in this paper, the GoF coefficient is 90 %. Thus, all the necessary quality conditions for the model under study are met.

For further analysis, let's present the internal model in the form of the following equation:

$$LV_{tourism} = 0.673 LV_{soc.comfort} + 0.227 LV_{ecology} + 0.206 LV_{economy} + error_{tourism}.$$

Estimates of latent variables by means of a system of equations:

$$\begin{cases} \widehat{LV}_{tourism} = 0.969 X_{h.c.i.} + 0.932 X_{n.t.} + 0.819 X_{s.h.r.}, \\ \widehat{LV}_{soc.comfort} = 0.918 X_{d.j.s.} + 0.934 X_{n.h.e.i.}, \\ \widehat{LV}_{ecology} = 0.975 X_{e.p.a.} + 0.888 X_{u.f.r.}, \\ \widehat{LV}_{economy} = 0.870 X_{i.i.} + 0.976 X_{d.s.l.p.} \end{cases} \quad (11)$$

It is possible to conclude that all the characteristics selected for the study have an impact on the level of tourism development in the territorial communities of the Zakarpattia region. However, it should be noted that the level of social comfort has the greatest influence among the studied latent variables (impact level 0.673). Also significant factors influencing development are the ecology of the region and its economic component with levels of influence of 0.227 and 0.206, respectively. Since the economic level has the lowest indicator, it is possible to assume that a sustainable level of tourism development is possible both in an economically developed region and in a developing one.

Based on the final model, it is possible to draw conclusions about the key factors characterizing the level of tourism development in the region:

1. Differentiation of the living standards of the population (indicates the socio-economic differences between members of society).
2. Emissions of pollutants into the atmosphere.
3. Healthcare institutions.
4. Number of educational institutions.
5. Number of tourists.

Let's believe that the improvement of the factors of this model will lead to positive changes in the tourism industry of the territorial communities of the Zakarpattia region. The value of the developed model lies in the fact that on its basis it is possible to calculate latent indices for each year and create a stimulator for predicting future values based on statistical trends of key influencing factors. The sustainability of development can be stated by improving the block weights for different periods.

7. SWOT analysis of research results

Strengths. The strengths of this research lie in the fact that, based on the economic indicators of the tourism industry, factors characterizing the level of tourism development were identified. The improvement of these factors can have a positive impact on the growth of the economic component of the territorial communities.

Weaknesses. Weaknesses are related to the fact that the developed mathematical model reflects the current resource potential in general and does not provide for specific steps to implement the qualitative and quantitative growth of the socio-economic aspects of the population's life. It can also be noted that with the emergence of new indicators of tourism development, it would be advisable to rethink the mathematical model with the corresponding changes at the stage of presenting the PLS-PM model.

Opportunities. Additional opportunities when using the above results can also affect the formation of an economically profitable strategy in the market and more efficient use of available resource balances. Equally important, the results of the study may have an impact on forecasting development trends of territorial communities based on economic indicators in the field of tourism.

Threats. The developed mathematical model is based on the analysis of existing indicators of the tourism sector and does not pay enough attention to factors that, without due attention, will worsen over time. These factors include: insufficient financial support for the industry, the use of outdated equipment, etc.

8. Conclusions

1. A mathematical apparatus has been selected and justified, which makes it possible to analyze the main factors influencing the development of the tourism industry, obtained on the basis of the PLS-PM model. This analysis can be used to successfully solve the problems of sustainable development of the tourism industry of territorial communities.

2. A PLS-PM analysis has been carried out, which made it possible to identify the key factors that determine the current opportunities for the development of the tourism sector of the territorial communities of the Zakarpattia region. The following factors turned out to be key: differentiation

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of the living standards of the population, emissions of pollutants into the atmosphere, healthcare institutions, the number of educational institutions, and the number of tourists. The level of social comfort received the greatest influence among the studied latent variables (influence level 0.673). Significant factors influencing development are the ecology of the region (influence level – 0.227) and its economic component (influence level – 0.206).

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