The level of railway rates as a factor of sustainable development of territories

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Abstract. This article attempts to assess the impact of the level of railway rates on the sustainable development of territories (on the example of Russia, freight and passenger rates, 2000-2018) using econometric modeling with an autoregressive model. As follows from the results obtained, in general, the statistically significant effect of the level of railway rates on the sustainable development of territories can be identified only for some indicators that assess certain aspects of sustainable development. Evaluation of the influence of the level of railway rates on integral indicators of sustainable development (on the example of the human development index) leads either to the identification of autocorrelation of the model residuals or does not give an unambiguous answer about the presence/absence of autocorrelation, which casts doubt on the conclusions on assessing the quality of the model and its coefficients.

1 Introduction

The concept of sustainable development has travelled a long way in its evolution. Its origin is associated with the ideas of "sustainable forest management" developed in Europe in the 17th-18th centuries as a reaction to the growing awareness of the problem of degradation of forest resources as a result of their destructive and excessive exploitation. The development of these ideas is associated primarily with the works by J. Evelyn, J.-B. Colbert, G.K. von Karlowitz, A. von Humboldt, G.L. Gartig. Later, in the XIX-early XX century, these works had effect on the activities of G. Pinchot (the idea of rational use of resources in forestry management) and A. Leopold, whose land ethics influenced the development of the environmental movement in the 60s. of the XX century.

Later, the developing environmental movement drew attention to the relationship between economic growth and development and environmental degradation, which was covered in the works by R. Carson, K.E. Boulding, G. Hardin. The Club of Rome in 1972 was one of the first to use the term "sustainable" in its modern sense in the classic report "The Limits to Growth", prepared by a group of researchers led by Dennis and Donella Meadows. The authors of the report described the desired "state of global equilibrium" as a

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world system that is resilient without sudden and uncontrollable collapse and capable of meeting the basic material needs of all people.

In 1980, the International Union for Conservation of Nature published a World Conservation Strategy that included one of the earliest references to sustainable development as a global priority and introduced the term “sustainable development”. Two years later, the UN World Nature Charter proclaimed five principles of nature conservation, according to which human behavior that has an impact on nature should be determined and evaluated.

Finally, in 1987, the UN World Commission on Environment and Development published Our Common Future Report, commonly referred to as the Brundtland Report. The report contains one of the most widely accepted definitions of sustainable development today: "Sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs". This definition includes two key concepts:

1. The concept of “needs”, in particular the basic needs of the world's poor, which should be prioritized;
2. The idea of the limitations imposed by the state of technology and social organization on the ability of the environment to meet present and future needs [1].

In the future, the concept of sustainable development continued to develop in the key of combining three main points of view: environmental, economic, and social. At the same time, a conflict has emerged between the position of economists who support this concept and the traditional economy oriented towards unlimited economic growth. This led in the formulation of the definition of "economy of a steady state" G. Daly and the emergence of ecological economy in the late 80s. of the XX century.

Unprecedented urbanization of the XX century also led to the introduction of sustainable development principles in urban and spatial planning. This adaptation of the concept of sustainable development was called “sustainable development of territories” and in Russia it was reflected in the Urban Planning Code of the Russian Federation in the following wording: “Sustainable development of territories - ensuring safety and favorable conditions for human life in the implementation of urban planning activities, limiting the negative impact of economic and other activities on the environment and ensuring the protection and rational use of natural resources in the interests of present and future generations” [2].

One of the problems of sustainable development in general and sustainable development of territories in particular due to the complex nature of the concept itself, continues to be the measurement of the level of sustainable development and its dynamics, outlining the factors of sustainable development, emphasized by a number of authors [3-6]. At the same time, there are 2 main approaches to solving this problem:

1. Creation of systems of indicators, which help to assess certain aspects of sustainable development (countries, territories, cities, etc.). A striking example is the system of sustainable development indicators developed by the UN Commission on Sustainable Development, which is one of the most comprehensive in terms of coverage (includes more than 100 indicators focused on achieving 17 main sustainable development goals);
2. Creation of integral aggregated indicators to comprehensively assess sustainable development. A well-known example of the implementation of this approach is the Human Development Index (HDI), which is calculated annually for cross-country comparison and assessment of literacy, living standards, longevity, and education by the United Nations Development Program. Another example of using this approach is the calculation of the adjusted net savings indicator by the World Bank (evaluates the compliance of the country's investment policy with the concept of sustainable development).

Transport, as one of the most important parts of the infrastructure of any territory, contributes to the sustainability of its development. At the same time, for almost 2 centuries the most important type of transport in Russia has been rail transport – an integral part of the country's transport infrastructure. Therefore, in general, the functioning of railway transport in the Russian Federation, as well as its individual aspects, can affect the sustainability of development of both individual regions of Russia and the entire national economy as a whole, as shown in some publications [7, 8]. Note, however, that there are few existing publications assessing the contribution of rail transport to the sustainability of development, including in terms of rail transport itself.

One of the most important aspects of the functioning of railway transport in the Russian Federation is the current system of rates for the transportation of goods and passengers. Indeed, rate revenues account for 90% of Russian Railways' revenues, and the corporation itself is one of the largest Russian taxpayers and is the largest employer in Russia. Therefore, a well-implemented rate policy in this area has a significant direct and indirect impact on the national economy and the level of well-being of the population of the Russian Federation.

In light of the objective need to strengthen the sustainable development of the Russian economy and its individual regions, it is interesting and relevant to assess the impact of certain aspects of the functioning of railway transport in the Russian Federation (on the example of the current rate system, in particular, the level of railway rates) on the sustainability of the development of territories (on the example of Russia).

2 Material and Methods

Traditionally, the level of prices (rates) is assessed by various price indices. For the purposes of this article, the rate indices for passenger and freight railway transportation in Russia in 2000-2018 (December to December of the previous year, in%) were taken as an indicator of the level of railway rates in Russia (as a factor of sustainable development). Note that with the gradual adaptation of the country's economy to market relations and the implementation of the structural reform of the Russian railway transport during 2000-2018 there was a steady decline in the level of railway rates reflected in the changes in these indices (Fig. 1).

For the purposes of this article, 7 indicators developed by the UN Commission on Sustainable Development (for Russia, for 2000-2018) were chosen as indicators demonstrating certain aspects of sustainable development in Russia. The Human Development Index (HDI) of the United Nations Development Program and the adjusted net savings of the World Bank (for Russia, for 2000-2018) served as comprehensive measures of the sustainable development of Russia.

Fig. 1.Rate indices for passenger and freight rail transportation in Russia in 2000-2018 (Rosstat, 2010, 2016, 2018) [9].

Assessment of the quantitative effect of factor variables on outcome variables in the case of time series is often done using dynamic econometric models. To assess the impact of the level of railway rates on the sustainability of the development of territories (on the example of Russia during 2000-2018), this article applied the autoregressive model, first used for econometric analysis by G.U. Yule and Slutskii E. [10, 11]. For our assessment, we applied a first-order autoregressive model of the form:

$$y_t = a + b_0 * x_t + c_1 * y_{t-1} + \varepsilon_t, \tag{1}$$

where y_t is the indicator of the sustainability of the development of the territory (the system of indicators of the UN Commission on Sustainable Development / HDI of the UN Development Program / adjusted net savings of the World Bank) for Russia at time t ;

a is the indicator of the sustainability of the development of the territory (the system of indicators of the UN Commission on Sustainable Development / HDI of the UN Development Program / adjusted net savings of the World Bank) for Russia at time $t-1$;

x_t is the indicator of the level of railway rates (an index of rates for passenger or freight railway transportation) for Russia at time t ;

ε_t is the remainder of the autoregressive model.

The coefficients of model (1) were assessed in 2 steps using the instrumental variable $\hat{y}_{t-1}$, substituted into model (1) instead of the lagged variable y_{t-1} and calculated using a regression model of the form:

$$y_{t-1} = d_0 + d_1 * x_{t-1} + u_t, \tag{2}$$

where u_t is the remainder of the regressive model (2);

d_0, d_1 are coefficients of the regression model (2), determined using the classical least squares method.

Note that before the assessment with the autoregressive model (1), we estimated the correlation of the factor and the resultant variable using the coefficients of pair linear correlation. The "factor variable-effective variable" pairs with weak (predominantly) and medium correlation (as a rule, statistically insignificant) were not assessed with the use of the autoregressive model (1).

3 Results and Discussion

The results of our assessment of the influence of the level of railway rates on the sustainability of the development of territories (on the example of Russia, in 2000-2018) according to the autoregressive model (1) for "factor variable-resultant variable" pairs with high (mainly) and moderate statistically significant correlation are given in Table 1 (the statistical significance of the models and the coefficients of the models was assessed using the Fisher test and Student t-test, respectively; the model was tested for the presence of autocorrelation of residuals using the Darbin h-test).

Table 1. Results of assessing the impact of the level of railway rates on some indicators of the UN CSD and HDI for Russia in 2000-2018 (according to the autoregression model (1); factors: x_{1t} are the indices of rates for rail freight transportation, x_{2t} are the indices of rates for travel in suburban trains, x_{3t} are the indices of rates for travel in a compartment car of a fast non-branded long-distance train)

Dependent variable y_t (UN CSD/HDI indicator)	Statistical significance of the model at $\alpha = 0,05$	Statistical significance of the coefficient b_0 of the model at $\alpha = 0,05$	Statistical significance of the coefficient c_1 of the model at $\alpha = 0,05$	Estimation of the coefficient b_0 of the model	Estimation of the coefficient c_1 of the model	Testing of the model for the presence of autocorrelation of residuals
Rail freight turnover, billion t-km	for x_{1t} : significant	for x_{1t} : significant	for x_{1t} : significant	for x_{1t} : -	for x_{1t} : -	for x_{1t} : criterion not applicable
Rail passenger turnover, billion pass-km	for x_{2t} : significant; for x_{3t} : significant	for x_{2t} : insignificant; for x_{3t} : insignificant	for x_{2t} : insignificant for x_{3t} : insignificant	for x_{2t} : -; for x_{3t} : -;	for x_{2t} : -; for x_{3t} : -;	for x_{2t} : -; for x_{3t} : -;
Processing industry value added, per capita, USD (2015 prices)	for x_{1t} : significant; for x_{2t} : significant; for x_{3t} : significant	for x_{1t} : significant; for x_{2t} : insignificant; for x_{3t} : significant	for x_{1t} : significant; for x_{2t} : significant; for x_{3t} : significant	for x_{1t} : -5.1083; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : 0.6878; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : without autocorrelation; for x_{2t} : -; for x_{3t} : with autocorrelation
Domestic material consumption per capita (total without breakdown by types of raw materials), t/person	for x_{1t} : significant; for x_{2t} : significant; for x_{3t} : significant	for x_{1t} : insignificant; for x_{2t} : insignificant; for x_{3t} : significant	for x_{1t} : insignificant; for x_{2t} : significant; for x_{3t} : significant	for x_{1t} : -; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : -; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : -; for x_{2t} : -; for x_{3t} : criterion not applicable
Human Development Index (HDI)	for x_{1t} : significant; for x_{2t} :	for x_{1t} : significant (at	for x_{1t} : insignificant; for x_{2t} :	for x_{1t} : -; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : -; for x_{2t} : -; for x_{3t} : -;	for x_{1t} : criterion not applicable;

Continuation of Table 1. Results of assessing the impact of the level of railway rates on some indicators of the UN CSD and HDI for Russia in 2000-2018 (according to the autoregression model

(1); factors: x_{1t} are the indices of rates for rail freight transportation, x_{2t} are the indices of rates for travel in suburban trains, x_{3t} are the indices of rates for travel in a compartment car of a fast non-branded long-distance train)

Dependent variable y_t (UN CSD/HDI indicator)	Statistical significance of the model at $\alpha = 0,05$	Statistical significance of the coefficient b_0 of the model at $\alpha = 0,05$	Statistical significance of the coefficient c_1 of the model at $\alpha = 0,05$	Estimation of the coefficient b_0 of the model	Estimation of the coefficient c_1 of the model	Testing of the model for the presence of autocorrelation of residuals
	significant; for x_{3t} : significant	$\alpha = 0,05$); for x_{2t} : significant; for x_{3t} : significant	significant; for x_{3t} : significant			for x_{2t} : with autocorrelation; for x_{3t} : with autocorrelation

Note: calculated by the authors according to Rosstat data [9, 12], UN [13], and the UN Development Program [14].

The results of evaluating the correlation for "factor variable-effective variable" pairs with weak (predominantly) and medium correlation (as a rule, statistically insignificant) are shown in Table 2.

Table 1 shows a statistically significant effect of the level of railway rates on the sustainability of territorial development (using the example of Russia, in 2000-2018) only for the pair of variables "index of rates for rail freight transportation/value added industry, per capita": both the autoregression model and the estimates of the coefficients b_0 , c_1 are statistically significant; there is no autocorrelation of residuals.

In all other cases, there is either the statistical insignificance of the model/coefficients or the presence of autocorrelation of residuals or the impossibility of assessing the autocorrelation of the residuals of the model. At the same time, 12 "factor variable/effective variable" pairs were not assessed using the autoregressive model (1) because of the predominantly weak and mostly statistically insignificant correlation (Table 2).

Table 2. Estimates of paired linear correlation coefficients of railway rate indices and some UN CSD indicators/adjusted net savings per capita for Russia in 2000-2018 (in brackets - two-sided p-value for the significance level $\alpha = 0.05$)

Pairwise correlation variables (horizontal - rail rate indices; vertical - some UN CSD indicators/adjusted net savings per capita)	x_{1t} are indices of rates for rail freight transportation	x_{2t} are suburban train rates indices	x_{3t} are indices of rates for a compartment car of a fast non-branded long-distance train
Annual growth rate of real GDP per capita, %	0.46 (0.045)	0.46 (0.046)	0.42 (0.074)
Annual growth rate of real GDP per person employed, %	0.36 (0.113)	0.38 (0.113)	0.39 (0.0943)
Share of people with income below 50% of the median income, %	0.44 (0.0600)	0.63 (0.038)	0.53 (0.0193)

Continuation of Table 2. Estimates of paired linear correlation coefficients of railway rate indices and some UN CSD indicators/adjusted net savings per capita for Russia in 2000-2018 (in brackets - two-sided p-value for the significance level $\alpha = 0.05$)

Adjusted net savings per capita, USD (current prices)	-0.55 (0.0145)	-0.66 (0.0023)	-0.62 (0.0051)
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Note: calculated by the authors according to Rosstat data [9, 12], UN [13], and World Bank [15].

4 Conclusion

1. As follows from Tables 1 and 2, the statistically significant effect of the level of railway rates on the sustainability of the development of territories (on the example of Russia, 2000-2018) was revealed using the autoregressive model (1) only in 1 pair of "factor variable/resultant variable" of the 24 pairs of variables, namely in "index of rates for freight transportation by rail/processing industry value added per capita".
2. The short-term multiplier in the autoregressive model (1) for a given pair of variables is $b_0 = -5.1083$, i.e. according to the model, an increase in the rail freight rate index by 1% leads to a decrease in the added value in the processing industry per capita in the same period by an average of \$ 5.1083 (2015 prices). The long-term multiplier is $b_0/(1-c_1)=-5.1083/(1-0.6878)=-16.3623$, i.e. according to the model, a 1% increase in the rate index for rail freight transportation in any period will lead to a decrease in the added value in the processing industry per capita in the long term by an average of \$ 16.3623 (2015 prices).
3. As follows from the results obtained, in general, the statistically significant effect of the level of railway rates on the sustainable development of territories can be identified only for some indicators that assess certain aspects of sustainable development of territories. Evaluation of the influence of the level of railway rates on integral indicators of sustainable development (on the example of the HDI) leads either to the identification of autocorrelation of the model residuals or does not give an unambiguous answer about the presence/absence of autocorrelation (Table 2), which casts doubt on the conclusions on assessing the quality of the model and its coefficients.

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