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Economic Assessment of Seasonal Unevenness in Railway Infrastructure Loading



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ABSTRACT

The article considers the problem of seasonal uneven transportation and its impact on transport infrastructure loading. The objective of the study is to develop scientifically sound recommendations for monitoring seasonal unevenness of transportation and infrastructure loading based on its adequate assessment; conducting economic assessment of the impact of seasonality of transportation on the indicators of current and investment activity of railway transport; making recommendations to further reduce unevenness of transportation, or at least prevent its growth.

The authors solved the following tasks: a reasoned, logically structured sequence of economic assessment of the impact of seasonality of transportation on the indicators of current and investment activities of railway transport was formed, and scientifically based recommendations were proposed to further reduce uneven transportation (to prevent its growth). The following methods were used: logical and analytical tools, methods of statistical analysis, economic-mathematical modelling and technical and economic calculations.

As a result of the study, the authors revealed that seasonal uneven loading of railway infrastructure leads to a decrease in quality of transportation and a deterioration in the market image of the railway industry, an increase in operating costs and cost of transportation, that is, to a decrease in efficiency and competitiveness of railways. The uneven transportation negatively affects the effectiveness of investments in development of railway transport.

The analysis made it possible to formulate a theoretical model of influence of seasonal unevenness of railway infrastructure loading on efficiency of its use and development. It is advisable to use the methodological toolkit for assessing seasonal unevenness of railway infrastructure loading for its in-depth retrospective analysis, identifying the main factors affecting unevenness indicators and determining the maximum permissible level of seasonal unevenness.

The developed model of influence of seasonal unevenness of loading on use and development of railway infrastructure allows to carry out economic assessment of seasonal unevenness, is a tool to improve planning and management of transportation activities and development of railways. The reduction in seasonal unevenness of transportation should be considered as a factor increasing the economic efficiency of not only the current, but also investment activity of the railway transport, while its growth should be considered as a specific type of risk for effectiveness of implementation of railway infrastructure development projects.

Keywords: transport, seasonal unevenness of infrastructure loading, railway infrastructure, normalized work, operating costs, transportation costs, economic efficiency.

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Background. The negative impact of unevenness of transportation on operational and economic indicators of railways has been noted by researchers since 19th century to the present [1–3]. The fundamental nature of this problem was disclosed in [4]. Moreover, seasonal unevenness (seasonality) of transportation is especially significant [5, p. 5], seasonality meaning «unevenness of transportation by quarters of the year and months» [6, p. 240].

Academician T. S. Khachaturov noted the negative impact of unevenness of transportation on both investment and operating costs of railways. The first is due to the fact that «it is necessary to provide... a reserve of technical equipment of transport due to unevenness of transportation, which accordingly increases the required investment» [6, p. 239]. The second is due to the fact that «during periods of maximum transportation difficulties arise with movement of trains, which causes a slowdown in movement of goods. All this results in increase in the cost of transportation» [6, pp. 239–240]. To this fair assessment, it should be added that slowdown in movement of goods entails significant macroeconomic losses associated with «freezing» of working capital embodied in the goods transported during the period of their transportation [7; 8, p. 92].

And the losses associated with slowdown in delivery of goods and increase in the cost of transportation [9] become especially significant in conditions of high and ultra-high filling of railway capacity («overload», in modern economic terminology [10]). Namely, such a situation exists in a number of key areas of the Russian railway network [11, p. 14]. Its overcoming requires development of railway infrastructure. The Comprehensive plan for modernization and expansion of the main infrastructure provides for large-scale tasks covering all types of transport, including railway, and aimed both at solving existing infrastructure problems and opening up opportunities for development of new points of economic growth [12; 13].

The analysis of the Comprehensive plan shows that it requires significant investment from not only the federal budget, but also from the regions (many of which undergo financial problems), as well as from business entities [14, pp. 32–36]. In particular, the Long-Term Development Program (LDP) of JSC Russian Railways until 2025, linked in terms of railway infrastructure projects with the Comprehensive plan, provides for a significant increase in investment. In accordance with the basic scenario of LDP, in 2019–2025 the average annual investment should amount to about 670 billion rubles, and according to the optimistic scenario, to about 830 billion rubles [15]. It is important that acceleration of investment in development of Russian railways has already begun. If in 2018 the volume of investments of JSC Russian Railways amounted to about 550 billion rubles, then in 2019 it was about 690 billion [16, p. 9]. At the same time, the possibility of such an intensification of the investment activity of the company and the overall success of implementation of LDP will depend on many factors, including environmental factors, and will entail significant risks, some of which have already appeared at the start of the program, in 2019 [17, p. 16].

The Comprehensive plan provides for implementation of the largest infrastructure projects. And for business development, and in the interests of ensuring mobility of the country's population, they «should be supplemented by grassroots activation of development of transport infrastructure that would solve the problems of the «last mile», local transportation, etc.» [18, p. 35]. For such projects, additional investments are needed, including private ones, the attraction of which requires appropriate institutional conditions.

Given that investment resources are always limited (this is common to any economic good [19, pp. 103–108]), an important task is to increase the efficiency of using the existing transport infrastructure. This allows to postpone investment, which gives the corresponding effect [20, p. 57].

Reducing seasonal unevenness of transportation is an important factor in ensuring for the economy and the population such a key economic good as modern transport infrastructure.

In 2016–2018, cargo turnover on railway transport increased by 10,8 %, with a decrease in its seasonal unevenness, estimated as the ratio of the maximum monthly value of the average daily cargo turnover during the year to the average daily cargo turnover for the year, from 105,6 to 103,3 %. It is obvious that in conditions of incomplete satisfaction of demand for loading resources during periods of «peak» demand, noted by shippers [21, p. 26; 22, p. 36], the problem of leaving trains without traffic («abandoned trains») persisting on the network, without reducing the level of seasonal unevenness of transportation, the actual dynamics of cargo turnover could not have been ensured. Based on the foregoing, it seems necessary:

• firstly, to monitor seasonal variations in transportation and loading of infrastructure based on its adequate assessment;

• secondly, to carry out economic assessment of the impact of seasonality of transportation on the indicators of the current and investment activity of the railway transport;

• thirdly, to develop recommendations to further reduce unevenness of transportation or, at least, prevent its growth.

The objective of this article is to develop scientifically sound recommendations for solving these problems. In this case, the logical and analytical method, methods of statistical analysis, economic and mathematical modelling and technical and economic calculations are used.

Assessing seasonal unevenness of infrastructure loading

In the works [23; 24] an improved methodological toolkit for assessing the seasonal unevenness of cargo and passenger transportation is provided. Two main differences from the traditional approach should be distinguished:

• for each period under consideration (month or quarter), daily average rather than aggregate values of indicators characterizing transportation volumes are used;

• seasonal unevenness of cargo transportation is assessed not by the «transported goods» indicator, but by two indicators: «cargo loading» and «cargo turnover». This allows to significantly clarify the characteristics of unevenness of transportation, as clearly shown in [24, p. 325].

It is advisable to assess the unevenness of transportation for each type of transportation (cargo and passenger), using appropriate indicators for this, as presented in [23, p. 5]. At the same time, in the conditions of combined movement of cargo and passenger trains, characteristic of domestic railways [25, p. 84], to characterize the load on the infrastructure, it is advisable to use the relevant integral indicator. The total gross cargo turnover covering passenger and cargo traffic [26] or the cited work [27] can serve as such an indicator. Given that the gross cargo turnover is an exclusively expenditure-forming indicator, and the indicator «normalized work» is used to assess the normalized transport production, productivity of the most important resources such as labour and infrastructure [27], it seems appropriate to assess the seasonal uneven loading of the railway infrastructure using this indicator. The reduced work (production) of railway transport is defined as the sum of cargo and passenger turnover [28, p. 121], while passenger turnover is doubled to determine labour productivity [28, p. 199]. It also substantiates the introduction of a special multiplying factor for container cargo turnover based on the higher cost and salary intensity of their transportation. As indicated in [29, pp. 45–46], the most accurately cited work for assessing infrastructure performance could be estimated using specially calculated normalization factors for cargo turnover and passenger turnover carried out by each category of trains having a coefficient of capacity load different from other categories. However, such an assessment is rather complicated, therefore, it is noted that it is possible to determine the given work for assessing the infrastructure productivity by the formula [29, p. 46]:

$$PL_{tar} = PL_{tar} + K_{norm} \cdot HL, \tag{1}$$

where PL_{tar} – tariff cargo turnover;

HL – passenger turnover;

K_{norm} – normalization factor.

The normalization factor can be assessed in various ways, it is important to note that in any case it will be more than one. In this study, the value $K_{norm} = 2$ is taken, as for assessment of labour productivity.

It is proposed to assess the seasonal unevenness of infrastructure loading using the following indicators (unevenness coefficients):

$$K^1_{unev} = \frac{\overline{PL}^{max}_{norm}}{\overline{PL}^{year}_{norm}}, \tag{2}$$

$$K^2_{unev} = \frac{\overline{PL}^{max}_{norm}}{\overline{PL}^{min}_{norm}}, \tag{3}$$

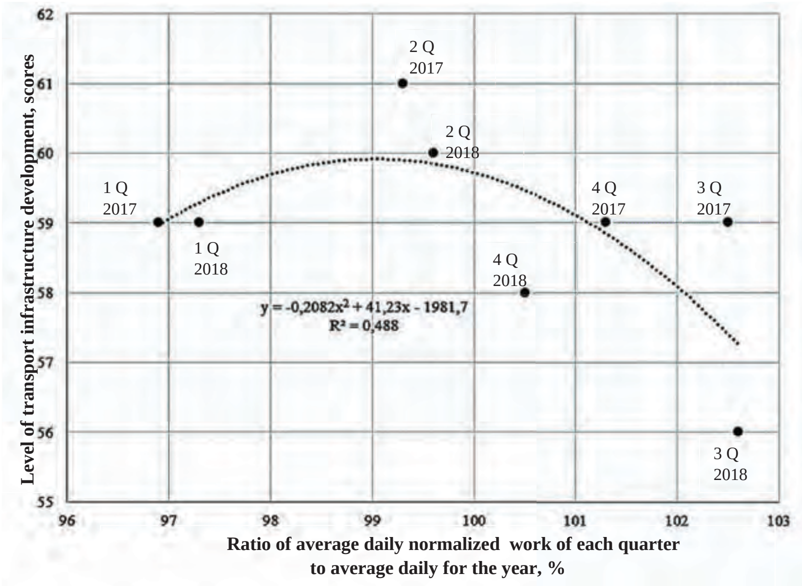
$$K^3_{unev\,i} = \frac{\overline{PL}^{i}_{norm}}{\overline{PL}^{year}_{norm}}, \tag{4}$$

where $\overline{PL}^{max}_{norm}$, $\overline{PL}^{min}_{norm}$ – respectively, the maximum and minimum quarterly (monthly)

Table 1

Seasonal unevenness of loading of the railway infrastructure, %

Year	K^1_{unev}	K^2_{unev}	$K^3_{unev\,i}$			
			I quarter	II quarter	III quarter	IV quarter
2017	102,5	105,7	96,9	99,3	102,5	101,3
2018	102,6	105,5	97,3	99,6	102,6	100,5



Pic. 1. Dependence of the assessment by shippers of the level of railway infrastructure development on the level of its loading.

value of the average daily normalized work during the year;

$\overline{PL}^{\text{year}}_{\text{norm}}$ – average daily normalized work for the year;

$\overline{PL}^{i}_{\text{norm}}$ – average daily normalized work for the particular quarter (month).

The indicated indicators, which can be expressed as coefficients or as a percentage, are not alternative, but complementary. Together, they make it possible to comprehensively assess the seasonal uneven loading of the railway infrastructure.

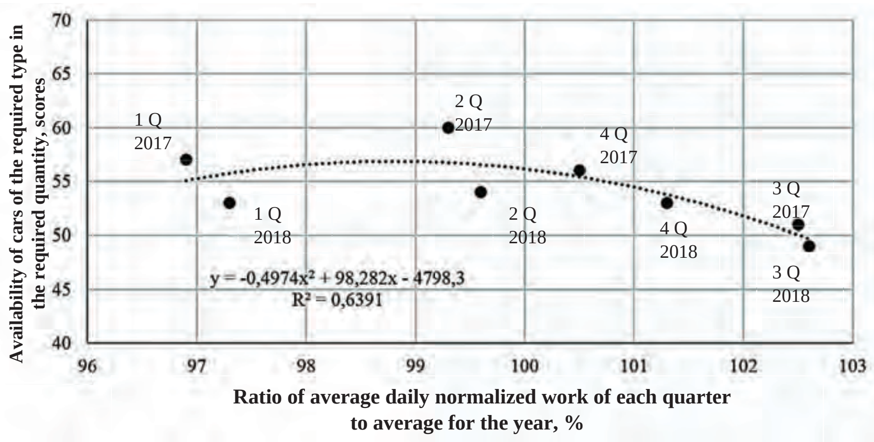
The coefficient K^1_{unev} characterizes the excess of infrastructure loading in the «peak» season over the average annual level. Its importance is determined by the fact that the capacity and carrying capacity of railways should allow to realize not only medium, but also maximum loads without loss of rhythm and stability of work. This is necessary to ensure the economic efficiency of their functioning. However, the ratio of loading of infrastructure in the «peak» season and the low demand season, which is demonstrated by the coefficient K^2_{unev}, is also important. Together, these coefficients give an annual characteristic of uneven railway infrastructure loading. But such a characteristic is not exhaustive. From an economic point of view, it is important (as will be shown below) to assess the loading level in each season, in comparison with the average annual rate using the coefficient $K^3_{unev\,i}$.

The characteristics of the seasonal (quarterly) uneven loading of the infrastructure of the Russian railways are shown in Table 1. As can be seen from the table, they are not subject to sudden changes.

An important theoretical and applied value belongs to identification of influence of seasonal uneven loading of railway infrastructure on economic performance of the industry.

Influence of seasonality of infrastructure loading on economic indicators of railway transport

Efficiency and competitiveness of railway transport, both current and long-term,



Pic. 2. Dependence of assessment by shippers of availability of wagons of the required type in the required quantity on the level of infrastructure loading.

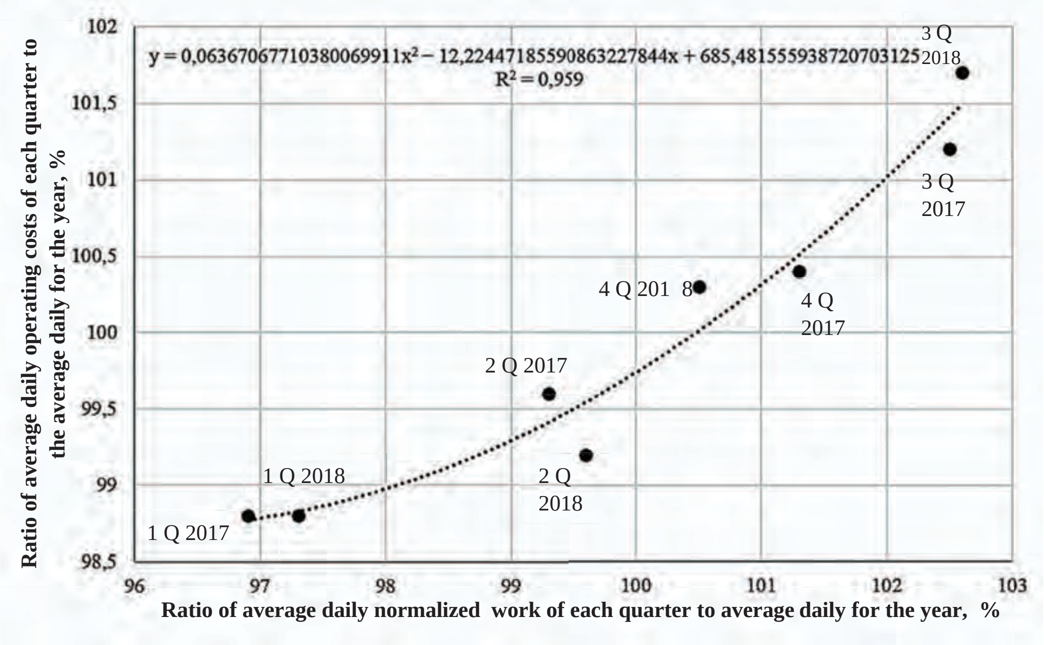
significantly depend on the level of quality of services provided to users [30; 31]. At the same time, not only transportation quality indicators objectively measured by industry statistics are important, but also *subjective* assessments of quality of services provided by the users themselves [32, p. 58; 29, pp. 147–148]. The use of such estimates to characterize quality of transport services not only reflects the principle of customer focus, but also corresponds to the fundamental principles of economic theory [33, p. 63]. After all, it is on the basis of their own subjective assessments that users decide on how to organize transportation (what modes of transport, which logistics scheme to use), and whether to carry out transportation at all. Using generalized assessments of cargo owners in the form of «Quality Index» made it possible to establish that the sensitivity of demand for cargo transportation to the quality level is almost twice as high as to the cargo charge level [34, pp. 40–41; 35, pp. 135–139].

Based on the foregoing, it is of interest to study the dependence of scores of cargo owners on quality indicators of transport services, which are components of a generalized Quality Index, on the level of railway infrastructure loading. When the infrastructure loading is more than 100 % of the average annual level, there is a tendency for shippers to reduce scores while assessing the level of development of transport infrastructure (Pic. 1). In other words, during periods of «peak» loading of infrastructure, its development is perceived by shippers as relatively worse than during periods of loading below the average level.

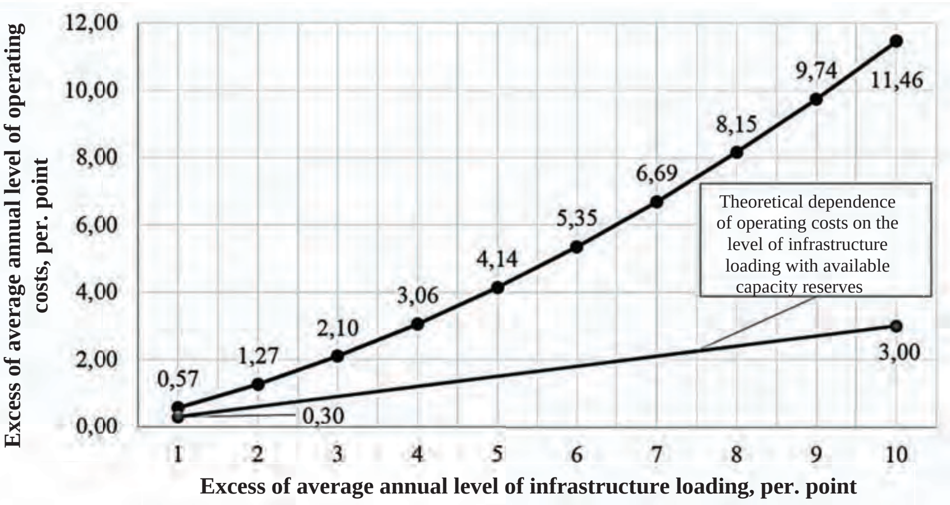
Interestingly, a much stronger correlation exists between shippers' assessment of availability of wagons of the required type in the required quantity and the level of infrastructure loading (Pic. 2). During periods of «peak» loading, these estimates are reduced, which is associated both with emergence of a shortage of wagons and increasing demand, and with difficulties in sending empty cars to loading sites due to the high and ultra-high filling of transit capacity at many sections of the railway network.

The analysis of dependence of the key economic indicator of railways (transportation costs or operating costs) on unevenness of infrastructure loading is of great importance. To carry out the corresponding assessment, the operating costs of different quarters were normalized to a comparable form by excluding from costs of I and IV («winter») quarters of additional costs associated with performance of operational work in the winter period (for fuel, snowfighting, etc.), and from costs of IV quarter of additional costs associated with the end of the year (payments on accounts, etc.). After these adjustments to the quarterly data, the average daily costs for each year and quarters were calculated, and the ratios of the average daily costs of each quarter to the corresponding average annual values were determined.

The assessment shows the non-linear nature of the dependence of operating costs on the level of railway infrastructure loading (Pic. 3). Such a result is empirical confirmation of the theoretical positions expressed in a number of works on the economics of transport [9, p. 87;



Pic. 3. Dependence of operating costs on unevenness of infrastructure loading.



Pic. 4. The increase in operating costs during infrastructure overloading.

36, pp. 96–97; 37, pp. 367–368] and consistent with the fundamental principles of economic theory, according to which, with an increase in production under the conditions of an unchanged amount of fixed capital, from a certain moment, the law of diminishing returns comes into effect [38, pp. 271–273]. As a result, marginal costs increase, and the growth of total costs becomes non-linear and accelerates.

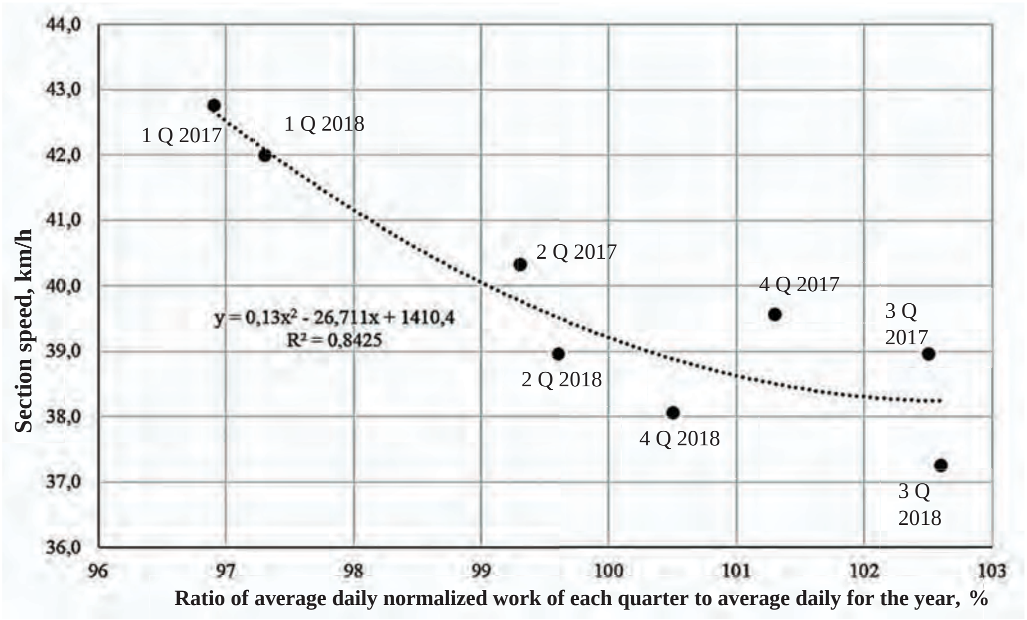
It is noteworthy that under the conditions under consideration, even before reaching the average annual level of railway infrastructure loading, growth of costs accelerates (Pic. 3).

This indicates that even with an average annual load, domestic railways are overloaded, i.e. operate in an economically suboptimal mode. With a significant excess of the average annual loading level, the growth of costs significantly exceeds the values observed with availability of transit capacity reserves and becomes faster than the growth in infrastructure loading (Pic. 4). The widening of the gap between the graphs of nonlinear growth in operating costs during infrastructure reloading and the theoretical graph in the absence of such is rather indicative.

Table 2

Dynamics of section and technical speeds of cargo trains and change in coefficient of section speed by quarter for 2017–2018

Indicator	2017				2018			
	I Q	II Q	III Q	IV Q	I Q	II Q	III Q	IV Q
Section speed	42,8	40,3	39,0	39,6	42,0	39,0	37,3	38,1
Technical speed	48,5	47,0	46,1	46,4	48,4	46,5	45,7	46,2
Coefficient of section speed	0,881	0,858	0,845	0,852	0,868	0,839	0,815	0,824



Pic. 5. Dependence of section speed of cargo trains on unevenness of infrastructure loading.

One of the main reasons for the nonlinear, accelerating growth in operating costs while increasing infrastructure loading is deterioration in quality of use of rolling stock over time, primarily expressed in decrease in train speeds. In a number of studies carried out in different years, it was found that when the loading of transit capacity of a railway line exceeds 70–80 % of the calculated value, section speed of cargo trains on these lines decreases [39; 40; 41, pp. 1–5], and the cost of transportation, respectively, grows [42, pp. 195–196; 43, pp. 67–68].

The empirical analysis of intra-annual changes in train speeds (Table 2) in comparison with seasonal unevenness of railway infrastructure loading (Table 1) indicates that during periods of higher infrastructure loading, train speeds decrease and their minimum values fall on III quarter, when the level of infrastructure loading is maximum.

The mathematical assessment of dependence of section speed on unevenness of railway infrastructure loading also indicates a decrease in section speed in case of infrastructure overloading (Pic. 5).

The scientific value of the simulation is that the dependence of section speed on the level of infrastructure loading is established not for individual lines, but for the railway network as a whole. As it is known, the cost of transportation and section speed are inversely related [37, pp. 269–276]. This means that with a decrease in section speed, the cost of transportation, and, consequently, the total amount of operating costs, increase.

At the same time, the decrease in section speed is only partially explained by the increase in operating costs, since the analysis shows (Tables 1, 2) that during periods of «peak» loading of the infrastructure not only section speed decreases, but also the section speed coefficient, defined as the ratio of section speed to technical [44, p. 246]. A decrease in the coefficient of section speed means that the downtime of trains at intermediate stations increases, and this additionally increases operating costs due to the increase in car-hours and locomotive-hours of downtime, as well as total crew hours of locomotive crews [45]. The combination of these factors explains the increase in operating costs, shown in Pic. 4. In addition, these downtimes lead to a slowdown in delivery of goods, which entails losses for product owners and the economy as a whole [46, pp. 6–7], and may also entail recovery of penalties from the carrier for late delivery of goods.

Thus, the seasonal unevenness of loading of the railway infrastructure leads to a decrease in quality of transportation and deterioration in the market image of the railway industry, an increase in operating costs and the cost of transportation, which reduces the efficiency and competitiveness of railways. Accordingly, unevenness of transportation reduces the efficiency of investments in railway transport development. Therefore, the possibility of increasing unevenness of transportation should be considered as a specific type of risk in implementation of both individual investment projects and integrated development programs, such as the Long-Term Development Program of JSC Russian Railways until 2025 [15].

The model of influence of seasonal unevenness of railway infrastructure loading on the efficiency of its use and development

The analysis and assessments made, taking into account the understanding of economic interconnections in the field of operation and development of transport systems, allow using the logical-analytical method [47] to form a theoretical model of influence of seasonal unevenness of loading of railway infrastructure on the efficiency of its use and development. The model is based on the following provisions.

1. The average daily value of normalized work ($\overline{PL}^{\text{year}}_{\text{norm}}$) of railway transport for the year with its existing structure by type and direction of transportation (S_{ij}) and a given level of tariffs (T) determines the annual income of the industry from transportation (D):

$$D = f(\overline{PL}^{\text{year}}_{\text{norm}}, S_{ij}, T). \quad (5)$$

In this study, we abstract from changes in traffic patterns and tariff levels in order to identify the effects of seasonal variation. Then expression (5) can be written as:

$$D = f(\overline{PL}^{\text{year}}_{\text{norm}}). \quad (6)$$

2. The maximum average daily normalized work of the intra-annual period (a quarter or a month) $\overline{PL}^{\text{max}}_{\text{norm}}$ determines both the required capital investments (K) in creating the transit and carrying capacity for realization of the corresponding transportation volume, and not only operating costs depending on transportation volume (variables) of the corresponding period, but also the annual conditionally-constant costs ($E_{\text{c-const}}$) associated primarily with infrastructure maintenance:

$$K = f(\overline{PL}^{\text{max}}_{\text{norm}}), \quad (7)$$

$$E^{\text{year}}_{\text{c-const}} = f(\overline{PL}^{\text{max}}_{\text{norm}}). \quad (8)$$

At the same time, the dependent (variable) operating costs during periods of «peak» volumes are determined not only by these volumes themselves, but also by deterioration of quality indicators of the transportation process, in particular, a decrease in motion speeds (ΔV):

$$E^{\text{max}}_{\text{dep}} = f(\overline{PL}^{\text{max}}_{\text{norm}}, \Delta V). \quad (9)$$

3. The effectiveness of the use of transport infrastructure ($Ef^{\text{u}}_{\text{infr}}$) depends on the ratio of revenues from transportation carried out using this infrastructure, and the corresponding operating costs, both dependent and independent of the volume of transportation (conditionally constant):

$$Ef^{\text{u}}_{\text{infr}} = f(D, E_{\text{c-const}}, E_{\text{dep}}). \quad (10).$$

Taking into account the dependencies (5–9), with the prevailing transportation structure and a given tariff level:

$$Ef^{\text{u}}_{\text{infr}} = f(\overline{PL}^{\text{year}}_{\text{norm}}, \overline{PL}^{\text{max}}_{\text{norm}}). \quad (11)$$

In turn, the average daily value of normalized work of railway transport for the year ($\overline{PL}^{\text{year}}_{\text{norm}}$) depends both on its level during the periods of maximum and minimum transportation and the ratio between them, and on the general distribution of transportation by period of the year, i.e. on the parameters $K^1_{unev}, K^2_{unev}, \{K^3_{unev\,i}\}$.

This implies the existence of the dependence:

$$Ef^{\text{u}}_{\text{infr}} = f(K^1_{unev}, K^2_{unev}, \{K^3_{unev\,i}\}). \quad (12).$$

4. When approaching the maximum level of railway infrastructure loading to the curve of production capabilities (CPC[1]), the law of

[1] CPC of the railway line shows what number of trains of different types (passenger, cargo) can be processed on this line per a certain time interval [37, p. 365].

$$\left\{\begin{matrix} \overline{PL}^{\,year}_{norm} \\ \overline{PL}^{\,max}_{norm} \\ \overline{PL}^{\,min}_{norm} \\ \overline{PL}^{\,min}_{norm} \\ \{\overline{PL}^{\,i}_{norm}\} \end{matrix}\right\} \Rightarrow \left\{\begin{matrix} K^{1}_{unev} \\ K^{2}_{unev} \\ \{K^{3}_{unevi}\} \end{matrix}\right\} \Rightarrow \left\{\begin{matrix} K \\ D \\ E_{\text{c-const}} \\ E_{dep} \end{matrix}\right\} \Rightarrow Ef^{\,u}_{infr}$$

$$\Downarrow$$

$$\left\{\begin{matrix} \Delta K^{1}_{unev} \\ \Delta K^{2}_{unev} \end{matrix}\right\} \Rightarrow \mathrm{T}_{post} \Rightarrow \mathrm{E}_{post}$$

Pic. 6. Scheme of assessment of seasonal unevenness of railway infrastructure loading on the efficiency of its use and development.

diminishing returns comes into force and there is a need for reconstruction activities [37, p. 366], requiring appropriate capital expenses (K_{rec}).

The capital expenses for reconstruction of the railway infrastructure should be paid off due to the income from transportation and other effects associated with the increase, due to reconstruction, in the volume of transportation (normalized work).

In a situation where there is a seasonal unevenness of infrastructure loading, i.e. coefficients K^{1}_{unev}, K^{2}_{unev}, K^{3}_{unev}, are not equal to unity, an alternative to reconstruction is to reduce unevenness of transportation, with a reduction in values of K^{1}_{unev}, K^{2}_{unev}, K^{3}_{unev}. At the same time, it becomes possible to postpone capital expenses for reconstruction by making them in subsequent years. The effect of postponement of expenses (E_{post}) for a given value of future costs for reconstruction of railway infrastructure that are being postponed for the future depends on time of postponement of costs (T_{post}), and the larger is it, the higher is the effect:

$$\mathrm{E}_{post} = f(\mathrm{T}_{post}). \qquad (13)$$

The essence of the effect of postponement of capital costs is due to the fact that during the period of postponement they will give effect with any alternative options of use. If the source of the corresponding investments is linked with borrowed funds, interest payments will be reduced.

In turn, time of postponement of expenses depends on reducing unevenness of infrastructure loading:

$$\grave{\mathrm{O}}_{post} = f(\Delta K^{1}_{unev}, \Delta K^{2}_{unev}). \qquad (14)$$

Hence:

$$\mathrm{E}_{post} = f(\Delta K^{1}_{unev}, \Delta K^{2}_{unev}). \qquad (15)$$

Thus, based on the logical analysis, the influence of seasonal unevenness of loading of railway infrastructure on the efficiency of its use and development is shown. In a generalized form, the described model is presented in Pic. 6.

Conclusion. It is advisable to use the methodological toolkit for assessing seasonal unevenness of railway infrastructure loading for its in-depth retrospective analysis, identifying the main factors affecting the unevenness indicators and determining the minimum achievable (maximum permissible) level of seasonal unevenness. This will allow forecasting seasonal unevenness for the future and developing measures to reduce it (to prevent exceeding the limit level). Measures to reduce unevenness of transportation can be based on tariff measures based on changes in cargo charges depending on the level of infrastructure loading [10, pp. 164–165; 48, p. 191; 49, pp. 69–70], and, in addition to them, on organization and technological measures, including those based on the use of big data analysis and computer modelling [50].

Current monitoring of seasonal unevenness of transportation, with assessment of effectiveness of the developed measures to reduce it and their further adjustment, should also be carried out using this methodological toolkit.

The influence of unevenness of loading of the railway infrastructure on assessment of quality of transportation services by shippers, the quality indicators of operational activity and operating costs of the railway transport, the developed model of influence of seasonal unevenness of loading on the efficiency of use and development of railway infrastructure revealed during the study make it possible to carry out economic assessment of seasonal unevenness on the results of current and investment activities of railway transport, and, thus, are tools to improve planning and management of transportation activities and development of railways.

At the same time, reduction in seasonal unevenness of transportation should be considered as a factor increasing the economic efficiency of not only the current, but also investment activity of railway transport, while its growth could be regarded as a specific type of risk for effectiveness of implementation of projects for railway infrastructure development.

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