

## A Study of Railway Development in Small States

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### Abstract

In the article, the author proposes a methodology that can be used to evaluate the development of the railway system in the country. The author illustrates this methodology by comparing the development of railways both in countries with an underdeveloped railway system and with a highly developed system. The development of railways is evaluated taking into account the area and population of the countries. The study revealed that in countries with a small railway network, the ratio of railway length to the country's area and population is no less than in countries with long railway lines.

**KEY WORDS:** *the development of the railway system, the country's area, population*

### 1. Introduction

When we talk about the development of the railway system in countries, we usually mean the length of the railways of one or another country. It is completely logical to believe that the United States of America has the most developed railways, the length of which is well over 200,000 kilometers, and the Chinese railways are not far behind them. Historically, Russia has many railways, the length of its railways is close to 90,000 kilometers. Vatican has the shortest railway line, its length is 850 meters, Monaco - 1.7 kilometers and Lesotho - 2.6 kilometers.

Each small region is part of a larger region, and its railways are part of the larger regional railway system [1]. Therefore, there is no single correct answer to evaluate the development of railways in such a region [2]. This is especially evident when considering passenger railways: there are long-distance trains and local trains. Their meaning differs for the region under consideration [3]. Also, when considering the significance of the railway for the region, it is important whether the railway will be dedicated to high-speed trains or not [4]. The nature of the railway has an impact on the timetables of the trains, and the timetable has an impact on the impact of the trains on the region [5]. Even such an area as the ticket reservation system has an impact on the possibility of using the passenger railway in one region or another [6]. Depending on the type of railway it is intended for, the fees for using that railway are calculated accordingly. Although not directly, this fact is also related to the significance of railways for the region [7]. Depending on the nature of the region (mountains, plains, lakes, rivers), the purpose and characteristics of the railway differ, so any assessment of its level of development is very superficial and conditional [8]. Sometimes individual objects, like a bridge and a tunnel, are decisive [9]. The same railway has the same meaning in a developed region, and may be completely different in a less developed region [10]. When examining the importance of the railway to the region, it is possible to distinguish between short-term effects on the region and long-term effects. Sometimes these are very different things, and sometimes they are very related [11]. A railway for freight trains and a railway for passenger trains have different effects on the spectacle [12]. Railways of lesser importance fall into disuse and are gradually abandoned. The causes and results of this are also analyzed in the literature [13].

The author of this study claims that the length of railways alone is not enough as an indicator to evaluate the development of railways in the country. In his previous works, the author of the article has proposed a methodology for evaluating the development of railways in various countries [14]. The essence of the methodology is that not only the length of the railways in the countries is evaluated, but also the area of the countries, the number of inhabitants and the gross domestic product [15]. The author uses the methodology previously described in the literature to compare the conditional development of the railway system in countries where the length of railways is long with countries where this length is short.

### 2. Methodology of Investigation

The main principle proposed by the author for evaluating the development of the railway system is to analyze the relationship between the length of the railway and the country's area and population [15]. Why are two ratios calculated for each country: the ratio of the length of the railway to the area of the country and the ratio of the length of the railway to the number of inhabitants [14]:

$$\begin{cases} I_s = \frac{L}{S}; \\ I_p = \frac{L}{P}. \end{cases} \quad (1)$$

where  $L$  - length of railways in the country, km;  $S$  - area of the country, km<sup>2</sup>;  $P$  - population in the country.

In order to generalize these indicators, it cannot be done simply because their measurement units are different, but it can be done by normalizing the indicators. The indicators are normalized with respect to the sum (so the sum of the normalized indicators is equal to one):

$$\begin{cases} I_{SN} = \frac{I_{Si}}{\sum_{i=1}^n I_{Si}}; \\ I_{PN} = \frac{I_{Pi}}{\sum_{i=1}^n I_{Pi}}. \end{cases} \quad (2)$$

where  $I_{Si}$  - relationship between the length of the railway and the country's area Table 1. Economic and social indicators of countries in "i" country;  $I_{Pi}$  - relationship between the length of the railway and the country's population in "i" country;  $n$  - number of countries.

A normalized average of the indicator can be calculated for each country. Arithmetic mean and geometric mean can be calculated:

$$\begin{cases} I_A = \frac{I_{SN} + I_{PN}}{2}; \\ I_G = \sqrt{I_{SN} \cdot I_{PN}}. \end{cases} \quad (3)$$

In order to perform calculations according to the presented methodology, the relevant data are required.

Table

Economic and social indicators of countries

Country code	Country	Length of railways in the country, km	Area of the country, km <sup>2</sup>	Population in the country
VA	Vatican	0.852	0.44	453
MO	Monaco	1.7	2	38300
LS	Lesotho	2.6	30355	7123205
RU	Russia	85513	17125191	147182123
CN	China	124000	9598962	1411778724
USA	USA	293564	9519431	336023460

Country codes are marked with abbreviations [16]. Table 1 shows that the USA, China and Russia have the largest railway network. The smallest railway network is occupied by the Vatican, Monaco and Lesotho. The author of the study argues that the length of the railways alone is not enough to assess the development of the railway network in countries. Therefore, it is proposed to evaluate also such indicators as the area and population of the country. It is also presented in Table 1. At first glance, it seems that the latter indicators are proportional to the length of the railways. However, the author suggests conducting more in-depth research. Based on table 1, the following studies shall be carried out.

### 3. Calculation Results

In this study, the results are the ratio of the length of the railways of different countries to the area of the countries and the number of inhabitants, as well as the arithmetic and geometric mean of the normalized values of this ratio and normalized values by country. The methodology set out above, (1, 2, 3) formulas and the data presented in Table, based on the results of the study. The ratio of the length of railways to the area of the country shown in Fig. 1.

Fig. 1 shows that the smaller the country, the larger the ratio of the length of the railways to the area of the country. Another relative rhodium, the ratio of the length of the railway to the population, is shown in Fig. 2.

When analyzing the ratio of the length of the railway to the population, you can already see the influence of the population of the large states. For example, the USA or Russia. Figs. 1 and 2 could summarise and assess the development of railways in a holistic way. However, this can only be done after the data has been normalized. The normalized ratio of railway length to the area of the country is shown in Fig. 3.

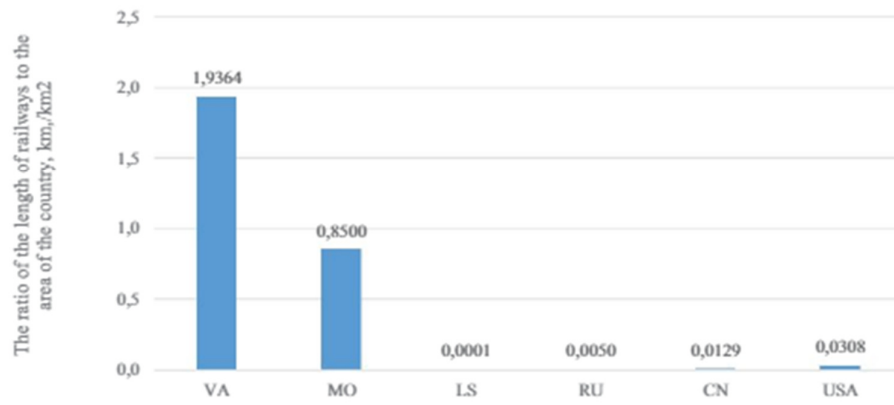


Fig. 1 The ratio of the length of railways to the area of the country

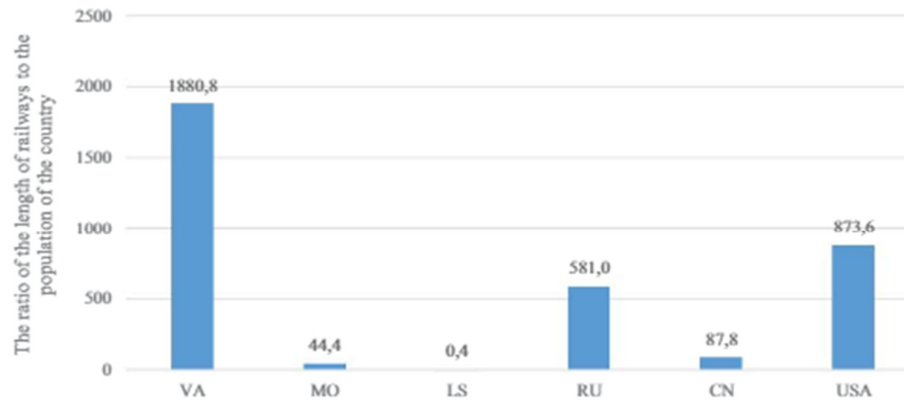


Fig. 2 The ratio of the length of railways to the population of the country

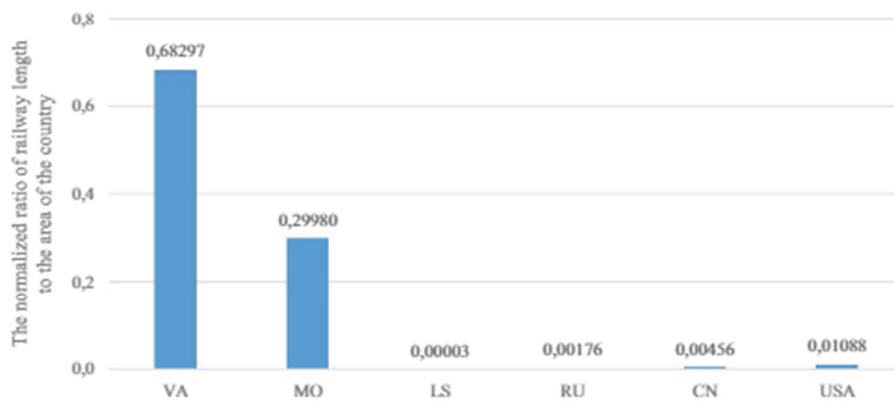


Fig. 3 The normalized ratio of railway length to the area of the country

Naturally, in Fig. 3 see the same distribution of meanings as in Fig. 1, since these are the normalized meanings of Fig. 1. Normalized ratio of railway length to the country's population is shown in Fig. 4.

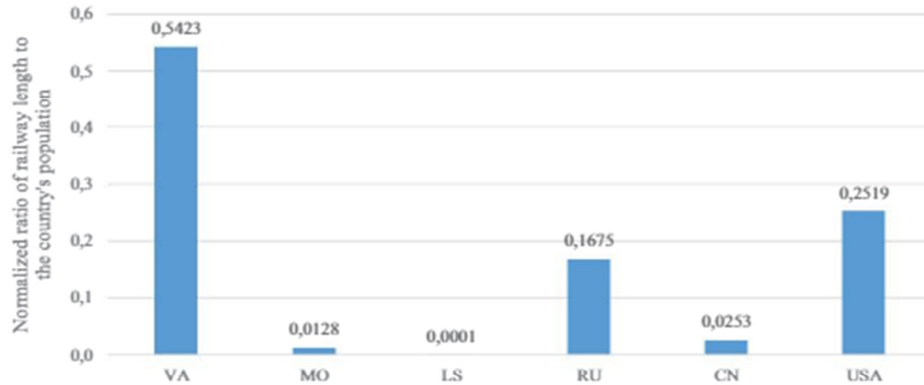


Fig. 4 Normalized ratio of railway length to the country's population

In Fig. 4, we see the same ratio of values as in Fig. 2, since these are normalized values in Fig. 2. The data in Figs. 3 and 4 can be summarized with each other. Since the data in Figs. 3 and 4 do not have units of measurement (they show the proportion of the data for each country in relation to their sum), it is possible to calculate the arithmetic mean or geometric mean between the relevant data. Average of normalized indicators by country is shown in the Fig. 5.

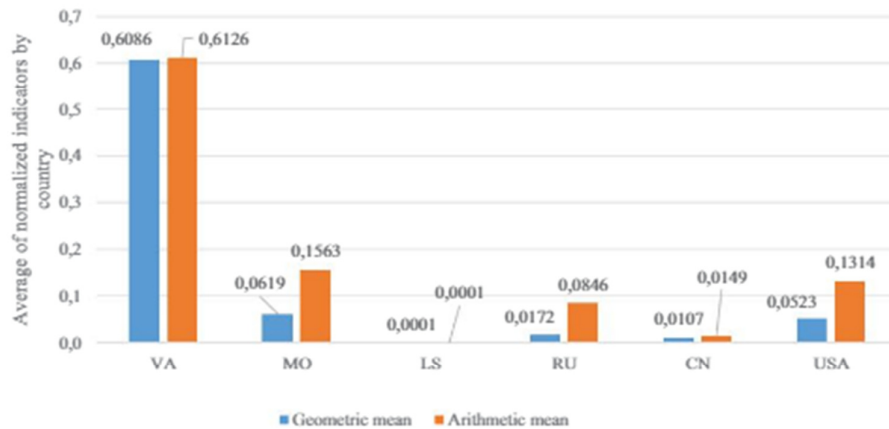


Fig. 5 Average of normalized indicators by country

Fig. 5 shows that, summing up the ratio of the length of the railways to the area of the country and to the population, it can be conditionally argued that the railways of the Vatican or Monaco are more developed in this respect than the railways of the United States or Russia.

#### 4. Conclusions

When assessing the development of rail transport in countries, it is important to assess the length of the railways in terms of the country's area and population.

Looking at the length of the railways in terms of the country's area and the number of inhabitants, it turns out that even in a country with a very small railway network, the railways develop relatively better than in countries with a large network.

A comparison of the indicators of the three countries with the largest railway network with the indicators of the three countries with the smallest railway network shows that countries such as the Vatican and Monaco have a relatively

better developed railway network than the USA or Russia.

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