Research on the Issue of Prognosticationing the Volume of Passenger Traffic on Railway Transport in Meanrn Conditions

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Abstract: Relevance of the research: The relevance of the study is due to the growing demand for passenger transportation in Ukraine and the countries of the European Union in the conditions of demand uncertainty and of the complexity of planning the work of railway operators. Given the fact that the railway transport system is quite inertial, including in the field of passenger transportation, a certain period of time is required for its timely restructuring, when certain factors affect it. The speed of adaptation to new conditions, as well as to their consequences, directly affect the quality of the system. That is why, to obtain the most optimal result, it is necessary to use the data obtained on the basis of prognostication. The purpose of the research: The purpose of the article is to analyze the factors influencing the predictive number of passengers to improve the processes of planning railway routes for the delivery of passengers due to the use of neural networks and minimizing the total cost of transportation. Approaches: Taking into account the specifics of the operation and management of passenger railway transportation is proposed an approach of using a software module based on neural networks as a decision support system regarding planned volumes of passenger traffic for railway operators of Ukraine and other countries. Results: The article presents the results of the software product based on neural networks for the analysis and theoretical generalization of the influence of various factors on the prognostication of passenger flows of transport systems of passenger service, supply chains involving railway transport. The significance of the results: The materials of the article are of practical value for the professional and industrial training of logistics operators, employees of transport companies for scientific and pedagogical workers in order to improve their professional competences.

Keywords: Passenger flow, Railway transport, Neural network, Passenger transportation, Transport operator.

1. INTRODUCTION

The life activity of the society of any country cannot exist without transport service, because in every country, transport is a connecting chain between settlements of different sizes. The dynamism of events taking place in the political, social and economic life of many different countries leads to an increase in the rate of migration activity of the population. In order for a certain person to be able to reach the settlement he or she needs, in particular, which is located at a great distance from him or her, he or she must use at least one of the existing elements of this chain. Every person who has used transport services at least once automatically becomes a passenger, and the totality of passengers moving in one direction turns into passenger flows.

Prognostication of passenger flows remains permanently relevant, since the conditions of market relations make impossible any forms and methods of directive management by the country. Reliable prognostication estimates become the only basis for the rational allocation and distribution of material and financial resources in the development of short-term and medium-term plans for the operation of the passenger complex, optimization of the volume and structure of both public and private investment in this segment of the transport industry (Balaka, 2021).

In meanrn economic conditions, the passenger economy needs to solve complex problems of adaptation to work in the conditions of development and improvement of the

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transport services market, find more effective technologies for organizing the process of transportation and methods of their implementation (Prokhorchenko, 2013). Accurate prognosticationing of passenger flow is quite difficult due to the chaotic nature of the transportsystem and the mechanism of influence of many factors (Prymachenko, 2018). Passenger traffic has a non-linear characteristic and a strongly expressed seasonal trend, and its burst is the main cause of overloading in any mean of transport (Qin, 2019). Therefore, the implementation of the passenger flow prognosticationing system should be based on a methodology that takes into account the vagueness of input information and has the ability to adapt in the short term (Butko, 2009). In this regard, an accurate prognostication of passenger flow in advance will make it easier for the dispatch service to organize passenger transportation(Yang, 2019; Osiejewicz, 2018).

2. METHODOLOGY OF THE STUDY

The purpose of the research. The purpose of this study is to build a multi-criteria model using artificial neural networks that will be able to fairly accurately predict the volume of passenger traffic in modern conditions, in particular, taking into account the level of morbidity of Covid-19 and the degree of influence of hostilities in the given regions on the example of railwaypassenger transportation in Ukraine, and as well as obtaining forecasted data for the possibilityof planning and organizing the most effective passenger transportation in the given conditions. **Research problems**. The constant growth of requirements and the influence of external factors on passenger transportation in Ukraine and the countries of the European Union, the complexity of operational planning of railway transport, especially for the current day, are themain problems of this study. The analysis of statistical indicators of passenger transportation proves the unevenness of the demand for railway transport services. In turn, the legislative framework in the field of railway transport and plans for the development of this industry take into account that passenger transport is socially significant and requires research into the issues of forecasting the volume of transport and ensuring a high level of service quality, and the study of the works of scientists in the field of passenger rail transport only confirms the existence and necessity solving the specified research problems.

Research methods used. To achieve the given goal, an empirical research method was used based on the factor analysis of passenger traffic on the example of railway transport of Ukraine, as well as the method of expert evaluations (for estimating the magnitude of the risk factors) and the modeling method to build a given multi-criteria passenger flow forecasting model based on neural networks.

Organization and progress of research. At the initial stage of this research, sampling and analysis of factors affecting passenger traffic was carried out. After that, the selected factors were formalized and a single array was created, which is the basis for forming the inputdata of the neural network. The activation function of the neural network was also proposed and the process of its training was performed. After that, passenger flow forecasting, calculation of the error value and comparison of this value according to other forecasting models were carried out.

Factors affecting passenger traffic. As it is known, each passenger flow is characterizedby intensity and volume of passenger transportation. The intensity of passenger traffic determines the number of passengers traveling on a given section of the route in one direction,for a specific period of time, using any mean of transport, and the volume of passenger transportation shows the number of passengers transported by a certain mean of transport for a specific period of time. In addition, passenger flows have their own characteristic feature - they are uneven, that is, they can change over time (Prymachenko, 2022). The degree of these changes, as well as the degree of the pace of migration activity, is influenced by a combination of political, social and economic factors, the components of which are: seasonality of transportation, the level of the average monthly wage in the country, monetary income per capita in the country, the level of industrial production in the country, income in certain sectors of the economy, the minimum consumer budget, the number of the population of the country or certain of its regions, the income rate from transportation, the level of morbidity, quarantine restrictions or hostilities, etc. However, many of these indicators are highly correlated, so adding all possible factors to the model will not increase its quality (Aloshynskyi, 2017). Basedon this, when creating a mathematical model for prognosticationing passenger flows, it is necessary to take only the most influential ones, the list of which is specified in the following subsections. The analysis of the influence of these factors on the passenger flow was carried out on the basis of railway transport of Ukraine.

2.1. Seasonality of passenger transportation.

The factor of seasonality of passenger transportation fully affects the amount of passenger traffic of certain directions. If you look at the dynamics of the number of passengers transported by rail transport in Ukraine, monthly, for 2021 (Fig. **1**), you can see a clear pattern that in the summer period, when the mass vacation season begins, and during the winter New Year holidays, the volume of transported passengers rapidly is increasing The coefficient of unevenness (k_n) at the same time is 1.24, which is a confirmation of the high level of influenceof this factor.

A strong example of the use of seasonality in passenger transportation is the appointmentof additional summer and winter trains by the management of the Ukrainian railway operator Joint-Stock Company "Ukrainian Railways" (JSC "UZ"). So, in 2021, 23 additional trains werescheduled only for the winter holidays (UZ said how many passengers were transported duringthe New Year holidays, 2022), and about 30 additional trains were added for the summer transportation period, and the schedule of more than 10 existing regular trains was adjusted routes ("Ukrzaliznytsia" launched about 30 new summer routes in 2021, 2021). Such optimization measures made it possible to avoid overloading and shortage of rolling stock, as well as to satisfy the needs of passengers as much as possible. A similar situation occurs with the daily formation of passenger flows, the analysis of which is shown in (Fig. **2**). This figure clearly shows the relationship between the number of transported passengers and the day of theweek. As you can see, at the end of each week, particularly on Saturday, the volume of passenger transportation is always higher than on the initial days, especially when compared to

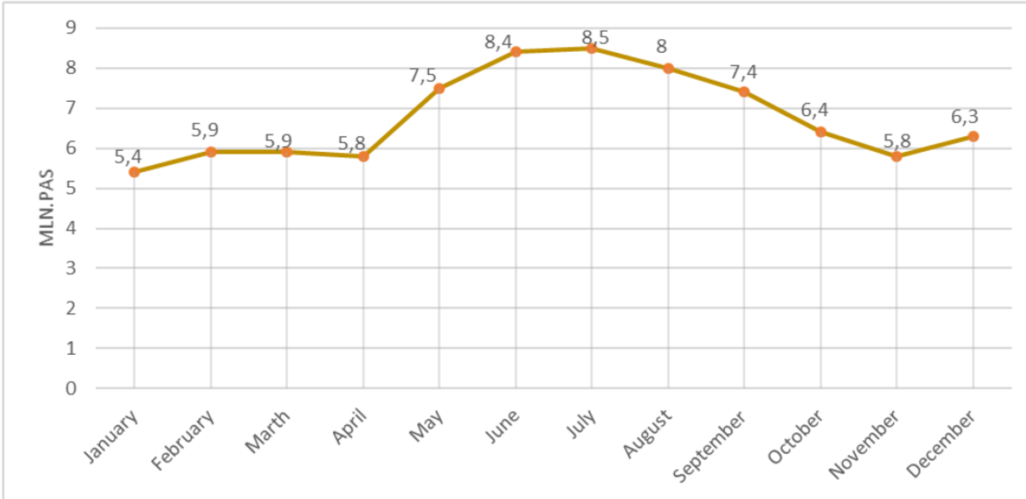

Fig. (1). Dynamics of the volume of passenger rail transportation in Ukraine for 2021 (CountryStatistics Service of Ukraine (2022, July 09)).

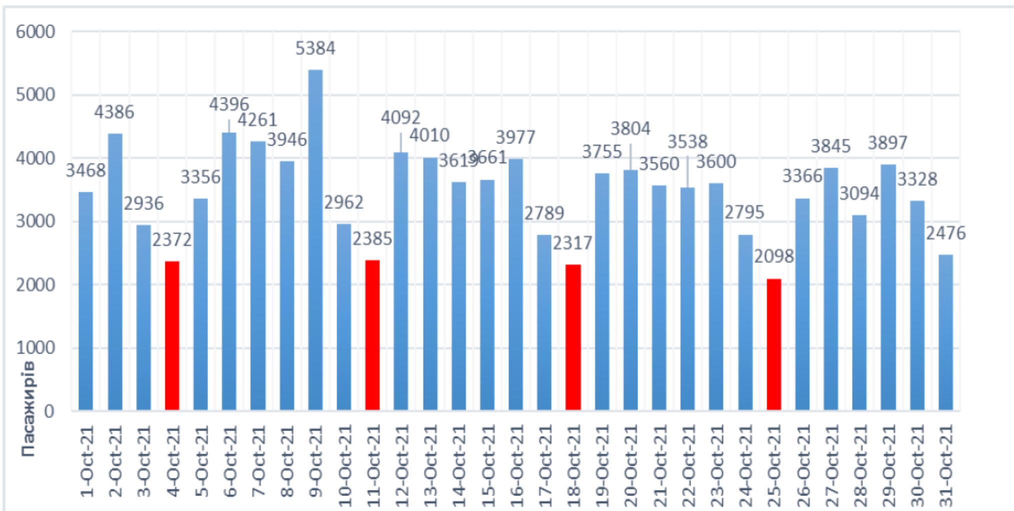

Fig. (2). The amount of passenger traffic on the Kharkiv - Kyiv section in October 2021.

Monday. This dependence of passenger transportation on the day of the week is also due to the seasonality factor and is called the "weekend effect" (Prymachenko, 2021). The properties of this effect are used by the operator of JSC "UZ" when planning the number of cars in the train.

2.2. Income Rate from Transportation, Average Salary and Population

Researchers, in a scientific work (Balaka, 2019), with the help of correlation coefficients, determined the most significant independent quantitative factors affecting the volume of passenger transportation and created a prognostication of this value for 2020 and 2021. These factors turned out to be: the income rate from transportation, the average salary and the numberof the population in the country, and the prognostication error, taking into account the suddenonset of the Covid-19 epidemic, was less than 10%.

The income rate from passenger transportation shows what income the carrier receives from passenger transportation per unit of work, i.e. per 1 passenger-kilometer. This indicator also directly reflects the amount of tariffs on a given type of transport. According to calculations (Balaka, 2019), it was established that the relations between the volume of passenger transportation, and, accordingly, passenger flows, and the income rate are inverse. In other words, an increase in the income rate entails an increase in transportation tariffs, which in turn reduces the demand for the use of a certain type of transport, and, accordingly, a decrease in passenger traffic (Inshyn et al., 2021).

Similarly, the degree of influence of the average salary, which has the same inverse relations with the volume of passenger transportation, was established.

The third indicator, from the above-mentioned, was the number of the population in the country. According to its correlation coefficient, this indicator had the closest connection with the volume of passenger transportation and, unlike the previous two, the connection was direct.In our case, when prognosticationing passenger flows, it is not appropriate to use the indicator of the population of the entire country, since different parts of the country may have different numbers of people, which is schematically depicted in Fig. (**3**).

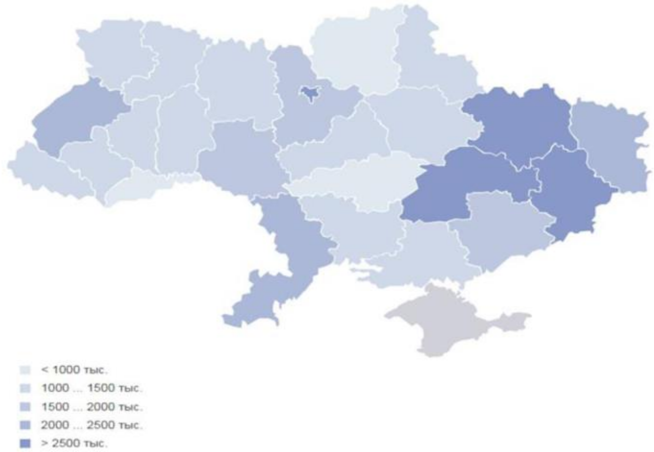

Fig. (3). Population in the regions of Ukraine in February 1, 2022 (Ministry of Finance, 2022).

Fig. (4). Scheme of Ukrainian railways (No news: Statistical Service, 2022).

Therefore, in order to reduce the error in calculations, when building a prognosticationing model, the total population of only those areas through which, according to the topology of Ukrainian railways (Fig. **4**), the passenger flow passes is used. For example, when prognosticationing the passenger flow between Kyiv and Kharkiv, the total value of the population in Kyiv, Poltava and Kharkiv regions will be taken, if it flows through Poltava and Kyiv, Sumy and Kharkiv regions, if the passenger flow flows through Sumy, between Kyiv and Odesa - Kyiv, Vinnytsia and Odesa region, etc.

2.3. The Danger Factor

As the experience of recent years shows, not only micro-level factors, but also macro-level factors can affect the volume of passenger transportation and, accordingly, passenger flows. The latter, in particular, can have a much greater impact than the former. A striking example is the emergence of the Covid-19 epidemic in 2020. The rapid spread of the coronavirus infectionin the world has led to the development of a global crisis in the field of health care, an overloadof national health care systems and serious economic consequences. A notable downside of the measures to contain the infection was, in particular, the drastic restriction of transport activity. If you look at the statistical series of the number of passengers transported by railway for 2020(Fig. 5), you can see that a few months after the beginning of the epidemic, this indicator dropped to zero (from April to June 2020), which indicates a complete stop of the passenger traffic (Britchenko & Saienko, 2017). However, after the rate of infection slowed down, the volume of passenger rail transportation began to grow again, but did not return to the level of those before the beginning of the epidemic. This is due to the fact that for a long time, the restrictions were slackened, but not removed completely.

Another example of the intervention of macro-level factors is the beginning of full-scale hostilities on the territory of Ukraine on February 24, 2022, as a result of which there was a sharp drop in the volume of passenger transportation, and passenger flows in the direction of Kupyansk, Bakhmut, Lysychansk, Kherson and many other occupied or front-line

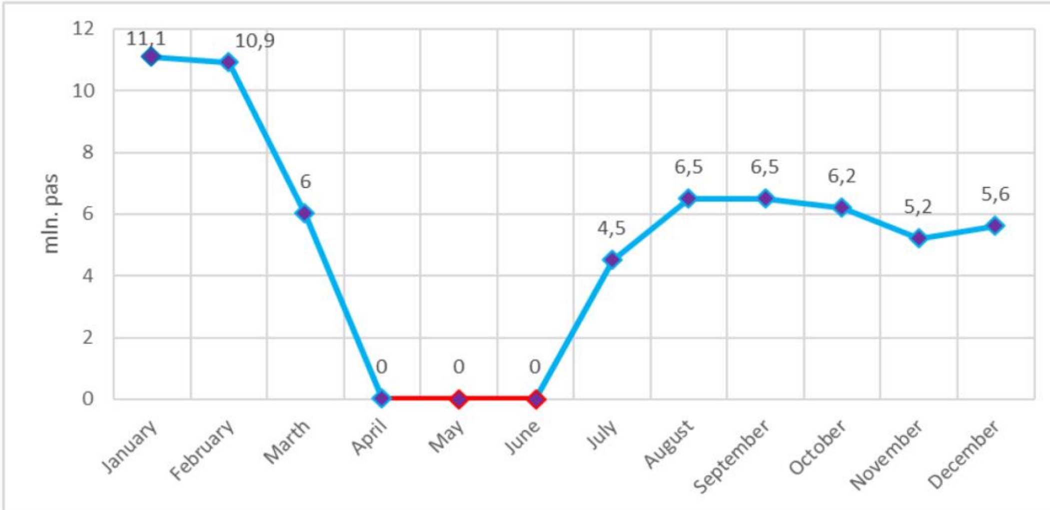

Fig. (5). Dynamics of the volume of passenger rail transportation in Ukraine for 2020.

cities temporarily stopped their existence, but with the improvement of the situation at the front-line, they can be revived again.

An example is the resumption of train traffic and, accordingly, passenger flows in the liberated territories (Kyiv-Sumi (RBC-Ukraine, 2022), Kyiv - Chernihiv (Lowcost avia, 2022), Kharkiv - Vorozhba (RBC-Ukraine, 2022), etc.).

Thus, among the above-mentioned macro factors, it is possible to distinguish the following elements of similarity: a high level of intervention and adjustment of passenger flows (in some cases may decrease to 0); duration of impact on the passenger transportation system; adaptability (depending on the epidemiological or front-line situation).

Therefore, on the basis of the above, the authors suggested that, when prognosticationing passenger flows in a certain direction, take into account the danger factor (D), which includes two components. The first component – the level of the incidence of Covid-19 (Dcov)is calculated according to the formula:

$$D_{\mathrm{cov}} = \frac{1}{n}\sum_{z=1}^{n} I_z, \qquad (1)$$

where n – the number of regions through which a given passenger flow passes;

I_z – morbidity index of a certain region.

The morbidity index, depending on the zoning established by the Ministry of Health of Ukraine, in which the region is located, can take the following values:

0 – green quarantine zone; 1 – yellow quarantine zone; 2 – orange quarantine zone; 3 – red quarantine zone.

The second component of the danger factor is the level of threat from artillery or airattack D_{art}:

$$D_{art} = \frac{1}{n}\sum_{k=1}^{n} I_k, \qquad (2)$$

where

I_k – the military danger index of a certain region.

The military danger index is established by the method of expert assessments based on the number of artillery and air strikes in the region, the distance to the front-line, the country border or the Black Sea water area, the presence of military or strategic objects on the route of passenger traffic. Also, like the morbidity index, it can have 4 values:

0 – low level of military danger;

1 – average level of military danger;

2 – high level of military danger;

3 - a very high level of military danger.

Then, the general formula for calculating the danger factor is:

$$D = D_{cov} + D_{art} \qquad (3)$$

3. RESULTS

As you know, prognosticationing is one of the most necessary, but at the same time one of the most difficult tasks of intelligent data analysis. Prognosticationing problems are associated with insufficient quality and quantity of input data, changes in the environment in which the process takes place, and the influence of subjective factors. A prognostication is always made with some margin of error depending on the prognostication model used and the completeness of the input data. When prognosticationing passenger flows of railway transportation, in particular during active hostilities and the Covid-19 epidemic, it is necessary to take into account their instability, as well as all the features of the country of war and quarantine restrictions. Therefore, prognosticationing should be carried out for a short period of time, and the method of artificial neural networks should be chosen as the most appropriate method for its implementation. Because this method can solve problems with unknown regularities, has adaptation to environmental changes and has potential ultra-high speed.

Neural networks have their own special property - the ability to "learn" based on data describing environmental objects

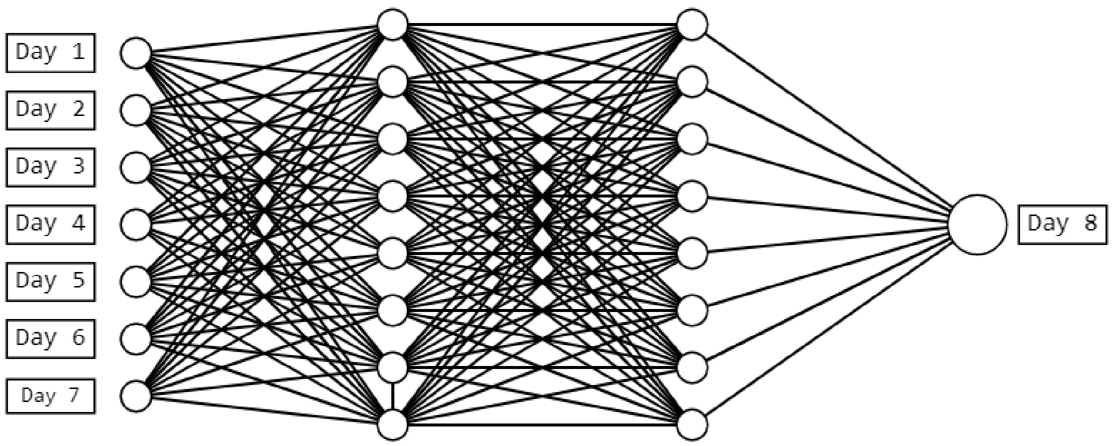

Fig. (6). Fully connected neural network of direct propagation for solving prognosticationingproblems.

(Lomotko, 2019). The learning of the neural network takes place by means of an interactive process of adjusting synaptic weights and thresholds. The ideal case is when the neural network learns the relations contained in the training data at eachiteration of the learning process. Building a system using neural networks begins with choosingits architecture (Lomotko, 2021). The architecture is always selected experimentally, based on the technical task. For the proposed passenger traffic prognosticationing system was chosen a neural network of a direct nature (Fig. **6**).

The value of indicators of previous periods is given to the input of the neural network. In our case, the period is one day. The following array of data corresponds to each day A_n:

$$A_n = [P, W, R, S, N, D], \qquad (4)$$

where P – the magnitude of passenger traffic for the selected day;

W – name of the day of the week;

R – amount of income rate from passenger transportation;

S – average salary level;

N – population;

D – the magnitude of the danger factor.

The value of the indicator for the next period is obtained at the output. The architecture of the neural network is fully connected. The number of hidden layers is also selected experimentally. The greater their number, the more accurate the result, but the duration of training will increase. The predicted value is compared with the actual value in the system. The obtained real value is recorded in the database and the system goes through another iteration of learning with some shift of the values by periods (Pedersen, 2010).

Since the environment is non-stationary, the statistical parameters of the input signals generated by the environment change over time. In such cases, the network is unable to track variations in the environment, so tutored learning methods are unsuitable (Sergiienko et al., 2022). Thus, it is worth constantly adapting the parameters of the network to the variations of the input data in reality, and the learning process in the adaptive system does not end until newdata is received for processing. This process is called continuous learning. Its algorithm is shown in Fig. (**7**) (Karp, 2018).

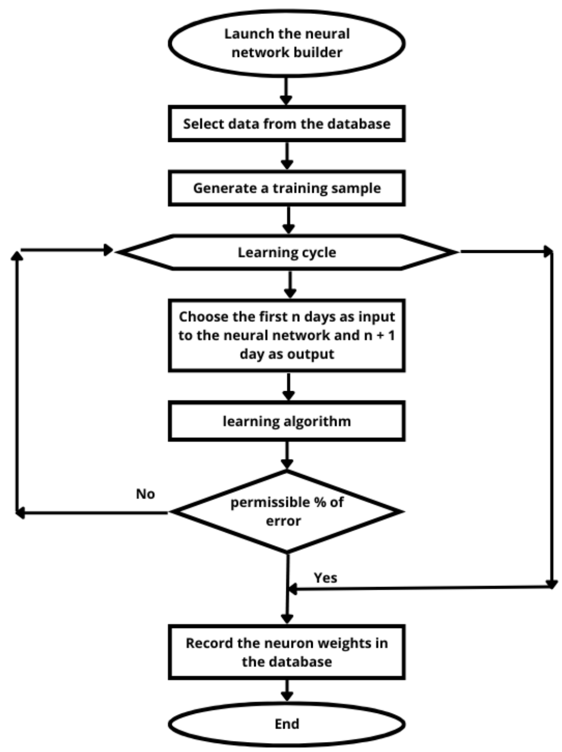

Fig. (7). A general algorithm for learning a system based on a neural network (Karp, 2018).

Before applying and training a neural network, it is necessary to normalize the values, which will significantly speed up the process of learning the system. Since passenger traffic prognosticationing is performed on the basis of a small amount of input data (passenger traffic values for only five past periods), linear normalization according to the "minimax" is used. Theformula for this type of normalization has the following form:

$$X_i' = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \qquad (5)$$

where X_i the value of passenger traffic for a certain month;

Table 1 – Results of Passenger Flow Prognosticationing.

Incoming Data		Day of The Week	Results			
Date	Size of Passenger Flow, mln. pas.		Date	Real PassengerFlow, mln.pas.	Received PassengerFlow, mln. pas.	Error, %
4-Oct-21	2372	Monday	11-Oct-21	2385	2457	3,04
5-Oct-21	3356	Tuesday	12-Oct-21	4092	3917	4,29
6-Oct-21	4396	Wednesday	13-Oct-21	4010	3837	4,32
7-Oct-21	4261	Thursday	14-Oct-21	3619	3836	6,00
8-Oct-21	3946	Friday	15-Oct-21	3661	3842	4,93
9-Oct-21	5384	Saturday	16-Oct-21	3977	4179	5,07
10-Oct-21	2962	Sunday	17-Oct-21	2789	2955	5,94
			18-Oct-21	2317	2139	7,70
			19-Oct-21	3755	3445	8,24
			20-Oct-21	3804	3358	11,72
			21-Oct-21	3560	3882	9,04
			22-Oct-21	3538	3159	10,70
			23-Oct-21	3600	3134	12,94
			24-Oct-21	2795	2379	14,88
			25-Oct-21	2098	2336	11,33
			26-Oct-21	3366	3805	13,05
			27-Oct-21	3845	3370	12,36
			28-Oct-21	3094	2649	14,38
			29-Oct-21	3897	4576	17,44
			30-Oct-21	3328	3831	15,10
			31-Oct-21	2476	2920	17,91

X_{min} – minimum value of passenger traffic;

X_{max} – the maximum value of passenger traffic.

As a result, the system can operate with values in the range from 0 to 1, which makes it possible to use the sigmoidal function as the activation function of the neural network:

$$f(x) = \frac{1}{1+e^{-x}} \quad (6)$$

The prognosticationing task was solved using a software complex in the C# language,the main element of which is a neural network.

The choice of network architecture is based on the type of prediction. Since short-term prognosticationing is used in our case, a forward error propagation network with the number of inputs equal to seven was chosen. An array of data was supplied to each input A_n . Neuron weights were stored using an MS SQL database. ADO.NET technology was used for data access, as it can provide maximum speed. To predict the dynamics of the passenger traffic indicator, the optimal structure of the neural network was experimentally determined: 7 inputsthat will correspond to the array of input data for the previous 7 days and 2 hidden layers of 8 neurons each. The results of the research are summarized in Table **1**.

As you can see, the values of passenger flows obtained as a result of mathematicalmodeling almost coincide with the real ones. It is worth noting that the longer the period forprognosticationing, the greater the value of the error. Thus, the average error in the period from October 11 to 17 (1 week) is 4.8%, and in the period from October 11 to 31 (3 weeks) it is 10.02%. Such a change in error once again confirms that this model is appropriate only forshort-term planning. A similar forecasting model was used by scientists when forecasting thepassenger flow in the city bus service (Jie Deng 2019), the error of which is also around 10%.It is not reasonable, in these conditions, to use the method of forecasting with the help of correlation-regression analysis (Balaka, 2019, Balaka 2021), since the conduct of hostilities is chaotic and the error value can increase significantly.

So, the developed model can be practically used for the formation of a decision-makingsupport system at the operational and tactical levels, both by the Ukrainian railway operator JSC "UZ" in the subsystem of the Automated Passenger Transportation Management System of Ukrzaliznytsia (ASK PP UZ), and in its foreign counterparts.

4. DISCUSSION

Based on the chosen optimal method of prognosticationing passenger flows on a certain direction, railway operators perform cost calculations for various technologies of passenger delivery to destinations, which depends not only on the direction of movement, but also on thesize of passenger flow, the ability of a certain direction to serve such passenger flow and the class of trains (Golinska, 2011). At the same time, passenger capacity restrictions for railwaysin most countries of the European Union are much smaller than in Ukraine (Krasheninin, 2016).Therefore, the transportation of a given number of passengers by train is equated to several motor vehicles, which provides cost savings in the case of transportation by rail transport (Butko, 2019). Whereas with multimodal transportation, the cost calculation is made taking into account the transportation along the entire route from the point of departure of passengersto the destination, taking into account several types of transport, which reduces costs and becomes especially profitable when transporting mass passenger flows (Dărăban, 2012).

It is the combination of several types of transport in the form of multimodal transportation of passengers that will ensure the appropriate level of quality of services provided to passengers and will ensure the saving of time and money, and, accordingly, increase the level of competitiveness of railway transportation (Kandee, 2001)). And for this, it is necessary to prognosticate the volume of passenger flows for clear planning of the work of several transport operators (Golinska, 2012).

Management of service supply chains is a natural extension of the concept of integratedlogistics in the directions of cross-functional and inter-organizational logistics coordination not only for cargo transportation, but also for passenger transportation (Andrzejewski, 2012). Today, software products for the management of service supply chains are available only in the most developed integrated corporate management systems, and their adaptation to the automated management systems of transport operators will allow the passenger transportation system to be brought to a qualitatively new level (Lomotko, 2021).

In a changing operating environment, transport operators in the field of passenger transport need to move from the traditional "cost-service" paradigm (directly proportional dependence) to a new one, in particular, when the service profile improves simultaneously with the reduction of service costs (Butko, 2020), and for the service sector passengers, it is very important.

Today, in Ukraine, and not only, the transition and active implementation of e-economy is being carried out (Congli, 2016), which affects all spheres of business, respectively, and thetransport industry is not left out. There is also an evolution of the value chain for passengers (Kawa, 2010). The life cycle of the transportation service is shortening, the variety of types ofservices is increasing, and mass customization of typical alternatives in the service supply chainis appearing, passenger transportation is extremely sensitive to such requirements, therefore, this approach must be taken into account in the prognosticationing of passenger transportation volumes (Fechner, 2012).

Today, the process of passenger delivery is complicated by: low speed of the logistics cycle; the long process of issuing travel documents, especially with multimodal connections, and the presence of errors in it; storage and delivery of luggage together with the passenger. Organizing all movement, reducing costs to a minimum - this is the main task of transport logistics and modern passenger transport operators.

The main tasks of passenger logistics today include the maximum reduction of passengertransportation times, simplification of the procedure for issuing travel documents and ensuringsecurity, and keeping luggage (Jha, 2008). Currently, it is impossible to imagine any transport enterprise that does not deal with solving logistics problems, so passenger transport operators are no exception (Porter, 1998). Thus, logistics in the activity of a transport enterprise allows to optimize financial and information flows, as well as significantly shorten the time interval between receiving a request for transportation and delivering a passenger to the destination (Prymachenko, 2018).

The introduction of the "just in time" principle into the logistics process of enterprise management will allow to achieve a reduction in both time and money costs when serving passengers, will allow to significantly reduce costs and the cost of services and improve the quality of the enterprise's logistics service (Islam, 2014).

5. CONCLUSIONS

So, the article proves that the life of the society of any country cannot exist without passengertransport services. Migration activity of the population is always present in any country. It isargued that the prognosticationing of passenger flows remains relevant even now, despite the significant amount of research in this area and the number of developed methods and softwareproducts for determining prognosticationed passenger flows. When creating a mathematical model for prognosticationing passenger flows, the main factors influencing passenger flows for railway transport of Ukraine were selected, namely, seasonality of passenger transportation, income rate from transportation, average salary and population, danger factor. It wasestablished that prognosticationing problems are associated with insufficient quality andquantity of input data, therefore emphasis is placed on methods of obtaining them, changes inthe environment in which the process takes place, therefore an example of methods of its assessment is given, and the influence of subjective factors, therefore a method of expert evaluation is proposed evaluations to reduce subjectivism. Risk factors take into account thecurrent situation in Ukraine, namely, the period of active hostilities and the Covid-19 epidemic. It is noted that prognosticationing should be carried out for a short period of time. The method of artificial neural networks was chosen to determine the prognostication volumes of passenger traffic on railway transport, because it can be used to solve problems with unknown regularities, and many factors are often unknown when prognosticationing, and the method of artificial neural networks allows adaptation to environmental changes, and most importantly - has the potential for ultra-high speed. Artificial neural networks have the ability to "learn" on the basis of data describing environmental objects, so this method was chosen as optimal for predicting passenger flows. An interactive process of adjusting synaptic weights and thresholds was chosen as a method of training artificial neural networks. As a result, a neural network of a direct nature with a fully connected architecture was chosen for the system of prognosticationing passenger flows on railway transport. Passenger flow prognosticationing in the work was carried out for a short-term period, therefore, a linear "mini-max" and a direct error propagation network with a number of inputs equal to seven were used for normalization. Thus, a software package in C# was created to obtain experimental results of prognosticationing passenger flows in railway transport with the preservation of neuron weights using the MS SQL database. ADO.NET technology was chosen for predictive data access as the technology with the highest performance. The conducted experiment made it possible to determine the optimal structure of the neural network: 7 inputs and 2 hidden layers with 8 neurons each.

The theoretical values of passenger flows almost coincide with the empirical ones. The average value of the error was from 10.02% to 4.8%, that is, the model developed in the work is appropriate for short-term planning of passenger flows in railway transport. The model is recommended for the formation of a decision-making support system at the operational and tactical levels for railway transport operators.

The selected method of prognosticationing passenger flows using artificial neural networks in a certain direction for railway operators of both Ukraine and foreign railway transport operators allows for cost calculations for various technologies of passenger delivery to destinations for each direction of traffic and class of trains. Minimizing the costs of a railway transport operator is the main task in modern conditions, and information with high accuracy on the planned volume of passenger traffic allows to prognostication the company's income and, accordingly, the share of profit.

In all functional areas of railway transport operators, an important task is the monitoring of current processes, namely, orderly and, as far as possible, continuous processing of data to identify deviations or discrepancies between planned and actual values of logistics indicators, as well as the analysis of these deviations to identify the causes of discrepancies. These factors must be taken into account when prognosticationing.

In order to maintain high competitiveness, the railway system must constantly develop and improve. For this, it is necessary to analyze the performance of the transport system, which shows the efficiency of its work from the operational, economic and technical points of view. The financial indicators of railway transport operators are easily determined, allow to compare the obtained results, give an overall picture of the current country of the transport system in a certain period of time in a certain region, but may reflect past results, because they react slowly to changes, depend on a number of accounting methods, do not take into account important aspects of logistics that do not show specific problems and ways to eliminate them. Thus, the proposed approach to predicting the volume of passenger traffic for railway transport operators allows obtaining a system-wide assessment of the results with a minimum error in the conditions of the changing external and internal environment of transport companies. In addition, the use of the principles of neural networks in the process of modeling the process of prognosticationing passenger flows depending on many factors characteristic of the country, region, route of traffic makes it possible to take into account the variability of the passenger transportation system during its research and design, to reveal the regularities of its behavior, functioning and development for the purpose of optimization the economic effect of the activities of transport operators and the satisfaction of passengers from the service received. The economic effect is also achieved due to cost savings when planning multimodal routes of passenger service supply chains, which are carried out continuously and jointly by various means of transport, with the lowest costs and high quality services for passengers. The effect consists in saving the time of delivering passengers to their destinations when there is a prognostication number of passengers on a certain route of their movement, the possibility of setting competitive prices for the transportation service, reducing logistical risks, implementing a "win-win" strategy for the railway transport operator and for passengers, etc.

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