DOI: 10.58168/DMSTTP2024_48-56
УДК 656.1/.5

FORECAST ANALYSIS OF TRANSPORT DEMAND FOR SOCIO-ECONOMIC DEVELOPMENT, ROAD NETWORK DEVELOPMENT AND ROAD SAFETY IN VORONEZH

A.A. Shtepa, E.A. Maklakova, E.A. Yakovleva

Voronezh State University of Forestry and Technologies named after G.F. Morozov, Voronezh, Russia

Abstract: The article considers the main forecast indicators of urban, economic and social development. The forecast indicators of transport demand, development of road and road network, organization and safety of road transport, as well as the negative impact of transport and its infrastructure on the environment are briefly presented.

Keywords: analysis, safety, forecast, indicators, transportation.

ПРОГНОЗНЫЙ АНАЛИЗ ТРАНСПОРТНОГО СПРОСА ДЛЯ СОЦИАЛЬНО-ЭКОНОМИЧЕСКОГО РАЗВИТИЯ, РАЗВИТИЯ ДОРОЖНОЙ СЕТИ И БЕЗОПАСНОСТИ ДОРОЖНОГО ДВИЖЕНИЯ В ВОРОНЕЖЕ

А.А. Штепа, Е.А. Маклакова, Е.А. Яковлева

ФГБОУ ВО «Воронежский государственный лесотехнический университет имени Г.Ф. Морозова» Воронеж, Россия

Аннотация: В статье рассматриваются основные прогнозные показатели городского, экономического и социального развития. Кратко представлены прогнозные показатели спроса на транспорт, развития автомобильных дорог и дорожной сети, организации и безопасности автомобильного транспорта, а также негативного воздействия транспорта и его инфраструктуры на окружающую среду.

Ключевые слова: анализ, безопасность, прогноз, показатели, транспорт.

Transport demand forecasting is an important tool for planning and optimizing the transport system. It can be used to determine future demand for transport services and to identify the need for additional vehicles, routes or infrastructure changes.

– predictive analysis can be based on a variety of techniques, including statistical models (e.g. ARIMA, SARIMA, Holt-Winters and others), machine learning (e.g. neural networks, decision trees, random forest, etc.), expert judgement and historical data.

– the key steps in predictive travel demand analysis include

– data collection and processing: collecting data on current transport demand and its structure, as well as historical data on demand dynamics.

– predictive model building: selecting and building an appropriate predictive model based on available data and expert judgement.

– model validation: assessing the accuracy and reliability of the forecasting model using various validation methods such as cross-validation, hold-out and others.

– extrapolation of results: using the model to forecast future transport demand under different scenarios and assumptions.

Forecasting the indicators of urban planning, economic and social development, indicators of transport demand, development of the road and road network, organisation and safety of road transport, as well as the negative impact of transport and its infrastructure on the environment, it is necessary to individualise each indicator based not only on the analysis of the current state of the transport system of Voronezh, but also on the indicators of transport work of previous years. [1, 6, 7]

Urban development is assessed by such indicators as density of construction, number of storeys of buildings, presence and condition of green areas, transport accessibility, level of landscaping. Economic development is determined by the volume of production, the level of employment, the income of the population, the attractiveness of investment. Social development is characterised by the level of education, health care, culture and quality of life of the population.

Indicators of transport demand may include the number of cars, motorcycles, buses, taxis and other modes of transport on the roads, and the volume of freight and passenger traffic. Road and road network development is assessed by road length, road network density, availability of interchanges, bridges, tunnels and other infrastructure. Traffic organisation includes analysis of traffic lights, traffic management at junctions, availability of pedestrian crossings and road safety is assessed by the number of accidents, deaths and injuries on the roads.

One of the indicators of the negative impact of transport on the environment is the emission of pollutants into the atmosphere, such as carbon dioxide, nitrogen oxides, hydrocarbons and particulate matter. Noise pollution, waste generation and water pollution are also taken into account.

According to the plan for the development of the Voronezh conurbation, the permanent population is expected to grow to 1300000 people, which is 17,6% higher than the current figure, and the number of employees to 600000 people, which is 17% higher than the current figure. [5]

According to the grid of settlement areas grouped into conditional transport zones, the forecast values of the population settlement indicators, the location of the population gravity points, the presence of gravity points for the agglomeration as a whole and the average settlement radii are determined.

The calculation and analysis of population distribution in an urban agglomeration includes the study of population density, the distribution of population across the agglomeration, and the study of the relationship between population density and the location of various facilities (such as shopping centres, parks, schools, hospitals, etc.). Spatial analysis may involve the use of various methods such as cartographic analysis, statistical analysis, modelling and others. The purpose of such analyses is to determine the optimal locations for new infrastructure, businesses, residential areas and other facilities to provide convenience and comfort to the residents of the agglomeration. Calculations and analyses have shown that: [5]

– the average settlement radius of the population in relation to the city centre will increase slightly due to the development of peripheral areas and will be about 6,8 km, which is 10% higher than the existing value of 6,2 km. The settlement radius of workers will be in the order of 5,8 km, which is 5% less than the existing 6,1 km. However, the urban activity zone is concentrated in the central, middle and partly peripheral areas of the agglomeration, not exceeding about 6,8 km^2. This is where 92% of the population and 94% of the places where the workforce is concentrated will be.

– with equal population growth in all zones of the city, the largest part of Voronezh's population – 84% of the total population – will live in the periphery – 52%

(about 640600 people) and in the centre – 32% (about 398400 people) of the city. About 8% will live in the most remote areas.

– the majority of jobs – 78% of the total number of employees, as at present - will be located in the central – 37% and peripheral – 41% zones of the city, 15% of the centres of gravity will be located in the centre and about 7% – in the remote periphery.

The distribution of population and number of jobs by estimated transport areas and ring transport areas is presented in Table 1.

Table 1 – Forecast indicators of the Voronezh agglomeration

Indicators	Existing situation
Population, total, thousand people: Including by zones – central – middle – peripheral – remote periphery	 1233,6 / 100% 90,8 / 7% 398,4 / 32% 640,6 / 52% 103,8 / 9%
Number of employees, total, thousand people: Including by zones – central – middle – peripheral – remote periphery	 576,5 / 100% 88,8 / 16% 213,0 / 37% 237,4 / 41% 37,3 / 6%
Radius of population settlement relative to the city centre, km	6,8
Radius of gravity points location relative to the city centre, km	5,8

The assessment of the supply of jobs in the city in the wards over the period shows that the city continues to have a deficit of about 165000 jobs (about 21% of the total working age population), while the central, southern and south-eastern parts of the agglomeration continue to have a surplus of jobs (compared to the residential areas in the north-west). As a result, commuter flows for work purposes will be mainly in the direction north-west – centre – south-east).

In the radius of 6,5-7 km there will be an active urban area, which will carry the main traffic load, as it is now (about 6,7 km.), where 92% of the population lives (52%

(about 640600 people) in the radius of 6,5-7 km), 32% (about 398400 people) in the peripheral areas, 41% (about 237400 people) in the peripheral areas, 16% (about 88800 people) in the central areas of the agglomeration.

The directions of the main passenger flows in the Voronezh agglomeration will be centripetal, mainly along the north-west – centre – south-east axis, which is determined by the planned settlement of the population and the population centres.

The directions of pendular migration (movement of people from one settlement to another, to work or study, and back home during the day or week), formed in the peak periods by work trips, are determined by the existing surplus of gravity points in the central, southern and south-eastern parts of the city, and the lack of gravity points in residential areas located in the western, north-western and northern sectors of the city, which determines the main vector of population trips to gravity points.

Forecast indicators have shown that the most probable values of the motorisation rate of the population in the Voronezh agglomeration by 2035 will be 400 units per 1000 inhabitants. Due to the poor quality of the existing passenger transport system, the average annual number of passengers tends to decrease, but the data of the sociological survey show that there is a high probability of a redistribution of demand from individual transport to public transport if a new system of public transport is introduced in the city and changes are made to improve the quality of public transport services. It is estimated that the introduction of the new system can increase the volume of public transport by up to 23%.

The development of external connections is determined by the existing urban planning solutions and socio-economic burden. [1-4] Thus, the development of transport infrastructure solutions for the Voronezh agglomeration takes into account proposals for road construction solutions on Antonov-Ovseenko, Tverskaya, 9 Yanvar, and Moskovsky Streets, as well as in the area of Otradnensky and Yamensky rural settlements.

Due to the development of external transport links, the road network is expected to grow (Table 2).

Table 2 – Main forecast indicators for the development of the road network in the Voronezh agglomeration

Indicators	2019 year	2035 year
Length of street and road network, km.	1 454,38	1563,64
Transport network density, km/km^2	2,4	2,6
Share of the length of public motorways of local significance that meet regulatory requirements, %	54,5	100
Total length of all routes, km	2859,575	2379,048

By 2035 the most probable values of the level of motorisation of the population of the Voronezh conurbation will be 400 units. per 1000 inhabitants, and the projected population will be 1138460 people. (according to the average variant). Based on the expected level of motorisation of the population and its number by 2035, we can calculate the forecast value of the number of vehicles in the Voronezh area. The forecast is that there will be 455384 vehicles.

In the transport model of the Voronezh agglomeration the parameters of road traffic for the forecast periods are calculated, which are shown in Table 3, and the forecast of road safety indicators is shown in Table 4. [8]

Table 3 – The main forecast values of road transport parameters for the future until 2035 in the city of Voronezh (I – zero scenario, II – pessimistic, III – average, IV – optimistic).

Variant	I	II	III	IV	Average, taking into account the development of the mass transport system
Average time of realisation of transport correspondences, min (actual/forecast. Individual transport and public transport, rush hour)	69	45	43	40	38
Level of utilisation of the street and road network, %	79	59	57	54	52
Share of movements by public transport (including walking, cycling, scooters, etc.)	0,6	0,6	0,6	0,6	0,72
Share of movements by private transport	0,4	0,4	0,4	0,4	0,28
Average trip length by all modes of transport, km	35	30	28	27	27

It is planned to increase the required level of traffic organisation and safety on the streets and road network of the Voronezh conurbation by implementing measures to equip unregulated pedestrian crossings with additional lighting, artificial road bumps, additional traffic lights, additional traffic signs with internal lighting (or LED display), and other technical elements to improve traffic organisation and safety. It is also necessary to plan the introduction of an adaptive system for regulating traffic organisation.

Table 4 – Main forecast values of traffic safety in the Voronezh area

Целевые показатели	2018 year	2024 year	2030 year
Number of road accidents	26335	15989	12321
Social risk from road traffic accidents, fatalities per 100000 population	6,11	less than 4	less than 4

In order to reduce environmental risks and improve the urban environment, it is necessary to relieve the main traffic arteries. It is necessary to create a more effective protection of the population from industrial and transport impacts and to expand the system of intra-district landscaping. Located at the crossroads of the main transport corridors, the Voronezh agglomeration will become an even bigger transport hub of the Central Black Earth Zone and one of the most important in the entire European part of the Russian Federation. The development of the city transport system will lead to a significant increase in the length of the main road network and its density. [1-4, 8]

At the same time, it is obvious that radical improvement of the air quality can be achieved only with radical changes in the transport system, reduction of freight traffic within the city limits, construction of high-speed urban transport. The solution of the set tasks will make it possible to minimise the reduction of toxicity of exhaust gases from car engines, to develop and implement a set of organisational and technical measures aimed at reducing emissions into the environment, including stricter control over the technical condition of vehicles, toxicity.

References

1. Vaksman, S. A. Problems of development and organization of functioning of transport systems of cities // Socio-economic problems of development of transport systems of cities and areas of their influence: materials of the VIII International Scientific and Practical Conference. – Ekaterinburg: AMB. 2002. – Pp. 10-15.

2. On the organization of road traffic in the Russian Federation and on amending certain legislative acts of the Russian Federation : Feder. Law from 29.12.2017 № 443-FZ ed. from 15.04.2019 // Reference legal system «ConsultantPlus». – Mode of access: http://www.consultant.ru.

3. Gonchar, M. P. Role and effectiveness of the complex scheme of traffic organization when introduced into the existing traffic organization / M. P. Gonchar // Young Scientist. – 2020. – № 22(312). – Pp. 583-585.

4. On approval of the Rules for the preparation of documentation on the organization of road traffic [Electronic resource]: Order of the Ministry of Transport of Russia from 26.12.2018 № 480 // Reference legal system «ConsultantPlus». – Mode of access: http://www.consultant.ru.

5. On approval of the Comprehensive scheme of traffic organization of the urban district of the city of Voronezh : resolution of the administration of the urban district of the city of Voronezh from April 12, 2022 № 325 // Electronic fund of legal and regulatory-technical documents. – Access mode: https://docs.cntd.ru/document/406160660

6. Shtepa, A. A. Actualization of the issues of the transport system of Voronezh / A. A. Shtepa // Prospects of development and major issues in science : Proceedings of the National Scientific and Practical Conference, Voronezh, March 15, 2023 / Editor-in-Chief V.A. Zelikov. – Voronezh: Voronezh State Forest Engineering University named after G.F. Morozov, 2023. – Pp. 42-47.

7. Shtepa, A. A. Transport and socio-economic characteristics of the urban agglomeration of Voronezh / A. A. Shtepa // Actual issues and prospects of development of modern science : Proceedings of the National Scientific and Practical Conference, Voronezh, March 15, 2022 / Editor-in-Chief V.A. Zelikov. – Voronezh: Voronezh State Forest Engineering University named after G.F. Morozov, 2022. – Pp. 76-83.

8. Yakimov, M. R. Analysis of the influence of different scenarios of development of the transport system of a large city on the possible variants of violation of the integrity of the urban structure // Vestnik Transport Povolzhye. – 2011. – №1 (25). – Pp. 18-24.

Список литературы

1. Ваксман, С. А. Проблемы развития и организации функционирования транспортных систем городов / С. А. Ваксман // Социально-экономические проблемы развития транспортных систем городов и зон их влияния: материалы VIII Междунар. науч.-практ.конференции. – Екатеринбург : АМВ, 2002. – С. 10-15.

2. Об организации дорожного движения в Российской Федерации и о внесении изменений в отдельные законодательные акты Российской Федерации : Федер. закон от 29.12.2017 № 443-ФЗ в ред. от 15.04.2019 // Справочно-правовая система «КонсультантПлюс». – Режим доступа: http://www.consultant.ru.

3. Гончар, М. П. Роль и эффективность комплексной схемы организации дорожного движения при внедрении в существующую организацию дорожного движения / М. П. Гончар // Молодой ученый. – 2020. – № 22 (312). – С. 583-585.

4. Об утверждении Правил подготовки документации по организации дорожного движения : Приказ Минтранса России от 26.12.2018 № 480 // Справочно-правовая система «КонсультантПлюс». – Режим доступа: http://www.consultant.ru.

5. Об утверждении Комплексной схемы организации дорожного движения городского округа город Воронеж : постановление администрации городского округа город Воронеж от 12 апреля 2022 г. № 325 // Электронный фонд правовых и нормативно-технических документов. – URL: https://docs.cntd.ru/document/406160660.

6. Штепа, А. А. Актуализация вопросов транспортной системы Воронежа / А. А. Штепа // Перспективы развития и важнейшие проблемы науки : материалы Всерос. науч.-практ. конференции, Воронеж, 15 марта 2023 г. / гл. ред. В.А. Зеликов. – Воронеж, 2023. – С. 42-47.

7. Штепа, А. А. Транспортные и социально-экономические характеристики городской агломерации Воронежа / А. А. Штепа // Актуальные вопросы и перспективы развития современной науки : материалы Всерос. науч.-практ. конференции, Воронеж, 15 марта 2022 г. / гл. ред. В. А. Зеликов. – Воронеж, 2022. – С. 76-83.

8. Якимов, М. Р. Анализ влияния различных сценариев развития транспортной системы крупного города на возможные варианты нарушения целостности городской структуры / М. Р. Якимов // Вестник транспорта Поволжья. – 2011. – № 1 (25). – С. 18-24.