СЕКЦІЯ 9 МАТЕМАТИЧНІ МЕТОДИ, МОДЕЛІ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В ЕКОНОМІЦІ

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Dolya K.V.
Ph.D, Senior Lecturer at the Department of GIS, Land and Real Estate Appraisal
Kharkiv National University of Municipal Economy O.N. Beketov

Dolya O.I.
Research Assistant of Department of Project Management
in Municipal Economy and Construction
Kharkiv National University of Municipal Economy O.N. Beketov

ECONOMIC-MATHEMATICAL MODELING INFLUENCE OF ENVIRONMENT AT THE DEVELOPMENT OF SYSTEMS PASSENGER TRANSPORT

In the article the problem influence of environment on the development of passenger transport systems. Was made mathematical modeling of the impact of environment on the system. Invented mathematical model improves the known scientific approaches to forecasting of passenger transport system, it unlike the known provides an account of influence environment on the development of the transport system of bus passenger transport.
Keywords: passenger, transport, demand, money, cost, bus, system, transport.

Доля К.В., Доля О.І. ЕКОНОМІКО-МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ ВПЛИВУ СЕРЕДОВИЩА НА РОЗВИТОК ПАСАЖИРСЬКИХ ТРАНСПОРТНИХ СИСТЕМ
У статті розглянуто питання щодо можливості винаходження впливу середовища на розвиток пасажирських транспортних систем. Здійснено математичне моделювання впливу середи на систему. Отримана математична модель удосконалює відомі наукові підходи щодо прогнозування стану пасажирської транспортної системи, що на відміну від існуючих забезпечує врахування впливу середовища на розвиток транспортної системи автобусних пасажирських перевезень.
Ключові слова: пасажир, перевезення, попит, гроші, вартість, автобус, система, транспорт.

Доля К.В., Доля Е.Е. ЭКОНОМИКО-МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ВЛИЯНИЯ СРЕДЫ НА РАЗВИТИЕ ПАССАЖИРСКИХ ТРАНСПОРТНИХ СИСТЕМ
В статье рассмотрены вопросы изучения влияния среды на развитие пассажирских транспортных систем. Проведено математическое моделирование влияния среды на систему. Полученная математическая модель совершенствует известные научные подходы к прогнозированию состояния пассажирской транспортной системы, в отличие от существующих обеспечивает учет влияния среды на развитие транспортной системы автобусных пассажирских перевозок.
Ключевые слова: пассажир, перевозки, спрос, деньги, стоимость, автобус, система, транспорт.

The statement of the problem. Decision-making processes in system management of projects are in the environment of uncertainty, which is associated with lack of information in full measure, subjective factors and influence of factors. We can assume that in a case of project management, procurement of vehicles depends on the volume and price of the sold products, this can be attributed to the volume of transported passengers and tariffs for transportation, the spending for the construction mostly depend on the cost of fueling and lubricating materials, the cost of borrowing depends on the price of the vehicles [1, 2]. In science, to plan a design decisions in the production of authors [3] proposed using economic-mathematical models. The use of such models ensures optimum invention of options in the puzzle of certain conditions.

Therefore, creation of economic-mathematical model to influence environment on the development of transport system, is a key issue.

An analysis of recent research and publications. Management of transport system of passenger transportation includes planning scheme route, route network density, urban design, choice of vehicle brands and timetables [4-8]. The brand of vehicle, timetable and route setting circuit parameters affect the volume of passenger traffic [9-10]. In turn, the volume of passengers carried for the period, is considered as the number of users of the services of transport on passenger routes in a period at a certain cost of services. In [11] the author defined demand as the number of goods; the consumer is ready to buy at a certain price level over a specified period.

Setting the objectives. To develop economic-mathematical model to influence on the environment on the development of bus passenger transportation system.

Summary of the main material research. The author [12] indicated that there is aggregate demand, which is necessary, on the market in cash. In other words, it is the amount of goods and services that consumers (residents and nonresidents) buy at a certain price level.

From these definitions, it follows that there is a relationship between the volume of production, prices and demand. This dependence is described by the demand. The essence of this law is that consumers (citizens, businesses, government and foreigners) all other conditions being equal to purchase the greater the amount of goods and services, the lower the general price level and vice versa., the level of prices and the real volume of aggregate demand growth exists inverse relationship.

A similar dependence was also obtained in [13] regarding the scope of population on transport services.

$$k_{on} = \frac{Q_2 - Q_1}{Q_1} = -0{,}382 + 1{,}286\frac{\Delta Ц'}{Ц'_н} - 0{,}0031 l_м + 0{,}0754\frac{Ц'_н}{Ц'_a} + 0{,}0101 l_{cp} \quad (1)$$

Where: k_{on} – coefficient of relative changes of volume of traffic;

Q_1 – the number of transported passengers by bus one day before the change of tariff;

Q_2 – the number of passengers on a bus in the newly created Tariff;

$\Delta Ц'$ – changing the fare on the route, UAH;

$\Delta Ц'_н$ – the newly created the fare on the route, UAH;

$\Delta Ц'_a$ – fare on bus routes to competitors, UAH;

$\Delta Ц'_{min}$ – fare on the routes of electric transport, UAH;

$l_м$ – length of the route that is under consideration, km;

l_{cp} – the average distance a passenger travel from route to route, km.

Reduced dependence proves that coefficient of comparative changes the traffic volumes carried increases at reducing $\Delta Ц'$ and $\Delta Ц'_н$, i.e. if the cost of travelling is reduced, this will automatically increase the amount of passengers.

This confirms the possibility of application of mathematical law demand, which is the next general view [10]:

$$Q_d = f(P) \quad (2)$$

Where: Q_d – demand, units;

P – cost, UAH.

The cost of production for the user in the application of a passenger transport system is a quantitative display spent on travel money or amount used in fares [10].

$$P = \sum T_i \quad (3)$$

Where: T_i – the tariff on i routes

Simultaneously considering dependence (1) note that the coefficient of relative changes in the traffic volume increases with the length of the route. This dependence is based on the properties of demand, namely of elasticity.

Elasticity – a measure of responsiveness in one variable to change in another; more precisely this is a number that shows the percentage change in one variable due to a one percent change in another variable. A striking example is the pricing of elasticity demand, which reflects the change in quantity demanded for a particular commodity, when it changes price. The degree of elasticity or inelasticity demand is measured by the coefficient calculated by the formula [14]:

$$E_p = \frac{\Delta Q_d}{\Delta P} \quad (4)$$

Where: ΔQ_d – the change of demand, %;

ΔP – the change in value, %.

With increasing length of the route, elasticity coefficient decreases. This is due to a decrease in opportunities to use the services of other routes to meet the needs of the movement.

However, expression (2) provided a fair amount of money unchanged and is based on the quantity theory of money equation [12]:

$$MV = PY \quad (5)$$

Where: M – amount of money;

V – the velocity of money;

Y – the physical gross volume of domestic product

With consistent huge amount of money in equations (5), increased price levels demonstrates the following [12], namely:

1. Increases the demand for money, increase interest rates, the credit cost more, aggregate demand falls.
2. Reduces the real purchasing power of accumulated financial assets with fixed money value.
3. Leads to the fact that an increasing number of foreign buyers becomes unprofitable to buy products on the domestic market because there comes a time when domestic prices are higher than foreign. The Dynamics of exchange rates and gross domestic product (GDP) in themselves can have an impact on aggregate demand [12].

From the foregoing, it is established that fluctuations of exchange rates, GDP, fares and route characteristics influence demand. In this demand – volume of transported passengers on the route are combined processes that select the type of vehicle, number of vehicles, setting schedules and route maps [4].

From the above you can make the assumption about the existence of the influence of transport demand for passengers on routes in general use of quantitative characteristics reflecting the purchase of vehicles. Let us Analyze how the influence of currency fluctuations, average monthly income of the Ukrainian citizen and the GDP on the development of passenger transportation system of Ukraine in terms of the acquisition of the bus business entities that are registered in the city of Kharkov and Kharkov region. To conduct this analysis data used from the state statistics service of Ukraine [15] and Financial portal of the Ministry of Finance of Ukraine [16] are summarized in table. 1.

Table 1

Quantitative indicators, obtained from government websites.

Year	GDP per capita, dollars GDP (Pers./ USD.)	Average monthly income of a Ukrainian citizen SZP, UAH	Currency exchange rates, KUR – 100$/ 100 UAH	The number of buses purchased during the year, business entities, Units	Number of purchased new buses per year – A», Units
2000	729	178	544,02	22	1
2001	782	230	537,21	8	0
2002	871	311	532,66	19	7
2003	1046	376	533,27	89	22
2004	1370	426	531,92	91	22
2005	1825	590	512,47	97	55
2006	2304	806	505,00	174	84
2007	3065	1041	505,00	258	124
2008	3874	1351	526,72	285	147
2009	2529	1806	779,12	204	35
2010	2953	1906	793,56	230	34
2011	3559	2239	796,76	657	305
2012	3866	3026	799,10	503	129
2013	4030	3026	799,30	412	73
2014	3014	3265	2411,27	126	9

$$k_A = \frac{A_1 - A_2}{A_2}, \quad (6)$$

Where: A_i – the amount of sold units of bus a year.

$$k_{A`} = \frac{A`_1 - A`_2}{A`_2}, \quad (7)$$

Where: $A`_i$ – the amount new buses purchased per year.

Processing of the obtained data (table. 2) in the program statistics allowed us to determine the following regression equation:

$$n_A = 0.576 + 0.436x_1 - 0.01x_2 - 0{,}18x_3 + 0{,}509x_4, \quad (8)$$

A correlation analysis demonstrates the value of the factor x_2 and x_3, so these factors were excluded from further consideration.

The Obtained regression equation is:

$$n_A = 0.76 + 0.605x_1 + 0{,}503k_A, \quad (9)$$

in this case, the correlation coefficient is **0.65**, which indicates an average relation between the factors.

Assuming that the coefficients on the relative changes on the quantity of purchased buses $k_{A`}$ – and the relative change of volume of acquisition new buses $k_{A`}$, is affected by the factors shown in table. 2.

We will check the adequacy of resulting linear model using the Fisher criterion. This model is adequate if the following inequality is satisfied [17, 18].

$$F_p = \frac{S^2_{ад}}{S^2_y} \le F_T, \quad (10)$$

Where $S^2_{ад}$ – variance of adequacy;

S^2_y – Variance of reproducibility.

The table value of the Fisher test at 5% significance level when the number of degrees of freedom for the variance $K_{ад} = 11-2-1 = 8$ and the adequacy of the number of degrees of freedom for the variance of reproducibility $K_y = n = 11$ becomes $F_T = 2{,}95$.

That is: $F_p = 1{,}25 < F_T = 2{,}95$

Indicating the adequacy of the obtained model.

The mathematical model for determining the coefficient of relative change of volumes for the purchase of new buses if you change the basic economic characteristics of the environment is as follows:

$$n_A = \frac{A_{нов2`} - A_{нов1`}}{A_{нов2`}} = 0.76 + 0.605\frac{VVP_2 - VVP_1}{VVP_2} + 0{,}503\frac{A_2 - A_1}{A_2}, \quad (11)$$

Conclusions from the study. The obtained regularity of the coefficient of relative change of volumes of purchase of new buses, if you change the basic economic characteristics of the environment it allows the prediction on the development of passenger transport systems. This will ensure that the customer transportation has the opportunity to plan the number of vehicles that serve individual destinations or routes. The basis of the determined dependence provides the ability to plan procurement of vehicles and to predict risk factors for projects of passenger traffic.

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Table 2

Initial data for the use of constructing functions of the relative change of volume of acquisition of new buses

№	$(VVP_2-VVP_1)/VVP_2$ (x_1)	$(SZP_2-SZP_1)/SZP_2$ (x_2)	$(KUR_2-KUR_1)/KUR_2$ (x_3)	$(A_2-A_1)/A_2$ (x_3)	$(A_{нов2}`-A_{нов1}`)/A_{нов2}`$ (n_A)
1	2	3	4	5	6
1	0,898	0,740	1,009	1,375	0,4
2	0,833	0,827	0,999	3,684	2,143
3	0,764	0,883	1,003	0,022	0,000
4	0,751	0,722	1,038	0,066	1,500
5	0,792	0,732	1,015	0,794	0,527
6	0,752	0,774	1,000	0,483	0,476
7	0,791	0,771	0,959	0,105	0,185
8	1,532	0,748	0,676	-0,284	-0,762
9	0,856	0,948	0,982	0,127	-0,029
10	0,830	0,851	0,996	1,857	7,971
11	0,921	0,740	0,997	-0,234	-0,577
12	0,965	1,000	1,000	-0,181	-0,434
13	0,000	0,000	0,000	-1,000	-1,000