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DEVELOPMENT OF SYSTEM APPROACH TO PUBLIC TRANSPORT TARIFF FORMATION

Vladimir Postnikov (a)*

* Corresponding author

(a) Perm National Research Polytechnic University, 29 Komsomolsky Ave., Perm, Russia, postnikov-pstu@mail.ru, 89519289734

Abstract

Nowadays the key problem of suburban passenger railway transport functioning in Russia is unprofitability, that testifies necessity of system revision, organization, management and financing of this transport type. Perfection of tariff formation of passenger traffic is effective instrument of optimization for public passenger transport financing. The existent methods analysis of tariff formation for public transport services is conducted in this paper. Nowadays these methods do not reflect interests of all market participants and also do not take into account all influencing factors. The necessity perfection of tariff formation approach is underlined. The new tariff regulation approach that includes three interfacing models (optimal model, transport model and sociological model) and interests of three market participants (authority, passengers and operators) is presented. The aims of all participants are defined. Interaction between optimal, transport and sociological models is described, and the process of its building is also characterized. On the basis of approach to tariff formation the economic-mathematical model is constructed. Approbation of model for optimization of suburban passenger transport tariff system in Perm Region is carried out. The received conclusions demonstrate that more effective tariff system decrease budgetary subsidies for suburban transport financings and increase railway company profitability.

Keywords: Tariff regulation, public transport, optimal model.

1. Introduction

The transport development is an important indicator of regional social and economic development and an increase in its competitiveness. It provides production links between industry and agricultural, realizes

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transportation of goods and passengers, it is a basis of work geographical development. The amount and structure of transportations, as a rule, reflect the level and the structure of economy.

A specific place in transport system is held by passenger traffic that is caused by their high social and economic value in life of society and ensuring transport and population mobility. City and suburban passenger traffic satisfies the population needs for movement on short distances, promoting development urban and residential suburbs and their integration into regional economy.

Now a key problem of passenger transport functioning in Russia is its unprofitability (the income from transportation activities covers less than 50% expenses on implementation of transportations) that testifies to need of the system review, organization, management and financing of this transport type.

The theory economy of transportation management and the world practice provide various methods of optimization transport services financing:

- involvement of "indirect users";
- preferential taxation;
- creation of the specific taxes and charges;
- cross subsidizing, when income, gained on profitable routes, goes on covering losses from rendering services of passenger traffic on socially important routes;
- forming of lots of uniting low-profitable and unprofitable socially important routes with profitable ones.

One of methods of optimization public passenger transport financing and methods of public passenger transport market economic regulation by authorities is enhancement the tariff regulation system for passenger traffic.

Public transport performance is an important figure of the socio-political and economic city development. Proper organization of public passenger services meets the interests of all economic actors who interact as efficiently as possible with such organization.

According to the Federal Law "General Principles of Local Government in the Russian Federation", public transport services, arrangement of conditions for transport services, organization of transport services within the boundaries of settlements, maintenance and construction of public roads are under the jurisdiction of the city council. It means that the city council is fully responsible for the public transport system. That means that the function of the financing of public transport is performed by the local authorities that is the city budget, which is mostly busy.

An effective way of optimization the public transport financing is the passenger traffic tariff regulation. Modern Russian and foreign scholars consider various methods of pricing.

1.1. Literature and Research Reviews

Tryakin and Shefter Ya (2007), Semchugova, Volodkin & Zagorski (2012) determine the tariff for transportation is the ratio of costs and profit margins of the annual traffic capacity (the normative method). Nowadays, most municipalities use the normative method for calculating the rates.

Larin and Smolin (2010) propose to differentiate the rates depending on the type of the rolling stock, and Vorobyeva (2005) considers the tariff differentiation during the day for the passenger traffic regulation and trucking companies' income.

Sutanto (1999), May, Shepherd and Timms (2000), Berg, Kroes & Verhoef (2008) determines the limit of passenger transportation tariffs calculating the minimum and maximum possible fare. The maximum rate is determined by the ratio of the average monthly work income at the level of consumption for urban passenger transport to the average number of trips per month. The minimum fare is based on economic feasibility and the state subsidizes costs associated with the transportation of privileged passengers.

Legkhii (2010) considers the principle of determining prices for passenger transport services on the basis of their value for the consumer. Value is determined on the basis of the existing alternatives (competitive services). The journey price cannot be below costs. Services value level, according to the authors, is determined by many factors: comfort, safety, regularity, etc. The main disadvantage of this approach is the difficulty of formalizing quality indicators. In addition, the authors offer only the principle of the calculation, not a specific methodology.

Litman (2004), Nagendra (2012), Dodlova (2013) and others consider taking into account the demand elasticity for passenger transport by price is necessary for developing an optimal tariff policy. This approach of tariff determining based on a research of passenger demand and modelling passenger response to price changes. In the framework of this approach, they proposed to develop a questionnaire, which goal is to find out the passenger attitude to the price, comfort and journey time and also to allocate segments of users and types of their strategies. The disadvantage of this approach is the complexity and cost in conducting the surveys and calculations. Additionally, the respondent's answers are subjective.

Thus, in Russian and foreign practice the methods of tariff setting are considered from different perspectives. But at the moment, most attention is drawn to a standard method of pricing with its different variations (for instance, the adjustment of the level of services quality). The main lack of a regulatory method consists in accounting of only carriers interests, since economically reasonable rate consists of the costs, which are provided by them. In turn, it does not stimulate to cost reduction on transportations. In addition, modern methods of tariff regulation consider only two parties in the process of passenger transportation which are carriers (normative method of tariff regulation) and passengers (calculation of tariff adjustment to the service quality level and the tariff determination limits with the income of people), excluding the interests of the authorities, which play a key role in the rate formation and regulation. Also the existing methods of tariff formation practically do not take into account transport demand and supply considering them as a constant value. Also optimization economic-mathematical methods of tariff formation are practically not considered by authors, though they allow receiving an optimum value.

Thus, the problem of assessment and accounting factors completeness and optimization economic-mathematical methods using, when forming rates for suburban passenger transport services in the scientific environment has not been thoroughly studied and needs additional researches. The problem of transport demand and supply modelling, when forming tariffs also needs additional researches.

So in our opinion, it is necessary to consider the issue of tariff formation for all stakeholders and to take into account the changes of transport supply and demand. This approach is possible when building an optimal model of tariff formation and its integration with the transport model of the city and the sociological model of attitudes towards tariffs.

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2. Research Methods

There are two subjects in the market of passenger traffic: producers and consumers of services. Producers of service are carriers (operators), who are divided into the private transportation companies performing bus transportations, and the companies with the state participation performing railway traffic and transportations by the electric transport. In addition to routes service (transportation of passengers), operators create investment policy, perform the choice of using a type of vehicles on routes (by criteria of cost value, fillability, a regularity and intervals of movement), make payments in the budget as taxes and in the resources market. Consumers of services are divided into passengers (paid and preferential category) and not passengers (budget). The passengers who paid all-in cost of a rate belong to the paid category. The preferential category uses travel documents, and the rest of a market tariff is paid from budgetary funds through compensating payments. Pupils, students (in certain regions), regional and federal recipient belong to the preferential category. Passengers perform the choice for the benefit of mass or individual transport modes and determine the amount of consumption of public transport services. Also, they are the main source of financing of services (basic incomes of carrier). Not passengers (budget), on an equal basis with passengers, renders additional financing through subsidizing of losses along social and directed routes (other incomes). In addition, there is a market regulator that is authorities. State regulation of the passenger traffic market is connected with infrastructure nature of transport industry and its social importance, and for a rail transport is also with its monopoly position. The regulator exercises control of the market subjects in the course of the passenger traffic organization to create and regulate tariff policy, to determine route network and the schedule, to distribute subsidies, to hold a competition on distribution of routes between carriers, to create the necessary quality level of transportations. Rates for transportation of passengers in suburban trains regulate regional authorities. Tariff formation and subsidizing of unprofitable, but socially important transportations is one of market control instruments of transport services.

Such approach causes a number of problems. First, it does not stimulate a carrier to cost reduction. Secondly, interests of passengers when forming a rate since the regulator of the market are guided only by the amount of the budget subsidies, and the costs of carriers are not considered. Thirdly, changing of the transport demand and supply are not taken into account. The existing tariff policy does not allow solving these problems.

Based on the market model of public transport services, the rate formation is influenced by three stakeholders: the government, passengers, and transporters. The authorities form and regulate tariff policy, carry out competition of routes distribution among carriers and establish the necessary level of service quality. Passengers influence the process through the consumption of public transport services and the choice of public or individual transport. Transporters perform transportation on the routes, form the investment policy, exercise the choice of using types of vehicles on routes (according to the criteria of cost, occupancy rate, regularity and intervals).

Thus, each party of the transportation process has its purpose (Postnikov, 2014):

- authorities: maximum efficiency of budget expenditures through the minimum budget subsidies sizes in the high quality transportation by carriers of their functions;

- passengers: minimum journey cost during the high quality transportation;

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- carriers: maximum profit from the performance of its obligations under the contract.

Thus, we receive the multidirectional purposes: passengers want that transport had high route frequency with a minimal cost of journey; at the same moment, it is not profitable to carriers to start the blank transport because of high expenses that leads to increasing intervals in the schedule. Besides, the decreasing amount of the budget subsidies is possible only due to the growth of passengers journey costs and, other way, passengers journey cost reduction is possible only due to the increasing amount of the budget subsidies in case of the invariable level of profitability.

Therefore, there is a question of harmonization market participants' interests, when forming rates. The solution of this problem requires creation of the model of tariff forming which would consider interests of all public transport services market participants, and also reaction of the transport demand and supply to tariff changes. The solution of model would allow optimizing the purposes of participants, and the regulator could choose an optimum tariff system proceeding from the purposes: increasing number of the transported passengers; increasing revenue of carriers, when preserving a passenger traffic; and other purposes.

We should take into account the interests of each public transport services market participant in optimal tariff formation. This is possible by constructing an optimal model where the target formation rate is at least the cost of passenger journey and budgetary subsidies to cover the losses of the carriers, and the system limitations will reflect the profitability interval for carriers, thus, setting the level of profit.

Additionally, it is important to notice that in the real economic situation the demand for transport (passenger traffic) and traffic supply (the value of transport) respond to tariff changes. With increasing tariff the passenger traffic will decrease since fewer people will be willing to use public transport and the amount of work will increase, because the intervals between routes will get smaller, and the number of routes will grow with the rise of competition in the market. At the same time, the amount of work also affects transport demand through the change of intervals and the vehicle filling rate. The greater the amount of transport work is, the more people will be willing to use public transport. In this case, the intervals and the vehicle filling rate will characterize the quality of services.

Therefore, the question of constructing functions according to the passenger flow of the tariff rate and the amount of transport work is of great importance. Modeling the dependence of transport demand on tariff is based on sociological model, using the method of declared preferences. For this purpose, it is necessary to interview the respondents and to identify the dependence of ridership on tariff. Detailed analysis of application of the method of declared preferences for public transport is considered by Dudlova (2013), Beck (2012) and others.

We can use the transport model of the city, in which there is a distribution of trips by all types of transport and routes for modeling the dependence of transport demand on transport work amount. The transport model of the city is built using the Visum software. The transport system data of the city are recorded in the Microsoft Access database and in Visum, where the simulation of passenger flow on each route is taking place. The passenger traffic data are recorded in Microsoft Access again, and then is exported to Microsoft Excel. The source data for the operation of public transport is also recorded in Microsoft Excel. On the basis of a constructed mathematical model, the "Finding solutions" add-on runs optimization of the variables that are stored in an Excel Worksheet. Then the amount of transport work in Microsoft Access is exported to Visum, and the ridership of each route is recalculated. The cycle

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continues until the optimal solution will be found, i.e. the rate has reached the extremum of the objective function when performing system limitations.

Thus, let us present the approach to formation of tariffs for services of public transport, which consists of three interrelated models: optimal, sociological and transportation (fig. 1).

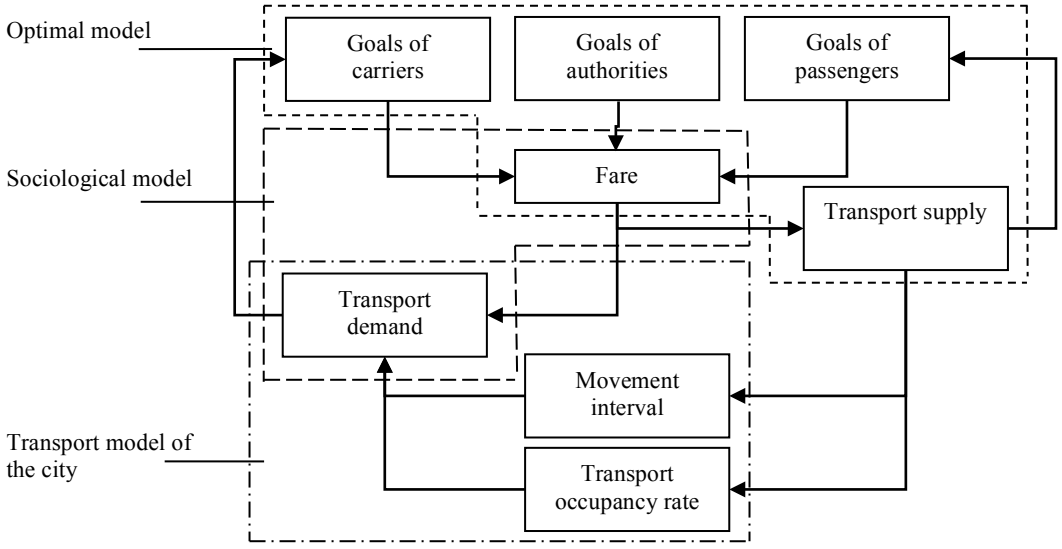

Fig. 1. Approach to formation of tariff.

In the optimal model, the rate calculation is based on the three market participants objectives. The sociological model is a function of the passenger's flow dependence on the tariff. The transport model of the city simulates the transport demand based on the amount of transport work. This approach to the tariff formation allows us to take into account the interests of the public transport market participants, and the impact of transport supply and demand. The conversion of the optimal tariff formation model, the transport model of the city and the sociological model of dependence of traffic flow on the rate is shown inthe figure (fig.2).

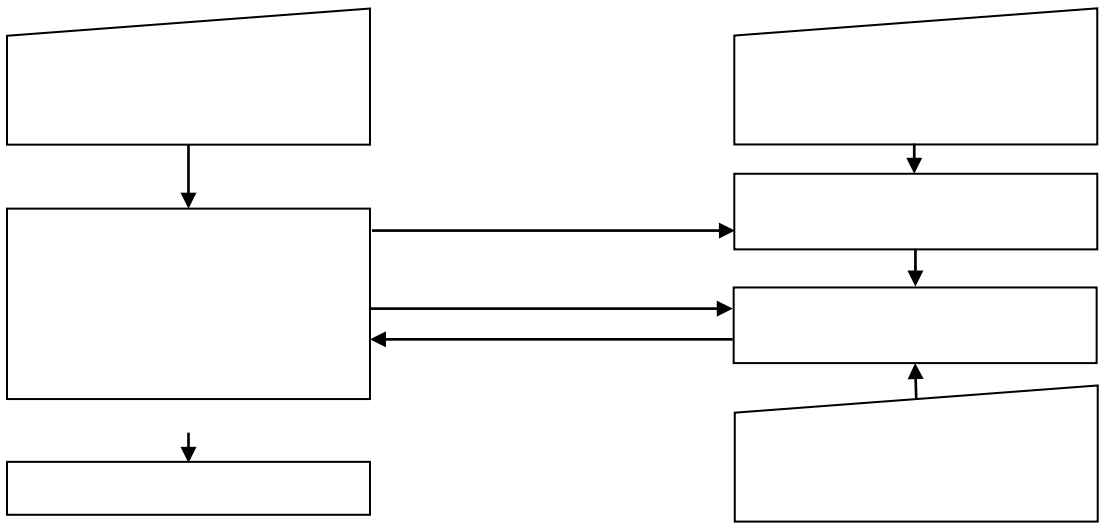

Fig. 2. Access cycle between optimal model of tariff formation, transport model of city and sociological model.

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3. Methods & Results

As we can see, it is necessary to take into account interests of each market participant during tariff formation. It is possible on the basis of creation optimal model with target of tariff formation and set of constraints.

Suburban transport carries passengers for n directions. Tariffs depend on journey distance which can be divided into m tariff zones. The maximum distance of journey is S km. Number of headings is , number of tariff zone is, journey distance is.

It is required to define tariff system for the purpose of target optimality criterion achievement: minimization of passengers' expenses, minimization of the budgetary subsidies, maximizing profit of carrier. The given system of restrictions must be taken into account.

The model is created on the basis of minimum of the budgetary subsidies as criterion of optimization. The model reflects the regulator purposes where target function is a minimum of the budgetary subsidies, and the system of restrictions consists of restriction for profitability of transportations, paying capacity of the population and competitiveness of transportations. We receive the task of the conditional extremum target function z from a row of the variables in case of several restrictions.

The resulting table (tab. 1) contains information about indicators of Perm suburban company functioning before and after simulation of tariff system modeling.

Table 1. Calculating indicators of Perm suburban company functioning during tariff scale changing by optimization criteria.

Indicators	Current value	Minimum subsidies
Tariff growth rate, %	0,0	26,5
Budgetary subsidies for privileged passengers transportations, mln. rub	76,5	88,9
Budgetary subsidies for loan losses, mln. rub	232,7	176,3
Total budgetary subsidies, mln. rub	309,2	265,2
Passengers expenses, mln. rub	504,3	586,1
Financial result of carriers without budgetary subsidies, mln. rub	-200,6	-101,9
Financial result of carriers with budgetary subsidies, mln. rub	32,0	74,4
Profitability rate, %	4,1	9,6
Budgetary financing share, %	39,6	34,1
Passenger traffic, ppl.	7 306 843	6 452 153

Results of tariff systems modeling at various criteria of optimization have been received and, respectively, at various strategies of adoption administrative decisions at suburban railway transport tariff formation. Average growth of tariffs at target criterion of subsidies will make 26,5%, the maximum growth 50,0% is observed at near distance to 65 km, at distance of 106-125 km tariff decreasing is observed. Thereby there is a stimulation of passengers movement on a long distance. At the same time the budgetary subsidies will decrease by 44,0 million rubles, and the share of the budgetary financing will make 34,1% (265,2 million rubles) in relation to the current value of 39,7% (309,2 million rubles). There will be a growth of carrier profit on 42,4 million rubles and increase in expenses of passengers by 81,8 million rubles.

4. Conclusion

Thus, the research purpose was working out of flexible tariff regulation approach that is sensitive to market participants interests, that allows us to harmonize interests of all participants of the public transport market. There are information collection and the analysis, research of the scientific literature, which raise questions of tariff formation; an approach to passenger traffic tariff calculation is created for achievement of an effective purpose in the article.

Results of the conducted research show that the existing tariff formation approach does not consider interests of all passenger traffic market participants, and there isthe influence of the tariff on transport demand and supply changing. It leads to disagreements during tariff formation. The regional authorities try to maintain the growth of the budget subsidies to compensate the carriers activities losses, which, in turn, requires increasing tariff for the passenger traffic profitability growth. But too high growth of tariffs can result in social tension on the side of passengers.

The results of the study can be used by authorities when planning budgetary subsidies and improving tariff policy of public passenger transport.

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