New Approaches to the Economic Assessment of Transport Projects in the Context of Changing Urban Mobility

Elena Volkova(✉)

Emperor Alexander I Petersburg State Transport University, 9, Moskovskiy Prospekt, 190031 St. Petersburg, Russia
Moonlight34@yandex.ru

Abstract. Nowadays, significant changes are taking place in urban transport systems. They are connected, on the one hand, with the growing demand of the population for transportation, on the other hand, with the change in the structure of the supply of transport services, the emergence of new forms of urban mobility, new business models of transport companies. In addition, digital technologies are developing rapidly, and the scope of their application in transport is expanding. Under these conditions, traditional methods of the economic assessment of transport projects are losing relevance. At the same time, most of these projects are implemented using various forms of public-private partnership. This leads to the need for a cost assessment of the social effects and benefits resulting from the implementation of transport projects. The article substantiates the need to supplement the existing methods of economic assessment of transport projects. The authors systematized the social effects in transport projects and analyzed the available methods of their assessment. It is proved that there is a problem of accounting for some social effects due to the lack of an adequate methodology or the impossibility of valuation. As an example, the assessment of social effects in the project of construction of a transport hub is given. Taking into account the social effects, the structure of the sources of financing of the project implemented with the use of public-private partnership is proposed.

Keywords: Population mobility · Urban mobility · Social benefit · Transport projects · Economic assessment · Public-private partnership

1 Introduction

Nowadays, the process of urbanization continues, leading to the concentration of the population in large cities. New forms of settlement are being formed - agglomerations, megacities, conurbations, megalopolises. Territorial specialization of agglomeration leads to the need to manage significant passenger and transport flows. Not only the demand of the population for transportation is changing, but also the requirements for the quality of transport services: the speed of transportation, the comfort during the

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trip. Passengers highly appreciate the opportunity to use free wi-fi during the trip, additional services at transfer points. New forms of urban mobility are emerging, such as joint consumption of vehicles (carsharing is the most common), joint trips using special applications.

The features of new forms of urban mobility are considered in different works by both domestic and foreign scientists. Thus, Wruk, D. et al. [1] consider the issues of quantitative assessment of the segment of joint consumption. Duan, Q. et al. not only note the socio-economic efficiency of carsharing, but also pose the problem of determining the future demand for this service in Chinese megacities by dividing the factors affecting it and their subsequent quantitative assessment [2]. Bellini, F. et al. classify business models of joint mobility and identify their key characteristics, as well as describe the prospects for solving existing problems in the field of urban mobility [3]. Some researchers note that all the existing business models of joint mobility are changing urban transport markets by increasing competition and opportunities for product differentiation [4].

Some studies are devoted to the forms and methods of pricing in the carsharing and carpooling markets. Thus, Farajallah et al. note the uniqueness of the new segment of the transport market, which is manifested, among other things, in the development of new methods for setting prices [5].

Nevertheless, passenger transport management in megacities is often inefficient, which leads to some problems. Among them are traffic jams caused by a high level of motorization, aggravating the environmental situation in megacities; an increase in the number of accidents, low level of transport accessibility of remote and new residential areas, a lack of rail transport routes (including metro). New forms of urban mobility also give rise to new problems of transport functioning. Laa and Emberger, Link et al. highlight the main problems and barriers faced by new segments of the transport market. Among them are administrative (political and legal) barriers and the lack of adequate methods of state regulation [6]. The problem of the development of bike-sharing in Vienna is also confirmed in the study of Link, C. et al. [7]. The listed problems are usually considered as a single “transport problem”.

As a rule, the reason for the so-called “transport problem” of agglomerations lies in the fact that population growth significantly exceeds the rate of development of transport infrastructure. In some cases, there are also infrastructural limitations due to the impossibility of developing the historical center of the city, existing planning decisions, dead-end schemes for the development of previously built transport routes. In addition, the development of transport infrastructure requires significant capital investments, which also hinders the implementation of infrastructure projects.

Partial removal of infrastructural restrictions in the urban transport system is possible under the condition of effective passenger and transport flows management, improvement of pricing and transport planning. For example, in the case of carsharing and other forms of joint mobility, identification of factors influencing consumer choice plays an important role. Thus, in the article of Hahn, R. et al. the results of quantitative research and surveys of focus groups of carsharing users in one of the German universities are presented. The authors concluded that the success of carsharing development is determined by the compatibility of the lifestyle and habits of users, on the one hand, and the parameters of the service provided, on the other hand [8]. Papu Carrone et al. prove that the key factors

determining the willingness to use carsharing services are the availability of parking and convenient access to vehicles [9]. In the article of Aguilera-García, Á. et al. a model has been developed that includes factors influencing the frequency of scooter sharing among the population of Spanish cities. Such factors include age, level of education and other socio-demographic characteristics that determine the choice of a passenger trip option [11]. Some authors, for example, Hartl et al., prove that financial benefits are the key factor of choice for consumers [12].

In addition, less capital-intensive projects solving the "transport problem" are aimed at improving the efficiency of elements of the transport system. Such projects include the development of transport hubs [13, 14], the introduction of "smart" traffic regulation systems, "smart" stops, the development and implementation of a unified fare payment system, etc. It can be noted that the interest of Russian researchers in the methods of solving the transport problem in megacities is growing, which is reflected in the publications of Zhuravleva N.A. and Shavshukov V.M. [15], Kazanskaya L.F. and Proskuryakova E.A. [16]. Some works emphasize the transformation of the Russian market of urban transport [17] and the development of intelligent technologies in transport [18–20]. The emphasis is placed on the fact that for the sustainable development of urban transport systems, new forms of interaction of market entities are needed [21], which include effective resources management based on "smart" solutions [22], and the emergence of new forms of urban mobility.

Despite many methods of improving the efficiency of the urban transport system are considered, the problems of their economic assessment, considering features of the development of technologies, new forms of mobility, are not fully disclosed. In this regard, the development of new methods of economic assessment of urban transport projects becomes relevant.

This article is aimed at systematization of social effects arising in urban transport projects and analysis of available methods of their assessment.

2 Materials and Methods

The theoretical basis for the research is the scientific works of domestic and foreign researchers in the field of city logistics, transport economics, the economy of shared consumption, and market analysis. To conduct the research, such general scientific methods as analysis and synthesis, induction and deduction, generalization, analogy were used. To assess social benefits in case study, we use some special methods developed by Evreinova N.Yu (Russian University of Transport, Moscow) in her thesis connected with the economic assessment of functioning of transport hubs.

For this article, we use data from open sources containing data on urban transport system and transport development projects in St. Petersburg, Russia. For the case study, we use data from the official website of the Committee for the development of transport infrastructure (St. Petersburg) about transport hubs projects. We use the description of Devyatkino transport hub to identify social benefits of the project. We also get data for calculating the effects from simulation modeling and using expert assessments.

3 Results

Based on the analysis of open sources data and scientific publications, it can be concluded that most urban transport projects generate not only commercial benefits, but also public effects. That is why many transport projects are implemented on the initiative and with the support of the state. At the same time, one of the options for combining commercial and public effects in the project is its implementation based on public-private partnership (PPP).

Public-private partnership is a combination of state financing and private capital in the project; there are different forms of PPP, for example, a concession agreement. In any case, when using PPP, the question of the funding structure, the ratio of the shares of the state and the private investor is relevant. We believe that the share of each party should correspond to the amount of benefits (effects) it receives from the implementation of the project. This presupposes the need for full and accurate accounting of social effects, the recipient of which is the state. To solve this problem, it is necessary to systematize the social effects generated by transport projects considering the growing need of the population for fast comfortable transportation, the emergence of new forms of urban mobility. Based on the materials of open sources, we concluded that the main social effect of such projects is reducing travel time. It is also advisable to specify which component of the total travel time is being reduced - driving time, waiting time for transport vehicle, time for a transfer, taking into account the specifics of a particular project. The second significant social effect is environmental. It consists in reducing carbon emissions, noise pollution of the environment by redistributing passenger traffic by transport modes, reducing the level of motorization, and increasing the intensity of use of public transport. The third effect is a reduction in the number of road accidents. It is also a consequence of a decrease in motorization and congestion on highways. An important effect for society is cost savings for passengers, which is typical for new forms of joint mobility, for example, for carsharing. Some researchers also identify such an effect as more comfortable trip. This effect, on the one hand, contributes to an increase in demand for public transport, and on the other hand, reduces transport fatigue, which can also affect labor productivity indicators.

The listed effects manifest themselves in different ways, considering the specifics of the project being implemented. Table 1 shows an attempt to systematize them depending on the content and focus of the project.

In addition to description of social effects, their cost assessment is necessary to substantiate the structure of funding. As an example, let us consider a project for the development of a passenger transport hub, which include an intercity and international bus station, a railway station and a metro station, as well as business infrastructure facilities, pedestrian crossings and parking (Fig. 1).

The project is supposed to be implemented in the form of a public-private partnership (a concession agreement for a period of 40 years).

The social effects in transport hub projects reflect the interests of passengers, as well as car owners and the city (region) on whose territory the facility is being built. The most important externalities include:

– reduction of passengers' travel time on the territory of the city.

Table 1. The main social effects generated by urban transport development projects.

Focus (content) of the project	Main social effects
Smart traffic regulation	Reduction of driving time (by reducing waiting for a traffic light signal), reduction of transport fatigue, reduction of accidents
Passenger transport hub development projects	Reduced transfer time, increased demand for public transport services
Projects for the development of forms of joint mobility	Saving passengers' costs, reducing the level of motorization, environmental effect
Smart stops and stopping points	Reducing the waiting time of the vehicle, increasing the level of comfort, increasing demand for public transport services
High-speed urban transport development projects	Reduced driving time (due to increased speed), increased comfort level, increased demand for public transport services, environmental effect, reduced accident rate
Multimodality development projects	Reduction of waiting time and transfers, increase in comfort level, increase in demand for public transport services, environmental effect, reduction of accidents

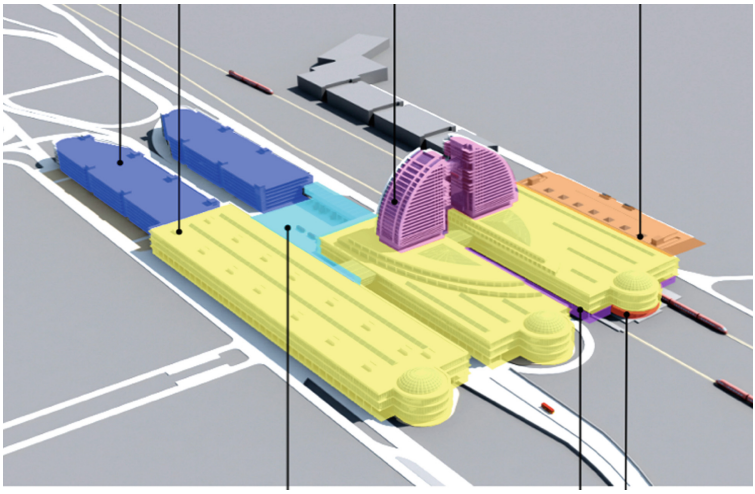

Fig. 1. Layout of passenger transport hub

– unloading of the road network because of the growing attractiveness of public passenger transport.

To carry out a quantitative assessment of these effects, we will use the methodology proposed by Evreinova N.Yu. The assessment of the social effect of reducing the time of passengers on the road, rubles per year (E_{pass}^{year}), is carried out according to the formula:

$$E_{pass}^{year} = 288 * P_{day} * GRPp * \frac{\Delta t}{60}, \quad (1)$$

where P_{day}– is the daily passenger turnover of the considered transport hub (passengers per day);

GRPp– gross regional product created by a passenger per hour (rubles per hour);

t – saving passengers' transfer time (minutes).

The GRP created by the passenger per hour is calculated by the formula:

$$GRPp = GRP/(365 * 24 * N), \quad (2)$$

where *GRP* – the value of the annual GRP of the region in question (rubles);

N– the number of economically active population of the region (people).

To assess this effect, we used data from official state statistics, as well as the results of simulation modeling of the transport hub functioning in a situation "with a project" and "without a project". The data for the calculation are presented in Table 2.

Table 2. Data for calculation the public effect of reducing passengers' travel time.

Indicator	Unit of measurement	Indicator value	
		min	max
Total passenger traffic	thousand people	2 185, 509	2 185, 509
Saving passengers' time spent on transfer	minutes	5	9
Daily passenger turnover in the transport hub	pass/day	70000	85000
GRP	billion rubles	3 742	
Number of economically active population	thousand people	2 980,90	

According to Table 2, the social effect of reducing the travel time of passengers according to the maximum option will be from 240.7 to 526.2 million rubles per year.

Unloading of the road network because of the use of the transport hub is provided by transferring some motorists to public transport. This social effect E_{road}^{year}, rubles per year, can be estimated using data on the cost of mileage of cars according to the following formula:

$$E_{road}^{year} = 365 * \Delta N_{day}^{cars} * S_{km} * l_{avr}^{route}, \quad (3)$$

where ΔN_{day}^{cars} – reduction of daily traffic intensity at the entrance to the city and at the entrance to the city center, cars per day.

S_{km} – average cost of 1 km of passenger car mileage, rubles.

l_{avr}^{route} – average length of a route, km.

Table 3. Data for calculating the public effect of unloading of the roads.

Indicator	Unit of measurement	Indicator value
Reduction of daily traffic intensity at the entrance to the city and at the entrance to the city center	cars per day	5 000
Average cost of 1 km of passenger car mileage	rubles	9,57
Average length of a route	km	29

Data for calculating the effect were also got from simulation modeling and using expert assessments. They are presented in Table 3.

According to Table 3, the economic effect of unloading the road network because of using the transport hub will amount to 506.5 million rubles per year. Thus, according to our preliminary calculations, the social effects in the transport hub development project can range from 0.75 to 1.03 billion rubles per year.

4 Discussion

The cost assessment of social effects obtained in the example above can serve as a basis for determining the structure of funding for the development of a transport passenger hub. In this case, the shares of the state and the private investor should be proportional to the effects they receive.

At the same time, the assessment of social effects in some cases is difficult or impossible for several reasons. First, there are effects that cannot be quantified. Thus, the following effects cannot be correctly estimated: an increase in the level of comfort; convenience; reduction of transport fatigue. These effects describe the new quality of urban transport, increase its level of development, therefore, when evaluating investments in relevant projects, they cannot be ignored. However, the question of its assessment and the impact on the structure of funding of the project remains open.

Secondly, when trying to assess some effects, difficulties may arise, consisting in the availability of alternative approaches to evaluation, the impossibility to consider all the components of these effects, or the difficulty of assessing the impact of the project on the dynamics of macroeconomic indicators. For example, when assessing the effect of reducing travel time, the average salary of a passenger can be the basis of a cost assessment. An alternative approach to assessing the effect of reducing travel time involves using the value of the gross regional product per capita created in the region per hour as the cost equivalent of the time saved. However, this approach ignores the fact that the released time can be spent not only on work, but also on rest. In addition, it is not possible to assess the impact of the projects on the growth of macroeconomic indicators, an increase in tax revenues that occur under the influence of many factors.

Thirdly, the problem of assessing social effects lies in the varying degree of objectivity of the proposed approaches based on conditional indicators and assumptions. Thus, the available methods for assessing the environmental effect and reducing accidents are based on stochastic methods and expert assessments, which casts doubt on the cost indicators obtained.

5 Conclusion

Summing up the results of the study, we can draw the following conclusions.

At first, new forms of urban mobility led to the emerging of new business models, new methods of pricing, and gave rise to new problems of transport functioning.

Secondly, problems of economic assessment of transport projects, considering features of the development of technologies and new forms of mobility, are not fully disclosed.

Thirdly, most urban transport projects generate not only commercial benefits, but also public effects. When using PPP, the question of the funding structure is relevant. This presupposes the need for full and accurate accounting of social effects, the recipient of which is the state.

Finally, it is important to identify and assess social benefits of particular transport project, taking into account its features and the scope.

Thus, the assessment of social effects in transport projects is a complex task, connected with some problems. However, it is obvious that the projects under consideration bring the urban transport system to a new level of development. Therefore, it can be concluded that such projects require the fullest possible identification of social effects and further refinement of methods for their cost assessment.

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