

# Fiscal instruments for regulating the sustainable development of urban transport systems in Russia

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**Abstract.** The article explains the role of public transport pricing. It proves the need for a systemic approach to building a modern public transit system. The authors argue that the main objective of the approach should be to reduce the use of private vehicles in the urban environment and increasing public transport use. It is proven that for the consumer of transport services the price per trip is an important factor when deciding whether to travel by car or by public transport. The authors analyze the available literature assessing the effects of widespread car ownership on users of the city transit system. Conflict situations that occur due to the unabated desire of city residents to travel by car are analyzed. A research method is proposed. It is shown that public transport fares have been growing in Russia at an accelerated pace when compared to the overall increase in prices of all goods and services, including motor vehicles, petrol and oils. The fare growth has resulted in a 3.6-fold drop in demand for public transport services over the 15 years being analyzed. Over the same period, the number of privately owned cars grew 120 percent. A conclusion is drawn that regular fare hikes have encouraged urban population to gradually opt against travelling by public transport. That resulted in higher demand for car travel and, eventually, in an accelerated growth in car usage. One can conclude that a persistent institutional trap has taken shape in Russian metropolises. Essentially, it means that higher public transport fares have led to lower demand for public transit services. As ridership goes down, public transport operators have to again increase prices, thus driving the demand for their services down. It is proven that escaping the trap will require restoring the ratio of prices to make sure that the price charged for a public transport trip is far lower than the cost of travelling by car. The aim of this study is to assess the influence of the factor of public transport fares on demand for private car usage and public transport ridership.

**Key words.** Public transport, private transport, transport pricing.

## 1. Introduction

All too often, we underestimate the role of the transport system in the harmonized development of the urban area we live in. We usually view the city transport system as a local system for transporting passengers and cargo within a specific area. Meanwhile, the real function of the city transport system is much broader; the system defines the look and viability of the modern city.



As Vuchic rightly points out, transport is the "lifeblood" of cities, connecting all other subsystems and functions (economic, recreational, social etc.) Consequently, the efficiency of the urban transport system determines the effective performance of other systems in a modern megalopolis.

As a rule, city authorities confuse cause and effect when trying to address emerging transportation problems. Congestion is a typical example of that. City authorities believe that it is the main problem of the transport system and try to deal with it in a traditional way by increasing road capacity. However, the more roads there are and the high their capacity, the more cars take to the roads, creating more traffic jams. Eventually, such solutions only have a short-term effect, and congestion will only get worse over time.

That being said, traffic jams are not the cause, but the effect of an incorrect urban transport policy. Systemic measures are needed to eliminate traffic jams. The measures should be primarily aimed at giving people an incentive to use public transport and discouraging them from travelling by car. Applying these measures holistically will increase the effectiveness of the city transport system in the future.

A systemic approach to building a modern urban transport system consists in setting the right priorities for the development of different modes of transportation. Urban transport modes include bicycle, car, bus, tram, or metro. In a majority of Russian cities the bicycle can be used only a few months a year due to weather conditions. As a result, the strongest competition for passengers occurs between public and private transport.

There is a burning need in all Russia's cities to work out effective fiscal and administrative measures for regulating the development of different modes of urban transport. When doing this, one should carefully assess the implications of changing the structure of transport and the short-term and long-term effects of changing the structure in terms of environmental impacts. The main goal of such regulation should be reducing the use of private vehicles in the urban environment and increasing the use of various modes of public transport.

Analysis of pollutant emissions into the atmosphere shows that, in general, during the period of 1995–2015 these emissions have not increased. However, the structure of the emissions changed. The share of vehicle emissions in the total emissions in Russia has increased to 45 % (Table 1).

**Table 1.** Dynamics of pollutant emissions into the atmosphere

Indicator	1995	2000	2005	2010	2015	Increase,%
Emissions of pollutants into the atmosphere, million tons	32.3	32.3	35.8	32.7	31.3	97
Emissions of air pollutants from stationary sources, million tons	21.3	18.8	20.4	19.1	17.3	81
Emissions of air pollutants from motor vehicles, million tons	11	13.5	15.4	13.6	14.0	127
Share of vehicle emissions in the total emissions of pollutants into the atmosphere	34.06	41.80	43.02	41.59	44.70	131
Emissions of pollutants from motor vehicles per unit of land area, t/km <sup>2</sup>	0.64	0.79	0.90	0.80	0.82	128

The most significant contribution to the increase of emissions has been made by private cars. It is obvious that the traffic of private cars should be reduced. The most effective tool is a fiscal impact on car owners.

The price per trip is one of the most effective instruments for regulating demand for public and private transport. For the consumer of transport services the price of per trip is an important factor when deciding whether to travel by car or by public transport. If the cost of a car trip is lower than the fare paid for travelling to the same destination by public transport, the city dweller will opt for riding in a car.

The aim of this study is to assess the influence of the factor of public transport fares on demand for private car usage and public transport ridership.

## 2. Literature review

A rapid growth in car ownership rates in the middle of the 20th century is considered to be the bifurcation point in the evolution urban transport systems. It was that process that redefined the traditional idea of the perfect structure of urban transport systems because the processes that were actually taking place in cities were unrelated to conventional standards of transport planning. Mass car ownership resulted in a number of conflict situations that started to occur in all big cities.

Such situations stem from city dwellers' unabated desire to use their private cars and the limited capacity of the road network. Another conflict is due to motorists' desire to park their vehicles in a walking distance from their terminal destination (workplace, school, leisure facility) and limited parking space. Mass car ownership also gives rise to a conflict between public and private transport because they start to compete for access to the road network. Mass car ownership reduces the travel speeds of surface modes of public transport and makes them less attractive to passengers. Mass car ownership generates a serious conflict between downtown and suburban areas when well-off inhabitants move to suburbs, cities sprawl outward, and downtown areas see a decline. For a long time, these conflicts were not treated theoretically.

Pioneering studies of urban transport systems amid rapidly growing car ownership were conducted by Wardrop [1] and Hollatz [2]. Wardrop studied an equilibrium distribution of public and private transport flows within a section of a road network. The point of equilibrium was determined by comparing total disutility (total costs) of all travellers. Wardrop proved that when each road user chooses their preferred means of transport, this choice is not socially optimal. It is necessary to implement incentives encouraging the use of public transport. At the same time, it is necessary to adopt measures to discourage the use of private transport. Hollatz and Tamms showed that high concentrations of cars in a city not only lead to lower efficiency of the entire transport system of the city, but generally decreases the quality of life and safety for the entire urban community.

Burrington proved that mass car ownership results in time loss and other effectiveness tradeoffs for all users of the transport system. Johnson proved that growth in car ownership is detrimental to the natural and manmade urban environment [3, 4].

Bruun and Vuchic [5] used the two-dimension measure of "time-area" to illustrate the efficiency of public transport. The measure expressed in square meter-minutes per trip was used to produce a simple and clear comparison of the amount of space required by various travel modes – walking, driving and bus transit.

Vuchic [6] also proposed an original graphic method using the time-area coordinates to demonstrate differences in modal capacities by a sketch of facilities required for transporting 15,000 persons/hour. Vuchic proved that automobiles take up far more space in the city streets than other modes of transport: transporting that number of passengers by automobile will require 17 lanes plus 34.5 ha of parking area.

Vuchic [7] proved that encouragement of public transport use and pedestrian traffic will give a city an edge over suburbs in terms of variability, comfort and overall transit costs. The more car-dependent a city is and the more it ignores public transport alternatives, the more likely its downtown areas are to fall into decline. Burchell [8] substantiated the idea that urban sprawl and the appearance of so-called edge cities have proved ineffective not only in terms of initial area development costs, road building and other infrastructure, but in the purely functional sense too.

Pucher [9] and Holtzclaw [10] performed a comparative analysis of public expenditures and subsidies associated with urban travel. They claim that car users pay only a portion of the transportation costs. They do not cover social, environmental and other indirect costs. Car users only defray around 60 percent of total urban travel costs. These subsidies to automobile users substantially exceed the government subsidies to public transit. All modes of public transport require public investment in infrastructure and rolling stock and partial subsidies to cover their operation expenditures. Users' expenditure is limited to the amount of the fare paid. In Western European cities and the USA the farebox recovery ratio usually ranges from 20 to 90 percent. In the USA, federal investments in public transport, including planning, research and funding for city infrastructure amounted to a mere 3bn to 5bn dollars a year between 1970 and 1990 and showed practically zero growth.

Gómez-Ibáñez [11] proved that demand for public transport services is very sensitive to fares. Federal and local subsidies, however, did not result in fare decreases, but led to ineffective spending.

Small [12] substantiated a connection between road pricing and higher quality of bus transit. Mayburov and Leontyeva [13] substantiated the need for cardinal changes in Russian cities' approach to long-term transport planning. These include programs encouraging people to switch to public transport and fiscal instruments discouraging car use [14].

### 3. Materials and methods

The hypothesis of this research is that disproportionate growth of public transit fares, as compared with overall increases in consumer prices, leads to a substantial shift in user preferences in the long-term run: passengers decide against using public transport in favor of private automobiles.

We proceeded from the following facts when formulating our hypothesis:

- (1) The mobility of urban population is high and will only grow further. Urban mobility is supported with either with public or private transport. At the same time, public transport and private vehicles compete against each other for the same road network that was paid for by the entire local community.
- (2) The use of public and private transport in the urban environment are two interrelated and interdependent indicators. The more people travel by private transport, the lower the need for public transport. And vice versa: the more people use public transport, the less they need private vehicles.
- (3) There is a global trend toward fiscal regulation of the costs of car usage with the aim of increasing them through the introduction of transport-related charges (tolls, parking fees, fuel taxes etc.) Government fare regulation is poorly developed and is usually linked to the processes of approving fares that will ensure a substantiated profit margin for public transport operators.
- (4) We believe that in a modern city public and private transport are equally accessible, so we do not take the accessibility factor into account further on. The time of travel factor and comfort of various modes of transport in the city environment are neglected, too.

When developing a method of studying the impact of the pricing factor of public transport services on the demand for various modes of transportation, we took the following parameters into account.

The analyzed period is from 2000 to 2015. The database for the analysis was provided by the data of the Federal State Statistics Service that reflects national average figures.

To estimate the intensity of public transport use we employ ridership data for electric propelled public transport (tram, trolleybus and subway). This information is available on the website of the Federal State Statistics Service ([www.gks.ru](http://www.gks.ru)).

The intensity of private car use was estimated through the number of privately owned automobiles. Unfortunately, the Federal State Statistics Service does not employ the car use indicator. The application of this indicator is accompanied with certain reservations because the ownership of a vehicle is not the equivalent of using it, although there is a direct correlation between them, which enables us to use this measure in our analysis.

The pricing factor of public transport services was estimated through the base fare growth index for electric propelled modes. This index is calculated by multiplying the chained (annual) fare indices

for electric propelled modes of public transport in corresponding years. The value of the base fare growth index reflects the general trend in fares for electric public transport over the period of analysis. The chained (annual) index describes the trend in fares for electric public transport services throughout a year. Chained (annual) fare indices can be found on the website of the Federal State Statistics Service.

The growth in electricity powered public transport fares unadjusted for inflation was estimated by using the base fare growth index that is unadjusted for inflation. The measure was calculated as the ratio of chain (annual) public transport fare indices to the values of the chained (annual) consumer price index in corresponding years. The chain (annual) consumer price index is available on the website of the Federal State Statistics Service

Values of the consumer price growth index indicate inflation rates over the analyzed period. We calculated the measure by multiplying the chained (annual) consumer price index levels over relevant years.

The obtained values were put in the same coordinate system. Dependencies were identified by processing the data with Microsoft Excel.

#### 4. Analysis of results

The results of the performed calculations for some years are shown in Table 2.

One can see that over the analyzed period between 2005 and 2015 the base fare growth index increased ten-fold. At the same time, the base consumer price growth index increase five times. Consequently, the prices of public transport services grew twice as fast as overall inflation. This means that the growth in public transport fares in Russia has outpaced the increase in prices of all goods and services, including cars, petrol and motor oil.

A similar situation was observed in the USA where the average bus fare grew from 39 cents to 88 cents between 1980 and 1992 in constant dollars. Over the same period, the price of gasoline went down 2 percent from 122 to 119 cents per gallon (from 31 to 30 cents per litre) [15]. The downward trend in petrol prices and the upward trend in public transport prices were clearly targeted against low-income people. Higher petrol taxes alleviate the anomaly at least partially, especially if the tax revenue is spent on improving alternatives to car travel.

**Table 2.** Values of the public transport pricing factor and demand for various modes of transport in Russia's cities

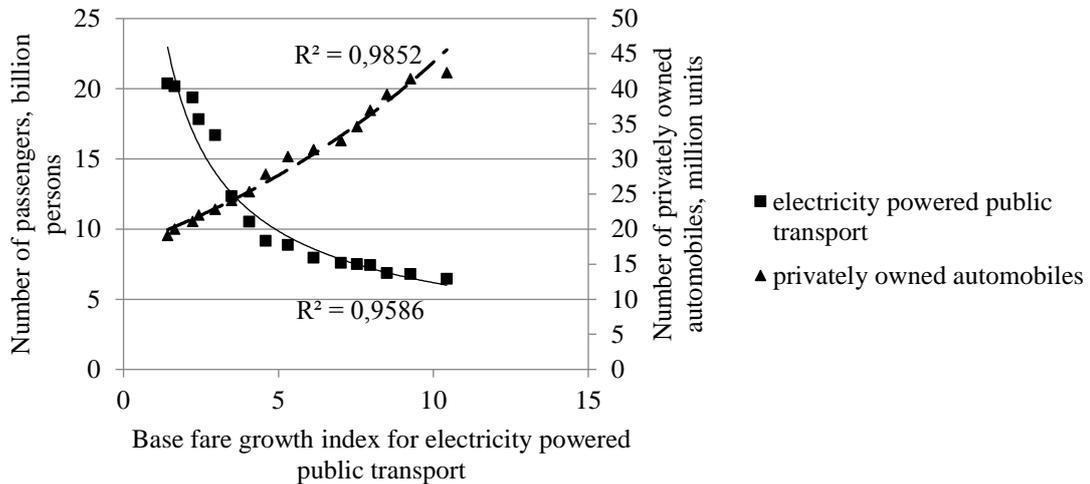
No	Indicator	2000	2005	2010	2015
1	Base consumer price growth index	1.2	2.28	3.72	5.64
2	Base fare growth index for electricity powered public transport	1.42	3.48	7.02	10.43
3	Base fare growth index for electricity powered public transport unadjusted for inflation	1.18	1.53	1.88	1.85
4	Number of passengers carried on electricity powered public transport in cities, billion persons	22.9	12.34	7.58	6.44
5	Number of privately owned automobiles, million units	19.1	24.1	32.6	42.3

The growing public transport fares have resulted in a 3.6-fold drop in the demand for public transport services over the 15 years of analysis. Over the same period, the number of automobiles owned by individuals has grown 120 percent. It is possible to conclude that public transport services have a high price elasticity of demand. Regular fare hikes encourage people to gradually stop using public transport, replacing it with higher demand for car rides. As a result there has been observed an accelerated growth in case use.

It would be wrong to state with confidence that the growing car ownership rates are exclusively the result of erroneous urban transport policies. The growth was spurred on by the mass ownership

of cars that swept Russia's cities 30 to 40 years later than developed countries. However, the accelerated growth in public transport fares has undoubtedly had a considerable negative impact on the structure of demand by public transit and made the situation with growing car ownership worse.

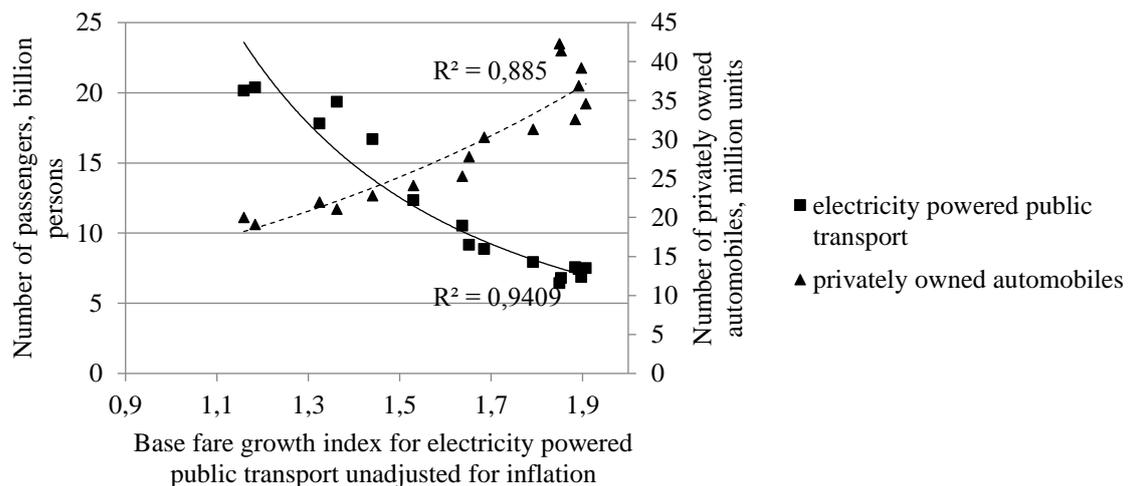
The graph below illustrates the results of the performed calculations (Figure 1).



**Figure 1.** Impact of the pricing factors of public transport services on demand for various modes of transport

One can see that there is a power-law dependence between a drop in the demand for public transport and the fare growth index. Meanwhile, there is an exponential dependence between the growing demand for private car travel and the fare growth index.

Since one of the causes of fare hikes is the inflation-driven rise in price levels, we recalculated the considered dependences after eliminating the inflation impact in the Russian economy. The resulting dependences shown on Figure 2 use the base fare growth index unadjusted for inflation.



**Figure 2.** Impact of the pricing factors of public transport services unadjusted for inflation on demand for various modes of transport

The graph provides a lot of information. It makes it possible to see that the dependence of the decrease in the demand for rides on public transport on fares is clearly manifested until the index reaches certain high levels (around the 1.8-fold point). Further growth in public transport fares does not lead to such a sharp drop in demand. When the fare growth index reaches high

values (around the 1.7-fold point), the previously obvious exponential dependence of car ownership rates fades away.

This effect might be attributed to the fact that objectively there is some demand for public transport services that does not depend on the price of these services. The minimum demand for the services is provided by people, who do not have driving licenses, by young people, tourists and other categories of passengers. For them, the price elasticity of demand is very low. As a rule, these categories of passengers do not change their transport choices.

## 5. Conclusion

As we can see, urban transport policy aimed at ensuring the break-even performance of public transport operators and attracting private business into the sector results in profit making becoming the key goal of the provision of public transport services. Consequently, all transport companies start to increase their prices (or seek an approval for the increase by the regulator) in order to ensure their competitive edge amid falling demand.

As a result, we witness a persistent institutional trap has taken shape in Russian cities over the past 15 years. Essentially, it means that higher public transport fares have led to lower demand for public transit services. As ridership goes down, public transport operators have to again increase prices of their services, thus driving the demand further down. This ineffective urban transport policy brings about a considerable change in the structure of demand for city trips. An increasing number of city residents prefer to travel by car, which leads to a sharp growth in car use in the city environment and associated negative impacts.

It is very difficult to escape the institutional trap. In order to reverse the observed negative trends in the structure of the demand for urban transport it is necessary to restore the right price ratios when the cost of travelling by public transport is much lower than the cost of a car ride. To achieve that, an adequate city transport police needs to be developed that would result in lower public transport fares and make it costlier to use a private car in the city.

Additionally, high public transport fares, by contrast with a fairly low cost of travelling by car, leads to uncontrolled spread of car use and eliminates the dependency of the demand for public transport services on the cost of the services.

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