Forming the social optimum of passenger flows in urban agglomerations in Russia

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Abstract. The article asserts the role of transport policy in making a city comfortable for living and tourism. A theoretical framework is built for reaching the social optimum of passenger flows. The authors argue that reaching the social optimum is only possible by implementing a system of measures that would encourage the use of public transport and, in parallel, by implementing measures that would discourage people from using private cars. Substantiation is provided for an idea that an unregulated urban transport system is less effective than a regulated transport system that provides targeted incentives and deterrents for various personal preferences of city dwellers in order to reach the social optimum. The authors that variable taxes have the strongest effect on travel behavior. Comparative analysis is done of the specific features of various types of variable transport taxes. The authors propose measures for encouraging the use public transport and calculate the fiscal impact of introducing a distance-based toll levy in Yekaterinburg. The authors argue that a charge that vary by the time of day will make it possible to ensure a more even use of roads and parking space.

Introduction

Creating rationally structured transport systems is critical for improving the quality of life in modern urban agglomerations. The image of urban agglomerations and the quality of life there depends on how this issue is addressed.

Cities that commit themselves to encouraging the use of private cars have to expand their road networks at an accelerated pace. In densely built-up residential areas, such expansion is inevitably associated with changes in the structure of urban land. Roads take over land designated for other purposes, with land for recreational use (parks and boulevards) being the first one to go. When the capacity of the road network grows, privately owned vehicles start to be used with an increasing intensity. As a result, using a car in the city becomes even more attractive an option; the number of rides goes up; congestion reappears, spurring the need for more and wider roads. This spiral kept unwinding in the majority of US cities in the second half of the 20th century.

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Cities that adopt the policy of encouraging greater use of public transport have achieved completely different results. Many urban agglomerations in Europe integrated all modes of public transport into a single network and focused on the development of rail transit, thus achieving a shift in individuals' preferences to public transport. As a result, the cities were able to create an environment that is comfortable for city dwellers and tourists.

Transport policy in most Russian urban agglomerations is yet to take shape, so the problem of setting the right priorities is of prime importance to Russia.

1 Theoretical framework of the social optimum of passenger flows

The search for a social optimum in traffic allocation was pioneered by John Glen Wardrop [1]. In 1952, he 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 travelers. Wardrop proved that when each road user chooses their preferred means of transport, this choice is not socially optimal (Figure 1).

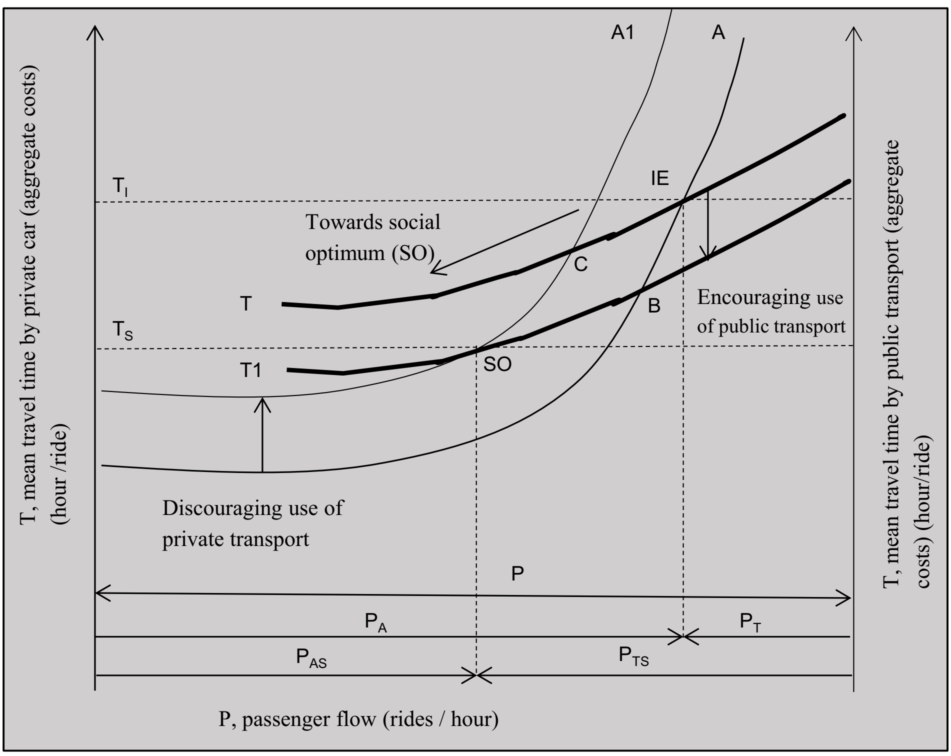

Fig. 1. A combination of transport policy measures aimed at shifting equilibrium of individuals' preferences towards the social optimum (SO)

The passenger flow, P, moves along the abscissa to the right for the A-curve (total expenses of a motorist) and from right to left for the T-curve (total expenses of a public transit passenger). In an ordinary situation, the dependences of aggregate costs on the density of the traffic flow for private and public transport intersect at point IE.

The point is the equilibrium point of individuals' preferences. A number of city dwellers (PA) decide to travel by automobile, while another part (PT) of them prefer public transport

(PA>PT). The aggregate expenses of all city dwellers are given by the area of the triangle restricted by line T1.

V. Vuchic argues that individuals' preferences as to the means of transport are pretty stable [2]. Despite any swings of the preferences, urbanites will eventually return to the point of equilibrium. In order to move the equilibrium point to the left towards the social optimum and ensure the stability of the new combination of individuals' preferences it is necessary to simultaneously take a set of measures. 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.

If any of the sets of measures is adopted in isolation, the structure of the passenger flow will change insignificantly. For example, if incentives are provided for the development of public transport only, the T-curve will be shift to the position T1, while equilibrium will move to the point B. The time of travel will change only a little and there will be a certain growth in the number of public transport users. If only measures discouraging the use of private cars are introduced, effects will be insignificant either, with the A-curve moving to the position A1. Equilibrium will move to the point C.

Only combined adoption of all measures of transport policy ensures a shift of the both curves, while equilibrium moves to the social optimum point (SO) that has a completely different set of parameters. There, passenger flows are almost equally divided between public and private transport (PA~PT), while aggregate expenses of all urban dwellers who use both private and public transport are significantly reduced. The social optimum can, therefore, be defined as the point SO where total expenses of all road users are minimized.

A city public transport system that governs itself and functions in accordance with the laws of the market ensures equilibrium of individuals' preferences at the level IE. Such a system is less effective in all cases and generates bigger negative effects than a regulated transport system that provides targeted incentives and discourages various preferences towards the social optimum SO.

Specific ways that each urban agglomeration works out in order to shift the curves of preferences for private and public transport towards the social optimum should become the foundation of a long-term transport policy.

2 Discouraging private car use

Such disincentives should be introduced in the form of a set of monetary measures that increase car owners' expenses on car travel and make the use of a privately owned car less attractive.

Travel behavior of a city dweller will be a derivative of the price of the planned trip. In addition to the price the city dweller will make his or her choice by taking into account such factors as time and convenience.

The price of the planned trip will be the key choice factor, so taxes and charges levied upon the trip will have the greatest influence on changing the travel behavior of car owners [3, 4].

Transport taxes and charges are not essentially homogeneous; they have different impacts on the behavior of car owners. Similarly to fixed and variable costs, it is useful to divide mandatory transport charges into fixed and variable ones.

2.1 Fixed transport taxes and levies

Tax rates are not pegged to the intensity of car use. They are paid on a one-time basis when a car is purchased and then on a regularly basis regardless of how often the car is used. In Russia, fixed transport taxes include VAT and a stamp duty on newly purchased cars, registration fees, the car recycling fee, and annually paid vehicle tax. The size of the taxes is a determining factor in the affordability of a car [5]. If fixed taxes are fiscally insignificant, (less than 10 to 15 percent of the cost of owning a car), larger groups of the population can afford to own a car. This increases car ownership rates among city dwellers and brings about serious negative transformations in the urban environment. Higher fixed taxes (25 to 30 percent of total costs of owning a car) is an instrument of keeping some city dwellers (usually those on a low income) from owning a car. At the same time, fixed taxes have a neutral effect on the intensity of car use. They influence long-term decisions as whether to own a car, but have not impact whatsoever on people's travel behavior.

2.2 Variable taxes and levies

These are taxes on car use. They are designed to compensate for negative externalities that are generated by the running of automobiles. High rates of variable taxes have the greatest effect on people's current travel behavior [6]. Urban agglomerations in Europe actively use variable taxes such as fuel excise duties, toll charges, vignettes, congestion charges, distance-based electronically collected tolls, toll lanes, paid parking (Table 1).

Table 1. Comparative analysis of variable taxes

Tax (levy)	Description	Use limitations	Supplementary effects
Fuel duty	Surcharge on fuel price	Impossible to take into account the local transport infrastructure	
Vignettes	Paid when a vignette is bought for a limited period of time	Unrelated to intensity of car use	Absence of additional enforcement costs
Congestion charge	Paid upon entering a certain area within a specific time frame	Imposes additional enforcement costs of setting up collection checkpoints	It is possible vary the charge depending on time of day or week (by excluding weekends or off-peak hours)
Road toll	A one-time payment that depends on the covered distance	Additional costs of setting up toll collection checkpoints	Can vary depending on time of day
Distance-based electronically collected toll	Distance-based payment debited from an in-vehicle device	Substantial one-time investment; vehicles need to be equipped with onboard payment collection devices	Toll can vary depending on time of day Can be used for collecting payment for and control of paid parking Can be used for speed limit enforcement
Toll lanes	Payment debited when the car crossed into a toll lane; does not depend on the distance covered	Additional cost of control equipment	Can vary depending on time of day

In Russia, only fuel excises have found wide application, while paid parking and road tolls are only starting to be introduced. The process, however, is extremely slow and is meeting strong opposition from car owners. There are not examples to be cited of congestion charges and distance-based road tolls in Russian urban agglomerations. The fiscal burden of fuel excises is insignificant. We have calculated that they do not exceed

4 percent of the costs of car ownership. Such a light fiscal burden does not change the transport behavior of city dwellers.

Russian urban agglomerations must develop new fiscal instruments that would meet the following fundamental requirements: (1) toll revenues must be spent strictly on the objectives of transport policy in the urban agglomeration where the road system was used; (2) tolls must be levied according to the distance travelled and be related to the type of the road (federal, regional or municipal); (3) the charge should vary depending on the day of the week and the time of the day (the highest during peak hours and a minimal charge during the rest of the day); (4) the minimal charge should match the marginal costs of road use, while the maximum rate should also include a surcharge. The surcharge would balance demand for the road network and its capacity. Such an approach to toll setting is outlined in the 2004 recommendations of the Council of the European Union and has already been successfully tried and tested.

Distance related electronic tolling meets the requirements best. It can be considered as a promising fiscal instrument for Russian urban agglomerations.

3 Incentives for public transport use

Public transport use should be encouraged with the help of a set of measures that alleviate the disutility of travelling by public transport. The disutility could be reduced by increasing the speed of transporting passengers to their destination, offering alternative modes of public transit, making public transport safer and more comfortable; introducing unified fares and universal travel cards; streamlining and cutting transfer time during intermodal journeys [7].

In Russian urban agglomerations the disutility of public transport can potentially be mitigated by: (1) identifying sources of long-term investment; (2) accelerated development of all means of rail transport with dedicated lanes; (3) consolidating the ownership of public transport and building a unified municipal public transit system with a single owner who is capable of aligning the timetables of all means of transport and implementing unified transport logistics; (4) adoption of long-term planning and involving people living in the agglomeration into the planning process..

4 Calculation of fiscal impact of distance-related charge in Yekaterinburg

For the calculations, we used financial indicators of a new electronic road pricing system that is being introduced in Singapore. The system offers additional advantages such as total speed and parking control in the city and the option of issuing parking and speeding tickets.

Table 2. Financial dimension of introducing an electronic toll system in Yekaterinburg

№	Indicator	Value	Note
1	Total cost of introducing an electronic toll system		Including the installation of a control system and equipping vehicles with onboard electronic units
	million dollars.	300	
	billion roubles	21 000	US dollar to Russian ruble exchange rate set at 1 to 70.
2	General characteristics of city traffic flows		
	Daily mileage of an automobile, km/day	38	According to a survey conducted by Klakson newspaper

	Number of automobiles, thousands.	451.7	In Yekaterinburg
	Dailycity transport mileage, thousand km/day,	17 165	
	Annual city transport mileage, million km/year	6 265.2	
3	Estimated payback period, years	5	It is advisable to estimate a minimum payback period because technological solutions quickly become obsolete
4	Annual toll revenue ensuring payback period, million roubles/year	4 200	
5	Minimal toll charge, roubles/km	0.67	
6	Daily toll to be paid by one motorist, roubles/day	25.46	
7	Annual toll charge per car owner, thousand roubles/year	9.3	
8	Daily petrol expenses (with average fuel consumption being 8 ltr / 100 km and petrol price of 35 roubles per litre), roubles/day	105	
9	Annual petrol expenses, thousands roubles/year	38.3	

The calculations show that the minimum daily cost of using a car in the city will be 25 roubles, which is less than 25 percent of what the car owner spends on petrol. Additional revenues are guaranteed from freight vehicles. It is possible to vary the charge depending on the time of day, thus encouraging a more even use of the road network and parking space.

Conclusion

Russian urban agglomerations must adopt radically new approaches to long-term transport planning. It is necessary to introduce programs of public transport development and rail transit development in the first place. It is also necessary to adopt fiscal instruments that discourage the use of private transport in urban agglomerations. It is necessary to develop modern systems of distance-related toll. There is good potential for an electronic toll collection system that has the option of contactless pay-as-you-go payments.

References

1. J. G. Wardrop, Proceedings of the Institution of Civil Engineers. **1**, 325–362 (1952)
2. V.R. Vuchic, *Urban public transportation: systems and technology.*(Englewood Cliffs, NJ, 1981)
3. L.N. Lykova, Journal of Tax Reform,**1**, 76–89 (2015)
4. S.H. Burrington, *ConservationLaw Foundation (CLF)*(Boston, 1994)
5. The European Electronic Toll Service (EETS). Guide For the Application of the Directive on the Interoperability of Electronic Road Toll Systems. (Luxembourg, 2011)
6. I. Mayburov, Y. Leontyeva,*8th Conference of the Euromed Academy of Business. Readings book proceedings*, 1529–1541 (2015)
7. A. Jonathan,*Congested and Nowhere to Go: Congestion, Road Infrastructure, and Road Pricing in MetroVancouver* (2013)