

# Monetary Factors of Suburbs Residents' Transport Behavior Change: Experience of Ukraine

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**Abstract.** Today the suburban passenger traffic flow plays an important role in the metropolis transport system, a significant share of which consists of private cars. A socially important is the introduction of fair principle "who rides, that pays" in the suburban passenger transportation. Its practical implementation should take place through the payment of negative effects (environmental pollution, maintenance of roads system in good condition, urban infrastructure development for human' benefit etc) by those who drive private cars in suburban traffic. The research is devoted to estimation of the suburban trip cost increasing, which can motivate a person to abandon the usage of a private car and switch to public transport. Another important factor in transport behavior changing of a suburban resident (the owner of a private car) should be increasing of customer value by public transport. This article proposes approach and method for estimation of increasing of suburban trip cost by private car, which motivate its owner to change transport behavior in favor of public transport when making suburban trips. The research results can be used by managers of passenger transportation companies, local authorities, and subjects of legislative initiatives to increase the share of passenger traffic flow carried by public transport.

**Keywords:** customer service value, suburban trip, transport behavior, pricing, driver costs, measurement of price tolerance, environmental pollution, ecology, road infrastructure

## I. Introduction

Modern megacities are becoming inconvenient for the citizens and are getting uncomfortable for suburban residents and guests who visit megalopolis. The pollutions that get into the air, three quarters consist of road transport emissions. The megacities road infrastructure is subordinated to cars. A significant share of traffic flow from the suburbs to the city is private cars. Therefore, changes in transport behavior of suburban residents who use private cars to travel to the city is the urgent need.

TDM (Transportation Demand Management) companies, which are designed to regulate transport behavior of a suburban resident, have a low efficiency. They do not take into account the specific motives of the person who uses the private car or public transport in suburban trips. The analysis of the choice between public transport and private car cannot be limited only by non-monetary part of the expected customer value (CV) of the trip. The person will not always choose the option of the trip that will have a higher level of the expected CV [1]. Since the cost of a suburban trip by the private car can make up a significant part of the family income, in the context of traffic behavior management there is a research question: "What level of cost increase of a suburban trip by private car can motivate the person to prefer public transport?".

## II. LITERATURE REVIEW

Sometimes the price sensitivity researches give accurate results, but in the most cases such efforts provide too superficial idea of the person's willingness to pay for the product [2, p. 490].

The structure of the driver's direct costs depends on the type (suburban direct, combination of public transport modes, own car direct or combined with public transport) and parameters of the trip (distance, marshroute, the need of parking, time of the day). Therefore, human economic motives that affect the choice of the moving in space are complex and branched. Thus in contrast to urban trip, the transport behavior of suburban car owners depend not only on the amount of their direct travel expenses, but also on their structure (distribution by cost items).

According to [3, p. 127-139] the ratio of direct expences and the sum of fixed and one-time costs in the United States is 13% to 87%. Drivers only partially compensate for external environmental and infrastructure expences. In US the coverage of all these costs is only 8%.

In Ukraine private car drivers cover only about 1% of the road network maintainance cost by paying excise duty on fuel. The need to introduce and (or) increase tolls for road use in the city is intensified by two factors [3, p. 347]. Firstly, it is necessary to increase the efficiency of their operation. Secondly, there is a desire to implement the principle of "who rides, that pays" to compensate for road transport's negative social and environmental consequences. The practical implementation of such initiatives is the most effective way to manage the transport behavior of private car drivers.

The idea that the consumer has all information to make decisions is one of the foundations of economic theory [4, p. 133; 5, p.14]. However, over the last fifty years, there have been many studies showing limited consumer knowledge about prices [6]. Thus the first step to increase the cost of the driver is the analysis of his price sensitivity, which uses various methods [2, p. 66-118]. However, it is important that the passenger transportaion companies managers and local authorities do not allow the dominance of estimates obtained as a result of respondents surveys when deciding about the trip to the city price [2, p. 534].

The classification of organization and price sensitivity measurement methods is given in work [2, p. 491], and its version adapted to suburban trips by private car and public transport is shown in Fig. 1.

		Measurement conditions	
		Uncontrolled	Controlled
Nature of variables	Trips by private car (current actions)	Panel of car drivers	Experiment with modeling of decision making process (field or laboratory)
	Public transport trips that can be used by the owner of a private car (intentions)	Survey or In-depth interview	Experiment with modeling of decision making process (field or laboratory). Conjoint analysis

**FIGURE 1.** Matrix of organization and methods of price sensitivity measurement for suburban trips by private car  
Source: adapted by the authors for [1, p.491]

Procedures for price sensitivity measuring (Fig. 1) differ in two main areas (and the variables that correspond to them): 1) measure travel variables that are already carried out by private car owners; 2) evaluate their intentions to travel by public transport. The conditions of such measurements can be uncontrolled (a person expresses a point of view about travel, and the researcher is an observer) and controlled (the researcher has the ability to manipulate variables that affect a person's decision to choose how to trip to city).

The choice of price sensitivity measuring procedure and method cannot be random [2, p. 533]. In our case we should distinguish the Gabor-Granger method and the van Westendorp method – PSM (Price Sensitivity Meter) among the acceptable methods of price tolerance measuring [7]. Both of these methods require a person's knowledge of the total cost of trip to the city by car. For succesfull implementation of economic sanctions for decrease of share of trips to city by car a person have to be able to answer the question: "How much will my expences increase?" and "How many times will my expenses increase?". The basis of comparison will be known as trip cost. The person will perceive such growth according to Weber-Fechner's law [8]. According to it, the reaction to the geometric increase of a suburban trip cost will be in the arithmetic progression nature. If the value of the suburban trip total cost is unknown to the person, or he is wrong in his estimation, the increase of the trip cost will be estimate as an absolute value and compared with the prices of other goods, services, family income. As wecan see the base of comparison here has changed. Therefore, the answer to the search question "What level of cost increase of a suburban trip by private car can motivate the person to prefer public transport?", is a non-trivial task. Based on these notes, the Gabor-Granger method is more acceptable in our research.

In the paper [4, p. 159-161] it is proved that the width of the transport ticket price range estimates depends on the prices knowledge for similar market offers. Thus in our case we check whether private car owner's reaction to the increase of the suburban trip cost (due to economic destimulation) will depend on the

knowledge of its initial cost. Achieving this goal is possible using the following research technique. The respondent is asked to indicate on the price scale as soon as possible (to avoid mental calculations) the cost of today's trip. The real cost is calculated based on clarifying questions about the amount of fuel consumption by a car of a certain model, distance of trip, cost for parking. The modulus of absolute error, which the driver estimated the cost of the trip, is measured as a percentage of its real value, and from the array of data, we get the average relative error. This average value of the relative error can serve as a point that divides respondents into price experts and those who do not know them.

### III. METHODOLOGY

Daily trips to work and study in Kyiv from satellite towns – Irpin, Bucha, Brovary – are becoming a factor that significantly changes the way of their residents' life. They try to decide what is better: wait for the bus, look for random companions for car-pooling, drive your own car or buy personal electric vehicles [9]. Instead, the management of suburban transportation companies and local authorities faces a managerial problem – search and realization of such motives of transport behavior of residents of suburbs which increase a share of passenger transportations by public transport.

The research problem [10] is the part of managerial – management has no information about the content and level of the CV trip "suburb-city" both by car and by public transport, when the person who owns a private car, will prefer public transport. The authors solved just a part of it – the task of finding economic motives and factors that motivate the person to choose one of the ways to move in the suburbs – a private car or public transport.

The boundaries of the marketing research was the traffic on the route Brovary - Kyiv. Time limits for the study of passengers' and drivers' transport behavior were limited to weekdays. The research participants were only those people who alternately use both public transport and private cars to travel into the city.

The main method of marketing research was a survey conducted on September 5-12, 2020 in the parking area in front of the shopping and entertainment mall "Terminal" in Brovary. In determining the attitude of private cars' drivers to the increase of commuter travel cost, 67 people were interviewed, so the study can be considered as pilot.

### IV. RESULTS

As a part of the European Union's Sustainable and Smart Mobility Strategy, it is planned to make 100 European cities climate-neutral by 2030 and reduce greenhouse gas emissions by 90% [11]. Even brief analysis of the transport situation in Kyiv metropolitan area shows that such goals in Ukraine seem extremely ambitious. According to the Kyiv City State Administration, 1.2 million cars are currently registered in the capital, 20% of them are trucks and the rest are cars. The infrastructure of the city is designed for 400 thousand cars only. In 2019, the number of cars increased by 30% due to used foreign cars, which were not cleared through customs in accordance with current legislation. Residents of the Ukrainian capital lose an average of 30 minutes in traffic jams every day, which accumulates in 9 days and 11 hours a year. In 2020, Kyiv ranked the 12th in the world and the third in Europe in terms of congestion [12]. It is noteworthy that the vast majority of the top fifteen countries in this sad ranking belong to the third world countries – they suffer the most from poor management of transport systems. This situation is partly explained by the fact that Ukraine's capital infrastructure acquired its general design in the 60-80s of the last century. Therefore, significant improvement in road capacity is almost unrealistic today.

Meanwhile, the pace of suburban housing construction is only growing. In 2014, pendulum migration to the capital was measured with the help of cellular operators and amounted to half a million people a day. Demographers estimate that Kyiv's population is about three million, so its daily population increased by one-sixth at that time. In 2020, given the number of housing built outside the city, pendulum migration can be estimated at 700 thousand people. According to the forecast, in 2025 Kyiv and suburbs residents will spend twice as much time on travel than in 2020 [13].

Suburban passenger traffic flow makes a significant contribution to congestion in the city limits of Kyiv and at its entrances. Thus, in 2020, the busiest subway station is Lisova (57 thousand passengers per day). This record flow rate is generated by Brovary satellite town. People traveling to Kyiv from Brovary choose a combined bus-metro and private car-metro trips or use only private cars throughout the journey. In fact, Brovary town generates the most of the pendulum migration. Therefore, release of the road infrastructure capacity part for public transport becomes an extremely important state task here. However, residents of the capital and suburbs do not see public transport as an alternative to their own cars [14].

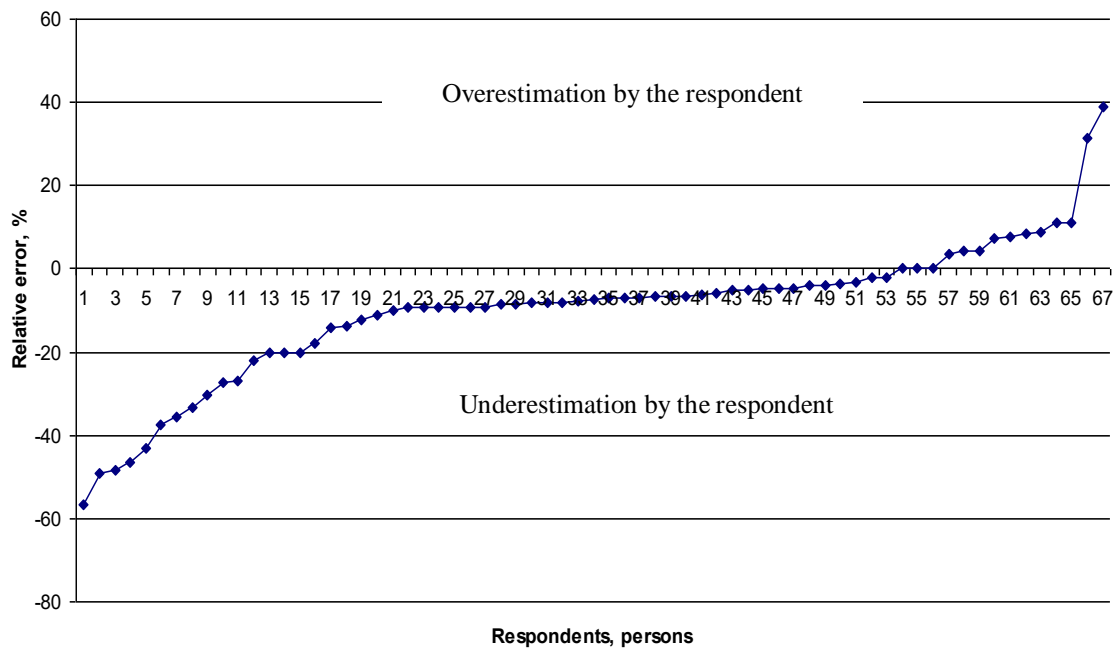
The open results of researches did not answer the authors' questions about the possible level of the cost increase of the suburban trip to Kyiv from satellite towns, which would be aimed at replacing a private car with public transport. It prompted us to conduct own research.

To find the answer on the search question "What are the amount of expences for traveling by private car, UAH according to the respondent?" spontaneous human reaction was recorded. The real direct cost of trip were calculated as the sum of the expences for fuel and parking in the city. According to the values of real cost and those that the respondent imagined when expressing a spontaneous reaction, the relative error of the person's assessment of travel costs  $\delta$  was calculated:

$$\delta = (E_t - E_r) / E_r \cdot 100\% \quad (1)$$

where  $E_t$  – estimation of expenses for a suburban trip by the respondent, UAH;  
 $E_r$  – estimation of real direct cost for a suburban trip, UAH;  
 $(E_t - E_r) = \Delta$  – absolute error, UAH.

Data for the array of respondents are presented in Fig. 2.



**FIGURE 2.** Relative error's distribution of the trip cost assessment by the private cars' owners on the route Brovary – Kyiv  
 Source: developed by the authors

From the data of Fig. 2 it follows that:

- 81% of respondents underestimate the real cost of the trip;
- 26% of people make mistakes in estimating costs by more than 20%;
- 59% of respondents estimate the cost with an error of up to 10%.

Additionally, surveys revealed that the share of those who (in their opinion) should have paid for parking was 43%, and only 9% paid for it.

So we can draw the following conclusions. Firstly, those who travel in suburban connections by private car tend to underestimate the cost of travel. Therefore, it makes sense to introduce TDM campaigns, which will be based on public informing about the effect of real cost underestimating. Secondly, the vast majority of people are well aware of the cost. This gives certainty that economic destimulation of car use can affect a significant share of passenger traffic flow and, if correctly determined, be effective. Thirdly, a quarter of the respondents still do not know (do not realize) the real value of cost. This requires extensive public information about structure and level of all cost items of trip by the private cars. Fourthly, payment for parking in the city limits is not inevitable. For example, the penalty from the patrol police for car parking in a forbidden place has the highest level of distinction in the courts. Drivers can avoid and avoid such punishment [15].

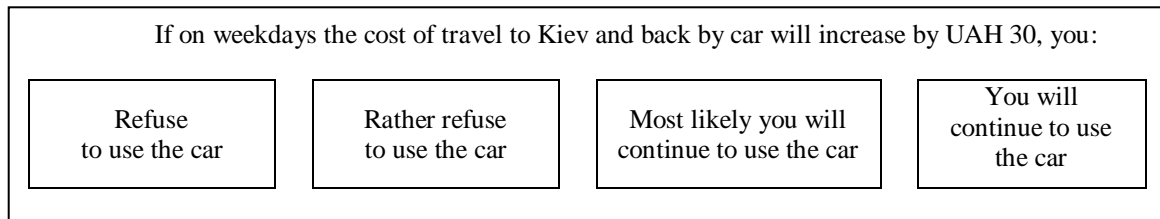
In order to find the answer to the range of values by which the cost of traveling by private car can be increased, a group of experts was selected. Five in-depth interviews were conducted with them on the

possible range of absolute increase in the cost of a suburban trip from Brovary to the center of Kyiv. As a result, it was decided to limit testing of human sensitivity to the increase of the available travel cost by the method of Gabor-Granger in the range of 30-150 UAH.

The probability distribution of private car owners' transport behavior changing depending on the increase of the travel cost was determined using the author's modified Gabor-Granger method. The modification was as follows.

First, the technique was used when one half of the respondents showed an increase in the cost of the trip from 30 to 150 UAH, and the second showed a decrease – from 150 to 30 UAH. This avoided a shift as a consequence of price demonstrations' effect order.

Secondly, the intention to switch from a private car to public transport when the cost of a suburban trip increased was recorded on the Likert scale [16] (example at Fig. 3). The price steps of the trip cost increase (decrease) were the values: 30, 60, 90, 120 and 150 UAH.



**FIGURE 3.** Example of measure intention to replace a private car with public transport when the cost of a suburban trip increases in 30 UAH  
Source: developed by the authors

Third, when using the Gabor-Granger method, such answers of respondents are often translated into a dichotomous scale "buy" and "do not buy". They are used to calculate the shares of those who buy and refuse to buy at each price step. However, in our case, the answers were digitized as a series of such probabilities - 0.25; 0.5; 0.75; 1. After the survey, the data for the entire array of respondents were processed, the average probabilities of continuing usage of the car for each price step were obtained.

Intentions (average probabilities) to replace a private car with public transport when the cost of a suburban trip increases in a range of UAH 30-150 presented in Fig. 4.

The data of Fig. 4 shows that if the cost of the trip increases by UAH 30, the probability of continuing using the car will be 0.7, and if it increases by UAH 150 – 0.28.

As we can see the change of choice of the way of commuter trip in half of the private cars drivers would be necessary to increase the cost of a suburban trip from Brovary to Kiev by 60 UAH. At the same time, the average real cost of the trip from Brovary to Kyiv in the our sample was UAH 72.2, which included only direct costs for fuel and parking in the city (in cases where it was paid). So the increased cost of the trip should be UAH 132.2. Therefore, given the current parking tariffs in Kyiv, it is not necessary to increase its price. Enough to do so that payment for parking will inevitability.

## V. DISCUSSION

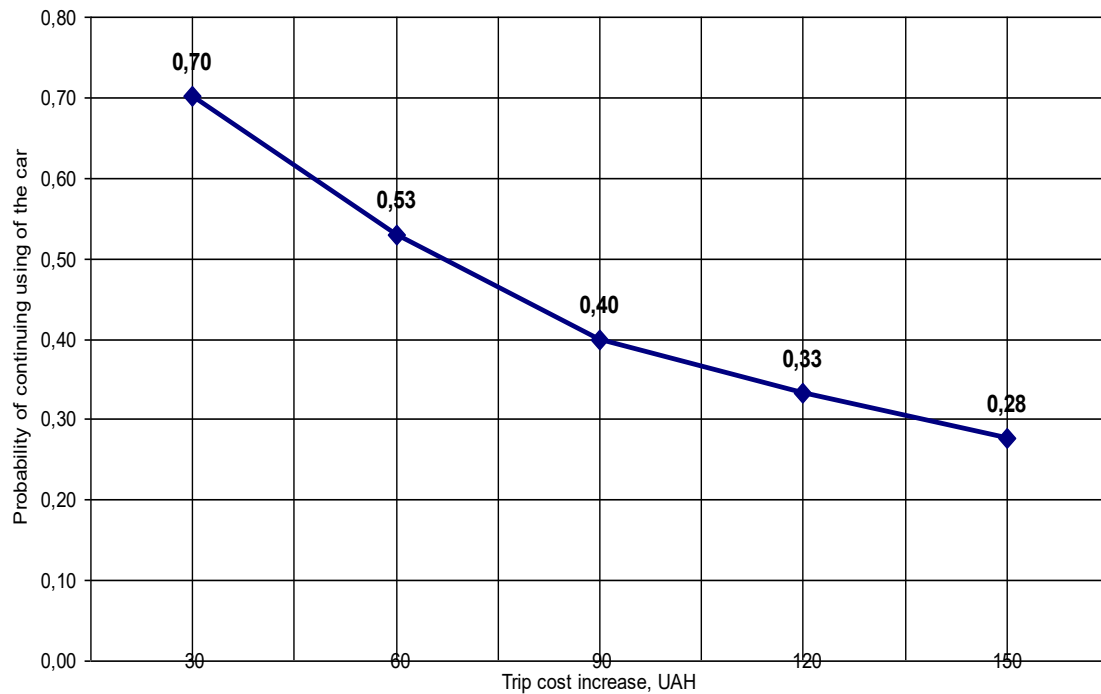
There is a public vital need to introduce a fair principle "who rides, that pays" in the suburban passenger transportation. Its practical implementation should take place through the payment of negative effects by those who operate private cars in suburban traffic. This have to improve the environmental and social situation by increase the share of those who use public transport when travelling to the city.

An important factor in the transport behavior of private car owners is knowledge of the true cost of commuter trip. Some of TDM campaigns (or it parts) can be built on educational communications to transfer such knowledge.

According to the authors, various ways of discriminating against drivers, related to the ban on travel, will work preferably within the city. And in suburban traffic, they can only be a part of the human transport behavior management.

Suburban residents will not want to give up the benefits of traveling by car, because significant part of the "suburbs - downtown" trip lies outside of city limits, where traffic congestions is not serious. In cases when the car still gets into a traffic jam (for example, at the entrance of the city), there will be public transport next to it (on suburban roads and intercity routes, usually there are no separate lanes for it). During such stop, the comfort in the car will always prevail over the conditions of stay in the cabin of public transport (process of transportation) [11]. The exception for driver may be greater traffic fatigue – a consequence of the need to drive a car in difficult road conditions. And in context of the commuter trip result (duration of travel, time

flexibility to start the trip, the ability to choose the route) the driver of a private car will always win compared to a passenger of public transport. Therefore, in addition to the expenses for traveling by private car, a significant factor in changing the transport behavior of suburbs resident should be increase in CV travel by public transport.



**FIGURE 4.** Respondents' intentions of replacing private car with public transport with suburban travel cost increasing  
Source: developed by the authors

## VI. Conclusions

Given the current tariffs for parking in all zones in Kyiv, it is not necessary to increase price. The important monetary influence for switching of suburb residents to use public transport instead of a private car is the inevitability of paying for parking in the city to everyone who comes to it. Other factors are improvement of content and increasing of CV of suburb passenger transportation by public transport.

Simultaneous creation of such preconditions of transport behavior and their accompaniment by educational communication campaigns capable to produce synergetic effect.

**Practical implications.** Managers of suburban passenger transportation companies and local authorities can use the results of research to increase the share of suburban passenger traffic flow carried by public transport instead to use of a private car.

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