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PRICE ELASTICITY IN PUBLIC TRANSPORT – A CASE STUDY OF THE CITY OF ZAGREB

ABSTRACT

A tariff policy with sound-based guidelines for ticket pricing in public transport is essential for shifting passengers from their private cars to public transport, and thus, for making urban mobility sustainable. The price elasticity is an important indicator of transport demand management in public transport that should be mandatory for every tariff policy; therefore, it is important to have the public opinion on the prices. This paper will present the current state of ticket pricing in public transport in the City of Zagreb; furthermore, it will present the results of the research related to price elasticity in public transport conducted on public transport users; and finally, it will provide the most important conclusions related to ticket pricing, providing further recommendations for improving the current tariff system in public transport.

KEY WORDS

City of Zagreb; price elasticity; public transport; tariff policy; transport demand management

1. INTRODUCTION

The price elasticity is defined as the percentage change in consumption caused by each one-percent change in its price of other characteristics such as travel speed or transit service. A negative sign indicates the effect is opposite from the cause (e.g. service-price relationship), and the positive sign indicates that the effect is positive (e.g. service-frequency relationship) [1]. Several methods have been used to calculate price elasticities, and the precision of the method depends on the situation. The most familiar are: shrinkage ratio (based on linear changes, useful for shorter changes) and arc elasticity (based on logarithmic changes, useful for wider range of changes) [2].

In recent years, there has been an increasing interest in transportation demand management, including pricing reforms, to achieve planning objectives such as congestion, accidents and pollution reductions. Critics sometimes claim that vehicle travel is insensitive to pricing, citing studies of declining price elasticities and examples of fuel or toll price increases that caused little reduction in vehicle travel. This implies that pricing reforms are ineffective at achieving planning objectives and significantly harm consumers [1]. Bresson et al. (2003), combining economic determinants with structural determinants showed that price elasticity of public transport is mostly related to the motorisation rate, making the financial equilibrium of the industry problematic [3].

As well as considering the direct effects of a change in fares, it is often important to consider the effects of fare changes on other modes. The usual method to consider the effect that other modes have on the demand for a mode of public transport is to use cross-elasticities, estimating the demand elasticity for a competing mode with respect to the change in the given mode [4]. The cross-elasticities should therefore be mandatory for observing the changes in demand, considering every mode of transport in

the urban area. Holmgren (2007) used meta-regression to emphasize the importance of level of service, income, price of petrol and car ownership to be added to the price elasticity [5].

To help analyse cross-elasticities, it is useful to estimate mode substitution factors, such as the change in automobile trips resulting from a change in transit trips. These factors vary depending on circumstances. Other trips will shift from non-motorized modes, ridesharing (which consists of vehicle trips that will be made anyway), or be induced travel (including chauffeured automobile travel, in which a driver makes a special trip to carry a passenger). Conversely, when a disincentive, such as parking fees or road tolls, causes automobile trips to decline, there is generally a 20 to 60 percent shift to transit, depending on conditions [6].

Price elasticities have many applications in transportation planning. They can be used to predict the ridership and revenue effects of changes in transit fares; they are used in modelling to predict how changes in transit service will affect vehicle traffic volumes and pollution emissions; and they can help evaluate the impacts and benefits of mobility management strategies such as new transit services, road tolls, and parking fees [6]. Matas (2004) used aggregate demand function to obtain demand elasticities to observe long-term impacts of introducing travel-card scheme, to conclude that passengers are most sensitive to price and quality variables [7].

2. BACKGROUND

The City of Zagreb is the capital and the largest city of the Republic of Croatia, with population of an estimated 0.8 million [8], and a population density of 1,200 residents per square metre. The metropolitan area of the City has the population of 1.1 million. The City itself is located on the southern slopes of Medvednica mountain, divided by the Sava river, with rough terrain only in the northern peripheral parts of the City. It consists of 17 municipalities, divided into 70 neighbourhoods.

The road traffic in the City is characterized by local streets, higher priority streets, and city avenues. Most of the city avenues stretch from east to west, making the current state of traffic subject to the capacity of roads connecting northern and southern parts. Since motorisation rate is 430 vehicles per 1000 inhabitants, and passengers are used to their private cars, traffic congestion is usual in the morning and the afternoon peak periods on each main road and avenue.

Public transport in the City is organized mostly by trams and buses. Passengers ride on 140 bus lines and 15 tram lines, with approximately 740,000 daily trips, and the public transport vehicles record very high passenger densities in morning and afternoon peak periods. Public transport network is stretched throughout the City, covering every significant part of the City, resulting in 10-minute walks in the city centre and 15-minute to 20-minute walks in the periphery. Although the fare charging scheme offers different price plans for public transport users, the dynamic performance represents the weak link, with 12 km h^{-1} operating speed unsatisfactory for passengers.

The mobility in the City of Zagreb is highly related on purchasing power, comfort provided by the private cars, and a poor transport policy by the city administration. Due to the financial crisis starting in 2008, one third of people use private cars, one third use public transport, and the remaining third is divided into pedestrians and cyclists, with a continuous increase of bicycle traffic in the past several years. Although public transport has become financially more acceptable than private car, it still does not represent an acceptable choice for passengers.

The city public transport authority, Zagreb Electric Tram (ZET), offers different types of tickets (paper and electronic) – single tickets, daily tickets, multiple daily tickets, monthly tickets, and yearly tickets [9]. With the increase of the validity period, the tickets become cheaper per unit period. Also, long-period tickets are cheaper for the privileged passenger groups, such as students or elderly people. At the time, the single ticket cost 10 HRK, and its validation was limited to 90 minutes. Ticket control is conducted by ZET officials in vehicles, usually randomly considering time and vehicles. The fare charging system is zonal (Figure 1), with the first zone covering the urban area, and the second zone

covering suburban areas of Zagreb County (such as Zaprešić and Velika Gorica). The cost of the single ticket is constant in both zones; however, the transfer between zones cancels the validity of the current single ticket, and an another one should be bought to legally continue the ride.

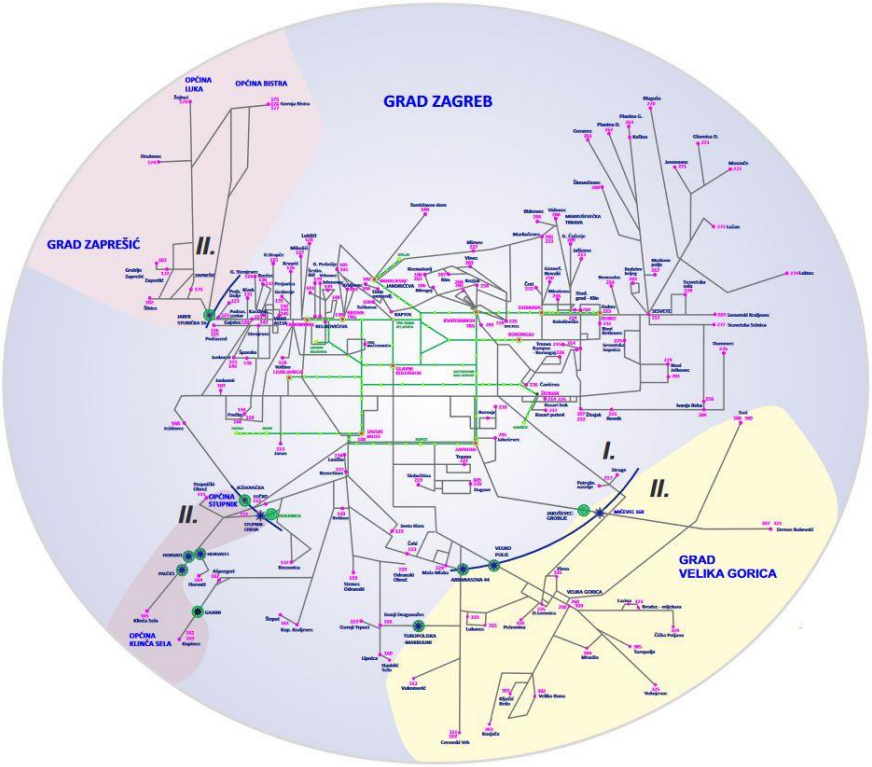


Figure 1 – The City of Zagreb – fare charging zones in public transport
Source: [10]

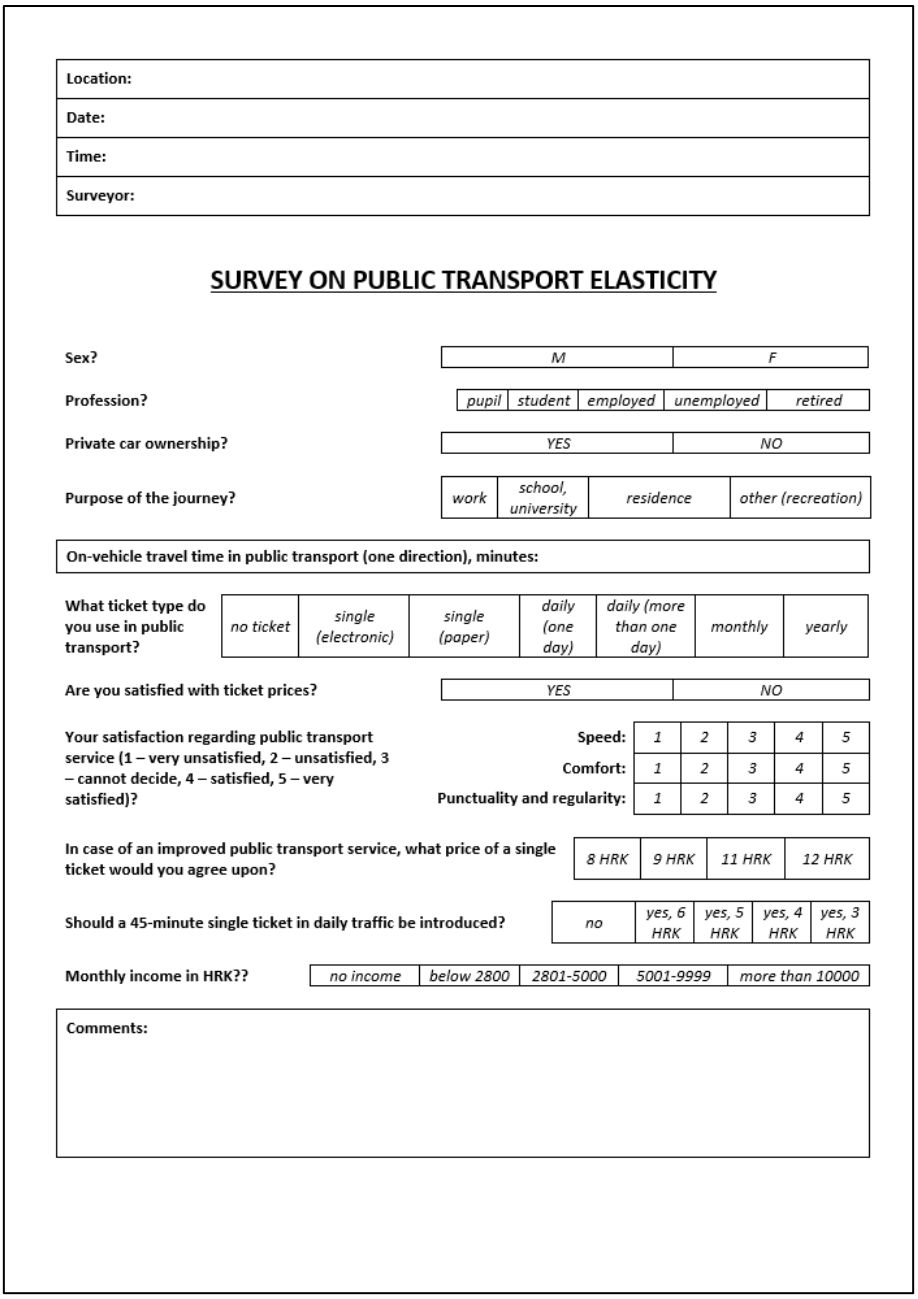
The research described in the paper was a part of the scientific research project "Evaluating the effects of measures and strategies of sustainable transport in cities", carried out by the Faculty of Transport and Traffic Sciences of the University of Zagreb. The goal of the project was to analyse the efficiency of the planned and applied sustainable transport measures and strategies, by observing cost efficiency, and implementing cost-benefit analysis. The planned project methodology was used to analyse the current progress on implementing sustainable urban mobility plans, and, by collecting relevant data, to analyse the current state regarding sustainable urban mobility plans in the Republic of Croatia. A great amount of the project focused on understanding user behaviour in transport system in the urban environment by analysing price elasticity in public transport and car parking management.

3. METHODOLOGY

The research on this paper is focused on public transport users, considering both public transport modes (tram and bus), since the single ticket is valid for the entire tram and bus network (as stated in the previous chapter, only the interchange between zones causes single tickets to expire).

The input data for the research was gathered by a survey on public transport users (Figure 2) in the City of Zagreb (the questionnaire used was originally in Croatian). The main purpose of the collected data was to get the information about price elasticity of the single ticket. The survey was conducted during October and November 2016 by the students of the Faculty of Transport and Traffic Sciences in Zagreb. The reference sample had the following characteristics:

- time periods: workdays (Tuesday, Wednesday, Thursday) at morning peak periods
- locations: 25 tram and bus stops with high transport demand
- data: 790 samples



Location:					
Date:					
Time:					
Surveyor:					

SURVEY ON PUBLIC TRANSPORT ELASTICITY

Sex?	*M*	*F*			
Profession?	*pupil*	*student*	*employed*	*unemployed*	*retired*
Private car ownership?	*YES*	*NO*			
Purpose of the journey?	*work*	*school, university*	*residence*	*other (recreation)*	

On-vehicle travel time in public transport (one direction), minutes:

What ticket type do you use in public transport?	*no ticket*	*single (electronic)*	*single (paper)*	*daily (one day)*	*daily (more than one day)*	*monthly*	*yearly*

Are you satisfied with ticket prices?	*YES*	*NO*			

Your satisfaction regarding public transport service (1 – very unsatisfied, 2 – unsatisfied, 3 – cannot decide, 4 – satisfied, 5 – very satisfied)?					
Speed:	*1*	*2*	*3*	*4*	*5*
Comfort:	*1*	*2*	*3*	*4*	*5*
Punctuality and regularity:	*1*	*2*	*3*	*4*	*5*

In case of an improved public transport service, what price of a single ticket would you agree upon?	*8 HRK*	*9 HRK*	*11 HRK*	*12 HRK*

Should a 45-minute single ticket in daily traffic be introduced?	*no*	*yes, 6 HRK*	*yes, 5 HRK*	*yes, 4 HRK*	*yes, 3 HRK*

Monthly income in HRK??	*no income*	*below 2800*	*2801-5000*	*5001-9999*	*more than 10000*

Comments:

Figure 2 – The questionnaire form used in the research
Source: authors

The data was then input manually using the Microsoft Excel and processed according to the type of questions and answers provided to get the insights. The elasticity mandatory for the research was the linear elasticity, as described in [11]:

$$E = \frac{P\ \Delta Q}{Q\ \Delta P} \tag{1}$$

, where $\Delta Q\ Q^{-1}$ is the percentage change of demand, and $\Delta P\ P^{-1}$ is the percentage change in price. Since the price elasticity in this paper is observed on single-ticket pricing, it is obvious that higher prices should result with less transport demand, and lower prices could attract more passengers to the public transport – the price elasticity will then always be negative, evaluated as [11]:

- Below minus one: elastic (the demand changes faster compared to the price)
- Minus one: unit elasticity (any price changes result in equal demand changes)

- Between minus one and zero: inelastic (the demand changes slower compared to the price)
- Zero: no elasticity (the change in price does not have any effect on the demand)

In this case, the information about the price elasticity was extracted from the question asked to the participants, related to a hypothetical scenario in which the ticket price changes from the current 10 HRK to possible 8 HRK (-20 %), 9 HRK (-10 %), 11 HRK (+10 %), and 12 HRK (+20 %). The elasticity was calculated as a linear function, with 8, 9, 11, and 12 HRK as independent variables, for two types of categories:

- private car ownership: two cases (yes; no)
- income in HRK: four cases (below 2,800; 2,801 – 5,000; 5,001 – 9,999; above 10,000)

Besides the price elasticity, the research results were divided into three additional groups, due to the importance of these additional results to the elasticity itself:

- The percentages of passengers for each ticket category (including illegal rides)
- User satisfaction
- The opinion about introducing the 45-minute single ticket

4. RESULTS

The results regarding the percentages of passengers for each of the ticket categories are shown in Figure 3, indicating approximately one third of active people. Single tickets (paper and electronic combined) belong only to one fifth of the total number of passengers. The interesting is also the fact that one fifth of total passengers ride illegally (no ticket).

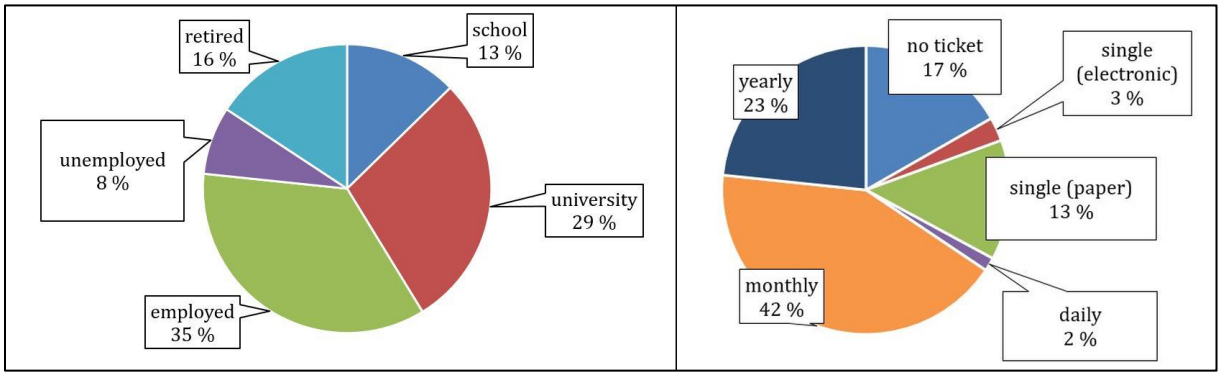


Figure 3 – Passenger categories – per occupation (left) and per type of ticket (right)
Source: authors

Regarding the user satisfaction, 54 % of passengers claimed that ticket prices are satisfactory. The satisfaction was also measured in three categories on the scale from one to five, and the results were:

- for the punctuality and regularity: 3.2
- for the comfort: 3.4
- for the speed: 3.2

The results regarding the most common passenger complaints are shown on Figure 4, with the following explanations:

- operating speed: vehicles running too slow, or their priority is neglected,
- information: passengers are poorly informed (pre-trip and on-trip)
- network: poor network density and stop accessibility
- personnel: inconsiderate drivers
- tariffs, fare charging schemes: fare charging schemes that do not meet the passenger requirements
- punctuality and regularity: vehicle departures not synchronized with the timetable

- prices: tickets inadequately expensive
- vehicles: poor cleanness and interior configuration
- timetables: insufficient vehicle scheduling

The most common passenger complaints can be summarized into two main categories:

- complaints about the quality of service (operating speed, information, network, personnel, punctuality and regularity, vehicles, timetables): approximately two thirds of passengers
- complaints about ticket pricing (tariffs, prices): approximately one third of passengers

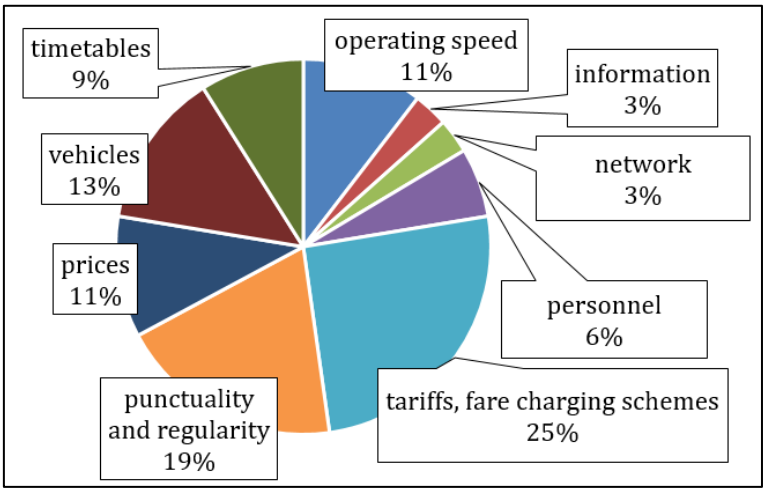


Figure 4 – The most common passenger complaints
Source: authors

Regarding the possibility to introduce the 45-minute single ticket, the results are shown in Figure 5. Approximately two thirds of passengers agree on introducing the ticket, with the majority opting out for the cheapest variant (3 HRK), and the variant in which the price was the half (5 HRK) compared to the current situation. Also, most passengers ride shortly: approximately two thirds under 30 minutes, and approximately four fifths under 45 minutes.

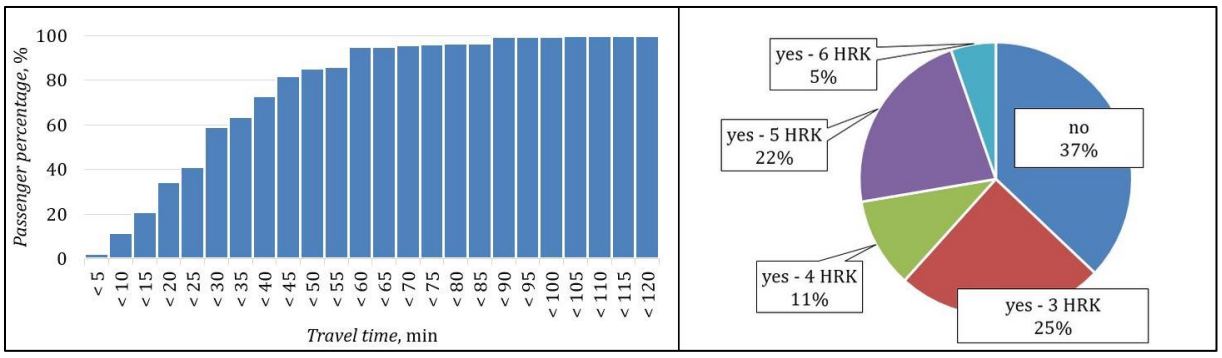


Figure 5 – The 45-minute single ticket – passenger percentage per travel time (left) and opinion about introducing the ticket (right)
Source: authors

The price elasticity per private car ownership is shown in Figure 6. For approximately one third of passengers who own a private car, the elasticity of -0.92 suggests mildly inelastic transport demand, and for the rest, the demand is mildly elastic (-1.09).

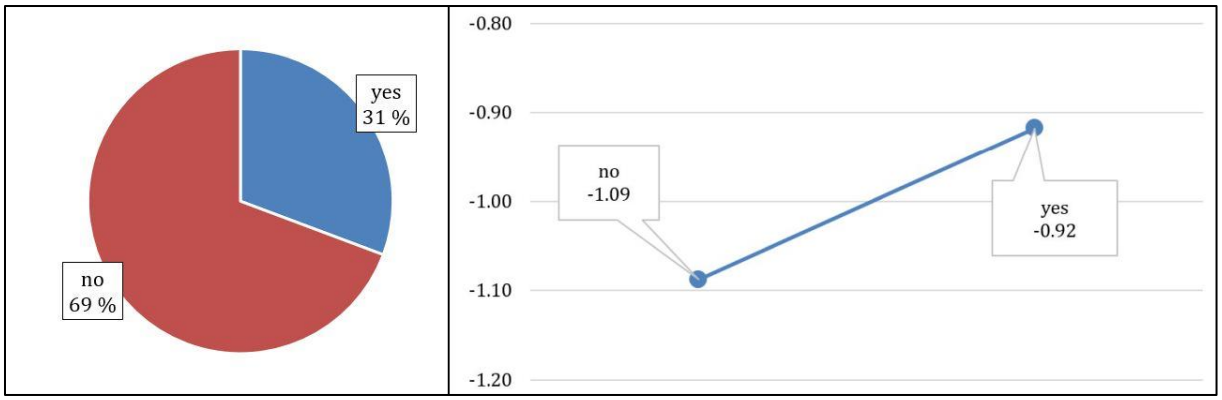


Figure 6 – Price elasticity per private car ownership: sample percentages (left) and the values (right)
Source: authors

The price elasticity per income in HRK is shown in Figure 7:

- For approximately two thirds of passengers who belong to the lowest-ranked income categories (no income, below 2,800), the joint elasticity of -1.10 suggests mildly inelastic transport demand
- For approximately one third of passengers who belong to the middle-ranked income categories (2,801 – 5,000, 5,001 – 9,999), the elasticities of -0.96 and -0.93, respectively, suggest mildly inelastic transport demand
- For a very few passengers, who belong to the more than 10,000 category, the demand is inelastic (-0.61)

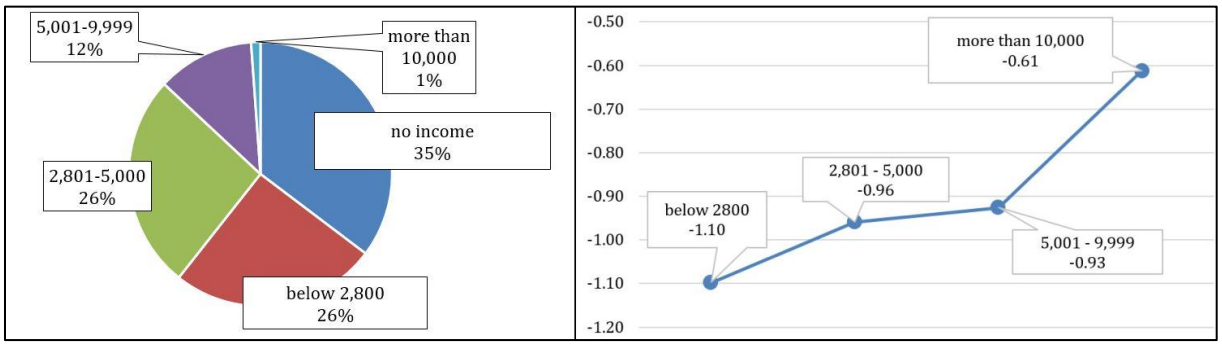


Figure 7 – Price elasticity per income category in HRK: sample percentages (left) and the values (right)
Source: authors

5. DISCUSSION

The paper focuses on passengers who use single tickets on their trips (one fifth of the sample). However, for a high-resolution analysis, the price elasticity should be observed for the rest three fifths, which use monthly or yearly tickets. The concerning illegal rides suggest that the existing ticket control should be improved. Also, most illegal passengers are more likely to become potential single-ticket users, making the research results more relevant.

The passengers were mostly complaining about the quality of service (two thirds). Therefore, the minority of passengers complaining about the pricing are directly connected to the mildly inelastic transport demand, regarding both private car usage and usual income categories. In other words, passengers put the problems related to the quality of service on top of the problems related to ticket pricing. This is also supported by the results on average opinion (comfort better than speed, punctuality and regularity).

Although the passengers were asked about the hypothetical scenario in which the quality of service would be improved, the majority (two thirds) would agree on introducing 45-minute single ticket,

which is consistent with the two thirds of passengers traveling under 30 minutes (passengers tend to have spare 15 minutes, to cover almost every journey). The choice on the minimum offered price of 3 HRK for most passengers (25 %) could be merely a psychological effect – every passenger would like to ride more cheaply. In practice, the 45-minute single ticket, which would have exactly a half validity period compared to the existing single ticket, could cover even four fifths of the current journeys. In practice, two benefits arise from introducing such a ticket – less illegal rides, and possible modal shift from private car to public transport for some passengers; both resulting in higher income for the public transport operator. However, for the mentioned four fifths of passengers, 45-minute single tickets monthly (2 rides a day, average 22 workdays in a month) could become a cheaper option if compared to the existing monthly ticket price of 280 HRK or yearly tickets, so the higher incomes for the operator cannot be guaranteed long-term.

The results for the price elasticity suggest the usual mindset among the passengers – for the ones who do not own a private car (and therefore, not having the private car option), the demand is naturally more elastic, because they rely much more on public transport for crossing longer distances. Considering the incomes, the situation is similar – the higher the income, the demand becomes less elastic, because the purchasing power determines whether the users will rely on public transport.

At the project dissemination, the representatives of the Zagreb Electric Tram were present as well, and they were informed about the research results regarding price elasticity in public transport. Approximately one month after the project dissemination, the City of Zagreb (the local administration body in charge of Zagreb Electric Tram) decided on introducing 30-minute single tickets for 4 HRK. The response of the public was satisfactory, and ZET has compared single-ticket revenues in February 2017 (14.8 million HRK) with the ones in February 2016 (9.0 million HRK) – a 64 % revenue increase [12].

6. CONCLUSIONS AND RECOMMENDATIONS

Regarding the price demand elasticity in public transport of the City of Zagreb, the research resulted with the following conclusions:

- the observed one fifth of citizens who use single (plus the additional fifth of illegal rides) are considerable for the observation, especially when the newly-introduced 30-minute single ticket could attract passengers who use monthly or yearly tickets – nevertheless, the research should be expanded to the entire passenger sample
- mildly elastic and mildly inelastic transport demand suggest that passengers prioritize the quality of service over the pricing in scope of the possible improvements
- the introduction of the 45-minute single ticket could cut down the illegal rides and shift some passengers from private car to public transport (at least for short-term) – this has been proven by the introduction of the 30-minute single ticket at the beginning of February 2017

Price elasticity can be an important indicator for creating an efficient tariff policy which could be able to manipulate the existing transport demand, and make modal shift from private cars to public transport for a considerable number of passengers. The future research would have to include a comprehensive price elasticity analysis, not only in public transport, but for the entire urban transport system, involving each mode. Only this kind of analysis would indicate how a sound-based tariff policy should be designed, contributing to the integration of the fare-charging schemes and more sustainable urban mobility in the City of Zagreb and its gravitational area.

ACKNOWLEDGEMENTS

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