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THE SURVEY OF POSSIBLE APPROACHES TO PRICE ELASTICITY IN PUBLIC PASSANGER TRANSPORT

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1 The Price Elasticity's Concept

Also after the entrance of Czech Republic into EU is more important focussing on support and development of such means of transport which are in light of power consumption, appropriation of land, influences on the life environment and operation regulation the most thrifty, complying with requirements on the life style, entireness of the environment, life standard and at the same time human's free will in relation to choice of time, route and the way of transport, limited only with regard to other public interest and enforcement of conceptual and programme approach which is based on cooperation of public and private sector and methodological experiences of EU's countries which are matured in transport

Transport functioning influences many other spheres and economic actual: impacts on regional development, landscape formation, planning huge agglomerations, situation of life environment or consumption of energy are above all perceivable.

One of the many tools which help to completion these ambitious goals and which can be used by the transport managers is also the concept of price elasticity of public passenger transport. The demand elasticity represents important complex of information which can be used for aiming of the advertising campaigns and for gaining information about adequate reaction of passengers or potential passengers on different price proposals. The price changes can be used for setting additional number of passengers or revenues which can be achieved by the change at price policy.

Price elasticity of demand (e) measures the change (sensitivity) of demand by changing price. So it's percentage change of dimension Y by percentage change of dimension X.

If e is smaller than –1 the demand is elastic and so the decrease in price by 1% will increase the demand by more than 1%. In case that e = 1 the demand is proportional so the percentage change at demand is the same as percentage change at price. In case when e is bigger than –1 the demand is non-elastic and the percentage change at demand is smaller than percentage change at price. If the elasticity is near to -1 it can be usually assumed heavy impact of regulatory interventions thanks economic tools. If the elasticity is near to 0 and if the regulation is a purpose of the policy, it has usually small impact. [3].

In the literature there is often described so called cross elasticity of demand which expresses the sensitivity of run on transport services of one hauler by change at price (tariffs) of another hauler. The income elasticity is the next, often described type of elasticity, above all in Czech literature and it measures range of changes at demand versus user's income.

2 Factors which influence the demand elasticity

Back in 1980 *The Transport Research Laboratory* (TRL) have published its summarising report which describes the demand in public passenger transport (Webster, Bly, 1980). This publication afterwards known as „ *The Black Book*"have described many factors which influence demand including their limits and limitations. The general principles published in „Black Book"remain still valid for almost 30 years of further research of demand in transport and their elasticity.

The demand elasticity in transport is influenced by many factors such as type of user (e.g. so called transit–dependent and non-transit dependent users, different demographic groups of inhabitants, cars' owners, people with different incomes etc.), type of journey (journey to work, journeys in free time etc.), geographic conditions, type of price change and its direction (e.g. changes at toll-road fee, changes in quality of services and parking charges), mean of transport (train, bus) and time period (**Gillen**, 1994), which must be taken into consideration during decision making process.

Another factor which must be taken into the consideration is time period – Longtime and short-time period– the users and companies are more adaptable to price changes in long-time period than in short-time period. So the demand is more elastic in long-time period than in short-time. Theoretically the users and companies are able to change their place of action even the assets in long-time period (property of vehicles, buildings etc.) whereas this is not possible in short-time period. According to this fact the long-time period models of demand should consider user's or company's choice of locality and property of assets (vehicles) together with transport demand. The Thombani's (1984) and Mannering with Winston's (1985) studies are the examples. They mould behaviour of households which possess car in reference to demand in public passenger transport. The values of the elasticity of demand in public passenger transport vary from –0.01 to –0.78, while the most of the values lay between –0,1 and –0,6. These values show that demand of public passenger transport is rather non-elastic. It's totally in accordance with other researches of the elasticity of demand in public passenger transport which were made by e.g. Frankena (1978) and Goodwin (1991). The elasticity of public passenger railway transport lays in range from –0,12 to –1,54. The authors [9] find outs further after the analysis more than 60 studies that a part of studies doesn't consider the presence of the intermodal competition that's why they recommend to include and emphasize price and quantitative characteristics of competing transport depatrments.

Tab. 1 *Values of elasticity for different type of passengers* (Gillen 1994)

Factor	***Value of elasticity***
Všeobecné jízdné	-0,33 till –0,22
Passengers under age 16 years	-0,32
Passengers aged 17-64 yeras	-0,22
Passengers elder more than age 64 years	-0,14
Passengers with lower incomes	-0,19
Passengers with lower incomes	-0,28
Owners of cars	-0,41
People who don't posses car	-0,10
Journeys to work	-0,10 till –0,19
Journeys for shopping	-0,32 till –0,49
Off-peak journeys	-0,11 till –0,84
Peak journeys	-0,04 till –0,32
Journeys shorter than 2km	-0,55
Journeys longer than 2km	-0,29

The Melichar's work [1] belongs among principal works which deal to the topic the price elasticity in public transport in CR. Further information about possibilities of usage of the price elasticity, including some results can be found in works of Brůhová-Foltýnová [29], which deal with the price elasticity of fuels, individual transport and particularly also with the elasticity in public transport related to the possibility of regulation of transport emissions. Together with mentioned above is probably the only one, more complex works which are devoted to the price elasticity in the CR, in addition to this they contain also the own results.

Tab. 2 *The Price elasticity* (Brůhová-Foltýnová, 2006)

	fare (public transport)	***price of fuels***
Individual transport (city)	-1.04	0.28
Individual transport (countryside)	-0.4	0.03
Public transport	-0.65	0.3

Also the works relating to the project Cycle 21 (Research of the transport behaviour of inhabitants in Plzeň) particularly deal with the topic the price elasticity e.g. Braun-Kohlová [28] and other applications of different companies or organisations which are engaged in transport planning (e.g.: Centre for Transport Research, Edip or iRFP, see also the used literature below this paper).

The aggregated time series are the most often used methods for analysis of the price elasticity in the CR. They enable to pick up long-time impacts of economical-political tools and disposals for single transport departments and so called cross-sectional data used for moulding short time impacts of regulations.

Foreign literature and resources, above all Anglo-Saxon, provide huge amount of information, studies and data concerning the price elasticity. The BTE Transport Elasticity Database Online [16] seems to be probably the most extensive resource, containing hundred references to this topic.

Unlike the CR is used a time differentiation more frequently, when it's used differentiation on short-time period (shorter than 2 years), medium-term (till 5 years) and long-time period (more than five years). Among the most important foreign studies and meta-analysis concerning the price elasticity in public passenger transport can be included (apart from above mentioned):

The American Public Transportation Association have published Pham a Linsalaty (1991, [21]), concerning the price elasticity in bus transport and its outputs are often used for moulding and transport planning in North America. In short time period study there were analysed impacts of the price changes in fares in 52 transport systems in the United States at the end of 80ties in the last century. Here is also mentioned so called Simpson-Curtino rule which says that each increase of fare by 3% it will cause the decrease in number of journeys by 1% (but this rule is considered directly by the authors as too much simplified and it's not suitable for detailed planning and moulding).

Goodwin [9] has made the detailed reinterpretation of international studies in 1992. The author assumes that price effects influence the demand in public passenger transport are during the time period increasing thanks to other possibilities of the passengers (increase of real incomes, accretive property of cars and the supplement of new telecommunication possibilities, which can substitute physical travelling to a certain degree). According to this study the price elasticity in passenger railway transport is –0.65 in short time period, in long time period then –1.08, the price elasticity in bus transport –0.28 or – 0.55 in long time period.

Luke and Hepburn have published the study in 1996 which regards to the price elasticity in public transport in Australia. The values found out by them (e.g. the price elasticity in bus transport in short time period –0.29, in railway transport –0.35 etc.) are used in many Australian transport-planning applications.

Gillen [8] has studied the elasticity for different groups of passengers and different journeys in year 1994 to prove by evidence how many different factors influence the price elasticity. He demonstrated e.g. that the owners of cars are more elastic than so called transit-dependent passengers and has confirmed that journeys to work are less elastic than journeys for shopping or entertainment.

Dargay and Hanly have studied the price elasticity in bus transport in log term period in Great Britain in year 1999. They have used the dynamic econometric model for it which operates with number of journeys per person, income per person, the level of fares and the level of services. Among others they have found out that demand has a tendency to be more elastic for higher fares.

The next study - Dargay et al., 2002 – has compared the price elasticity in Great Britain and in France between years 1975 and 1995. It turned out that number of journeys done by the public transport is decreasing by increasing incomes (although not in Paris where rich people are using public transport more than in other areas) and by increasing fares.

The elasticity depending on passengers' incomes alludes e.g. Paulley et al. The value of the elasticity in demand of bus transport in relation to passengers' income lays in the range from -0.5 to -1.0 in long term period.

The value of the price elasticity of fares in bus transport –0.4 in short term period, -0.56 in medium term period and 1.0 in long term period are mentioned in the study [26] The Transportation Research Laboratory (TRL) from the year 2004, for the underground then -0.3 in short/term and -0.6 in long term and – 0.6 for suburban railway transport in short term period. There is evident sizeable difference in the comparison with values which have been published more than 20 years ago in „Black Book" which were based on international aggregated parameters in short term period1. The results from this study led to, among others, setting „standard"value of the elasticity of fares in public transport whose value is -0.3.

Wardman and Shires have published the wide meta-analysis which use regress model and is focused on the values of the elasticity of fares in short term and long term period in Great Britain in year 2003. Meta-analysis had worked with almost thousand values of the elasticity which were published in 104 studies within years 1951 to 2002 in Great Britain. Some of the values of the elasticity calculated on the base of this meta-analysis are shown in the table nr. 3:

Tab. 3 *The elasticity of fares as a result of meta-analysis* (Wardman a Shires, 2003).

Mean of the transport / time period	***Elasticity***
Bus / short	- 0.36
Bus London / short	- 0.37
Bus in peak hours / short	- 0.30
Bus in off-peak hours / short	- 0.40
Suburban railway /short	- 0.52
Suburban railway in peak hours / short	- 0.42
Suburban railway in off-peak hours / short	- 0.65

Kain and Liu (1999) have studied demographic and other factors influencing volume of transport (number of carried out journeys. According to the authors one percentage increase in employment rate will increase the number of carried out journeys by 0.25%, while 1% increase in fare will decrease the number of journeys by 0.32%.

Tab. 4 *Some factors influencing elasticity* (Kain a Liu, 1999*)*

Factor	***Elasticity***
Employment in region	0.25
Population density in the centre	0.61
Change of serve (number of travelling km)	0.71
Fares	- 0.32

[1] Interesting is that suburban railway transport measured in short term period has the similar values round -0,5 which is not changing too much.

Phillips, Karachepone and Landis are dealing with so called service elasticity in their work from year 2001. Service elasticity shows how the number of carried out journeys is influenced by the quality of transport service such as availability, reliability, speed, comfort etc.

Voith had shown already in year 1991, that the price elasticity as well the service elasticity have increasing tendency in time. He concludes that „*reduction in subsidies in public passenger transport can lead into higher fares and lower quality of the transport service, what could finally cause higher subsidy costs* ". He illustrates also that „*increase in prices in public transport and decrease in the level of service's quality causes the decrease in number of journeys, requiring other increase of fares and consequently decrease in number of journeys* ".

Evans (2004) deals with the topic effect of changes in quality of services on the volume of carried out transport. The elasticity of volume of transport (number of carried out journeys) with regard to increase of services (e.g. newly implemented lines) does in this work [25] 0.6 to 1.0. It means that each improvement of services (in this case measured by increase of number travelled kilometres by vehicle or running hours) will increase the number of carried out journeys by 0.6 to 1.0%. The values so called „headway elasticity", elasticity of exploitation of public transport with relation to the frequency of this transport was 0.5 in average. Wide range of values is influenced by the character of the service, geographic and demographic factors in this case.

Preston and James have considered the topic the demand elasticity in dependence on the passenger's waiting time in their study from year 2000. The average value of elasticity was – 0.64, while the values for off-peak journeys were higher.

The interesting concept of the „service elasticity"is also time spent in a vehicle (IVT – in-vehicle time). The data about „IVT elasticity" from totally eight studies have values from -0.4 to – 0.6 for bus transport and the values in range -0.4 to -0.9 for regional railway transport.. (Paulley, 2006).

In Germany, in year 2001 there Storchmann has proved that sensitivity of usage mass transportation for free time activities (holiday, entertainment) on the price of fuels is significantly lower than for travelling by mass transportation to work (c. 3-5times lower). Jong and Gunn in year 2001 and in USA West a William in year 2004 have made the similar conclusions. So it can be said that despite of different methodologies it is achieved the similar results (as well in the CR, as some results of Cycle21 indicate).

Some other researchers use data from analysis of elasticity and cross-elasticity for constructing so called. multi-modal models which are used for predictions how different combinations of changes in fares, transport services and operating costs of vehicles can influence the number of journeys. These models are also used for solving tasks concerning the choice of different strategies, solving congestions and reduction of emissions. They also help to predict the contributions of integrated transport systems. One of the most known– METS - (Metropolitan Transport Simulator) was developed at the beginning of eighties in Great Britain. It enables to its users to predict the changes in public and individual transport which can results from changes in a quality of transport services, frequency of connections, prices and operating costs.

In year 1997 Henser has developed the model of cross-elasticity which examines relationships among different forms of public and individual transport. This model can be made for usage for predictions of impacts of changes in fares of public passenger transport on range of individual transport and effect of different levels of toll-road fees and parking fees on the number of journeys done by public transport.

So called „The Millenium Cities database" (created by International Association of Public Transport) covers hundred of world's cities and it contains demographic data, data about the city's structure, transport infrastructure, daily mobility or environmental factors.

Conclusion

From the studies, meta-analysis and researches done in CR results: it doesn't exist universal value of the price elasticity for all situations – different factors influence the price elasticity – e.g. type of passenger and journeys, geographic conditions, time period and many more others.

Available resources show that the price elasticity in public passenger transport is usually in range between –0.2 to –0.5 in short term period (first year) and it's increasing to –0.6 to –0.9 in long term period (5 – 10 years)2.

It seems that combination of decreasing fares, higher fees (parking fee, toll-road fee), improving service and better transport marketing can be particularly effective in an effort to increase number of journeys done by public passenger transport by reduction individual car transport.

Next it can be claimed that the price elasticity of so called transit-dependent passengers is lower than by „non-dependent"passengers. The price elasticity of off-peak journeys and free time journeys are almost two times bigger than peak and journeys to work. The cross-elasticity between public passenger transport and individual car transport is relatively low in short term period (c. about 0.3 to 0.4). It's necessary relatively high reduction of fares (in the case of free time journeys) for „conversion" of car's users and their transition to public passenger transport. In addition to this some passengers are more sensitive to other factors such as speed, frequency and comfort of transport.

It can be generally established from available sources in Czech Republic that the price elasticity of mass transportation ordinal correspondents to the results from other countries, the price elasticity of individual car transport is (in absolute values) rather higher than is mentioned in researches from other countries.

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[2] Usually is (with regard to indeterminateness and uncertainty) recommended to use the range of values

In the most of developed societies (usually in the suburbs) there the) transit-dependent passengers are only small part from total population, while non-dependent passengers („the ones who travel in free time" or those who have the possibility of choice) are potentially huge, but more „price sensitive"market segment.

Current models of price demand functions in single segments of demand in public passenger city and railway transport can be used for estimating fall-outs of price changes (tariffs of fares in passenger transport) on the size of demand. However the reality of mentioned estimations is limited by the fact if there will not be significant changes in average incomes of passengers and simultaneously new transporters will not enter with offer lower substitute services in public passenger transport at the transport market.

Knowledge of the demand is appreciable advantage for all transport managers, single companies, market analysts or state agents. Published values and approaches can be used for prediction how changes in fares or quality of the transport services can influence revenues and the volume of rides in the next year, while data from long term period analysis are suitable for strategic planning. Conventional transport models based on the data from short and medium term periods can be used for solving problems which concern transport congestions and emissions.

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Summary

THE SURVEY OF POSSIBLE APPROACHES TO PRICE ELASTICITY IN PUBLIC PASSANGER TRANSPORT

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This article summarises price elasticity and cross-elasticity for use in public transit planning, it describes elasticity and how they are used and shortly examines previous research on transit elasticity. Price elasticity can be used to predict the ridership and revenue effects of changes in transit fares, they are used in modelling and predicting how changes in transit services will affect vehicle traffic volumes and pollution emissions and they can help evaluated the impacts and benefits of mobility management strategies such as new transit services, road tolls and parking fees. An important conclusion of this small research is that no single transit elasticity value applies in all situations: various factors affect price elasticity including type of user and trip, geographic conditions and time period. Commonly used transit elasticity values primarily reflects short- and medium-run impacts. The resulting elasticity values may be appropriate for predicting how a change in transit fares or service will affect next year's ridership and revenue, but long-run elasticity values are more appropriate for strategic planning.

Zusammenfassung

DIE UMFRAGE MÖGLICHER ZUGRIFFE ZUR PREISELASTIZITÄT IN ÖFENTLICHEN PERSONENVERKEHR

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Der Artikel fasst die Preiselastizität und die Kreuzelastizität für die Anwendung in der öffentlichen Verkehrsplanung zusammen, es beschreibt die Elastizität und wie ist sie genutzt und kürzlich erforscht die vorige Forschung in der Verkehrselastizität. Die Preiselastizität kann für die Prognose der Mitreisenden und für die Erträge der wechselnden Fahrpreise genutzt sein, sie sind in der Modellierung und die Prognose genutzt, wie die Volumenänderung der Verkehrsmittelanzahl in dem Verkehrsdienst und die Produktion der Emission ändern werden, sie können bei der Bewertung der Auswirkungen und der Nutzen helfen, sowieso neue Verkehrsdienste, die Straßenbenutzungsgebühren und die Parkgebühren. Das wichtige Ende der Forschung ist, dass sich nicht die einfache Verkehrselastizität in allen Situationen lohnt: verschiedene Faktoren der Preiselastizität befassen den Typ der Benutzer und der Weg, die geographische Bedingungen und die Zeitperiode. Üblich nutzt die Verkehrselastizität, wie die Werte die kurz- und mittelfristigen Auswirkungen spiegeln. Die resultierenden Elastizitätswerte können für die Prognose in den Fahrpreisen oder in den Diensten passend sein, wie die Mitreisenden und die Erträge das nächste Jahr beeinflussen werden, aber die langfristigen Elastizitätswerte sind sehr durch die strategische Planung beeinflusst.