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Influence of the Fare Funding Type on Public Transport Demand – Case of Pilsen

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Abstract: The contribution deals with the evaluation of the influence of the change of the fare amount on the size of the demand for the urban public transport. In this context, it also deals with the impact of this change on the size of the sales of a relevant transport company. The assumption is that the primary task of the municipal transport company is to transport as many passengers as requested by the contracting authority. Like this, the transport company will comply with the definition of the city public transport as a public service from the long-term sustainability point of view with regard to the limited funds provided from public sources. Possibilities of funding public city transport are compared 1) with a hundred percent,2) partial and 3) zero amount of subsidy with regard to different sizes of the elasticity of demand. Comparisons are made on the basis of a simplified assumption of changes only in the prices of the individual types of tickets.

***Keywords*:** urban public transport; fare; public transport subsidy; tariff systems optimization; Czech Republic.

JEL: *R15, R48, R53.*

Introduction

The urban public transport is part of a complex of public services and therefore both the inhabitants and municipalities themselves are interested in their flawless functioning. At the same time, the local authorities at least partly participate in their management. Therefore, it is in the municipality's interest that transport service is provided in sufficient quality and range. This requirement is increasingly accompanied by the requirement of long-term sustainability. In this respect, the public urban transport can be perceived in a several levels:

- as a *supply corresponding to the demand*; it is necessary to meet the demand even of those groups of inhabitants who may not be very attractive from the economic point of view – the retired and handicapped people and such like;
- as an *incentive for inhabitants and tourists* to use the public urban transport (operated by the transport company anyway) as much as possible (effective use of the costs incurred);

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- as a *substitute for (mainly) car transport*; especially in large cities it causes a number of various problems: traffic jams, excessive pollution of the environment, excessive noise and such like; the cities then use the public transport as a return service for restrictive measures leading to restriction on car traffic in some selected parts of the cities.

Economic impacts of the changes of the fare, based on varying amount of public subsidies, will be analyzed in the article. The paper aims to analyze several factors influencing the demand for public transport, and to show methods applicable in analyzing the economic impact of the fare change. This will be shown on the example of Pilsen – a medium sized industrial city in the Czech Republic. This city, among other things, declares its preference for the city public transport in case of which "… it is necessary to further develop its network with the emphasis put on preference in such places where it is slowed down by the car traffic, and to implement comfortable junctions or to introduce further measures in such a way that the city transport can compete with the individual car transport in terms of comfort and speed." (Kozler, 2010, p. 6). In the analysis it is, however, necessary to see the costs and revenues of the transport company in a realistic way, as it must meet not only the requirements and needs of the city but it must also, as a minimum requirement, cover its own costs. The extreme examples of zero and one hundred percent subsidies from the city will be discussed with a compromise solution of partial coverage of costs of the public city transport from public sources.

1. Theoretical background and literature review

The demand for the public urban transport, the fare, public subsidies, quality of transport and sustainable development belong to the topics examined in relation to the public transport from various points of view and from various aspects of reciprocal impacts (Parry and Small, 2009), (Tisato, 1998). The requirements of the range and quality of the public urban transport are determined both by the needs of the user and by the economic possibilities of the given transport company or, as the case may be, the municipality. Two opposed objectives of the authorities meet here, i.e. the city, defending the interests of the passengers, and the operator. The process of optimization should, from the point of view of the transport company, aim at cutting costs in the passenger handling system and at the increase in the effectiveness of the operated connections(e.g. Danek at al. 2010, Cerny and Cerna, 2013). At the same time, it is necessary to maintain an adequate network of the public urban transport for all the groups of users. The appropriate price, knowledge ability and an adequate network of distribution channels for selling tickets can be seen as motivating factors whose existence is a precondition for the increased demand in case of the public transport.

The demand for the private transport increases in connection with the growth of the standard of living in developed countries. Although some studies point to the inefficiencies of the public transport systems(Harford, 2006), (Muñoz and Grange, 2010) or (Kilani et al., 2014), there are more and more people favoring the **sustainable development** in the sense of supporting the public transport, e.g. Redman et al. (2013). Abrate et al. (2009) point to the fact that the focus on restrictive measures concerning the private transport has overshadowed complementary policies aimed at improving the public transport service. Sharaby and Shiftan (2012) pay attention to the increase in demand for the public transport in connection with the necessity of reducing congestion and air pollutant emissions in city centres. They point out, however, the impact of fare integration on transit ridership and travel behaviour. Hodge et al. (1994) refers to the fact that it is complicated to quantify the environmental costs and benefits of the public transport. In his view the public transport should be supported significantly even by introducing a fare-free system but he adds that the urban transport in itself cannot solve the growing environmental problems. Grange et al. (2012) affirm that by the extension of the urban rail network by 10% the use of passenger cars will drop by 2% and the use of the public transport will increase by 3%. They have also found a positive impact (on average 20 – 30%) on the growth of the demand for the public transport in the regulation of the passenger transport in road pricing or taxes on car acquisitions. People´s preference for the public transport and cars was analyzed also by Beirão and Cabral (2007) who, among other things, infer that to increase the attractiveness of the public transport it is necessary to remove potential barriers in its use.

A question arises here **what way the demand for the public transport can be increased** and how to motivate the inhabitants of the developed countries to reduce the individual transport and, on the contrary, to use the public transport more. The possible measures can be divided into three basic groups: 1) *restriction of the individual transport*, e.g. imposing a charge on entering the city centre, high charges of parking or the complete ban on entering some zones, see for example Hensher (1998) and Cats et al. (2014), 2) *price incentives*, and 3) *non-price incentives*. The first type of measures is primarily engaged in non-public transport, which is not the subject of our study. Therefore, we will deal with the qualitative and economic aspects of the public transport as potential sources or incentives for increasing the demand for the public transport hereinafter.

The public transport is influenced by a number of external factors of a non-price nature, i.e. those that can be influenced neither by transport companies, nor by municipalities. In this connection we can mention economic, legislative, demographic, technological and other factors. Kuby et al. (2004), for example, observed hundreds of bus stops in 9 US cities and his conclusions point to the importance of factors, such as land use and accessibility, employment, population, percent renters within walking distance, park-and-ride spaces and such like. Taylor et al. (2009) tested dozens of variables measuring transit system characteristics while all of them are outside the control of the public transport system. These factors have been dealt with by more authors (Maa et al., 2013), (Hunecke, Blöbaum, 2001), (Redman et al., 2013).

Habitual behaviour is considered to be one of the main obstacles of the transition from car or motorcycle to the public transport (Chen, Chao, 2011). Baker and White (2010) come to the conclusion that affiliation to a specific social class, and namely the age, has absolutely the highest influence on the demand for the public transport and not even the fare-free system can make some groups of inhabitants change their car for bus. The influence of the income on the demand for public transport was examined by Dargay and Hanly (2002). They prove that the income elasticity is negative in the long-term, as the bus transport is inferior good, but at the same time they claim that higher income groups seem to be more sensitive to changes in bus fares (Rajnoha, Lesnikova, 2017). Taylor et al. (2009) was interested in relatively big differences in using the public transport in large cities in US and in this connection he points to the strong correlation of using the public transport with the size (according to the number of inhabitants) of the examined serviced area.

The services on offer and their quality are within the competence of the individual transport companies (Murray, 2011). The quality of the offered transport services must be observed not only on the basis of the subjective attitudes of customers. Eboli and Mazzulla (2011) or Tirachini et al. (2014) proved that it is also essential to consider the viewpoint of transport companies and their resources. Bureau and Mines (2011) focused on two alternatives leading to the increase in attractiveness of the public transport when they compared the effect of increasing the speed of public transport and reducing the fare. Similarly Kain and Liu (1999) and Taylor et al. (2009) showed the positive impact of a significant increase of the service standard and fare reduction. An original mathematical model expressing several criteria describing the quality by a single value is presented in Sivilevicius and Maskeliunaite (2014) for the case of the rail transport.

The quality of the public transport, as defined above, is closely connected also with the dwell time (e.g. Fernández et al., 2010). Fletcher and El-Genedy (2012) proved a substantial influence of the fare collection method on the dwell time, namely at the moment when 60% of the bus capacity is surpassed. Tirachini and Hensher (2011) also point to the importance of the chosen payment methods in connection with the high demand while they consider various payment methods and prove that an off-board payment system is the most cost effective. These conclusions have been verified by Sasaki (2014). It is obvious that the qualitative and price characteristics of the public transport cannot be easily split from each other as they are closely interlinked and they influence each other. Pelletier et al. (2011) (similarly also Song et al. (2014) and Bagchi and White (2005)) state in this connection that smart cards are not only an important source of income but also a precious source of data, for example in the field of price modifications or demand forecast.

The optimization of tariff systems definitely belongs to the solution of the price policy of transport companies. It also has an indirect impact on qualitative aspects of the public transport as they influence the size of demand. Indirectly they also effect the issues discussed above, as illustrated e.g. by Sharaby and Shiftan

(2012) on the example of Haifa in Israel. Abrate et al. (2009), on the basis of an analysis of 69 Italian local public transport companies, recommends specific Integrated Tariff Systems. According to Jansson (2008), complicated zone systems may be simplified significantly even when maintaining its economic efficiency (Nica, 2016; Rahman et al., 2017).

The price elasticity is an important factor influencing the size of the demand for the public transport and consequently the process of decision making of the municipalities. Price elasticity may be examined from different points of view and in various studies it acts both as an independent and dependent variable. Nevertheless, it is quite obvious that it attains various values depending on a number of factors and these values depend on more variables. Dargay and Hanly (2002) examine the demand for local bus services in England with regard to per capita bus patronage to bus fares, income and service level. Also Paulley et al. (2006) analyze the elasticity of demand for the public transport in England in relation to the influence of the fare but also to other factors, such as innovations in the price policy and developments in ticketing. Dargay and Hanly (2002) prove, by means of statistical methods, that the price elasticity grows with the amount of fare. They add that the increase of fares, when accompanied by the increase of services, leaves the demand almost unchanged. Bresson et al. (2003) use econometric models to estimate the short-term and long-term elasticity of the demand (Wroblowská, 2016). Hensher (1998) points to the differences in the fare elasticity among the individual types of tickets (individual fares versus season tickets). Borndörfer et al (2012) examined the cross-price elasticity for the changes of prices of the individual and monthly tickets by 5%, and he gained values in the range of (-0.93;0.25). At the same time he noticed that users of monthly tickets are more price sensitive than those buying tickets for the individual journeys. Song et al. (2014) found out that the travel time sensitivity is much higher with buses than with the underground.

On the basis of the above it is possible to identify the following parameters of the price elasticity:

- ⟨0.2; 0.5⟩[2] in the short-term period and ⟨0.5; 0.8⟩[1] in the long-term period, while values fall with the growth of agglomeration (Bresson et al., 2003);
- in the long-term period it is 1.5 up to 3 times higher than in the short-term period, while it moves within the range from0.1[1]in the short-term period up to 0.8[1]in the long-term period (Dargay and Hanly, 2002);
- -0.4; -0.55; or -1.0 for the short-, medium- and long-term periods (Paulley et al., 2006);
- in the range of⟨-0.43; -0.51⟩ (Taylor et al., 2009));
- in the range of⟨-0.23; -0.33⟩ (Kain and Liu, 1999).

[2] *Here the exact values stated by the individual authors have been preserved, even though it is obvious that the size of the demand in case of the public transport always develops in the opposite direction than the amount of price, i.e. the fare.*

The amount of the fare is inseparably connected with the municipality contribution. Generally, the municipality determines the conditions for the public transport that the transport company has to comply with. The amount of fare and the range of services on offer belong to these conditions, among other things. The costs consequently incurred to the transport company can be claimed from the municipality in the form of **public subsidies**. On the example of Oslo (Jansson, Truls, 2012) it is possible to demonstrate that the size of subsidies plays an important role in case of the increase of the demand for the public transport. The fact that without subsidies it is very difficult to upgrade the offered services, to reduce the fare or to extend the offer is proved by Baker and White (2010), by Tirachini and Hensher (2011) and also by Kain and Liu (1999). Bresson et al. (2003) prove that the measures focusing on reducing the fare by means of subsidies from the public sources can play a substantial role in the growth of using the public transport, and, contrary to that, in reducing the individual transport. Drevs et al. (2014) analyses the influence of subsidies on the willingness of the individuals to pay for the public transport.

High subsidies into the public transport are substantiated in case of a really high quality of the services on offer. Metaxatos (2013), in connection with subsidies, deals with the issue of the financial sustainability and simultaneously with the necessity to safeguard the transport for seniors who cannot drive their own car any more. Tirachini et al. (2014) states that reducing subsidies is not realistic in such a case when the main aim is to increase the demand. Under such a condition the competent authorities should buy means of transport with higher capacity or increase the frequency of the individual connections, which, by default, implicitly influences the amount of funds provided from the public sources. Similarly Grange et al. (2012) prove that it is suitable to invest funds in metro or rail networks. By these measures it is possible to influence the size of the demand for the public transport. However, no evidence is submitted proving that fare subsidies encourage the use of the public transport.

Borndörfer et al. (2012) dealt with verifying the reciprocal relationship between the amount of fare, demand and public subsidies. By means of non-linear models they were looking for such an amount of subsidy for which the demand would be the highest. They find a particular amount of subsidy which would enable the transport in a city for free together with maximizing the demand. But they claim also that it is not possible to identify "the best" amount of subsidies unambiguously as the ratio of the rising subsidies and the rising demand is nearly constant.

2. Methodology

Based on the above, it is obvious that a suitable fare in the public urban transport can help keep an acceptable ratio between the individual car transport and the public transport. This way it can motivate selected groups of potential passengers to a higher rate of using the public transport. Nevertheless, before starting our exploration we considered fare to be one of most important factor while investigating the relations between fares and public transport demand. Studies of secondary sources show, however, that this assumption was not entirely correct. Public transport demand is influenced by a complex of factors (largely qualitative), and fare is a partial criterion only.

For these reasons we, on the contrary to most previous studies, tried to examine the influence of the amount of public subsidies on the demand. We will calculate the impact of selected tariff strategies on the amount of the demand for the public transport. The need of subsidies needed to balance the company´s different amounts of costs and revenues with different levels of fare and demand may be calculated on this basis. On the case of the examined city the impacts of three possible empirical models of fare will be gradually demonstrated: a) *market fare with zero subsidies,* b) *fully subsidized fare* and c) *partially subsidized fare*.

The market fare model prefers the economic point of view and the final price of the ticket must cover the implemented costs. On the contrary, the free fare model prefers social and environmental aspects of the public transport. Although there are also extreme options implemented somewhere in the world, they are not very usual. The model with subsidies covering only a certain part of costs seems to be the most frequent one.

The impact of each of the three models mentioned above will be verified in the following steps:

1. The corresponding amount of fare will be calculated on the basis of the chosen type of funding;
2. The change of the amount of the demand for the public transport will be predicted by means of the price elasticity (E_{DP});
3. In relation with the change of the expected amount of the demand the estimated financial claims of the transport company towards the municipality will be re-calculated;
4. Finally, the long-term sustainability of the individual options will be discussed.

As stated in the previous chapter, many of the factors influencing the demand of passengers depend on the individual conditions of the individual locations. The implemented research demonstrates, however, that under certain conditions it is possible to generalize the economic aspects. This enables us to use the above mentioned findings concerning the price elasticity for our further examination. Although the results of various studies indicate that the price elasticity of the demand for the public transport is rather low, the influence of the change of the fare amount is by no means negligible. In our calculations we will operate with the empirically traced elasticity (see the above research) in the range (-0.3; -0.8).

A transport company can implement financial revenues from numerous activities (Plevny, 2014). We will, however, focus exclusively on the sales from selling different types of tickets. Apart from that a transport company receives subsidies from the municipality. On the basis of the pre-arranged conditions, every year the company draws up a plan of costs and revenues for the following year which is then submitted to the city representatives. The compensation must cover the difference between the costs and revenues. Furthermore, it must secure an appropriate profit. The ratio of sales from the fare and the total operating costs is monitored by the so called firebox (recovery) ratio which states how much of the cost is covered by the sales from the fare (Roskovcova, 2012). With all the calculations, unless otherwise stated, we will work on the data based on the last examined year.

2.1. Market fare model

When applying the market fare the transport company must set the amount of fare in such a way that it covers all the costs connected with providing transport in the given area. One of the most important reasons for implementing market fare model are excessively high requirements of subsidies, which a municipality may not be able to cover. The company cannot, however, require the full fare from all the passengers. Some specific groups of inhabitants must be by law provided with a discounted fare. The market fare may be quantified in two different ways.

The first calculation keeps the amount of the total annual revenues on the level of the last examined year, which means that revenues from passengers maintain recent level of profit. The second form of calculation is based on the substitution of previous subsidies by market fares. Therefore, we must determine the percentage of subsidies on the total revenues first of all.

When calculating the market fare and other characteristics we will use the data about the share of the sales from the particular types of tickets in the overall sales from all types of tickets. We also will use the data about the share of particular tickets on the overall compensation from the municipality and the share in number of the particular types of tickets sold in comparison to the total number of sold tickets. Calculated market fares will be used by prediction of the transport demand and overall revenues. Zero subsidies will be required in this case.

2.2. Free fare (fully subsidized) model

If it is in the interest of the given municipality that all the network of the public transport is free of charge for its inhabitants, it must adequately adjust or increase subsidies to the transport company. Provision of the service of the public transport free of charge suggests itself under the condition of the low coverage of costs from sales and high transaction costs for paying tickets. There are several arguments why to provide the public urban transport free of charge. Removing the costs related to collection and administration of payments and fast handling of passengers on bus stops can be considered an unambiguously positive consequence.

As mentioned in the literature review chapter, there are municipalities that have experience with the fare-free system. Among them, usually smaller communities are better served by fare-free policy (Hodge et al., 1994) but the ridership in those cases grows much more than it is predicted when applying the standard relationships valid for price elasticity. However, new problems arise - the problem riders, a higher number of riders, and such like. Some problems could be solved by the duty to own and use a customer card. Within this suggestion of the fare-free public transport we will consider the passengers who cannot or do not want to buy such a card as if the fare was maintained in their case.

We have divided passengers to those travelling regularly (they use any season ticket) and the visitors of the city, or, as the case may be, irregular passengers (they use the individual fare) with the share of 23.6% in the overall sales in the examined transport company (see Table 1 below). For the irregular passengers the fare would not change and their demand would then stay on the same level, or, as the previous empirical data show, the corresponding linear trend will be maintained.

With regular passengers a growth in demand may be assumed. Passengers would pay CZK 300 in a lump sum for the customer card as the cover for administrative costs, which is an amount customary also in other cities in the Czech Republic in which the fare is free. For the calculation of the necessary amount of subsidies we need to know the amount of costs and sales. With both the indicators a linear trend was traced on the basis of the figures from the past years which we will consider in our calculations.

2.3. Partially subsidized fare model

The model of the partially subsidized fare is one of the most frequently used models and it is applied even in the examined transport company. In this part of the text we will try and suggest some improvements in the system of fare of the Pilsen City Transport Company (Czech abbreviation is PMDP) which will not consist in significant changes of the fare amounts.

The aim of this solution should consist in removing the weaknesses of the existing tariff system. To understand the suggested change better it is necessary to describe the existing system in more detail.

Currently in Pilsen, the following types of tickets are applied according to the type of handling passengers:

1. Pilsen card – it serves as a season ticket (valid for a month, half a year, a year);
2. Pilsen ticket (a preloaded contactless card meant for paying for the individual rides);
3. SMS ticket;
4. Paper ticket – the individual fare bought from the driver or outside the means of transport.

Table 1 gives the most frequent distribution channels of tickets with stating the expense-to-sale ratio of their operation as related to the sales over the last four years:

Table 1.Expense-to-sale ratio of the individual distribution channels (in % from sales)

Distribution channel / Period	x-3	x-2	x-1	x
Card terminals (Cardman)	30.14	26.60	23.50	23.62
Independent distributors	7.15	7.15	7.28	7.31
Selling points of the transport company	7.12	6.91	6.92	10.43
Ticket vending machines in public spaces	51.06	46.97	47.76	54.47
Drivers of the means of transport	49.95	47.36	45.78	44.66
SMS	-	-	34.50	34.50

Note: „x“stands for the last examined year

(*Source:* Kozler; 2010)

It is obvious that the sales of tickets from the drivers and from the traditional vending machines located in public spaces are the most costly. Because the sales from the tickets purchased directly from drivers grow in the long-term, their expense-to-sale ratio decreases over the time. Vending machines and selling points show growth in expense-to-sale ratio by a few percentage points. This is caused by the growing preference of the distribution channels based on using modern technologies (Cardman – card terminals, SMS tickets) which take part of the sales away, although the absolute costs of operation of other distribution channels remain the same. 70% of the overall sales from the fare come from the season tickets, one fifth comes from the sales of the individual non-transfer tickets, and 7% comes from the sales of tickets purchased in card terminals. Sales of other types of tickets represent only a very small percentage.

The sales from selling tickets do not cover the overall costs of the transport company at all and therefore it is necessary to subsidize its operation from the funds of the city. In Pilsen the compensation in the long-term varies between 50 – 60% of the overall annual revenues, in case of the fare box ratio it is approximately 25 – 30%, in other words the income from the fare covers only one quarter up to one third of the overall costs. In the last examined year the subsidies from the city represented 59.28% of the total revenues of PMDP, the remaining part of the cash flow of the transport company was represented by the sales from the fare (23.48%) and the revenues from additional activities (17.24%) (PMDP, 2014).

Let us examine the impact on the demand for the Pilsen ticket if the price of the card itself decreases. The price of the Pilsen ticket is CZK 100 plus a loaded amount which can be loaded again after depleting all the funds. The price of a card with the loaded price CZK 120 is CZK 80.A day ticket purchased through Cardmancosts CZK 60. Thus the price of the card forms 166.67%, or, as the case may be, 133.33% of the price of the day ticket. Just for comparison, for example in Stockholm the price of the SL Access card represents 17.39% of the price of one day ticket. The proportion of prices in the Swedish metropolis motivates passengers to buy the chip card much more than in Pilsen. This motivation is especially strong if the passenger does not plan to use the card on the next visit of the city. The costs of production of the Pilsen ticket are approximately CZK 40 (Roskovcova, 2012). If more passengers used Cardman tickets, the expense-to-sale ratio of the channel would decrease with the growth of interest in this type of passenger handling. By high availability of the Pilsen ticket even the problem of the absence of the day ticket for the irregular passengers could be solved.

It is not necessary either to get rid of the paper tickets which still bring the company one fifth of sales from the fare and their distribution channels are the least costly. PMDP could find inspiration in books of tickets which can be found, for example, in Budapest (BKV, 2012) and other cities. A discount of 10% on one ticket purchased in a packet of 10 tickets can be suggested as a second option.

3. Results of the models

3.1. Market fare

The calculation of the first suggestion of the market fare is based on the fact that the sales from the fare amounted to 26.2% of the revenues in the last examined year. In case the existing system of discounts is not changed, the price of one full-price non-transfer ticket is CZK 46, and that of the discounted ticket is CZK 23, the price of the annual full-price season ticket amounts to CZK 13,200 and the price of the discounted annual season ticket amounts to CZK 7,600.

In case of the second way of calculating (Tab. 2) we consider the fact that from the individual fare it is necessary to cover 30.66% of compensation, particularly CZK 211million. The growth of price of one ticket would have to amount to CZK 22.31. If we want to maintain the system of discounts, it is not possible to increase the price of the full-price and discounted tickets by a fixed amount.

Table 2. Market Fare – suggestion No. 2

	Individual fare	***Annual ticket***
Compensation in CZK thousands	211 000	153 098
Share in overall compensation in %	30.66	69.34
Share in compensations for season tickets	---	32.00
Number of tickets sold	9 469 846	440 277*
Full-price fare in CZK	**35**	**9545**
Discounted fare in CZK	**18**	**4772**

** The number includes both the annual and monthly tickets.*

(Source: own)

The influence of both the ways of calculating the market fare is shown by Table 3. However, it contains the results of the calculation for E_{DP} = -0.3. If E_{DP} = -

0.8the demand with both the ways of calculation and with all the analyzed types of fare attains theoretically negative values and the sales then amount to zero values.

Table 3.Impact on demand and amount of required compensation when applying market fare ifE_{DP}=-0,3

Fare:	**Original price** [CZK]	**Suggestion No 1**			**Suggestion No 2**		
		Market price [CZK]	**The amount of demand** [% from original amount]	**The amount of sales** [% from original amount]	**Market price** [CZK]	**The amount of demand** [% from original amount]	**The amount of sales** [% from original amount]
Individual full-price	18	46	15	57.50	35	42.50	123.96
Individual discounted	9	23	15	57.50	18	40.00	120.00
Annual full-price	3 910	13 200	45.55	128.22	9 545	47.24	130.32
Annual discounted	1 955	7 600	5.14	21.41	4 772	47.24	130.32

(Source: own)

The impact on the demand for the full-price and discounted fare is the same in case of suggestion1. But the demand for the annual discounted fare would fall dramatically in this case. In case of suggestion 1 the price of the discounted season ticket increased 3.2 times, while with suggestion 2 it was only 1.8 times. Suggestion 2 does not have such a significant impact on decreasing the demand and the sales even amount to higher values than in case of the original prices. Nevertheless, the calculated values of the demand and the sales must be perceived as the maximum because of the fact that the more the elasticity approaches the value -0.8, the higher decrease there will be both in demand and sales.

3.2. Fare-free public transport

The calculated impact on the demand, when applying the fare-free system for regular passengers, is obvious from Table 4. The growth of demand in absolute values, i.e. from 25,200 passengers to 31,900, or, as the case may be, to 42,900 passengers can be seen best on the example of annual tickets. With the other types we have to consider the fact that, for example, a monthly ticket is bought twelve times a year and so the number of passengers is not identical with the number of the season tickets.

Table 4.Impact on the demand when applying the fare-free system for regular passengers

		Value in year x	Value E_{DP} = -0.3	Value E_{DP} = -0.8
Change in demand in %		---	26.32	70.20
Theoretical number of season tickets [thousands of pcs]	All types	415.2	524.5	706.6
	Annual tickets	25.2	31.9	42.9

(Source: own)

If we assumed a linear development of sales, the sales would amount, in case of the unchanged system of fare, to the values stated in Table 5. The second line shows the likely values of sales from the fare collected from irregular passengers.

Table 5. Impact on the sales when applying the fare-free system for regular passengers

Year	**x+1**	**x+2**	**x+3**
Sales from the fare in case of unchanged tariffs [millions of CZK]	290.3	295.4	298.1
Sales from irregular passengers [millions of CZK]	59.6	60.7	61.2

(Source: own)

As we stated above, the demand for the public transport would grow in case of introducing the fare-free system of transport. The volume of services would have to grow as well in order to meet the demand in its new size. At the same time a part of the costs would be covered by the sales from irregular passengers and other revenues which are not influenced by price elasticity but by a long-term linear trend in this case. It is therefore possible to forecast their development even in the years to come as is evidenced by Table 6 which shows the calculation for the third future year.

Table 6. Costs and compensation when applying the fare-free system for regular passengers in year x+3 (in CZK millions)

	Overall costs	**Sales from the fare**	**Other revenues**	**Compensation**
Value when E_{DP} = -0.3	1 528.0	61.2	239.3	1 227.5
Value when E_{DP} = -0.8	2 058.7	61.2	239.3	1 758.2

(Source: own, based on PMDP, 2014)

In this case the amount of compensation would have to increase by CZK 439.3 m (55.73%), or, as the case may be, by CZK 970.0 m (123.07%) as opposed to CZK 788.2 m, which is the amount required by the transport company in case of the unchanged demand, but only on the assumption that the linear trend of the development of costs and revenues can be maintained.

3.3. Partially subsidized public transport

In table 7 a survey of the impact on the demand and the sales in case of the price reduction of the Pilsen card is given – from the current CZK 100 (or 80) to proposed CZK 40. The estimated growth of the demand in case of types 80+120 and 100+200 is in the interval from 6% to 16%. The sales would, however, decrease to 84.80%, or, as the case may be, to 92.80% of the amount collected before the change of the price. In case of type 100+500 the growth of demand would not be as significant. It would move from 3% to 8%. The sales would drop to 92.70%, or, as the case may be, to 97.20% of the original sales.

Table 7.Impact of price changes of the Pilsen ticket on the demand and sales

Type of ticket	CZK 80+120 to 40+100			CZK 100+200 to 40+200			CZK 100+500 to 40+500		
	Original price	when E_{DP} = -0.3	when E_{DP} = -0.8	Original price	when E_{DP} = -0.3	when E_{DP} = -0.8	Original price	when E_{DP} = -0.3	when E_{DP} = -0.8
Demand [%]	100	106	116	100	106	116	100	103	108
Sales from card sale [CZK]	200	140	140	300	240	240	600	540	540
Sales [% from original amount]	100	84.8	92.8	100	84.8	92.8	100	92.7	97.2

(Source: own)

If we require the drop of sales not to be higher than 10% of the original sales, it would be necessary for the price of the card with type 100+200 to be reduced only by CZK 40. In this case the demand would only grow by 4%, or, as the case may be, by 10.67%. The sales, as opposed to the original sales, would fall to 90.13%, or, as the case may be, to 95.91%. If it was possible to increase the demand by 12%, as opposed to the original demand with type 100+500, the same level of sales would be attained as without any change in prices. With types 80+120 and 100+200 this would mean the increase of demand by 16%.

The impact of creating a book of ten non-transfer full-price tickets will be analyzed below, which would cost CZK 162 instead of CZK 180 (we consider 10% discount). With discounted tickets it would cost CZK 81 instead of CZK 90. In Table 8 we can see the changes of the demand and sales in case of the full-price and discounted fare. In case of both the border values of the price elasticity there would be an increase in demand and a decrease in sales.

Table 8. Impact of introducing ticket books on the demand and sales

		Full-price fare			Discounted fare		
		Original price CZK 18	Change E_{DP} = -0.3	Change E_{DP} = -0.8	Original price CZK 9	Change E_{DP} = -0.3	Change E_{DP} = -0.8
Demand [%]		100	103.00	108.00	100	103.00	108.00
Sales for one book	[CZK]	180	162	162	90	81	81
	[% from orig. amount]	100	92.70	92.70	100	92.70	97.20

(Source: own)

If PMDP wanted to maintain or exceed the original level of services it would have to reduce the fare by 15% instead of 10% in case of the value of price elasticity being -0.8. In this case the sales would attain 100.80% of the original amount. One non-transfer full-price ticket in the book would cost CZK 15.30 and the discounted ticket CZK 7.65. In case of the lower border of the price elasticity interval the company would have to reduce the fare even by 35%. Then the sales would attain 99.45% of the original value. In this case passengers would pay CZK 11.70 for a full-price ticket and CZK 5.85 for a discounted ticket.

4. Discussion and interpretation of results

We showed that there would be an increase of demand in all the examined cases except the one based on the market fare. It is, however, necessary to compare the positive impacts of the introduction of various systems of fare with possible negative consequences or problems which would have to be solved before their introduction. Hodge et al. (1994), for example, points to the overall impact of the fare. For example, in case of its increase there will be, on one hand, a growth of revenues, reduction of compensations and thus also an improvement in the value of fare box ratio but at the same time there would be a decrease in ridership and mobility of various social groups. On the contrary, in case of the fare-free system there is a growth of demand for the public transport and mobility of the population, which helps reduce traffic jams and pollution but the fare box ratio considered to be the main fiscal benchmark is close to zero.

In case of introducing the market fare there would be a significant drop in demand (when E_{DP}= -0.3) approximately by 62%, which is in contradiction with the mission of the city of Pilsen as well as with the concept of sustainable development. This variant, therefore, becomes unacceptable.

In case of the fare-free transport system there will be a growth in demand but the sales will drop. To make sure that the standard of services does not drop either it will be necessary to subsidize the operation of PMDP more significantly (approximately by 60 – 123%) and to invest in the maintenance and purchase of new means of transport as well. At the same time it would be necessary to solve other issues, such as problem riders. Contradictory impacts of the introduction of a fare-free system were noticed, for example, in Tallin, Estonia, where the vast majority of the increased demand (98.8%) was caused by the factors, such as extending the network of the public transport and the increased service frequency (Cats et al., 2014). In the long-term horizon there is a threat of underfunding which results from the lack of direct and independent sources of income. Calculations for Brussels (Proost and Dender, 2008) also indicate that only limited welfare gains can be obtained by charging near-zero fares in peak hours. It is also necessary to consider a relatively realistic but almost unquantifiable possibility that some irregular passengers become regular passengers and this would mean that the sales of the transport company would drop even further.

In case of partial subsidies the books of paper non-transfer tickets would lead to the increase of demand for the public transport. But their introduction would be accompanied by a slight decrease of sales. This negative impact on the amount of sales could be eliminated by a suitably selected marketing which could attract more people to use the public transport. Suitable marketing communication is perceived as an important precondition in case of the suggested price reduction of the Pilsen ticket to CZK 40. To attain higher accessibility of the individual tickets for irregular passengers a further cooperation with the existing distributors of the individual paper tickets can be recommended (dense network of distributors and low costs). And, contrary to the above, selling tickets directly by the drivers is not perceived as suitable as it drags out the time of handling passengers on bus stops and like this it indirectly decreases the demand for public transport.

5. Conclusion

Three models of funding the public transport of the city of Pilsen were examined: fully subsidized fare, partially subsidized fare and fare without subsidies. Empirically traced values of price elasticity in the range ⟨-0.3; -0.8⟩ and the data of the transport company for the past years were applied in the calculations. In each model, the impacts of the chosen type of funding on the amount of fare were examined, and by means of the price of elasticity the impact on the demand and, consequently, on the financial claims of the transport company towards the municipality was prognosticated.

In case of the market fare the amount of demand and sales varied significantly in our model, according to the applied value of price elasticity of the demand. With the value $E_{DP} = 0.3$ the sales of some types of fare exceed the original value of sales but with the growth of the absolute value of elasticity (within the above stated interval) the demand and sales are near zero. With regard to the fact that the value $E_{DP} = -0.8$ is more valid for the long-term horizon, we cannot consider the market fare to be acceptable in the context of the sustainable development. The fare-free public transport implies a significantly higher demand but at the same time disproportionately high claims for subsidies. Some studies even label this model as ineffective. It has also been proved that a higher demand for the public transport decreases the quality of transport services, which is again in contradiction with the concept of the sustainable development. Therefore, a kind of modification of the existing system seems to be a solution. Both the suggested changes, the price reduction of the Pilsen card and the individual tickets sold in books lead, in case of both the monitored rates of elasticity, to an increase in demand (up to 16%). The influence on the sales is slightly negative (drop of up to 15.2%), but with regard to the declared principles of the development of the transport system of the city it can be seen as acceptable.

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