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Demand for urban public transport in the Czech Republic

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Abstract: The research aims to analyse the influence of selected factors on the demand for urban public transport in the Czech Republic. Urban public transport is important publicly provided service worldwide. In the Czech Republic this means public ownership of transport companies and massive subsidies from municipal budgets. In line with the literature, we tested the effects of the fares, the quality of services offered, the population´s income, car ownership, the urban population´s size and employment level. Using cointegration and regression analyses of data for 2004 to 2019, we constructed unique demand models for selected cities. Our analysis revealed a positive effect of quality, fuel price (as a cost associated with car ownership), and the urban population´s size. In contrast, unemployment and the price of fares have a negative effect on demand. The income effect depends on whether the transport company operates vehicles that cope better with traffic congestion.

Keywords: demand, local public service, urban transportation systems

JEL Classification: H4, R4

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Introduction

Urban public transport realizes the most extensive output measured in the number of passengers and the number of passengers-kilometres compared with other areas of transport in the Czech Republic.[2] It is a typical example of a local public good provided by municipalities (see e. g. Mulalic and Rouwendal, 2020). Urban public transport is even identified as a notional flagship public service provided by local governments (see Millward, 2005). In the Czech Republic, municipal authorities tend to be owners of transport operators, which are closely linked to the municipal budgets.[3] Transport expenditure in the Czech municipalities with at least 5,000 inhabitants (excluding the capital city of Praha),

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[2] See statistics of goods and passenger transport and transport outputs, Ministry of transport survey. Available at: https://vdb.czso.cz/vdbvo2/faces/en/index.jsf?page=vystup-objekt&pvo=DOP05-D&z=T&f=TABULKA&skupId=1613&katalog=31028&pvo=DOP05-D&c=v3~8__RP2021.

[3] In our sample cities, the transport operators (except in Teplice) are publicly owned.

where 60 % of the country's population lives, accounted for 17 % of the municipal budget in 2020, making it the second largest expenditure item (see Kameníčková, 2020).

An important argument for the public provision and subsidies for urban public transit is economies of scale (details see in Small and Verhoef, 2007). Carrying many passengers in a single vehicle is a more economical alternative to car travel, especially in urban agglomerations with a higher population density. Furthermore, shifting passengers to public transport and thus reducing car traffic is beneficial for the community and environment. Swianiewicz and Brzóska (2020) remind us that urban public transportation can be solution to problems with traffic jams, scarcity of parking spaces, reduced attractiveness of cities for pedestrians, excessive noise, and increased air pollution caused by cars. Finally, subsidised public transport fares are a vital help for people who would otherwise find it too expensive to get to work, schools, doctors, authorities, culture, sports etc.

For municipalities, as policy-makers in transport, founders of transport companies, or a major source of funding, it is crucial to know what factors affect demand for urban public transport services. For example, suppose a municipality wants to influence well-being, traffic safety or air quality in its territory. In that case, it can implement policies that will get more people to the public transport. Furthermore, if the municipal authority knows how passengers might react to external circumstances, it could respond in advance to anticipated demand developments by adjusting the extent of transit services accordingly.

Moreover, in line with the Niskanen´s (1996) theory of bureaucracy, we can assume a positive impact of a growing number of passengers on the farebox recovery ratio and subsequently on the efficiency of the bureaucratically managed public transit operators. For example, since new travellers come to previously unprofitable routes, and assuming that the range of services is maintained, revenues will increase with demand growth. Consequently, weaker pressure on subsidies can be expected.[4]

We have mainly observed stagnant or declining numbers of passengers in urban public transit in our sample of eighteen Bohemian, Moravian and Silesian cities between 2004 and 2019.[5] The demand has increased only in five cities (Praha, Plzeň, České Budějovice, Pardubice and Jihlava) during the period under review. Simultaneously, in almost all the cities public transport companies´ farebox recovery ratio has stagnated or declined. Only in Plzeň and Děčín did the farebox recovery ratio increase in the period under review. Unfortunately, our correlation analysis of the time series did not confirm an unambiguous relationship between the demand for urban public transport and the farebox recovery ratio. For example, the high positive values of the correlation coefficients in Zlín with Otrokovice, Chomutov with Jirkov and in Opava suggest that the transport companies are coping poorly with the decline in demand. Although they are trying to compensate for declining revenues by raising fares, their dependence on subsidies is high.

[4] An interesting analysis of the efficiency of urban public transport systems in the same cities as our sample (except Liberec with Jablonec) was conducted by Fitzová, Matulová and Tomeš (2018). Their analysis suggests, among other things, that the efficiency might be higher if there is a lower share of the subsidy in the operator´s revenue.

[5] We distinguish three historical lands of the Czech Republic.

Konečný and Brídziková (2021) have monitored a decline in passengers using public transport in Slovakia between 2013 and 2019 as well as Swianiewicz and Brzóska (2020) who report a drastic decrease in the number of passengers using the public transport in Polish cities over the last decades. Development of the demand for public transit in our country and our neighbors with similar history after World War II seems to be in line with the worldwide trend. Nelson and Weikel (2016) or Curry (2016) attributed this trend to several reasons, namely the rising standard of living of the population, which, together with falling fossil fuel prices, has led to greater availability of individual car transport. Another cause is the increase in fares as well as an outflow of passengers to alternative taxi services and other modes of individual transport. The decline of urban public transit passengers in twenty-five US and Canadian cities has been confirmed e. g. by Boisjoly et al. (2018). They explained their finding by reductions in the amount of transit service implemented, associated with rising fares, or by rising personal car ownership linked to falling fuel prices.

Our research aims to analyse how the demand for urban public transport is determined in the Czech Republic. Although there many experts specializing in the organization of public, and hence urban public transport, it seems that not many studies have been published on the economic analysis of the consumer demand for urban public transport in our country. The price elasticity of the demand has been calculated by Melichar (2003), Pojkarová and Ježek (2009) measured the sensitivity of the demand to income. While Pojkarová with Ježek used data for the whole country (for 2007), Melichar (2003) employed data only for one city (Pardubice for the period 1993 - 2001). Similarly, Plevný (2017) used data from one city (Plzeň) in his analysis of the impact of different subsidy policies on demand for urban public transport. In contrast to these Czech studies, we examine the influence of multiple factors on demand for urban public transportation across a number of cities. Analyses of the impact of multiple factors on demand for urban public transport are available in Slovakia (see Gnap, Konečný and Poliak, 2006 or Konečný and Brídziková, 2020) and Poland (see Swianiewicz and Brzóska, 2020).

The next section describes the urban public transport demand model, which is the empirical analysis´s background. The procedure and results of the analysis are presented in the following section. The last section concludes.

Model of the urban public transport demand

Economic theory teaches us that a price of goods or service determines the demand (quantity). However, there are no free market forces in urban public transport and fares don´t, in fact, reflect the marginal rate of substitution. Due to market failures and income inequality, the fares are massively funded by municipal budgets through subsidies to the transport operators.[6] Their pricing policy may be in addition influenced by interests of politicians and bureaucrats.

The sensitivity of the urban public transport demand to the price is a frequent research interest. Plevný (2017) agrees with Holmgren (2007) that estimates of the price elasticity

[6] In 2019, the farebox recovery ratio of the transport companies in our sample cities was on average 42 %, the smallest ratio was in Ostrava (22 %), the highest in Plzeň (62 %).

of the public transport demand vary between regions and over time and depend on the models used and the quality of data analysed. Moreover, a distinction should be made between short-, medium- and long-term elasticities (Balcombe et al., 2004). Preston (2015) gives urban public transport as an example of a service with inelastic demand with respect to price. Holmgren (2007) regards elasticity as equal to -0.3 as a rule of thumb in urban public transportation. It corresponds to the mean elasticity of -0.38 for eighty-one estimations included in Holmgren´s meta-analysis (elasticity values range from -0.009 to -1.32). Value -0.38 has been estimated for the price elasticity of the demand for urban public transport in Poland (see Swianiewicz and Brzóska, 2020).[7] This elasticity is said to be low and reflects a low level of fares. According to Swianiewicz and Brzóska (2020), the fare price would need to rise about three times so that it significantly impacted Polish passengers´ demand. This conclusion is consistent with the result of the insignificant price variable in their panel regression analysis. Subsidies would have to be removed so that demand became sensitive to the price of fares. Swianiewicz and Brzóska (2020) thus confirm a significant impact of subsidies on the fares and hence on demand. The effect of subsidies is also evident from Plevný´s (2017) simulation of how the demand would behave if the subsidy for the transport operator changed in the Bohemian city Plzeň.

On the assumption that the demand for urban public transportation in the Czech Republic is rather inelastic with respect to the price and that the price is not an instrument how to achieve profits of municipal transport operators, we incline to believe that the price of the fares will not be a significant determinant of the demand for the urban public transport services in the Czech Republic.

Holmgren (2007), Brechan (2017) and Swianiewicz and Brzóska (2020) are in agreement that the quality of the urban public transport service is more important than the price, even it might be the factor with the most substantial impact on the demand. Urban public transportation is quality when it is easily and quickly accessible. Small (2006) asserts that people prefer to shorten the time spent walking to the station or waiting for a vehicle to arrive than the time spent travelling inside a vehicle. The access costs of users can be cut by a larger route coverage and/or frequency of service. Various variables are used to proxy the quality of transit service in the research. Brechan (2017) mentions routes and schedules as the primary service attributes. The positive impact of the increasing scale of transport services on the transport demand has been confirmed e. g. by Boisjoly et. al. (2018). Furthermore, we regard urban public public transport as a paternalistic good, especially in Central and Western Europe, so local governments would prefer to expand transport services even if the expansion would not be economically advantageous in terms of the theory of clubs (see Buchanan, 1965).

A factor that must be considered when modelling the demand for public transport is the income of the population - potential passengers. In literature, public transport is characterized as an inferior good. The explanation is simple: higher incomes allow households to own cars and substitute them for public transport. This also applies to post-socialist converging economies where rising living standards and increasing availability of cars

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[7] Original source is Dydkowski, G., Tomanek, R. and Urbanek A., 'Taryfy i systemy poboru opłat w miejskim transporcie zbiorowym' [Tariffs and Toll Collection Systems in Municipal Public Transport], Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach, Katowice, 2018.

have led to a gradual proliferation of individual automobile transport (see Kraft and Prener, 2014). A negative and strong correlation between the number of cars and the demand for public suburban bus transport in Slovak regions has been revealed by Konečný and Brídziková (2021).[8]

The substitution between urban public transport and individual automobile transport may be affected by the costs of car travelling, i. e. price of fuel (see Currie and Phung, 2007 or 2008) and availability of parking (see Schofield, Garrett and Badland, 2010). Rising the costs can be expected to lead a certain number of individuals to prefer more affordable public transport. Furthermore, owning a car is not the only substitute for public transport. As outlined by Rekhviashvili and Sgibnev (2018) and empirically tested by Rayle et al. (2016) or Boisjoly et al. (2018), people can substitute public transport with alternative taxi services such as Uber or by renting a bicycle (bike-sharing). The availability of alternative forms of individual transport can induce an outflow of passengers from the public transport systems.

Swianiewicz and Brzóska (2020) consider the effect of income on the demand of urban public transport the most difficult to interpret because the income variable can have both negative and positive effect depending on a model specification. In our analysis we follow Simpson´s (1994) argument that the substitution between the urban public and the individual car kinds of transport can also depend on a mode of public transport, i. e. whether there are tramlines or metro in the city. Currie and Phung (2007) and Mulalic and Rouwendal (2020), in the case of the metro, have reached a similar conclusion. Trams and metro use special lines, which give them the advantage in coping with traffic congestion in the densely populated area. Therefore we assume that the demand for urban public transport will tend to increase as the standard of living and mobility associated with economic activity increase in cities operating a tram or metro network. In contrast the demand will tend to decrease in cities relying on buses or trolleybuses because more affluent citizens will prefer travelling by car in the densely populated area. Moreover, following Glaeser, Kahn and Rappaport (2008), who assert that low-income individuals have the highest elasticity of substitution between urban public transport and individual car transport, we also choose a wage of the first decile of the wage distribution as a variable expressing the income level.

Accessibility of transport is a significant determinant of an individual's success in finding a job, as argued, for example, by Marada and Květoň (2016). Therefore, we consider the need for daily commuting as an essential component of the demand for urban public transport services.

Finally, users of urban public vehicles should be primarily residents of the city. Therefore we presuppose that the city population is an important determinant of the demand for urban public transport. In addition, in attractive tourist cities the demand is also made up of tourists seeking cheap and efficient ways of moving between points of interest scattered around the city (see e.g. Albalate and Bel, 2010 or Půr and Jirsa, 2020). As tourists generally prefer to travel by public transport, we expect that tourism will contribute to the urban public transport demand.

[8] The mean elasticity with respect to car ownership in Holmgren´s (2007) meta-analysis is -0,86.

Estimation of demand for urban public transport in the Czech Republic

Data and methodology

The demand for urban public transport was examined separately for each city under the assumption that a local public good´s supply is adapted to the local population´s particular needs (see Tiebout, 1956; 1961). We focused on cities (metropolitan area / agglomerations with a common transport system) where the urban transport services are produced by transport operators that are members of the Association of Transport Companies of the Czech Republic. Then we could collect the necessary data on transport from the Association's annual reports. Three Association members were dropped for which data were not available for the entire examined period or for which the serviced area changed significantly during the given period.

We employed time series of eighteen cities from 2004 to 2019; shorter time series were used for Praha, Ostrava and Teplice due to a change in the methodology of the reported indicators. The time series were terminated in 2019 for results would not be biased due to the exceptional situation of lockdowns in 2020 and 2021. We think that the impact of covid-19 pandemics deserves special testing.

The demand for urban public transport was constructed as a one-equation regression model:

$$Y_t = c + \beta_1 X_{1_t} + \beta_2 X_{2_t} + \ldots + \beta_n X_{n_t} + a_t \qquad (1)$$

in which the demand as the dependent variable (Y_t) is measured by the number of passenger trips (in thousands) per year. Trips are approximated by the number of tickets sold (further modified by transfer coefficients, e.g. for return tickets, see Eisler, 2000). Independent variables representing the factors affecting the demand (X_t) were selected for the model based on the literature (see text above); their overview is presented in Table 1 (we constructed more than one variable for some factors). When appropriate, time-lagged variables (i. e. Quality, Population and Unemployment) were used.[9] The variable a_t is a non-systematic component of the model.

The monthly ticket was chosen as the price of urban public transport because of its almost universal availability in all cities. The monthly period corresponds to the usual household cycle of revenue collection or expenditure. In addition, longer-term time tickets are usually targeted at specific population groups and their purchase may represent a prohibitively high one-off expenditure for lower income residents. Since discounts are usually available on urban public transport fare for seniors was chosen as a proxy for a discounted price because pensioners are a numerically significant group dependent on urban public transport.

[9] A special variable reflecting the specific circumstances of ticket sales was used in the model for Praha.

Table 1. Independent variables definitions and data sources

Abbreviation	Definition and presumed impact (sign)	Data source
Fare	Price of full fares for people over 15 years age (−)	Association of Transport Companies' annual reports
$Fare_{Senior}$	Price of discounted fares for seniors (−)	
Mileage	Quality of service expressed as the transport output in thousands of kilometres travelled (+)	Association of Transport Companies' annual reports
Cars	Number of registered passenger cars per 1 000 inhabitants in the respective region (−)	Czech Statistical Office statistics
UBER & Bike-sharing	Dummy variables for the availability of alternative modes of transport (−)	various publications
Fuel	Price of fuel, i. e. a litre of standard Natural 95 motor gasoline (+)	Czech Statistical Office statistics
Parking	Paid parking zones, used only in models for Praha and Plzeň (+)	Transport yearbooks of cities Praha and Plzeň
GDP	Income expressed by GDP per capita for the respective region (−) / (+)	Czech Statistical Office statistics
$Wage_{Median}$	Income expressed by the median wage after income taxation in the respective region (−) / (+)	Information System on Average Earnings
$Wage_{Poor}$	Income expressed by the average wage after income taxation in the first decile of the wage distribution in the respective region (−) / (+)	Information System on Average Earnings
Pension	Income expressed by the average old-age pension in the respective district (−) / (+)	Czech Statistical Office statistics
Unemployment	Unemployment rate in the respective district (−)	Czech Statistical Office statistics
Population	Number of inhabitants in the city or agglomeration (+)	Czech Statistical Office statistics
Tourism	Number of accommodated guests registered by local accommodation facilities (+)	Czech Statistical Office statistics

It is in accordance with literature that the quality of urban public transport is approximated by a quantity variable in the demand model. An important qualitative aspect of the urban public transport, which is valued by individuals, is accessibility. It depends on the area and density of the transport network and the frequency of vehicle trips which can be conveniently measured with the transport output such as mileage. Moreover, the transport network and the frequency of vehicle trips may not be directly proportional to the population so that the variable *Mileage* need not be related to population.

There are several variables which are not measured on the city (or agglomeration) level. The *Pension* and *Unemployment* variables are measured on the district level, the *Cars* variable and three variables representing the income (*GDP, $Wage_{Median}$* and *$Wage_{Poor}$*) on the regional level. We believe that these variables may not be very inaccurate, as the public transport in the cities, which are capitals of regions or district towns, may be used by residents of entire districts or regions (an exemption is city of Mariánské Lázně). Furthermore, the same regional values had to be used for cities located in the same regions. These are cities in the Ústí nad Labem region (i. e. Ústí nad Labem, Děčín, Chomutov with Jirkov, Most with Litvínov and Teplice), Moravian-Silesian region (i. e. Ostrava and Opava) and Karlovy Vary region (i. e. Karlovy Vary and Mariánské Lázně).

The time series of all variables were subjected to cointegration analysis.[10] To test for stationarity the time series were subjected to the Dickey-Fuller (ADF) unit-root test. Time series of explanatory variables for which the test revealed the same order of integration were subsequently subjected to the multicollinearity test, and those for which multicollinearity based on pairwise correlation coefficients was assumed, were excluded from further examination. The parameters of the urban public transport demand regression model were estimated by the least squares method. Subsequently, cointegration using the ADF test was tested for models of individual cities. Finally, the models were subjected to a diagnostic check for the presence of autocorrelation and heteroscedasticity of the residuals and for the normality of their distribution, respectively.

Results and discussion

It was possible to compile the urban public transport demand model that meets all the specified tests for fourteen cities. For Ostrava and Děčín, it was not possible to estimate a model that does not suffer from autocorrelation of residuals. For Chomutov with Jirkov, it was not possible to verify the cointegration relationship of the time series of the considered variables. In the case of České Budějovice, it was not possible to exclude the presence of a unit root in the generating process of the time series of the explained variable even after the second difference.

Table 2 presents the reduced models that include only independent variables with statistically significant regression parameters. Table 3 shows the results of the diagnostic tests.

Apart from tourism, which is unimportant in all cities anyway, all the factors have proved to be statistically significant. However, no city model includes all the significant variables. Even just one factor is decisive for the demand for urban public transport in Brno, Pardubice, Opava and Karlovy Vary. Two factors influence the demand in Praha, Plzeň, Olomouc, Hradec Králové, Jihlava and Mariánské Lázně. The combination of factors varies across cities. The situation is also diverse in Zlín with Otrokovice, Ústí nad Labem, Most with Litvínov, and Teplice, where three factors play a role.

[10] All tests were performed at the 5% significance level.

Table 2. Urban public transport demand models in Bohemian, Moravian and Silesian cities[11]

Independent variable / City	Fare	Mileage	Fuel	$Wage_{Poor}$	Unemployment	Population	R^2_{adj}
Praha		0.049*** (0.007)		31.384* (11.820)			0.84
Brno				4.112*** (0.679)			0.70
Plzeň				1.599** (0.509)	-3 525.425*** (576.372)		0.80
Olomouc	-64.246*** (7.727)			1.529*** (0.245)			0.82
Hradec Králové		0.081*** (0.002)			-726.65** (205.057)		0.56
Zlín with Otrokovice	-31.364*** (4.689)			-0.696* (0.256)	-650.079** (187.311)		0.90
Ústí nad Labem	-46.761*** (5.527)	0.069*** (0.004)	546.979** (125.901)				0.92
Pardubice					-1 378.601** (299.153)		0.61
Most with Litvínov		0.057*** (0.008)	680.459** (161.270)	-1.973*** (0.407)			0.76
Opava						1.677*** (0.094)	0.96
Jihlava					-441.831** (72.226)	1.781*** (0.397)	0.78
Teplice			256.212** (69.080)		-489.947* (145.495)	1.682** (0.378)	0.64
Karlovy Vary	-31.049* (11.669)						0.29
Mariánské Lázně		0.315*** (0.029)		-0.619*** (0.088)			0.73

Note: Standard error is given in parenthesis, * indicates 95% significance level, ** 99% significance level, *** 99.9% significance level.
Source: author

[11] Cities (agglomerations) are ranked in descending order of their size, measured by the number of inhabitants.

Table 3. Diagnostic tests

Test	Cointegration test: ADF test		Autocorrelation test: Breusch-Godfrey test		Normality test: Jarque-Bera test		Homoscedasticity test: ARCH test	
	t-stat	p-value	f-stat / jb-stat	p-value	f-stat / jb-stat	p-value	f-stat / jb-stat	p-value
City								
Praha	-2.079	0.040	3.352	0.082	0.504	0.777	0.614	0.450
Brno	-2.575	0.014	0.021	0.979	0.305	0.859	0.296	0.595
Plzeň	-2.606	0.014	2.791	0.109	3.668	0.160	0.070	0.796
Olomouc	-2.410	0.020	0.455	0.646	1.966	0.374	0.865	0.369
Hradec Králové	-3.624	0.001	1.160	0.352	0.286	0.867	0.942	0.353
Zlín with Otrokovice	-2.622	0.018	0.081	0.923	0.445	0.801	1.239	0.289
Ústí nad Labem	-3.594	0.001	0.474	0.635	0.919	0.632	0.759	0.400
Pardubice	-6.705	0.001	0.052	0.950	1.791	0.408	0.493	0.497
Most with Litvínov	-3.851	0.001	0.552	0.593	0.939	0.625	0.005	0.943
Opava	-	-	0.655	0.537	0.708	0.702	0.022	0.885
Jihlava	-5.878	0.000	2.543	0.128	1.566	0.457	0.202	0.661
Teplice	-4.611	0.000	0.403	0.685	0.807	0.668	0.218	0.652
Karlovy Vary	-3.493	0.002	0.021	0.980	0.021	0.980	0.649	0.435
Mariánské Lázně	-8.081	0.000	0.092	0.913	1.029	0.598	0.458	0.512

Note: There was no need to perform a cointegration test in the case of Opava.
Source: author

The price, a textbook determinant of the demand, affects the passengers´ demand only in four cities, i. e. in Moravian Olomouc and Zlín with Otrokovice and Northern / Western Bohemian Ústí nad Labem and Karlovy Vary. For example, it is insignificant in Pardubice, which is consistent with Melichar´s (2003) finding that the demand in Pardubice is rather inelastic with respect to price. Moreover, the price is the only significant variable in the model for Karlovy Vary (their model is of the lowest quality). As expected, there is a negative relationship between the price and the demand. If the price of fares for passengers except seniors, who can travel even free of charge, goes up by one Czech crown, the annual number of passenger trips is reduced by 43 thousand on average in the given cities.

A positive relationship between the demand for urban public transport and the quality of the transport services was confirmed in five Bohemian cities, rather in the north and west, but also in Praha. If public vehicles travel a thousand kilometres more, there will be extra 114 trips on average in those cities. We dare to formulate the hypothesis that urban public transport is an example of goods when the supply creates its demand. A consumer who would otherwise show little interest in the services because of perceived low quality may show a much higher interest once the coverage of services and hence the perceived quality extends.

A significant coefficient for the fuel, which is a complement to the use of a car, can support the substitution between urban public transport and travelling by car. (The use of the alternative taxi services or bike-sharing is probably not widespread enough yet and the parking variable was present in only two models). The fuel price increase by one Czech crown means 494 thousand trips more on average in three models for Ústí nad Labem, Teplice and Most with Litvínov. These cities are situated in Northern Bohemia, the poorest region (NUTS 2) in terms of GDP per capita.[12]

The most frequent significant variable in the city models is income. In addition, it is the only significant factor in the model for Brno. As opposed to Pojkarová and Ježek (2009), who found that as an average wage rises, the number of passengers in urban public transit in the Czech Republic increases, our effect of income is not, as expected, unambiguous. If the wage increases by one Czech crown, there will be almost 10 thousand trips more on average in the four biggest cities, i.e. Praha, Brno, Plzeň and Olomouc (2.4 thousand if Praha is excluded). On the other hand, there will be approximately one thousand fewer trips in Zlín with Otrokovice, Most with Litvínov and Mariánské Lázně. Since the significant variable is attributed to low-income passengers, who are said to be more prone to substitute the public transport with a car when their income rises, this division of cities almost perfectly fits the hypothesis about the effect of the mode of transport. An individual on a low wage will prefer light rail urban public transport (i. e. trams or metro), if available in the city, to buying a car if his income increases. A slight deviation from this rule is Most, where the tram route especially connects Most with Litvínov.

Level of employment proved to be a significant factor in six cities across the Czech Republic, from which Pardubice is the city where only this factor affects the demand significantly. Fewer people will use urban public transport when more people are unemployed. More precisely, the growth of the unemployment rate by one percentage point translates into the reduction of approximately 1 202 thousand trips on average in given cities.

Finally, a statistically significant relationship between the city population and the interest in urban public transport is in models of three relatively smaller cities. When one more resident is added to Opava, Jihlava or Teplice the number of trips per year increases by 1 713 on average. Moreover, in Opava the population is the only significant variable (its model is of the highest quality).

Conclusion

Our empirical research aimed to analyse the influence of selected factors on demand for urban public transport in the Czech Republic. We focused on the factors that are usually studied in literature. We examined the impact of price of fares, quality of service, income, car ownership, municipal population size and employment using cointegration and regression analyses for each city separately, using time series for 2004 - 2019.

Our analysis resulted in models of demand for services produced by transport companies in fourteen cities across the Czech Republic, including regional cities, except Ostrava, České Budějovice and Liberec, where about a quarter of the republic´s population lives. Each city has its unique function. This suggests that demand is shaped by different social and economic conditions, determined by tradition and current developments. The

[12] See Gross value added decreased in all regions but four, Eurostat, retrieved from https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20220221-1.

diversity of demand functions also supports Tiebout's hypothesis that municipalities try to adapt the supply of publicly provided services to the specific needs of the local population. A single policy cannot, therefore, be recommended; the municipality is its policy-maker in this area.

Income is the most common factor that appears in the demand models. Although urban public transport is cited in the literature as an example of an inferior good, municipalities with rising living standards need not always fear a decline in demand. While individuals with higher incomes are expected to substitute public transport for a car, in cities with trams or subways, which use their routes and are thus less likely to be stuck in traffic jams, urban public transport may be a better mode of transport for them. Another reason for the growing interest in urban public transport among middle class citizens might be that residents are more environmentally friendly. Under improving the quality of the transport services, people are willing to prefer public transport to traffic jams (see Swianiewicz and Brzóska, 2020). On the other hand, in cities where buses or trolleybuses are more likely to provide transport, households may prefer to buy a car when their income increases in order to speed up their transport possibly. At the current time of high inflation, when real incomes in the Czech Republic are falling significantly, we believe (as data on public transport performance for 2022 are not yet available) that a more permanent situation, or a slight growth in demand, can be expected.

Furthermore, the unemployment rate is also expected to rise in the current recession. And this, according to our results, can have a clear negative impact on demand for urban public transport. Moreover, it seems that urban transport companies have limited possibilities to improve the quality of their services, which should induce demand. Not only do macroeconomists foresee a temporary decline in investment activity (in the case of transport companies, e.g. investment in a fleet or infrastructure may be reduced), but there is also a risk that transport performance in the Czech Republic may be seriously constrained due to a shortage of drivers.

While our analysis confirmed an inverse relationship between fares and the number of passengers, price is a statistically significant factor in only four cities. The reason why passengers do not respond clearly to the fare price is probably its low level due to massive subsidies. Urban public transport in the Czech Republic tends to be among the cheaper ones in international comparison, especially given its quality. In addition, even the current growth of costs (especially energy costs) is not fully reflected in the fares of all the transport companies. According to information in the mass media, fare increases are not expected in some, especially large, cities this year. In other cities, fares have already risen or are expected to rise during the year, not only because of rising energy prices but also because of falling passenger numbers. However, given that the public transport fare system includes different types of tickets in terms of passenger category, duration of validity or coverage of travel, and that changes in other parameters accompany changes in price, the question is whether the change in price will be so significant that the relationship between fares and demand will be clearly visible.

Nevertheless, according to our findings, the fuel price influences the demand for urban public transport. This is because fuel is an additional cost associated with using a car. Under the assumption that the fuel demand is sensitive to price, a shift of some people from cars to urban public transport can be expected. Finally, more passengers will use the services of transport companies if more residents are added to cities. At the same time, this might mean fewer residents in other municipalities and, therefore, fewer potential users of municipal services there.

The demand model can be refined by including additional factors or using more precisely measured variables. A challenge for further research may be, for example, to account for lockdowns during the covid-19 pandemics, when demand fell compared to the previous period. Moreover, the effect of the pandemics may be more long-lasting if some riders changed their habits and did not return to urban public transport after the pandemics.

With knowledge of demand, the supply of transport services can be optimised, especially when their provision has consequences for the public budget. Demand and the associated fares revenues can be a factor that affects the efficiency of a partially bureaucratically managed municipally owned enterprise. Furthermore, knowledge of demand can be used to attract more passengers to urban public transport, thereby relieving congested roads or improving the environment, particularly in densely populated areas with heavy traffic. However, it should be recognised that the interests of local politicians or bureaucrats, which may not be in line with the criteria of efficiency or equity of access to services, are also at play in decisions on public services.

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