JANI BEKÖ, D. Sc.
Univerza v Mariboru
Ekonomsko-poslovna fakulteta
Razlagova 14, 2000 Maribor, Republika Slovenija

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ESTIMATION OF DEMAND FUNCTIONS FOR SERVICES OF PUBLIC RAILWAY PASSENGER TRANSPORTATION: EVIDENCE FROM SLOVENIA

ABSTRACT

The paper deals with the estimation of demand functions for services of public railway passenger transportation in the case of Slovenia. Six demand functions were selected and separately interpreted. The aggregate values of demand elasticities reported in this paper suggest that the railway passenger demand is price- and income-inelastic. Coefficients of income elasticity below one show that the services of railway passenger transportation in Slovenia can be classified among normal goods. A hypothetical increase in average real fares leads to a percentage decrease in the number of passengers traveling by rail that is smaller than the percentage increase in fares. The estimated price elasticities imply that, in the short run, there is potential for improving revenues of the railway operator by increasing average real fares.

KEY WORDS

price elasticity of demand, income elasticity of demand, price policy

1. INTRODUCTION

Detailed descriptions can be found in literature of a range of factors and their specific characteristics (a variety of products offered by railway companies, complexity of the production process in railway transportation, and a business environment of the railway companies that is strongly affected by state regulations) which explain the dominant structural changes in railway transportation in either comprehensive or specific manner. However, there are fewer empirical estimates of the demand functions for services of railway passenger transportation that are directly based on the chosen parameters of consumer behavior. The result of these analyses is the identification of the degree to which these services are attractive for average consumers with respect to prices and their income. The opinion is that the demand for services of different modes of transportation is typically inelastic, since transportation costs are relatively small in comparison with the value or utility of these services. But the estimates for the coefficient of income and price elasticity of demand for railway passenger services can also be heterogeneous. The outcomes of the studies depend on the specification of functions, the level of aggregation, and the stiffness of the competition on the railway market and the transportation market in general. Despite the fact that several empirical studies [8], [1], [2], [7], [3] confirmed relatively inelastic price and income demand for services of railway passenger transportation, one should not ignore the tendency toward the gradually increasing value of coefficients of elasticity of demand that can be observed within a longer time horizon.

The article presents the estimates of responsiveness of demand for services of railway passenger transportation for the chosen price and income elements in Slovenia. The theoretical concepts of price elasticity of demand are described in the second section of the paper. In the third section, we first classify the groups of variables that are used in the empirically oriented literature abroad. We then compare them with the characteristics of the currently available database in Slovenia and, using methodological and content criteria, choose the set of data series to be used for estimation. Different specifications for the demand function for services of railway passenger transportation are delineated in the fourth section of the article. In the fifth section we show the estimates, and we conclude with a summary of the key findings.

2. CONCEPTS OF DEMAND ELASTICITY

The economic theory distinguishes between two concepts of demand functions: ordinary demand function and compensated demand function [4]. From this division two types of price elasticity of demand are usually derived: ordinary and compensated elasticity of demand [6]. The ordinary demand function

(Marshallian demand) is based on maximizing the consumer utility function, which is subject to the budget constraint. The Marshallian demand is formally set as follows:

$$X = d_X(P_X, P_Y, I, s, \varepsilon);$$
$$\max U = u(X, s, \varepsilon)$$

where X represents the quantity demanded, P_X the price of goods X, P_Y is the vector of prices for other goods, I is available income, s is a vector of socio-economic factors (economic activity in home economy, international economic environment, type of market structure, etc.), ε is a vector of stochastic disturbances, and U utility of a consumer. In the demand function set up in this way, the change of P_X causes two effects: substitution and income effect. The substitution effect shows changes in the demand of individuals due to changes in the reference price given the unchanged level of utility. The income effect occurs because the changes in the reference price change the real purchasing power of income, which affects the changes in the quantity consumed. The dynamics of this depends on the ratio of consumption to income.

The compensated demand (Hicksian demand) is based on minimizing the consumer expenditures (E) at a chosen level of utility. It can be formalized as follows:

$$X = h_X(P_X, P_Y, u, s, \varepsilon);$$
$$\min E = e(I);\ P_X * X + P_Y * Y = I.$$

Since the curve of the compensated demand represents the relationship between the changing reference price and the quantity demanded with unchanged other prices and utility, unlike the ordinary elasticity of demand, the compensated elasticity of demand shows only the substitution effect for the chosen changes of prices along a given indifference curve.

Choosing between both concepts of elasticity for empirical analysis, and before that between the concepts of demand functions is a question of their methodological suitability. The concept of the compensated demand function is appropriate to estimate, for example, the consumer surplus. However, the availability of data on the dynamics of income and price variables allows for easier estimation of the ordinary demand function. The problem concerning the compensated demand is also the utility function, which cannot be measured directly.

The demand functions for services of passenger transportation are usually formed under the assumption of the utility maximizing representative consumer subject to his own budget constraint. Therefore, almost all studies of the estimates for price elasticity of the demand for passenger transportation services cite elasticity that simultaneously includes income and substitution effects, although authors do not emphasize this and only rarely discuss the differences between the two concepts of elasticity [7], [6]. This study estimating the demand functions for services of public railway passenger transportation for Slovenia is also along these lines.

3. PRESENTATION OF DATABASE

In estimating the demand functions for services of public railway passenger transportation within the country, the authors usually include five groups of explanatory variables, which can be divided into two classes. [1]

The first class comprises the variables with which we are trying to capture socio-economic factors. It is possible to distinguish among four groups of variables:

- price variables;
- income variables;
- seasonal factors;
- other socio-economic factors.

The second class contains the group of variables that express qualitative components of the demand factors:

- frequency of arrivals and departures;
- saved traveling time in comparison with alternative travel modes;
- quality of services that supplement the basic service (transportation).

The choice of the variables to be used from among a range of those theoretically recommended depends on the chosen methodological procedures of the estimation of demand function parameters, the level or aggregation in demand functions, and on available statistical data.

In the present paper the widely used econometric method of ordinary least squares (OLS) is used. This requires, among others, sufficient length of time series.

3.1. Available time series

The demand functions estimated in this study reach the highest level of aggregation since the dependent variable represents the total number of passengers transported by railway traffic in Slovenia. [2] The dependent variable is thus not disaggregated into different routes, groups of passengers and fare classes.[3] Because of aggregate approach, we have to eliminate all the theoretically suggested variables from the second class in Section 3. Introduction of the qualitative components requires the disaggregation of passengers according to different routes, which can be alternatively supplemented with disaggregation of the number of passengers into different groups (transpor-

Table1 - List of available time series for different groups of independent variables

Price variables	Deflators	Income variables	Variables of seasonal factors	Variables of other socio-economic factors
Average fare	Railway passenger transportation price index (RPTPI)	Real gross domestic product	Dummy variables	Number of first-time registered private cars
Average fare per passenger kilometer	Services price index (SPI)	Registered real household income		Prices of gasoline
Railway passenger transportation price index (RPTPI)	Transportation price index (TPI)			Prices of representative private cars
Price of tickets without discount for second class journeys (21–25 kilometers)	Transportation and communications price index (TCPI)			
Price of tickets without discount for second class journeys (36–40 kilometers)	Consumer price index (CPI)			

Note: The list of available data series was compiled using the data of the Slovenian Railway Company, Statistical Office of the Republic of Slovenia and Bank of Slovenia. The income series was deflated by CPI.

tation to school, job commuting, etc.). Thus, we can use only socio-economic variables for the estimation of the equations, but we can choose among different time series (Table 1).

There are two candidates for the dependent variables: the number of transported passengers and the number of passenger kilometers. From Table 1 it can be seen that within the available series none of the income and socio-economic variables is expressed in terms of passenger kilometers. Because of the chosen methodology of elasticity estimation (OLS), we cannot use the "number of passenger kilometers" series.

Among the price variables we had to exclude the following variables: average fare per passenger kilometer, price of tickets without discount for second class journeys (average transport route 21–25 kilometers) and price of tickets without discount for second class journeys (average transport route 36–40 kilometers) since a comparable dependent variable is not available. Among available series for price variable the only suitable nominal category is the series railway passenger transportation price index (RPTPI). The series average fare represents non-weighted Tolar revenue per transported passenger. Since this series is also in nominal terms it is appropriate to calculate the real variable. By doing this we can choose among five deflators. Based on the nature of the problem the most suitable are the consumer price index (CPI) and railway passenger transportation price index (RPTPI). We also introduce transportation and communications price index (TCPI), transportation price index (TPI), and services price index (SPI). Based on the content, all additional deflators are placed within CPI, which is the most broadly based category, and RPTPI, which is the narrowest price category and is specially used also as a direct nominal price variable.

Concerning income variables, we can choose between real gross domestic product and registered real household income. The latter series comprises real net wages, other real receipts from employment and real transfer receipts. We cannot decide *a priori* between the two. However, taking into consideration the nature of the problem, the series of registered real household income is more appropriate. The final choice of income variables will be carried out on the basis of objective criteria of econometric analysis.

When analyzing passenger railway transportation, it is reasonable to expect seasonal influences. Simple graphical analysis of time dynamics of the number of transported passengers shows that the number substantially declines in the summer (June, July and August) or in the second and third quarters. Estimating the elasticities we can address the seasonal influences in two ways:

- using dummy variables, or
- seasonally adjusting the time series (multiplicative method X-11).

Based on *a priori* analysis of the content we cannot exclude from analysis any of the socio-economic time series (number of first-time registered private cars, prices of gasoline, prices of representative private cars). The choice will therefore be based on the results of the econometric analysis.

3.2. Usable time series

Several of the available time series are excluded based on the limitations arising from the chosen estimation method and content suitability. The set of available series can therefore be narrowed down to a set of usable series (Table 2). Series of this set satisfy the content and methodological criteria. Additionally, the following technical characteristics of the usable series have to be fulfilled:

- number of observations;
- frequency of the time series (monthly, quarterly);
- possible structural breaks recording data for certain series.

3.3. Series actually used in estimation of demand functions

Since we have three groups of explanatory variables – income, price and variables for other socio-economic factors – we require at least 90 observations at a monthly level, which corresponds to 30 observations at a quarterly level. The time series also should not contain structural breaks. Additionally we require stationarity of time series in order to prevent possible spurious regressions when estimating the equations.

Based on these criteria we can choose the set of time series from Table 2 that satisfies the methodological and content criteria and technical characteristics, and is therefore suitable for estimating the demand functions for services of railway passenger transportation. Because of the insufficient number of observations series O_1, O_5, O_6, O_7 and O_8 are excluded from the analysis, whereas series O_3 and O_4 have no stationarity properties. The set of the remaining time series suitable for econometric estimation is collected in Table 3.

The dependent variable (Q) covers the period 1993M1–2002M7. The same is true for both income variables (I_1 and I_2), series P_7 for price variable and series O_2 for the variable of other socio-economic factors. Other price variables P_1, P_2, P_3, P_4, P_5 and P_6 cover the period 1994M1–2002M7. Two groups of series can be derived from the available time series. The first group includes the monthly series for the period 1994M1–2002M7. In the second group are quarterly series that cover 1994Q1–2002Q2. All the selected variables have been used in the level form.

The analysis of the data set given in Table 3 for the quoted period reveals two basic features. First, the average annual growth rate of the number of transported passengers (1.7%) lags behind the average

Table 2 - List of usable time series

Symbol	Series name	Number of observations	Frequency	Break	Time period
Q	Number of transported passengers	115	Monthly	...	1993M1–2002M7
I_1	Real gross domestic product	115	Monthly	...	1993M1–2002M7
I_2	Registered real household income	115	Monthly	...	1993M1–2002M7
P_1	Average nominal fare	103	Monthly	...	1994M1–2002M7
P_2	Average real fare (deflator SPI)	103	Monthly	...	1994M1–2002M7
P_3	Average real fare (deflator TPI)	103	Monthly	...	1994M1–2002M7
P_4	Average real fare (deflator TCPI)	103	Monthly	...	1994M1–2002M7
P_5	Average real fare (deflator RPTPI)	103	Monthly	...	1994M1–2002M7
P_6	Average real fare (deflator CPI)	103	Monthly	...	1994M1–2002M7
P_7	Railway passenger transportation price index (RPTPI)	115	Monthly	...	1993M1–2002M7
O_1	Number of first-time registered private cars	67	Monthly	...	1997M1–2002M7
O_2	Average retail price of lead-free 95-octane gasoline	115	Monthly	...	1993M1–2002M7
O_3	Average retail price of lead-free 98-octane gasoline	115	Monthly	...	1993M1–2002M7
O_4	Average retail price of leaded 98-octane gasoline	114	Monthly	...	1993M1–2002M6
O_5	Average retail price of lead-free 91-octane gasoline	48	Monthly	...	1993M1–1996M12
O_6	Average retail price of representative car Renault 5	48	Monthly	...	1993M1–1996M12
O_7	Average retail price of representative car Renault Clio	67	Monthly	1999M1	1997M1–2002M7
O_8	Average retail price of representative car VW Polo	67	Monthly	1999M1	1997M1–2002M7

Note: For easier understanding of specification of regression equations of demand for railway passenger transportation we added symbols to the listed variables. We used the following symbols: Q – quantity of demand, I – income, P – price and O – other socio-economic variables. Since for a few variables several series are available, we added the numbered subscripts to the letters.

Table 3 - List of actually used time series

Symbol	Series name	Number of observations at monthly level	Number of observations at quarterly level	Time period
Q	Number of transported passengers	115	38	1993M1–2002M7
I_1	Real gross domestic product	115	38	1993M1–2002M7
I_2	Registered real household income	115	38	1993M1–2002M7
P_1	Average nominal fare	103	34	1994M1–2002M7
P_2	Average real fare (deflator SPI)	103	34	1994M1–2002M7
P_3	Average real fare (deflator TPI)	103	34	1994M1–2002M7
P_4	Average real fare (deflator TCPI)	103	34	1994M1–2002M7
P_5	Average real fare (deflator RPTPI)	103	34	1994M1–2002M7
P_6	Average real fare (deflator CPI)	103	34	1994M1–2002M7
P_7	Railway passenger transportation price index (RPTPI)	115	38	1993M1–2002M7
O_2	Average retail price of lead-free 95-octane gasoline	115	38	1993M1–2002M7

Note: The stationarity of all selected variables was checked by DF test.

growth of the registered real household income (3.8%) and behind the average growth rate of the real gross domestic product (4.3%). And second, the growth of average real fare (corrected by deflators in Table 3) exhibits high variability reflecting more the variations in the mix of sold tickets than the actual price changes, since the fares in railway sector in Slovenia are under government regulation. As the upcoming sections will demonstrate, both of the presented features have implications for elasticity estimates.

4. SPECIFICATION OF DEMAND FUNCTIONS FOR SERVICES OF PUBLIC RAILWAY PASSENGER TRANSPORTATION

Following empirical analyses [8], [5], [1], [7], we chose the following specification of the demand function for services of public railway passenger transportation:

$$Q_1=\beta_1 \cdot I^{\beta_2} \cdot P^{\beta_3} \cdot O^{\beta_4} \cdot \exp\left(\sum_{t=5}^{15} \beta_t \cdot D\right).$$

The specification was used on monthly time series and tackles seasonal influences through the use of dummy variables. The mathematical specification of this kind is not directly applicable for econometric estimation of individual coefficients since the function is not linear in parameters. However, this condition can be satisfied by taking logs of the above equation.

In what follows we present four different variants of theoretical specifications of the regression equations.

Equation 1 - Regression equation – monthly data and using dummy variables

$$\ln(Q^m)=\ln(\beta_1)+\beta_2 \ln(I_r^m)+\beta_3 \ln(P_r^m)+ +\beta_4 \ln(O_r^m)+\beta_5 D_6+\beta_6 D_7+\beta_7 D_8+u$$

Symbol:

Q^m – number of transported passengers per month

I_r^m – r^th income variable, monthly

P_r^m – r^th price variable, monthly

O_r^m – r^th variable for other socio-economic factors, monthly

D_6 – dummy variable for seasonal component in June

D_7 – dummy variable for seasonal component in July

D_8 – dummy variable for seasonal component in August

$\ln(\beta_1)$ – regression constant

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ – partial regression coefficients

u – random variable.

Equation 2 - Regression equation – monthly seasonally adjusted series

$$\ln(QSA^m)=\ln(\beta_1)+\beta_2 \ln(ISA_r^m)+\beta_3 \ln(PSA_r^m)+ +\beta_4 \ln(OSA_r^m)+u$$

Symbol:

QSA^m – number of transported passengers per month (seasonally adjusted)

ISA_r^m – r^th income variable, monthly (seasonally adjusted)

PSA_r^m – r^th price variable, monthly (seasonally adjusted)

OSA_r^m – r[th] variable for other socio-economic factors, monthly (seasonally adjusted)

$\ln(\beta_1)$ – regression constant

$\beta_2, \beta_3, \beta_4$ – partial regression coefficients

u – random variable.

Equation 3 - Regression equation – quarterly data and using dummy variables

$$\ln(Q^q) = \ln(\beta_1) + \beta_2 \ln(I_r^q) + \beta_3 \ln(P_r^q) + \\ + \beta_4 \ln(O_r^q) + \beta_5 D_2 + \beta_6 D_3 + u$$

Symbol:

Q^q – number of transported passengers per quarter

I_r^q – r[th] income variable, quarterly

P_r^q – r[th] price variable, quarterly

O_r^q – r[th] variable for other socio-economic factors, quarterly

D_2 – dummy variable for seasonal component in the second quarter

D_3 – dummy variable for seasonal component in the third quarter

$\ln(\beta_1)$ – regression constant

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ – partial regression coefficients

u – random variable.

Equation 4 - Regression equation – quarterly seasonally adjusted series

$$\ln(QSA^q) = \ln(\beta_1) + \beta_2 \ln(ISA_r^q) + \beta_3 \ln(PSA_r^q) + \\ + \beta_4 \ln(OSA_r^q) + u$$

Symbol:

QSA^q – number of transported passengers per quarter (seasonally adjusted)

ISA_r^q – r[th] income variable, quarterly (seasonally adjusted)

PSA_r^q – r[th] price variable, quarterly (seasonally adjusted)

OSA_r^q – r[th] variable for other socio-economic factors, quarterly (seasonally adjusted)

$\ln(\beta_1)$ – regression constant

Table 4 - List of used econometric tests

Requirement	Test
Stationarity of time series	DF test with constant, and with constant and trend
Distribution of residuals	JB test of normality
Autocorrelation	LM test for first-, second-, fourth-, sixth and twelfth-order autocorrelation
Significance of coefficients	p values, t statistic, confidence intervals
Stability of estimates	Inclusion of different deflators, Cusum and Cusum Q test
Specification of regression equations	RESET test
Explanatory power of equations	Adj. R^2 and F test

$\beta_2, \beta_3, \beta_4$ – partial regression coefficients

u – random variable.

5. ESTIMATION OF THE DEMAND FUNCTIONS FOR SERVICES OF PUBLIC RAILWAY PASSENGER TRANSPORTATION

For estimation of parameters for the functions specified in Section 4, we used the method of ordinary least squares. The choice of the method is appropriate because all the specified equations are linear in parameters, the chosen method is relatively simple to use and assures (given that certain conditions are satisfied) ideal statistical properties.

Using the time series, the method produces unbiased and best estimates if the estimated regression equation does not show autocorrelation (this means that there is no systematic component in the variable that measures the random deviations) and if the explanatory variables are not linearly related. The latter is related to the level of precision of the estimates, which is an important criterion when estimating elasticity. In order to be able to use classical approaches of statistical testing when checking for the mentioned requirements, it is necessary that the residuals of the regression model be distributed normally. To this we add a condition that the estimated regression coefficients be statistically significantly different from zero, which is checked with exact levels of significance (p values). Beside this, the explanatory power of individual regression equations was also considered.

For the estimated regression equations that satisfied the mentioned criteria we investigated the suitability of the specification (RESET test), the confidence intervals for regression coefficients and their stability (Cusum and Cusum Q test).

Most of the estimated variants of regression equations are related to the use of different price variables, which are the result of deflating with different price indicators. Therefore, among those with similar results, we considered the ones where the chosen deflator best matched the content criteria.

5.1. Estimates

Taking into account a number of different time series for measuring individual variables, two modes of including the seasonal components and two types of time frequencies (monthly and quarterly), the total number of regression equations that can be estimated is equal to 112. It turns out that the estimated regression equations for monthly data do not fulfil the condition of normal distribution of residuals (56 equations). For 28 of the equations that are based on the quarterly series, the inclusion of the variable for other socio-economic factors worsens the precision of the estimates (it increases the degree of linear relationship among explanatory variables). Seven regression equations which are based on seasonally adjusted quarterly data and include real gross domestic product as the income variable feature too weak explanatory power. Thus, there are 21 specifications, based on quarterly data, which are suitable for analysis. Of these, fourteen include dummy variables to capture seasonal components and seven of them are estimated using seasonally adjusted data.

Most of these 21 variants of regression equations are linked to the use of five deflators when calculating the price category of average real fares. We found that the use of different deflators does not cause important differences in estimates of point elasticity. Therefore, based on the content criterion, we decided to use both marginal deflationary indices and to include the following six estimated specifications in the final analysis: [4, 5]

- E1: $\ln(Q^q) = \ln(\beta_1) + \beta_2 \ln(I_1^q) + \beta_3 \ln(P_5^q) + \beta_4 D_2 + \beta_5 D_3 + u,$
- E2: $\ln(Q^q) = \ln(\beta_1) + \beta_2 \ln(I_1^q) + \beta_3 \ln(P_6^q) + \beta_4 D_2 + \beta_5 D_3 + u,$
- E3: $\ln(Q^q) = \ln(\beta_1) + \beta_2 \ln(I_2^q) + \beta_3 \ln(P_5^q) + \beta_4 D_2 + \beta_5 D_3 + u,$
- E4: $\ln(Q^q) = \ln(\beta_1) + \beta_2 \ln(I_2^q) + \beta_3 \ln(P_6^q) + \beta_4 D_2 + \beta_5 D_3 + u,$
- E5: $\ln(QSA^q) = \ln(\beta_1) + \beta_2 \ln(ISA_2^q) + \beta_3 \ln(PSA_5^q) + u,$
- E6: $\ln(QSA^q) = \ln(\beta_1) + \beta_2 \ln(ISA_2^q) + \beta_3 \ln(PSA_6^q) + u,$

Summary of estimates of all six functions are presented in Table 5.

The results of point and interval estimates of price and income elasticities, based on models E1–E6, are presented in part A of Table 5. The outcomes of the analysis can be summarized leading to the following conclusions:

- Point estimates of price elasticity of equations E1 and E2 are -0.2045 and -0.2032. Based on the calculations we infer that an increase in the average real fare by 1% will be followed on average by an approximately 0.20% decrease in the quantity of demand for services of railway passenger transportation. Low values of standard errors of the regression coefficient estimates for average real fares contribute to the satisfactory width of confidence intervals for the reference price elasticities.
- For equations E1 and E2 the calculated point estimates of income elasticities are 0.9286 and 0.9273. An increase in real gross domestic product by 1% thus causes an increase in the quantity of demand for services of railway passenger transportation of about 0.93%. Both coefficients of partial elasticities are statistically significant. However, they have relatively wide confidence intervals, which shows bad precision of the point estimates.
- Estimates of price elasticities in equations E3 and E4 increase in comparison with point estimates from equations E1 and E2. Also, the interval estimate of price elasticity parameters increases, which suggests a relative worsening of the precision of point estimates. From the results it follows that the increase in the average real fares by 1% will on average be followed by a 0.36% or 0.40% fall in the quantity of demand for services of railway passenger transportation.
- In equations E3 and E4 the series registered real household income replaced the real gross domestic product. The point estimates of income elasticity are lower and more precise compared to the ones in equations E1 and E2, since the confidence intervals are now approximately half the previous ones. Based on the income elasticities estimates from equations E3 and E4 it can be concluded that the number of transported passengers on average increases by 0.43% or 0.46% if the registered real household income increases by 1%, all other elements unchanged.
- In equations E3 and E4 considering the confidence intervals, the precision of the income elasticity estimates improved, but the precision of the price elasticities worsened in comparison with those from equations E1 and E2. For additional check of the magnitude of income and price elasticities we seasonally adjust the time series that are used for estimating equations E3 and E4 and use them for estimating E5 and E6.
- Point and interval estimates of price and income elasticities in equations E5 and E6 are very similar to those from equations E3 and E4. If the registered real household income increases by 10%, the demand for services of railway passenger transportation on average increases by 4.4% (equation E5) or 4.7% (equation E6). The parameters for variable real fares suggest that a 10% increase in average

Table 5 - Empirical results

	A						B			C	D	E	F
Equation	Point estimates of price elasticity	Point estimates of income elasticity	Confidence intervals for price elasticity	Confidence intervals for income elasticity	Confidence intervals for price elasticity, differences	Confidence intervals for income elasticity, differences	LM(1)	LM(2)	LM(4)	Adj. R^2	RESET test	Cusum and Cusum Q test	JB test
E1	-0.2045 (-2.9015)* (0.0070)**	0.9286 (5.6104)* (0.0000)**	[-0.3781, -0.0309]	[0.5211, 1.3360]	0.3472	0.8149	0.0012 (0.9721)	0.1566 (0.9247)	1.6729 (0.7956)	0.9686 (0.0000)	0.0015 (0.9698)	+	0.5548 (0.7577)
E2	-0.2032 (-2.7208)* (0.0109)**	0.9273 (5.2894)* (0.0000)**	[-0.3870, -0.0193]	[0.4957, 1.3589]	0.3677	0.8632	0.0000 (0.9945)	0.1676 (0.9196)	1.3513 (0.8526)	0.9677 (0.0000)	0.0130 (0.9099)	+	0.7463 (0.6886)
E3	-0.3586 (-3.2837)* (0.0027)**	0.4319 (4.9737)* (0.0000)**	[-0.6274, -0.0897]	[0.2181, 0.6457]	0.5377	0.4276	0.6334 (0.4261)	0.6405 (0.7260)	1.7858 (0.7751)	0.9647 (0.0000)	0.0875 (0.7695)	+	1.5761 (0.4547)
E4	-0.3966 (-3.2520)* (0.0029)**	0.4628 (4.7719)* (0.0000)**	[-0.6969, -0.0964]	[0.2240, 0.7016]	0.6005	0.4776	1.0390 (0.3081)	1.1259 (0.5695)	2.1352 (0.7109)	0.9645 (0.0000)	0.2484 (0.6221)	+	1.0838 (0.5816)
E5	-0.3681 (-3.5021)* (0.0014)**	0.4375 (5.2334)* (0.0000)**	[-0.6259, -0.1104]	[0.2325, 0.6425]	0.5155	0.4100	0.8198 (0.3652)	0.8510 (0.6534)	2.2102 (0.6972)	0.7281 (0.0000)	5.4809 (0.0261)	+	0.8419 (0.6564)
E6	-0.4061 (-3.4451)* (0.0017)**	0.4684 (4.9969)* (0.0000)**	[-0.6951, -0.1171]	[0.2385, 0.6982]	0.5780	0.4597	1.2137 (0.2706)	1.2151 (0.5447)	2.4055 (0.6616)	0.7256 (0.0000)	5.9878 (0.0205)	+	0.3354 (0.8456)

Notes: Part A presents the point and interval estimates of price and income elasticities. Below point elasticities in parentheses, marked by *, are t statistics, below t statistics in parentheses, marked by **, are p values. Interval estimates are calculated at the significance level 0.01. Part B contains values for the Breusch-Godfrey LM tests, values in parentheses are p values. Adj. R^2 are in part C with p values in parentheses. Results of RESET tests are given in part D (F statistics and p values in parentheses). In part E are the results of Cusum and Cusum Q tests with the level of significance 0.05. A + indicates structural stability of estimated parameters. JB tests of normality with p values in parentheses are listed in part F.

real fares would cause contraction of demand for services of railway passenger transportation on average by 3.7% (equation E5) or 4.1% (equation E6).

Our judgment of the explanatory power of estimated regression equations can be based on the value of adjusted coefficients of determination. It turns out that all equations show satisfactory explanatory power: 73% or 97% of variance in the number of railway transport passengers can be explained with the combination of variables that are included in the six model specifications. The results of the Breusch-Godfrey test of autocorrelation testify that none of the estimated models displays autocorrelation in the residuals of the regression equations.

The results of the RESET test (part D of Table 5) warn of the possibility of omitting an important explanatory variable from equations E5 and E6 (despite their satisfactory explanatory power, which is seen in part C of Table 5). Taking into account the results of testing for the presence of autocorrelation and the outcomes of specification tests of equations E3 and E4, we think that the outcome of the RESET test for equations E5 and E6 is mostly due to seasonally adjusted series and not directly incorrect specification of the regression equations. All the estimated coefficients of elasticity from equations E1, E2, E3, E4, E5 and E6 are structurally stable at an acceptable level of significance (á=0.05). We close the presentation of the content of econometric tests in Table 5 with checking the distribution of residuals for the chosen equations. Results derived from the Jarque-Bera test conclusively confirm that the residuals are normally distributed from all regression equations.

6. CONCLUSION

Taking into account the estimates of demand functions for services of railway passenger transportation in Slovenia we can conclude that it is price and income inelastic. Coefficients of income elasticity of demand below one show that for the average consumer the services of railway passenger transportation can be classified among normal goods, i. e. among essential consumer expenditures.

For the case of increased average real fares the number of transported passengers by rail decreases in percentage terms less than the fare increases (in percentage terms). Recorded price inelasticity of demand leads to the conclusion that the revenues of the railway operator increase when the average real fare increases.

We think that the presented estimates of elasticity, and the conclusions derived from them, offer useful suggestions for setting the comprehensive price policy for public railway passenger transportation in Slovenia. The presented coefficients of elasticity are result of the estimation of the aggregate demand functions. Therefore, it would be sensible to expand the current analysis in the future by comparable testing of demand functions for services of railway passenger transportation according to individual fare classes or according to different categories of sold tickets.

JANI BEKÖ, D. Sc.
Univerza v Mariboru
Ekonomsko-poslovna fakulteta
Razlagova 14, 2000 Maribor, Republika Slovenija

POVZETEK

OCENJEVANJE FUNKCIJ POVPRAŠEVANJA PO STORITVAH JAVNEGA ŽELEZNIŠKEGA POTNIŠKEGA PROMETA: REZULTATI ZA SLOVENIJO

Prispevek se ukvarja z ocenjevanjem funkcij povpraševanja po storitvah železniškega potniškega prometa v primeru Slovenije. V procesu selekcije je bilo izbranih šest agregatnih funkcij, katerih ocene posebej navajamo in komentiramo. Iz ocen funkcij izhaja, da je povpraševanje po storitvah železniškega potniškega prometa cenovno in dohodkovno neelastično. Koeficienti dohodkovne elastičnosti povpraševanja manjši od ena kažejo, da je moč prevoze v notranjem železniškem prometu za povprečnega kupca storitev železniškega potniškega prometa v Sloveniji uvrstiti med normalne dobrine. V primeru povečanja povprečnih realnih voznin se število prepeljanih potnikov na železnici zmanjša odstotno za manj kot znaša odstotni dvig voznin. Evidentirana cenovna neelastičnost povpraševanja nas navaja k sklepu, da se prihodki operaterja notranjega železniškega prometa pri zviševanju povprečne realne voznine povečujejo.

KLJUČNE BESEDE

cenovna elastičnost povpraševanja, dohodkovna elastičnost povpraševanja, cenovna politika

REFERENCES

1. The list of theoretically justified variables when specifying the equation of demand for services for railway passenger transportation was compiled on the basis of the following studies: [8], [5], [1], [2], [7], [9].
2. We discuss the choice of the dependent variable (the total number of transported passengers) below.
3. At the moment the computer processing of passengers in all fare classes in Slovenia amounts to between 67% and 74% of all passengers transported by railway. This incomplete treatment allows only for estimation of aggregate functions.
4. For the definition of variables check Table 3, and for the meaning of elements in specification check Section 4.
5. Results of the estimation of price elasticities, derived from other three deflators are available upon request from the author.

LITERATURE

[1] **G. de Rus**: *Public Transport Demand Elasticities in Spain, Journal of Transport Economics and Policy*, Vol. 24, 1990, pp. 189-201.

[2] **P. B. Goodwin**: *A Review of New Demand Elasticities with Special Reference to Short and Long Run Effects of Price Changes, International Journal of Transport Economics*, Vol. 26, 1992, pp. 155-169.

[3] **J. Luk** and **S. Hepburn**: *New Review of Australian Travel Demand Elasticities, Australian Road Research Board Ltd Research Report ARR* 249, 1993.

[4] **W. Nicholson**: *Microeconomic Theory. Basic Principles and Extensions*. Philadelphia, The Dryden Press, 1995.

[5] **T. H. Oum**: *Alternative Demand Models and Their Elasticity Estimates, Journal of Transport Economics and Policy*, Vol. 23, 1989, pp. 163-187.

[6] **T. H. Oum** and **W. G. Watters II**: *Transport Demand Elasticities*. In *Handbook of Transport Modelling*, editors **D. A. Hensher**, **K. J. Button**. Amsterdam, Pergamon, 2000, pp. 197-210.

[7] **T. H. Oum, W. G. Watters II** and **Y. Jong-Say**: *Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates. An Interpretative Survey, Journal of Transport Economics and Policy*, Vol. 26, 1992, pp. 139-154.

[8] **A. D. Owen** and **G. D. A. Phillips**: *The Characteristics of Railway Passenger Demand. An Econometric Investigation, Journal of Transport Economics and Policy*, Vol. 21, 1987, pp. 231-253.

[9] **M. Wardman, J. P. Toner,** and **A. W. Gerard**: *Interactions between Rail and Car in the Inter-Urban Leisure Travel Market in Great Britain, Journal of Transport Economics and Policy*, Vol. 31, 1997, pp. 163-181.