

# *Demand Functions for Services of Public Railway Passenger Transportation: An Empirical Analysis for Slovenia*

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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 unity 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 travelling 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.

## **Introduction**

In the literature we can find detailed descriptions 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 a comprehensive or a specific manner. However, there are fewer empirical estimates of the demand functions for services of railway passenger transportation that are directly based on 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

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*Managing Global Transitions 1 (2): 135–152*

of the studies depend on the specification of functions, the level of aggregation, and how stiff the competition is on the railway market and transportation market in general. Despite the fact that several empirical studies have confirmed relatively inelastic price and income demand for services of railway passenger transportation (Owen and Phillips 1987; de Rus 1990, Goodwin 1992, Oum et al. 1992, Luk and Hepburn 1993), one should not ignore the tendency toward the gradually increasing magnitude 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 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 data base 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. In the fifth section we show the estimates, and we conclude with a summary of the key findings.

### **Concepts of Demand Elasticity**

Economic theory distinguishes between two concepts of demand functions: ordinary demand function and compensated demand function (Nicholson 1995). From this division are usually derived two types of price elasticity of demand: ordinary and compensated elasticity of demand (Oum and Watters 2000). 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:

$$X = d_X(P_X, P_Y, I, s, \epsilon),$$

$$\max U = u(X, s, \epsilon),$$

where  $X$  represents the quantity demanded,  $P_X$  the price of good  $X$ ,  $P_Y$  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.),  $\epsilon$  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: the

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 comes about 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 depend on the ratio of consumption to income.

Compensated demand (Hicksian demand) is based upon minimizing consumer expenditures ( $E$ ) at a chosen level of utility. It can be formalized as follows:

$$X = h_X(P_X, P_Y, U, s, \epsilon),$$

$$\min E = e(I),$$

$$P_X \cdot X + P_Y \cdot Y = I.$$

Since the curve of compensated demand represents the relationship between the changing reference price and the quantity demanded with unchanged other prices and utility, the compensated elasticity of demand, unlike the ordinary elasticity of demand, shows only the substitution effect for 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, 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 compensated demand is also the utility function, which cannot be measured directly.

Demand functions for services of passenger transportation are usually formed under the assumption of a utility maximizing representative consumer, subject to his/her own budget constraint. Therefore almost all studies of the estimates for price elasticity of the demand for services of passenger transportation cite elasticity that simultaneously includes income and substitution effects, although the authors do not emphasize this and only rarely discuss the differences between the two concepts of elasticity (Oum et al. 1992; Oum and Watters 2000). This study estimating the demand functions for services of public railway passenger transportation for Slovenia is also along these lines.

### **Presentation of Data Base**

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.<sup>1</sup>

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.

In the second class we place the group of variables that express qualitative components of the demand factors:

- frequency of arrivals and departures;
- saved travelling time in comparison with alternative modes of travel;
- 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 we employed the widely used econometric method of ordinary least squares (OLS). This requires, among others, sufficient length of time series.

#### 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.<sup>2</sup> The dependent variable is thus not disaggregated into different routes, groups of passengers and fare classes.<sup>3</sup> Because of the aggregate approach, we have to eliminate all the theoretically suggested variables from the second class. 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 (transportation to school, commuting to job, etc.). Thus we can use only socio-economic variables for the estimation of the equations, however we can choose among different time series (Table 1).

Table 1: 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 personal cars |
| Average fare per passenger kilometre   | Services price index (SPI)                           | Registered real household income |                               | Prices of petrol                              |
| Railway passenger transportation price index (RPTPI)                           | Transportation price index (TPI)                     |                                  |                               | Prices of representative personal cars        |
| Price of tickets without discount for second class journeys (21–25 kilometres) | Transportation and communications price index (TCPI) |                                  |                               |   |
| Price of tickets without discount for second class journeys (36–40 kilometres) | Consumer price index (CPI)                           |                                  |                               |   |

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

There are two candidates for the dependent variables: the number of passengers transported and the number of passenger kilometres. 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 kilometres. Because of the chosen methodology of elasticity estimation (OLS), we cannot use the series ‘number of passenger kilometres’.

Among the price variables we had to exclude the following variables: average fare per passenger kilometre, price of tickets without discount for second class journeys (average transport route 21–25 kilometres) and price of tickets without discount for second class journeys (average transport route 36–40 kilometres), since a comparable dependent variable is not available. Among available series for the price variable, the only suitable nominal category is the series railway passenger transportation price

index ( $RPTPI$ ). The series average fare represents the non-weighted total revenue per transported passenger. Since this series is also in nominal terms, it is appropriate to calculate the real variable. When 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 the 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. A priori we cannot decide 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 the 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 personal cars, prices of gasoline, prices of representative personal cars). The choice will therefore be based on the results of the econometric analysis.

#### USABLE TIME SERIES

We exclude several of the available time series based upon the limitations arising from the chosen method of estimation and content suitability. The set of available series can therefore be narrowed down to a set of usable series (Table 2). The series of this set satisfy content and

methodological criteria. Additionally we require that the following technical characteristics of the usable series be fulfilled:

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

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 methodological and content criteria and technical characteristics, and is therefore suitable for estimating the demand functions for services of railway passenger transportation. The set of the time series suitable for econometric estimation is given 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. The other price variable  $P_1, P_2, P_3, P_4, P_5$  and  $P_6$  covers the period 1994M1–2002M7. Two groups of series can be derived from the available time series. In the first group we place the monthly series for the period 1994M1–2002M7. In the second group are quarterly series that cover 1994Q1–2002Q2.

### **Specification of Demand Functions for Services of Public Railway Passenger Transportation**

Following empirical analyses (Owen and Phillips 1987; Oum 1989; de Rus 1990; Oum et al. 1992), we chose the following specification of the demand function for services of public railway passenger transportation:

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

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

Table 2: List of usable time series

| <i>Symbol</i>        | Series name   | Number of observations | Frequency | Break  | Time period    |
|----------------------|---|------------------------|-----------|--------|----------------|
| <b>Q</b>             | Number of passengers transported                              | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>I<sub>1</sub></b> | Real gross domestic product                                   | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>I<sub>2</sub></b> | Registered real household income                              | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>P<sub>1</sub></b> | Average nominal fare  | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>2</sub></b> | Average real fare (deflator <i>SP1</i> )                      | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>3</sub></b> | Average real fare (deflator <i>TP1</i> )                      | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>4</sub></b> | Average real fare (deflator <i>TCPI</i> )                     | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>5</sub></b> | Average real fare (deflator <i>RPTPI</i> )                    | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>6</sub></b> | Average real fare (deflator <i>CP1</i> )                      | 103                    | Monthly   | ...    | 1994M1–2002M7  |
| <b>P<sub>7</sub></b> | Railway passenger transportation price index ( <i>RPTPI</i> ) | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>O<sub>1</sub></b> | Number of first-time registered personal cars                 | 67                     | Monthly   | ...    | 1997M1–2002M7  |
| <b>O<sub>2</sub></b> | Average retail price of lead-free 95-octane petrol            | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>O<sub>3</sub></b> | Average retail price of lead-free 98-octane petrol            | 115                    | Monthly   | ...    | 1993M1–2002M7  |
| <b>O<sub>4</sub></b> | Average retail price of leaded 98-octane petrol               | 114                    | Monthly   | ...    | 1993M1–2002M6  |
| <b>O<sub>5</sub></b> | Average retail price of lead-free 91-octane petrol            | 48                     | Monthly   | ...    | 1993M1–1996M12 |
| <b>O<sub>6</sub></b> | Average retail price of representative car Renault 5          | 48                     | Monthly   | ...    | 1993M1–1996M12 |
| <b>O<sub>7</sub></b> | Average retail price of representative car Renault Clio       | 67                     | Monthly   | 1999M1 | 1997M1–2002M7  |
| <b>O<sub>8</sub></b> | Average retail price of representative car vw Polo            | 67                     | Monthly   | 1999M1 | 1997M1–2002M7  |

Note: For easier understanding of the 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 some variables several series are available, we also added 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 passengers transported                     | 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 petrol   | 115                                     | 38  | 1993M1–2002M7 |

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

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 passengers transported per month  
 $I_r^m$  –  $r^{\text{th}}$  income variable, monthly  
 $P_r^m$  –  $r^{\text{th}}$  price variable, monthly  
 $O_r^m$  –  $r^{\text{th}}$  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  
 $\beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$  – 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 passengers transported per month (seasonally adjusted)  
 $ISA_r^m$  –  $r^{\text{th}}$  income variable, monthly (seasonally adjusted)  
 $PSA_r^m$  –  $r^{\text{th}}$  price variable, monthly (seasonally adjusted)  
 $OSA_r^m$  –  $r^{\text{th}}$  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 passengers transported per quarter  
 $I_r^q$  –  $r^{\text{th}}$  income variable, quarterly  
 $P_r^q$  –  $r^{\text{th}}$  price variable, quarterly  
 $O_r^q$  –  $r^{\text{th}}$  variable for other socio-economic factors, quarterly  
 $D_2$  – dummy variable for seasonal component in second quarter

$D_3$  – dummy variable for seasonal component in third quarter  
 $\ln(\beta_1)$  – regression constant  
 $\beta_2, \beta_3, \beta_4, \beta_5, \beta_6$  – 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 passengers transported per quarter (seasonally adjusted)

$ISA_r^q$  –  $r^{\text{th}}$  income variable, quarterly (seasonally adjusted)

$PSA_r^q$  –  $r^{\text{th}}$  price variable, quarterly (seasonally adjusted)

$OSA_r^q$  –  $r^{\text{th}}$  variable for other socio-economic factors, quarterly (seasonally adjusted)

$\ln(\beta_1)$  regression constant

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

$u$  – random variable.

### **Estimation of the Demand Functions for Services of Public Railway Passenger Transportation**

For estimation of parameters for the functions specified in previous section, 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 signifi-

Table 4: List of econometric tests used

| 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          | <i>p</i> values, <i>t</i> 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 <sup>2</sup> and F test  |

cance (*p* values). Besides 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.

#### 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 estimated regression equations for monthly data do not fulfill the condition of normal distribution of residuals (56 equations). For 28 of the equations that are based on 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, have 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:<sup>4 5</sup>

$$\begin{aligned} \text{E1} \quad \ln(Q^q) &= \ln(\beta_1) + \beta_2 \ln(I_1^q) + \beta_3 \ln(P_5^q) \\ &\quad + \beta_4 D_2 + \beta_5 D_3 + u \end{aligned}$$

$$\begin{aligned} \text{E2} \quad \ln(Q^q) &= \ln(\beta_1) + \beta_2 \ln(I_1^q) + \beta_3 \ln(P_6^q) \\ &\quad + \beta_4 D_2 + \beta_5 D_3 + u \end{aligned}$$

$$\begin{aligned} \text{E3} \quad \ln(Q^q) &= \ln(\beta_1) + \beta_2 \ln(I_2^q) + \beta_3 \ln(P_5^q) \\ &\quad + \beta_4 D_2 + \beta_5 D_3 + u \end{aligned}$$

$$\begin{aligned} \text{E4} \quad \ln(Q^q) &= \ln(\beta_1) + \beta_2 \ln(I_2^q) + \beta_3 \ln(P_6^q) \\ &\quad + \beta_4 D_2 + \beta_5 D_3 + u \end{aligned}$$

$$\begin{aligned} \text{E5} \quad \ln(QSA^q) &= \ln(\beta_1) + \beta_2 \ln(ISA_2^q) \\ &\quad + \beta_3 \ln(PSA_5^q) + u \end{aligned}$$

$$\begin{aligned} \text{E6} \quad \ln(QSA^q) &= \ln(\beta_1) + \beta_2 \ln(ISA_2^q) \\ &\quad + \beta_3 \ln(PSA_6^q) + u \end{aligned}$$

A summary of estimates of all six functions is presented in Table 5.<sup>6</sup>

#### DISCUSSION OF RESULTS

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 with 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 by on average an approximately 0.20% decrease in the quantity of demand for services of railway passenger transportation. The low values of standard errors of the regression coefficient estimates for average real fares contribute to a satisfactory width of confidence intervals for the reference price elasticities.

Table 5: Empirical results

| A        |                                     |                                      |   |  |  |
|----------|-------------------------------------|--------------------------------------|---|--|--|
| 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 |
| E1       | -0.2045<br>(-2.9015)*<br>(0.0070)** | 0.9286<br>(5.6104)*<br>(0.0000)**    | [-0.3781, -0.0309]                        | [0.5211, 1.3360]                           | 0.3472   |
| E2       | -0.2032<br>(-2.7208)*<br>(0.0109)** | 0.9273<br>(5.2894)*<br>(0.0000)**    | [-0.3870, -0.0193]                        | [0.4957, 1.3589]                           | 0.3677   |
| E3       | -0.3586<br>(-3.2837)*<br>(0.0027)** | 0.4319<br>(4.9737)*<br>(0.0000)**    | [-0.6274, -0.0897]                        | [0.2181, 0.6457]                           | 0.5377   |
| E4       | -0.3966<br>(-3.2520)*<br>(0.0029)** | 0.4628<br>(4.7719)*<br>(0.0000)**    | [-0.6969, -0.0964]                        | [0.2240, 0.7016]                           | 0.6005   |
| E5       | -0.3681<br>(-3.5021)*<br>(0.0014)** | 0.4375<br>(5.2334)*<br>(0.0000)**    | [-0.6259, -0.1104]                        | [0.2325, 0.6425]                           | 0.5155   |
| E6       | -0.4061<br>(-3.4451)*<br>(0.0017)** | 0.4684<br>(4.9969)*<br>(0.0000)**    | [-0.6951, -0.1171]                        | [0.2385, 0.6982]                           | 0.5780   |

Note: for explanation see note 6 on page 152.

- 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.

| Confidence intervals for income elasticity, differences | B                  |                    |                    | C                   | D                  | E                      | F                  |
|---|--------------------|--------------------|--------------------|---------------------|--------------------|------------------------|--------------------|
|   | LM(1)              | LM(2)              | LM(4)              | Adj. R <sup>2</sup> | RESET test         | Cusum and Cusum Q test | JB test            |
| 0.8149  | 0.0012<br>(0.9721) | 0.1566<br>(0.9247) | 1.6729<br>(0.7956) | 0.9686<br>(0.0000)  | 0.0015<br>(0.9698) | +                      | 0.5548<br>(0.7577) |
| 0.8632  | 0.0000<br>(0.9945) | 0.1676<br>(0.9196) | 1.3513<br>(0.8526) | 0.9677<br>(0.0000)  | 0.0130<br>(0.9099) | +                      | 0.7463<br>(0.6886) |
| 0.4276  | 0.6334<br>(0.4261) | 0.6405<br>(0.7260) | 1.7858<br>(0.7751) | 0.9647<br>(0.0000)  | 0.0875<br>(0.7695) | +                      | 1.5761<br>(0.4547) |
| 0.4776  | 1.0390<br>(0.3081) | 1.1259<br>(0.5695) | 2.1352<br>(0.7109) | 0.9645<br>(0.0000)  | 0.2484<br>(0.6221) | +                      | 1.0838<br>(0.5816) |
| 0.4100  | 0.8198<br>(0.3652) | 0.8510<br>(0.6534) | 2.2102<br>(0.6972) | 0.7281<br>(0.0000)  | 5.4809<br>(0.0261) | +                      | 0.8419<br>(0.6564) |
| 0.4597  | 1.2137<br>(0.2706) | 1.2151<br>(0.5447) | 2.4055<br>(0.6616) | 0.7256<br>(0.0000)  | 5.9878<br>(0.0205) | +                      | 0.3354<br>(0.8456) |

From the results it follows that increasing average real fares by 1% will on average be followed by a 0.36% or 0.40% lowering of 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 elasticity estimates from equations E3 and E4, we can conclude that the number of passengers transported on average increases by 0.43% or 0.46%

if the registered real household income increases by 1%, all other elements being 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 an 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 real fares would cause a contraction of demand for services of railway passenger transportation on average by 3.7% (equation E5) or 4.1% (equation E6).

We can base our judgment of the explanatory power of estimated regression equations 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 by 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 us about 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 to the 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 ( $\alpha = 0.05$ ). We close the presentation of the content of econometric tests in Table 5 by checking the distribution of residuals for the chosen equations. The



results derived from the Jarque-Bera test conclusively confirm that the residuals are normally distributed from all regression equations.

### **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 unity 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 by less than the fare actually increases (in percentage terms). The recorded price inelasticity of demand leads us to conclude that revenues of the railway operator increase when the average real fare increases.

We consider 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 a 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 tickets sold.

### **Notes**

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: Owen and Phillips (1987), Oum (1989), de Rus (1990), Goodwin (1992), Oum et al. (1992) and Wardman et al. (1997).
2. The choice of the dependent variable (the total number of transported passengers) is discussed 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 see Table 3, and for the meaning of elements in specification see pp. 143–145.
5. Results of the estimation of price elasticities, derived from the other three deflators, are available upon request from the author.

6. In part A are 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. In part B are 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.

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