IMPACT OF QUALITY OF TRANSPORT SERVICES ON DEMAND FOR BUS TRANSPORT DEPENDING ON THE GROUPS OF PASSENGERS

Vladimír Konečný
University of Žilina, Department of Road and Urban Transport
Žilina
Slovakia

Róbert Berežný
University of Žilina, Department of Road and Urban Transport
Žilina
Slovakia

ABSTRACT
The concept of quality is now increasingly important in the field of public transport. With the growth of living standards among passengers there is an increased needs for high quality transport services. Demand for public passenger transport is influenced by a number of factors. The quality of transport services is one of the most important. To assess the impact of quality on demand it is necessary first to propose a suitable methodology for measuring and evaluating the quality and subsequently assess the impact of changes in the quality on the change in demand. Knowing these contexts can serve to stabilize demand for public passenger transport. Quality requirements as well as satisfaction with quality criteria differ significantly in dependence on passenger groups. Research in this area is practically applied in a particular region in Slovakia.

Keywords: quality, public passenger transport, quality criteria, demand

1. INTRODUCTION

Quality can be defined as a concept for the generally positive features of a product or service. Quality is nowadays increasingly important in the field of public transport. Nowadays the success of a public transport system depends on the number of passengers which the system is able to attract and retain. [6] For this reason, the quality of a service becomes an issue of maximum importance because it is known that an improvement in the level of quality of the service leads to a higher satisfaction of the passengers and to an increase of the use of the system.[10] Also according to Eboli and Mazzulla [5] specifically in public transport, service quality is a matter of the greatest importance because an improvement of quality levels can attract further users.

The support of service quality is a tool of the passenger demand sustainability for the public passenger transport (PPT). The study of ITF recognizes the influence of the service quality to demand for services. Anderson et al. [1] when examining the sensitivity (elasticity) passenger demand to change a particular factor in study found that the quality of transport services is significantly more influential factor than fare and also more influential factor than income of the population. [2]

2. METHODS

Several methods can be used to assess the impact of quality on bus transport demand. The recommendations are based on an analysis of relationship and causal analysis tools as well as existing research in the Slovak Republic and abroad not only in transport and transport services.

2.1. Covariance coefficient

Whether two variables X and Y are in a linear relation (direct or indirect) can be convinced on the basis of the covariance coefficient of variables X and Y (designation cov xy) defined on the basis of the relationship (1):

$$cov\ xy = \frac{1}{n} * \sum_{i=1}^{n} (x_i - \bar{x}) * (y_i - \bar{y}) = \overline{x * y} - \bar{x} * \bar{y} \quad (1)$$

Interpretation of results:

- if the variables X and Y are independent, then *cov xy* = 0,
- if *cov xy*> 0, there is a direct linear relationship between X and Y,
- if *cov xy* <0, there is an indirect linear relationship between X and Y.

2.2. Correlation analysis

The correlation analysis tool is the so-called correlation coefficient. The correlation coefficient is the measure of the linear dependence of the two variables and we can express it using the following relationship (2):

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x}).(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 . \sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (2)$$

Interpretation of results:

- if r_{xy} = 1, there is a perfect positive relationship,
- if r_{xy} = 0.8 to 1, there is a fairly strong positive relationship,
- if r_{xy} = 0.6 to 0.8, there is a moderate positive relationship,
- if r_{xy} = 0.3 to 0.6, there is a weak positive relationship,
- if r_{xy} = 0 to 0.3, there is no correlation.

2.3. The theory of linear elasticity of demand

The notion of elasticity of demand is mainly used in the area of the economy, but we can also meet this concept in the transport sector. Linear elasticity is a very often used method for calculating elasticity. It is appropriate to use it if the monitored pointers are not expressed by function but by arranged pairs of points. It can be calculated based on the following relationship (3):

$$e_{x_i}^{line} = \left(\frac{\frac{y_2 - y_1}{\frac{1}{2}(y_2 + y_1)}}{\frac{x_{i2} - x_{i1}}{\frac{1}{2}(x_{i2} + x_{i2})}} \right) = \frac{(y_2 - y_i).(x_{i2} + x_{i1})}{(y_2 + y_1).(x_{i2} - x_{i1})} \quad (3)$$

2.4. Regression analysis

The significance of regression analysis is based on examination of the two codes X and Y. In regression modeling the task is to formulate which variable is to be considered independent (X) and which is the dependent variable (Y). Dependent variable Y (explained) is *demand* and independently variable X (explanatory) is *quality*. In our example, we expect the higher the quality level, the higher the demand. Generally it is possible to express the relationship between the values of the variables X and Y as follows (4):

$$y_i = f(x_i) + e_i \quad (4)$$

Particular regression line model has the shape (5):

$$\hat{y_i} = b_0 + b_1 x_i \quad (5)$$

Coefficient of determination R^2 measures the delineated dependence between X and Y using a linear model. It takes values from the interval <0,1> and its closer to 1 so the dependence of the variables is better captured. The R^2 .100% value expresses how much variable variables of the dependent variable Y are explained by the regression line. [8]

3. RESEARCH AND RESULTS

In this part of the article is processed a case study focuses on the application of selected methods, for assessing the impact of quality on demand in the suburban bus transport in the Žilina self-governing region.

To assess the impact of quality on demand it is necessary to know the measured level of quality of services provided by the carrier in the surveyed period and also demand for bus transport. The demand indicator may be the number of tickets sold or the number of passengers transported. This is the available statistical data tracked by carriers and performance providers. Demand for bus services in recent years, significantly decreasing applies to all groups of passengers. There is also a markedly proportional structure of demand in terms of passenger groups or type of travel. It can be said that the number of those who use the services they use is still decreasing. While 48 million passengers were transported in the Žilina self-governing region in 2005, it was only 24.8 million in 2017. This represents an approximately 23.2 million passenger drop in 12 years. [4]

The individual methods (analyzed in chapter 2) are examined alternatively in view of the method of determining the quality level:

- *Alternative I* - Quality level determined by measurement based on author's research
- *Alternative II* - Quality level determined by measurement based on data from carriers from internal quality measurement
- *Alternative III* - Quality level determined by measurement customer satisfaction based on author research

Quality level determined by measurement based on author's research was realized by controllers in the area a provision of transport services. The methodology recommended by European standards (EN 13816 and EN 15140) was applied.

Quality level determined by measurement based on data from carriers from internal quality measurement was realized by providing data from carriers in Žilina region from internal quality measurement over the years 2013-2017. [9]

To identify the satisfaction of passengers with the quality criteria, a questionnaire survey was conducted in the Žilina region in 2013-2017. These were the passengers who use the real services and have a personal experience with them. The actual sample size for the satisfaction survey was a sample of 3 928 respondents. The results of this survey show that satisfaction with selected quality criteria varies greatly depending on the passenger groups. [3]

Table 1. Standardized values of quality criteria in the suburban bus transport in Žilina region (Source: authors)

Quality criteria	*Alternative I* Measured quality - author's research (%)					*Alternative II* Measured quality - data from carriers (%)					*Alternative III* Passenger satisfaction (%)				
	2013	**2014**	**2015**	**2016**	**2017**	**2013**	**2014**	**2015**	**2016**	**2017**	**2013**	**2014**	**2015**	**2016**	**2017**
Punctuality	72	65	72	73	70	67,41	67,53	69,86	73,47	75,96	64	73	73	79	70
Information	80	77	86	99	99	94,00	94,83	96,18	96,12	98,93	56	73	76	93	83
Cleanliness	67	82	85	83	88	98,09	98,37	98,80	99,37	99,60	60	67	66	84	66
Driver behavior	64	88	89	95	88	99,95	99,95	99,96	99,98	99,98	67	68	68	83	72
∑	**71**	**78**	**83**	**87**	**86**	**89,86**	**90,17**	**91,23**	**92,24**	**93,47**	**62**	**70**	**71**	**83**	**72**

3.1. The application of the coefficient covariance and correlation coefficient

For the calculation of the covariance coefficient was used formula (1) and to calculate the correlation coefficient was used formula (2). Table 2 shows the calculated values of the covariance coefficient and the correlation coefficient between the quality level and the demand level in 2013 to 2017 by groups od passengers.

Table 2. Calculated values of the covariance coefficient and the correlation coefficient between the quality level and the demand level by groups of passengers (Source: authors)

Group of passengers	Alternative	Coefficient covariance	Linear relationship	Correlation coefficient	Linear dependence
Students	I.	2 962 148	direct	0.992816	strong
	II.	620 345	direct	0.919145	strong
	III.	2 747 275	direct	0.809384	strong
Economically active population (EAP)	I.	8 052 024	direct	0.933411	strong
	II.	1 881 142	direct	0.964003	strong
	III.	6 337 632	direct	0.645781	moderate
Retirees	I.	963 497	direct	0.930270	strong
	II.	222 589	direct	0.950059	strong
	III.	964 723	direct	0.818751	strong

3.2. The application of the linear elasticity method

A relationship (3) was used to calculate linear elasticity in two or more yearly changes in demand and quality. Table 3 shows the calculated linear elasticity values for quality impact assessment on demand in terms of two or more annual changes.

Table 3. Linear elasticity calculation with two and more yearly changes in demand and quality by groups of passengers (Source: authors)

Group of passengers	Alter native	Two or more year change						Average value	Value range
		2017/2015	2017/2014	2017/2013	2016/2014	2016/2013	2015/2013		
Students	I.	0.6874	0.5358	0.4503	0.4386	0.4030	0.3957	0.4851	0.40-0.69
	II.	1.0062	1.4546	2.1849	2.1083	3.1226	4.0761	2.3255	1.01-4.08
	III.	1.7450	1.8559	0.5765	0.2816	0.2818	0.4557	0.8661	0.28-1.86
Economically active population (EAP)	I.	2.3380	1.4670	1.1090	0.7433	0.7415	0.8308	1.2049	0.74-2.34
	II.	3.4221	3.9822	5.3808	3.5727	5.7456	8.5569	5.1101	3.42-8.56
	III.	5.9349	5.0808	1.4198	0.4772	0.5185	0.9566	2.3980	0.48-5.93
Retirees	I.	1.5348	0.7697	0.5052	0.6910	0.4780	0.2701	0.7081	0.27-1.53
	II.	2.2464	2.0893	2.4510	3.3212	3.7038	2.7821	2.7656	2.09-3.78
	III.	3.8959	2.6657	0.6467	0.4436	0.3342	0.3110	1.3829	0.31-3.90

3.3. The application of the regression analysis

In this method, it is first necessary to estimate the parameters of the regression line y versus x using the least squares method. Using the relations (5) for the regression line, we then calculate its coefficients b_0 and b_1. Based on researches for the period 2013 to 2017, single-criterion regression features have been established to express the dependency on demand for quality. (Table 4)

Table 4. Single-criteria regression model to assess the impact of quality on passenger demand by groups of passengers (Source: authors)

Group of passengers	Alternative	Characteristic			
		Equation of the regression line	R^2	Significance F	P-value
Students	I.	y=7179671+68095x	0.9857	0.000730	0.00034 0.00073
	II.	y=12775201+278690x	0.8448	0.027262	0.13576 0.02726
	III.	y=9201525+48797x	0.6551	0.096995	0.00823 0.09699
Economically active population (EAP)	I.	y=1277432+185104x	0.8713	0.020420	0.72733 0.02042
	II.	y=60966582+845104x	0.9293	0.008154	0.01577 0.00815
	III.	y=8210919+112569x	0.4170	0.239166	0.23399 0.23916
Retirees	I.	y=1772639+22149x	0.8654	0.021871	0.02275 0.02188
	II.	y=5572480+99998x	0.9026	0.013297	0.04878 0.01329
	III.	y=2339841+17135x	0.6704	0.090068	0.01833 0.09007

Table 5 shows a sample calculation of a single-criterion regression model for assessing the quality impact of a measurement based on the author's research and the demand of a group of student students.

Table 5. Sample calculation of a single criterion regression model for assessing quality impact on student demand (Source: authors)

Regression Statistics	
Multiple R	0.9928161
R Square	0.9856837
Adjusted R^2	0.9809116
Standard Error	62499.691
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8.06834E+11	8.07E+11	206.5516	0.000730146
Residual	3	11718633982	3.91E+09		
Total	4	8.18553E+11			

	Coefficients	*Standard E*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	7179671.1	384801.7005	18.65811	0.000336	5955060.322	8404281.82
X Variable 1	68095.362	4738.089318	14.3719	0.00073	53016.64722	83174.0769

4. CONCLUSION

The coefficient of covariance between the quality and demand reaches positive values which can be interpreted as a direct linear relationship (with increasing quality demand is rising).

The correlation coefficient for the EAP group in Alternative III is less than 0.8, which is a moderate linear dependence. In other cases, the correlation coefficient is close to 1, which can be interpreted as a strong linear dependency.

The calculated linear elasticity for two and more year changes in demand and quality is positive in all cases. These positive values mean that the increase in the quality of bus services increases passenger numbers.

The results obtained can be interpreted as an example of the average value of two or more annual elasticity of demand and quality (Alternative I) for a group of student students as follows:

- the average value of demand elasticity and measured quality is 0.4851, which means that if quality increases by 1% in the short term, demand will also increase by 0.4851%.

By applying the regression analysis method to assess the quality impact on demand, it was possible to determine the equation of the regression line, on the basis of which it is possible to estimate the future evolution of the demand for quality change. The null hypothesis is tested in the ANOVA section when applying a regression analysis method based on passenger groups. In almost all cases, the model as a whole is chosen correctly. This is evidenced by the Significance F value, which is in almost all cases less than 0.05.

Based on the results of measuring and evaluation the quality and customer satisfaction with suburban bus transport there is scope for increasing quality and satisfaction (values do not reach the ideal 100%) which can then be used to slow down the pace of passenger demand or stopping its decline.

The findings could be the basis for stabilization of development (deceleration decrease) in passenger demand for bus transport in the Žilina self-governing region by improving quality and increasing customer satisfaction with the quality of services.

5. ACKNOWLEDGMENT

This paper has been developed under support of project: MŠVVŠ SR VEGA No. 1/0566/18 KONEČNÝ, V.: Research on the impact of supply and quality of transport services on the competitiveness and sustainability of demand for public transport.

6. REFERENCES

[1] Anderson, R.; et al.: Measuring and Valuing Convenience and Service Quality, A review of global practices and challenges from the public transport sector, OECD/ITF, 2013.

[2] Balcombe, R.; et al.: The demand for public transport: a practical guide, 2004, TRL Report TRL 593, ISSN 0968-4107

[3] Berežný, R.; Konečný, V.: The impact of the quality of transport services on passenger demand in the suburban bus transport, In.: 12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport, Vol. 192, 2017, DOI: 10.1016/j.proeng.2017.06.007, pp. 45-46Wieregge, G.: Zerspanung der Eisenwerkstoffe, Verlag Stahleisen m.b.H. Düsseldorf, 1970.

[4] Document:Objednávanie výkonov pravidelnej prímestskej autobusovej dopravy v Žilinskom samosprávnom Available at: http://www.zask.sk/files/odbory/doprava/2017/dokumenty/sprava-primestskej-autobusovej-doprave-realizovanej-ramci-sluzieb-vov-verejnom-zaujme-uzemi-zsk-za-rok-2016.pdf

[5] Eboli, L.; Mazzulla, G.: A Stated Preference experiment for measuring service quality in public transport, TRANSPORTATION PLANNING AND TECHNOLOGY, vol. 31, Issue 5, pp.509-523, 2008, DOI: 10.1080/03081060802364471

[6] Friman, M.; Fellesson, M.: Service Supply and Customer Satisfaction in Public Transportation: The Quality Paradox, In.: Journal of Public Transportation, Vol. 12, No. 4, University of South Florida, 2009, DOI: http://doi.org/10.5038/2375-0901.12.4.4, pp.57-69

[7] Gnap J.; Konečný, V.; Poliak, M.: Demand elasticity of public transport, EKONOMICKY CASOPIS, vol. 54, Issue 7, pp. 668-684, 2006

[8] Hindls, R.; Hronová, S.; Seger, J.: Statistika pro ekonomy, Praha 2003, ISBN 80-86419-52-5

[9] Konečný, V.; Berežný, R.; Bartoníková, M.: Research on the Impact of Quality on Demand for Bus Transport, 18TH INTERNATIONAL SCIENTIFIC CONFERENCE-LOGI 2017, Vol. 134, No. 00024, DOI: 10.1051/matecconf/201713400024, 2017

[10] Ona, J.; Ona, R.; Eboli, L.; Mazzulla, G.: Perceived service quality in bus transit service: A structural equation approach, TRANSPORT POLICY, vol. 29, pp. 219-226, September 2013, DOI: 10.1016/j.tranpol.2013.07.001