

Ivana OLIVKOVÁ*

URBAN MASS TRANSPORTATION QUALITY EVALUATION
FROM PASSENGER'S POINTS OF VIEW
HODNOCENÍ KVALITY MĚSTSKÉ HROMADNÉ DOPRAVY
Z HLEDISKA SPOKOJENOSTI CESTUJÍCÍCH

Abstract

This paper deals with urban mass transportation quality evaluation from passenger's satisfaction points of view. The presented method of the urban mass transportation quality evaluation has been experimentally validated by the traffic survey of the passengers' satisfaction. The experiment was based on a designed list of questions, which has been used for a traffic survey of the passengers' satisfaction. Criteria of transferring quality have been evaluated from set of passenger's individual points of view in Ostrava urban mass transportation system conditions.

Abstrakt

Článek se zabývá problematikou hodnocení kvality městské hromadné dopravy z hlediska spokojenosti cestujících. Zejména se věnuje popisu metody hodnocení kvality MHD. Tato metoda byla experimentálně ověřena provedením dopravního průzkumu spokojenosti cestujících. Experiment byl proveden na základě navrženého dotazníku pro anketní dopravní průzkum cestujících. Kritéria kvality byla hodnocena z hlediska cestujících v konkrétních podmínkách systému MHD v Ostravě.

1 INTRODUCTION

Current level of a urban transport capacity is first and foremost reflection of the transport services quality level. The particular offers, benefits and disadvantages within the network of the transport system have proven complicated to follow for passengers. Passengers' decision depends on the offered transport services' quality.

The presented paper deals with urban mass transportation quality evaluation. Method of the urban mass transportation quality evaluation is theoretically described in detail. A mixed system method of the urban mass transportation displacement quality criteria has been created. The quantitative and qualitative criteria have been utilized.

2 METHOD OF THE URBAN MASS TRANSPORTATION QUALITY EVALUATION

The quantitative criteria (the values of the quantitative criteria can be formulated in metrical scale) and qualitative criteria (the values of the quantitative criteria can be formulated in ordinal scale) for urban mass transportation quality evaluation have been utilized. The values of the quantitative criteria can be statistical evaluated immediately. The values of the qualitative criteria must be formulated in points scale at first. The passengers graduate quality level of every criterion through assignment of points from five points scale. In this way can be achieved the statistical evaluating for qualitative criteria too.

Quality evaluation of criterion can be divided into following steps:

1. Definition scope of criteria utility function:
 - a) definition scope of criteria utility function,
 - b) sales chart of survey values through the point diagram,
 - c) species determination of regression function (criteria utility function) and parameters determination by method of least squares.
2. Separation of definition scope to the nominal value intervals and limiting nominal value determination.

* Ing. Ph.D. ING-PAED IGIP, Institute of Transport (342), Faculty of Mechanical Engineering, VŠB – Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic, tel. (+420) 59 732 3122, e-mail ivana.olivkova@vsb.cz

The criteria evaluation procedure depends on the criteria type. That is why can be divided below:

- quantitative criteria evaluation,
- qualitative criteria evaluation.

2.1 Quantitative criteria evaluation

Through the traffic survey of the passengers' satisfaction was evaluated following quantitative criteria: travel time, reach time the stop, waiting time, change time.

ad.1a) Definition scope of criteria utility function

The nominal value interval is the definition scope of criteria utility function. The nominal values were determined on the basis of survey values. The limit values of this interval can be marked as $x_{i \min}$ and $x_{i \max}$ where:

$x_{i \min}$ – lowest (minimal) value of criterion i [min],

$x_{i \max}$ – highest (maximal) value of criterion i [min].

ad.1b) Sales chart of survey values through the point diagram

By means of items up 1, 2, 3, 4 or 5, where 1 is best value and 5 worst value, informants assign utility value $u_i = 1, u_i = 0,75, u_i = 0,5, u_i = 0,25$ or $u_i = 0$ to the nominal value of criterion x_i . The ordered pairs $(x_i, u_i(x_i))$ form the point coordinates. These points can be diagrammatized through the point diagram. There are displayed the nominal values of criterion x_i on the axis x and assigned average utility values on the axis y .

ad.1c) Species determination of regression function (criteria utility function) and parameters determination by method of least squares

The regression (approximation) function can be solved by the method of least squares. This function has smallest squares deviation sum of observed (survey) values from calculated (theoretical) values y_i' (Fig.1). The method of least squares is based on the regression (approximation) function searching.

For this function must be applied:

$$\sum_{i=1}^n (y_i - y_i')^2 = \min \quad (1)$$

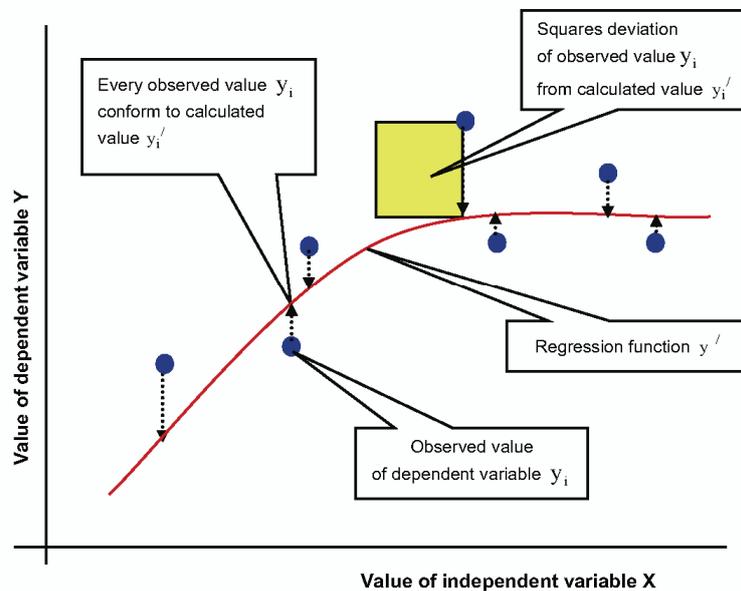


Fig. 1 Sales chart of the least squares method

The process of calculation will be presented on evaluation of criterion “travel time”. By means of items up 1, 2, 3, 4 or 5, where 1 is best value and 5 worst value, informants assign utility value $u_1 = \langle 1 ; 0 \rangle$ to the nominal value of travel time x_1 . The ordered pairs $(x_1, u_1(x_1))$ form the point coordinates. These points can be diagrammatized through the point diagram (Fig.2). There are displayed the nominal values of travel time on the axis x and assigned average utility values on the axis y.

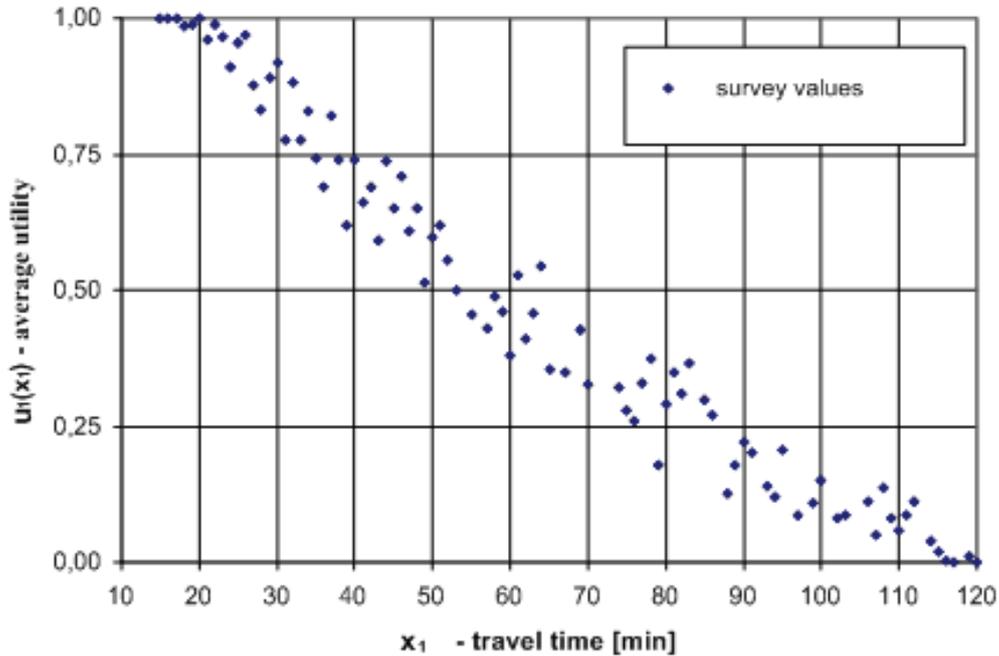


Fig. 2 The point diagram of the surveyed travel time values

The survey values of travel time criterion can be approximated by parabola (the quadratic function, the polynomial of degree 2) $y = f(x) = ax^2 + bx + c$ (Fig. 3). The parameters determination (a, b, c) can be calculated by method of least squares i.e. under condition:

$$\sum_{i=1}^n (y_i - a x_i^2 - b x_i - c)^2 = \min \quad (2)$$

Usability of regression (approximation) function can be ascertained by deterministic index (I^2):

$$I^2 = \frac{\sum_{i=1}^n (y_i' - \bar{y})^2}{\sum_{i=1}^n (y_i - \bar{y})^2} \quad (3)$$

The deterministic index (in Microsoft Excel is represented R^2) take the values from close range $\langle 0, 1 \rangle$.

The utility function of travel time criteria $u_1(x_1)$:

$$u_1(x_1) = 5E - 05 x_1^2 - 0,0167 x_1 + 1,2959$$

The deterministic index values $R^2 = 0,9758$ correspond to approximation rate.

The criteria utility function in the nominal value interval $x_1 = \langle 19; 120 \rangle$ is falling from the function value $u_1(x_1^1) = 1$ to function value $u_1(x_1^0) = 0$. The criteria utility function has the convex course. The travel time criterion has decreasing preference of the nominal value. The equivalent increase in nominal value of the criterion stands in declines of utility decreasing.

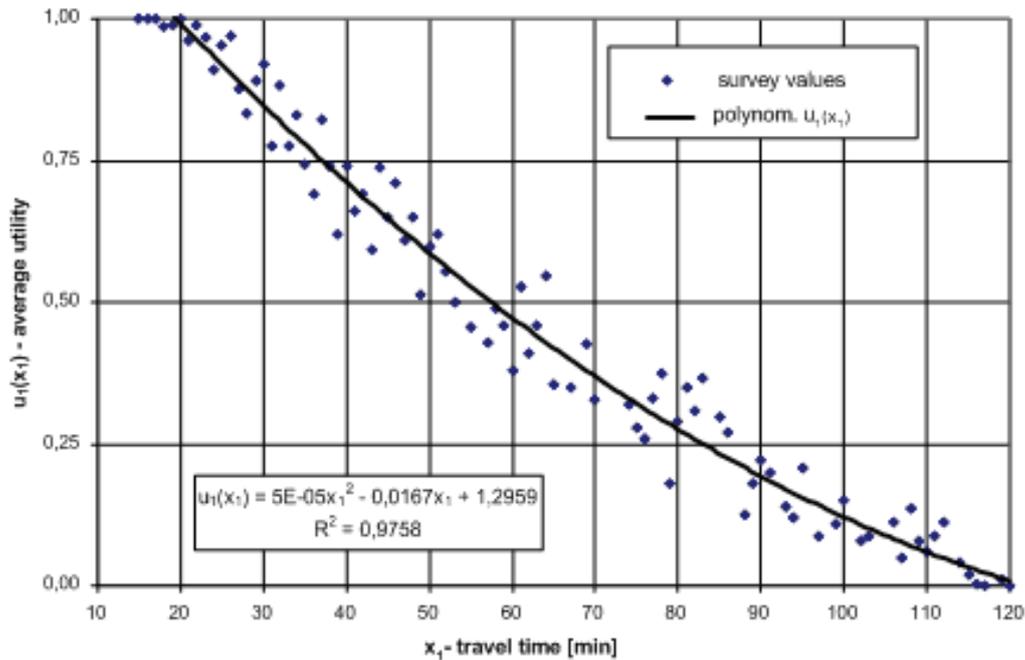


Fig. 3 The utility function of travel time criterion $u_1(x_1)$

ad.2) Separation of definition scope to the nominal value intervals and limiting nominal values determination.

The definition scope can be separated to the five nominal value intervals by means of items up transformation. By means of criteria utility function can be obtained limiting nominal values x_1^1 , $x_1^{0,75}$, $x_1^{0,5}$, $x_1^{0,25}$, x_1^0 , for that $u_1(x_1)$ is reaching the values $u_1(x_1^1) = 1$, $u_1(x_1^{0,75}) = 0,75$, $u_1(x_1^{0,5}) = 0,5$, $u_1(x_1^{0,25}) = 0,25$ and $u_1(x_1^0) = 0$. Means of items up transformation can be diagrammatized in the table 1.

Tab. 1 Means of items up of quality of travel time transformation to the nominal value intervals and limiting nominal values

Means of items up	Nominal value intervals [min]	Limiting nominal values x_1 [min]
very favourable	15-27	19
favourable	28-45	36
neither favourable – nor unfavourable	46-67	57
unfavourable	68-95	83
very unfavourable	96 - 120	120

Time travel evaluation can be evident from values set forth above. Highest utility answer the purpose of destination by 27 minutes. Time travel 45 minutes is evaluated by passengers “favourable”. In-

crease of time spending by travelling is evaluated neutral – “neither favourable – nor unfavourable” (by 67 minutes). Next extension of travel time is unfavourable from passengers’ point of view.

2.2 Qualitative criteria evaluation

Through the traffic survey of the passengers’ satisfaction was evaluated following qualitative criteria: accuracy and reliability, solution of stops, information about city line traffic, solution of ticket office, occupancy of vehicle, noisiness and vehicle vibrations, microclimate in vehicle, driving habits, solution of vehicle interior, costs of freight and influence of urban mass transportation to environment.

ad.1a) Definition scope of the criteria utility function

The limiting nominal values of criterion $x_i = 1, x_i = 2, x_i = 3, x_i = 4, x_i = 5$ are the definition scope of qualitative criteria utility function. The limiting nominal values were determined on the basis of survey values.

ad.1b) Diagrammatise of survey values through the point diagram

By means of items up 1, 2, 3, 4 or 5, where 1 is best value and 5 worst value, informants assign the limiting nominal values of criterion x_i . For these five values take $u_i(x_i)$ the value $u_i(1)=1, u_i(2)=0,75, u_i(3)=0,5, u_i(4)=0,25$ a $u_i(5)=0$. The ordered pairs $(x_i, u_i(x_i))$ form the 5 point coordinates. These points can be diagrammed through the point diagram. There are displayed the limiting nominal values of criterion x_i on the axis x and assigned utility values on the axis y.

ad.1c) Species determination of regression function (criteria utility function) and parameters determination using method of least squares

The regression (approximation) function can be figured out by the method of least squares. The process of calculation will be presented on evaluation of qualitative criterion “accuracy and reliability”. By means of items up 1, 2, 3, 4 or 5, where 1 is best value and 5 worst value, informants assign the limiting nominal values of accuracy and reliability x_2 . For these five values take $u_2(x_2)$ the value $u_2(1)=1, u_2(2)=0,75, u_2(3)=0,5, u_2(4)=0,25$ and $u_2(5)=0$. The ordered pairs $(x_2, u_2(x_2))$ form the 5 point coordinates. These points can be diagrammed through the point diagram. There are displayed the limiting nominal values of accuracy and reliability on the axis x and assigned utility values on the axis y.

The survey values of accuracy and reliability criteria can be approximated by line (the polynomial of degree 1) $y = f(x) = ax + b$. The parameters determination (a, b) can be calculated by method of least squares i.e. from condition:

$$S(a,b) = \sum_{i=1}^n (y_i - ax_i - b)^2 = \min \quad (4)$$

The utility function of accuracy and reliability criteria $u_2(x_2)$:

$$u_2(x_2) = -0,25x_2 + 1,25$$

Usability of regression (approximation) function can be ascertained by deterministic index (3). The deterministic index values $R^2 = 1$ correspond to the approximation rate.

The criteria utility function $u_2(x_2)$ in the nominal value interval $x_2 = <1; 5 >$ is falling from the function value $u_2(x_2^1) = 1$ to function value $u_2(x_2^0) = 0$. The criteria utility function has the linear course. The accuracy and reliability criterion have decreasing preference of the nominal value. The constant increase of the nominal value of the criterion stands constant utility decreasing.

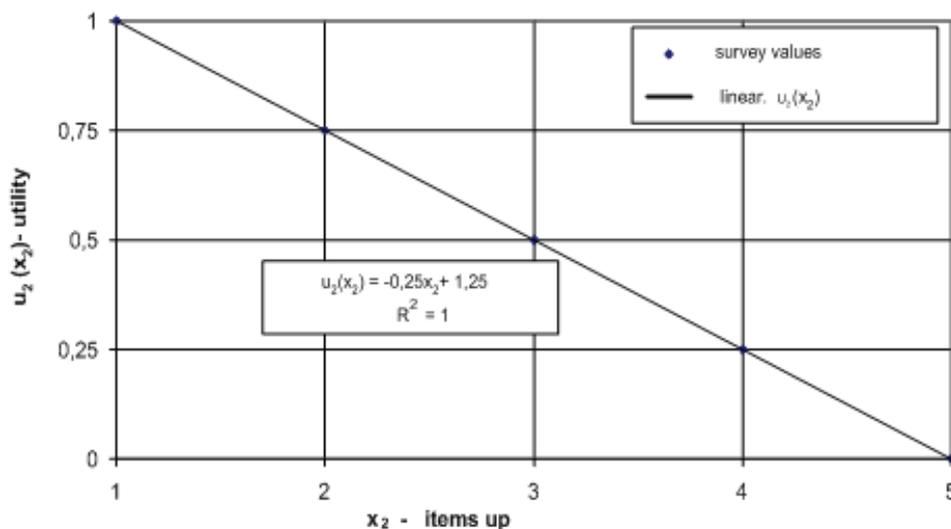


Fig.4 The utility function of accuracy and reliability criterion $u_2(x_2)$

ad.2) Separation of the definition scope to the nominal value intervals and limiting nominal values determination.

The definition scope of accuracy and reliability criterion cannot be separated to the nominal value intervals. The definition scope of accuracy and reliability utility function $u_2(x_2)$ include only limiting nominal values.

3 CONCLUSIONS

From the method of the passengers' satisfaction measuring and related theory comes following conclusions:

- Advantage of the method urban mass transportation quality evaluation is his theoretical base.
- The passengers' satisfaction can be evaluated by a mixed system method of the urban mass transportation displacement quality criteria. The quantitative and qualitative criteria have been utilized.
- The results of the traffic survey are very important for the designed method evaluation. The results show suitability of the method for practical exploitation, due the following reasons:
 - passengers' expectations identification possibility,
 - present quality level identification possibility,
 - gives data and information for quality improvement projects,
 - gives qualified results with trend evaluation possibility.

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