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QUALITY OF TRANSPORT TECHNICAL MEANS AND ITS EFFICIENCY

Abstract: *Problems of quality of transport services (municipal system) are presented as one of the most important issues determining the development of municipal transport services companies. The combination of the two superior fields in the transport services company action which are the quality services rendered and efficiency of vehicle stock, is the main goal of this paper.*

The attention was directed to the possibilities and methods of quality measurement. Parameters and their boundary values that are applied in municipal transport companies were pointed out. Meeting quality requirements is directly related to the system of use of vehicle stock. This signifies the description and quantification of connections between construction, technology and the operation of vehicle stock, and profitability in the form of appropriate characteristics.

Keywords: *Efficiency, Quality, Fixed assets, Vehicle stock, Municipal transport*

1. INTRODUCTION

The operation of technical systems is inseparable from an assessment of parameters and factors important for the achievement of aims, which reflect the potential of satisfying the needs. The most commonly used and complex measures for the assessment of confidence in a system's operation include the quality. Confidence is a term related to belief or conviction and is subjective in character, and the degree of confidence may significantly vary between people. There are also significant differences in the measurement of the confidence depending on whether we deal with a technical object in terms of a material technical means or activities such as, for instance, a service. Unlike the assessment of material goods quality, the assessment and measurement of confidence degree defined by the term of services quality is a fairly difficult task. The reasons chiefly stem from specialist features that distinguish services and their provision from production and nature of a product.

The fundamental distinguishing marks of services include:

- non–material character – in the majority of cases the customer cannot be absolutely certain of what he/she will get for their money's worth,
- inseparability – material products are first produced, next stored and finally sold and consumed, whereas services are first sold, next produced and consumed simultaneously,
- inconstancy – as a result of inseparability, elimination or limitation must be preceded by identification of cause,
- impermanence – services cannot be stored.

If a service is perceived as the effect of interaction between the service provider and customer, the aim of the activities being the satisfaction of the customer's needs, the assessment of service quality should be preceded by a definition of the assessment criteria and parameters. This, however, does not solve the problem because customers and service producers by no means need to perceive quality in the same way, and even if they do, their assessment may be different. This results from the relationship between expected, desired, provided and perceived qualities. What is of much greater significance, however, are other interactions between the company and customer, e.g. accessibility, availability of service, contact with staff. Taking them into account gives a basis to distinguish two dimensions of service quality, namely: technical quality and functional quality.

From the point of view of service producer, for whom the vital necessity is to guarantee the company's existence, the most important relationships are economic ones, connected with the services offered. The essential measures of economic relationships are effectiveness of performance, profitability and productivity of invested capital. Therefore, it is necessary to monitor and measure the quality of provided services through the prism of company's economic indices.

2. THE USE OF FIXED ASSETS AND THEIR PROFITABILITY

Companies should seek such solutions in fixed asset management which ensure reduced company costs, preventing an excessive use and decapitalization of fixed assets. The management of fixed assets understood in this way is reflected in an appropriate strategy for fixed asset management which considers two significant areas: modernization and recovery as well as an effective maintenance and repair policy [2].

The economics of use is a significant factor which conditions the company's survival and proper functioning. Today, effectiveness is closely correlated with operating methods and, consequently, with reliability and quality, because the reliability of fixed assets is linked to the cost of use. It may be assumed that the economics of the use of fixed assets represents an impact of reliability indicators on the cost of operating and maintaining fixed asset components, ensuring the required state of repair.

The reliability of the technical facility is a feature which defines the quality of performance of tasks by a given facility, taking into account the random changes of its functional characteristics. Quantification of the reliability of the technical facility is carried out through measures, known as reliability indicators, whilst their type and number is chosen adequately to the given facility and task. The appropriate use of reliability indicators has an impact on defining the economic period of use of technical facilities. Furthermore, in real operating situations, usually with a reduction in the reliability of the system (covering the collectivity of technical facilities), the probability of obtaining positive economic effects and in reverse is also reduced [1].

A significant role in fixed asset management is played by the asset's profitability, its distinct sets and individual components – an appropriate relation between outlays in a broad sense and the specific results of the use of the asset. An analysis of profitability factors should lead to optimum decisions related to fixed asset management in the area of the current monitoring and assessment of the economic effects of the use of fixed assets (facilities and sets of components). This signifies the description and quantification of connections between construction, technology and the operation of technical facilities, and profitability in the form of appropriate characteristics [1]. Otherwise, the profitability of fixed assets is confined to the determination of the economic and optimum period of use.

3. THE FACTORS WHICH DETERMINE THE PROFITABILITY OF FIXED ASSETS – MUNICIPAL TRANSPORT

There is a close correlation between the city's (gmina's) needs and the transport company's management strategy. The major objective of any transport company is to provide necessary transport services at a profit, while the profit is a significant stimulant of further development in terms of the quality and scope of services as a result of modernized vehicle stock.

As indicated above, it is possible to show the relations between the construction/design, technology, use and profitability of the vehicle stock in the form of the characteristics which make it possible to:

- promptly assess whether a vehicle (a group or type of vehicles) is profitable,
- predict profitability and make current adjustments,
- specify action to be taken to make necessary improvements,
- estimate the optimum durability of vehicles,
- specify the level of profit or necessary subsidies at any point of time.

The profitability of vehicles is the vehicle's ability to generate profit resulting from its use in a specific period of time. It is characterised by the following:

a. the total costs of use (K_s),
b. revenues (K_d),

The total costs of use (K_s) are composed of the following:

c. total costs of use (K_e),
d. capital costs (K_k).

Time expressed in years is an independent variable in the above specified values.

The total costs of use include the use itself, maintenance and repair as well as the costs of malfunctions (direct and indirect).

Capital costs (K_k) are components of company costs and result from the regular repayments of depreciation installments (including interest) in connection with the purchase of the vehicle stock.

The following correlation may be used to express annual expenditures (K) resulting from the recovery of initial outlays:

$$K = \frac{(K_w - K_l)}{n_o} + (K_w - K_l) \cdot \frac{i}{2} \cdot \frac{(n_o + 1)}{n_o} + K_l \cdot i$$

where:

K_w – vehicle's initial investment outlays (cost of manufacture, purchase),
K_l – expected residual value of the liquidated vehicle at the end of its useful life,
n_o – number of useful years (equivalent of vehicle's durability),
i – interest rate.

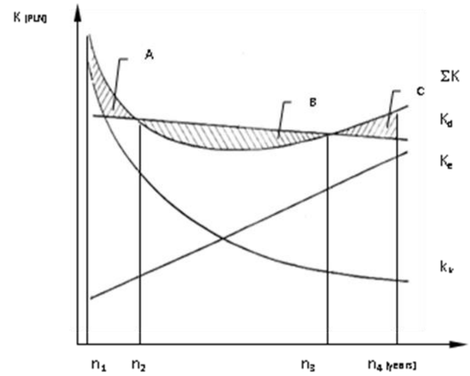
Another useful source of information includes losses resulting from early withdrawal of a vehicle. In such an event the value of the withdrawn vehicle (K_n) is higher, and the capital costs of the vehicle may be presented as follows:

$$K_{kn} = (K_w - K_n) \cdot \left(\frac{i}{n_a} + \frac{i \cdot (n_a + 1)}{2n_a} \right) + K_n \cdot i$$

where:

K_{kn} – capital costs when the vehicle's expected useful life is n–years,
n_a – vehicle's expected general useful life.

The relation between the construction, technology, use and profitability of the vehicle stock is based on profitability expressed by the curves (lines) which present the above mentioned characteristics (a, b, c, d). The general characteristics are presented in Fig. 1.
The relative position of the curve (line) of revenues and the curve of capital costs represents profitability (field B) or a deficit (fields A and C) in a specific period of time. Thanks to the graphical form of presentation it may be concluded that the deficit in both cases is caused by different factors.



Source: authors' own work based on [5].

Figure 1 – The general profitability characteristics of vehicle stock (technical facilities)

4. THE IMPACT OF CONSTRUCTION, TECHNOLOGY AND USE ON THE PROFITABILITY OF VEHICLE STOCK

A positive impact of the vehicle's design on its profitability may result from its modernization leading to:

- shortened time of travel,
- greater comfort,
- higher probability of travel without malfunctions,
- transfer from the static maintenance cycle (including repair) to the dynamic cycle.

The first two activities should increase revenues, while changes to the repair cycle result in considerable cost reductions, and may also increase revenues [5].

The impact of technology mainly indicates the impact of new techniques of manufacture of the vehicle's particular components enforced by low reliability levels. The detection of unsatisfactory reliability levels may result from an analysis of the following factors [10]:

- characteristics of the reliability of vehicles – facilities without renewal,
- characteristics of the reliability of vehicles – facilities with renewal.

The manner and conditions of using vehicles have a major impact on their profitability. The following factors should be considered:

- impact of use (preparation for, and use),
- impact of maintenance activities (technical

servicing, current repair, garaging),
- impact of repair (verification, renewal and withdrawal from use).

The favourable profitability indicators in terms of the use of vehicles are conditioned by an optimum use of technically effective vehicles, which may be expressed by the following stoppage coefficient:

$$k = \frac{t_p}{t_r} \Rightarrow k_{\min}$$

where
t_p, t_r – stoppage time (effective vehicle) and work time between anticipated repairs.

This is basically an organizational activity, which results in a more favourable position of the line of revenues. Favourable profitability indicators in terms of the use of vehicles are conditioned by strict technical supervision and current repair standards. They have a positive impact on the value of the stoppage coefficient, leading to a more favourable position of the line of revenues.

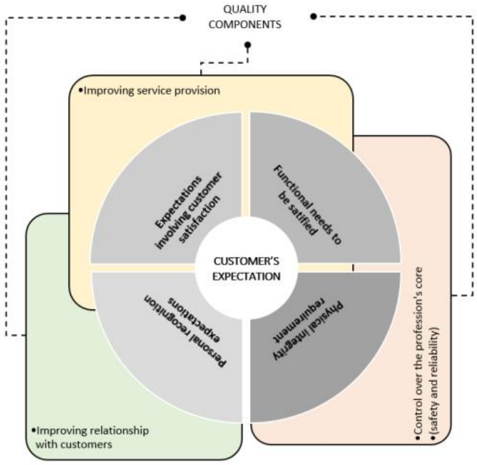
Modern organizational techniques of anticipated and emergency repairs result in:
- reduced repair costs,
- a more favourable value of the stoppage coefficient.

As a result, the line of the costs of use moves to a more favourable position (downwards) in a similar manner to the line of revenues (upwards).

5. QUALITY OF SERVICES IN MUNICIPAL TRANSPORT

Self–government authorities who aim at preventing new problems and improving the conditions in urban/municipal agglomerations promote the quality and mobility for all inhabitants by a sustainable development of the city. To reach this target collective transport facilities should be supported, which by enabling conflict–free mobility contribute to the region's economic vitality. The unrestricted use of individual transport soon reaches its limit in terms of the demand for journey space.

The only reasonable way of reconciling individual aspirations and the collective will (contradictory by the very nature) is to offer public transport services of the highest possible quality and in this way persuade a large number of inhabitants to regularly use public transport. At the same time, public transport of high quality is conducive to political decisions for the benefit of the region.



Source*:* authors' own work based on [16].
Figure 2 – Quality components vs. customer's expectations

The approaches to quality that favoured one aspect of service quality or another – punctuality, safety, customer service – overlooked the basic overall customer expectation. In the collective transport field, as in any other field, quality has to be taken into account in all the aspects of service (Fig. 2).

Quality begins with safety and reliability, continues with service provision corresponding to the expectations of passengers and is complete only when the interpersonal relationships are improved, i.e. between the operator's staff and the customers. These various aspects of quality do not compete with one another, they compete together as quality as perceived by passengers.

Quality assurance procedure cannot be implemented without the knowledge of the quality expected by customers. The impression of expected quality obliges all the participants of the transport process execution to view the service provided that customers want to experience and so they assess the current one. The difference between the planned quality and that achieved is expressed by the efficiency of the transport system and its capacity to achieve its targets.

Eventually, the customer has his own evaluation of the service offered to him. This is perceived quality. The difference between the perceived quality and expected quality allows considering customer's satisfaction, which is the primary objective of our quality actions.

The fundamental element of action is therefore a well–defined quality, in as much detail as possible, planned for customers and its expression in terms of results for customers. It is quality that makes it possible to devise managerial tools partnership procedures for improving quality and to assess the system's performance.

The advantage of such procedure – definition of service, measurement of results – is when it ends at all the levels of responsibility and services production, and the measurement and report of quality results at all the levels are an efficient tool for management and quality improvement.

6. QUALITY INDICATORS AND THEIR APPLICATION IN A MUNICIPAL TRANSPORT SYSTEM

The introduction of formal quality requirements largely depended on the preparation of legal acts on public procurements, covering also services including collective transport services. An important publication on the preference in the approach to quality in municipal collective transport is the Report of the Committee for Transport of the Polish Academy of Sciences called "Transport services on urbanized areas in Poland". The assessment criteria of significance for passengers proposed in this document count for 18 items [15]. On the basis of research results the most important basic specific measures were identified:

- waiting time,
- irregularity probabilistic indicator,
- punctuality indicator
- and complex measures including:
- average arduousness of travel,
- average equivalent travel time.

Quality indicators can be defined using the indices derived from the theory of probability. For instance, the probabilistic irregularity index (*F*), was defined as a difference (in minutes) between the real waiting time for 95 percentile (allowing for a case when a passenger will not be able to get on the nearest tram/bus because of lack of room) and the waiting time for 95 percentile when the traffic is irregular and the passenger can get on the nearest coming car at sufficient room supply:

$$F = 2{,}5\beta_t * 1{,}7t\ [min];\ \beta_t = s_t/t4)$$

where:

s_t – standard deviation of intervals,

t – average interval.

The quality assessment by *F–index* values is as follows:

- 0.0–0.9 – very good,
- 1.0–2.9 – good,
- 3.0–4.9 – satisfactory,
- over 5.0 – unsatisfactory.

The total quality coefficient – equivalent travel time (HT) – was defined as a sum of time equivalents of components: getting to/from the stop, waiting at the stop, travel in a collective transport vehicle, transfers, fare/ticket system, passenger complaints, travel safety and personal safety.

Each of the above variables is a function of many factors and was determined precisely by a corresponding set of numerical values. This method was devised to be applied in the assessment of the quality of a transport system servicing a city or another area of transport operation. It had been developed earlier and a quality assessment system for bus and tram services was proposed in which as basic requirements punctuality, regularity and travel comfort were adopted. The implementation of the concept of quality assessment must follow necessary regulations and consequences specified in the contract for transport operation provided.

Statistical control is based on selective gathering of information on certain elements [1]:

- control is executed on all lines and encompasses the entire period of transport operation (all day, all days of the week, all months),
- the size of samples is calculated so as to ensure accuracy at a given confidence level,
- choice of points and time is not known to the carrier,
- control is not executed in extreme conditions (heavy snowfall, fog, etc.),
- rules of check random selection are precisely defined.

The proposed programme of inspection is based on six groups of points, five time intervals across the day, type of day (four categories) and periods (six cycles). One series of measurements covers over 1500 two hour observations, which essential for obtaining an adequate sample.

Three quality indices are used in analysis [1]:

- punctuality/regularity,
- overcrowding in collective transport vehicles,
- failure to perform service.

For each basic service quality indicator there are available useful tables of correction and consequences (bonus/penalty). The bonuses or penalty are calculated as a per cent share of the monthly subsidy *A–indicator* – punctuality/regularity:

$$A = 0{,}6 * T + 0{,}4 * F\ [min]$$

$$T = 1/n \sum \sigma_i\ [min]$$

where:

T – indicator of arduousness of unpunctuality,

n – number of deviations observed,

σ_i – indicator for an individual deviation dependent on the difference between the time of arrival at stop observed and scheduled – h (min).

For punctuality/regularity indicator (*A*) gives the value of bonus/penalty, as per cent share of monthly subsidy (Tab. 1).

Similar tables are also prepared for the other indicators – occupancy rate exceeding 5 passengers/m2 and the third indicator – failure to perform rides.

Table 1 – Correction of monthly subsidy dependent on punctuality/regularity indicator

W (%)	Bonus (%)	Penalty (%)
<0.13	8	–
0.13–1.12	6	–
1.13–2.12	4	–
2.13–3.12	2	–
3.13–3.82	0	0
3.83–4.82	–	1
4.83–5.82	–	2
5.83–6.82	–	3
6.83–7.82	–	4
7.83–8.82	–	5
8.83–9.82	–	6
9.83–10.82	–	7
>10.83	–	8

Source: authors' own work based on [1].

The execution of the quality systems procedures is based on a contract for transit, which also specifies the control method. For instance, punctuality is checked and measured in the following way:

- arrival at a stop ahead of time (up to 2 minutes) is treated as punctual,
- delay less than 50% of scheduled interval or 5 minutes (or less) is treated as punctual arrival,
- control is performed at certain pints,
- control duration is not less than 100 hours monthly,
- punctuality index (calculated after formula: $P_r = N_p : (N_k – N_u)$, where: N_p – number of punctual arrivals, N_k – number of expected rides as scheduled, N_u – number of unpunctual rides or rides not executed due to justifiable reasons).

In the increasing number of Polish cities the satisfaction of public transport users is checked more or less systematically. Previously, it was usually part of standard surveys on travelling, such as complex surveys on sources/destinations. When 90 or more per cent of travelling was done by public transport, attention was focused on its availability, assurance of room in a vehicle, etc. Gradually other aspects became more prominent, e.g. punctuality. Recently, due to a rapid growth or motorization and a large portion of travellers preferring individual modes of transport, a new approach to public transport is becoming more common. City governments faced with the challenge of increasing traffic are interested in searching for ways of reducing the number of passengers preferring private cars to public transport. At the same time, carriers are becoming more interested in winning clients. Three categories of problems can be considered typical:

- satisfaction of public transport users from service provided,
- preferences in reference to various requirements,
- factors that can attract private cars owners to using public transport means.

The ranking of travellers' preferences (quality measures), specified in eight categories, is as follows:

- punctuality 19.37%,
- directness 14.37%,
- frequency 14.03%,
- availability 13.95%,
- low cost 11.82%,

- comfort 6.98%,
- speed of travel 6.81%,
- speed/time 6.39%.

It is evident that punctuality and frequency rank highest among the features of public transport, and contrary to popular opinion, fare is not that important.

7. CONCLUSION

The conclusions drawn from the observation of municipal transport systems exploitation indicate that quality begins with safety and reliability, continues through provision of services that fulfill passengers' expectations. The process of quality assurance is complete if it increases effects and stimulates economic rationality and when interpersonal relationships among the participants of the company's operation process are improved. These diverse aspects of quality are competitive but at the same time they compete as a quality perceived by customers.

It is obvious that the implementation of the concept of assessment of quality in municipal transport must be based on indispensable regulations and consequences included in the contract on the transportation activity, which must precisely specify the quality assessment criteria. Consequently, it is necessary to focus on services of high quality, which significantly affects the changes of the attitudes of public transport operators as well as adaptations in internal management. Since quality assurance policies cannot be implemented without the knowledge of the quality expectations of the customers, it is expedient to carry out regular survey and prognosis of the expectations of future users of municipal transport.

The conclusions presented so far indicate that there are certain relationships between operation quality and fixed assets components management in a company and their optimal use. In such approach the analysis of optimal use of fixed assets is reduced to checking the level of costs of using them. The evaluation of the financial result obtained by a transport company derived from the use of its fixed assets should be one of the major measures of the company's performance quality.

It should be pointed out that the presented aspects of the assessment of fixed assets management or their optimal use are applicable only in respect of the entire fixed assets and the company's results as a consequence of using these assets. In the analysis of the particular components of fixed assets or their typological aggregates it is necessary to adopt a different group of methods applicable in this respect.

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Acknowledgment: Publication financed by funds granted to the Management Faculty of Cracow University of Economics under the scheme for subsidising university research potential.