MEASUREMENT OF PUNCTUALITY OF SERVICES AT A PUBLIC TRANSPORT COMPANY

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Abstract

The timeliness index for the performance of the service is one of basic parameters of the assessment of the efficiency of logistics system operation. The results of surveys of passenger preferences nearly always identify punctuality as one of the three most important and also most recognizable features, which describe the functioning of public transport in a city. Punctuality as an element of the assessment of service quality is the subject of numerous studies in Poland and abroad. The aim of the article is to identify punctuality problems in public transport and description of the analysis of data from punctuality measurements conducted at a selected public transport company.

Keywords: Punctuality, public transport, measurement

1. INTRODUCTION

Punctuality of services in public transport is a priority for passengers - users of this transport, the public transport organizer (an appropriate unit of the local government) as well as the company providing transport services. The index specifying the punctuality level is one of the basic parameters assessing the level of transport services provided and, on numerous occasions, it influences the decisions of inhabitants on the choice of the means of transport to use in the city.

Striving to keep the highest possible punctuality index value is not an easy task. The time of passage between stops depends on many factors and some of them are difficult to predict due to the lack of statistical repeatability. For this reason, permanent analysis aimed at identifying this repeatability is of considerable importance. The results of such analysis can be used for improving the timetable so as to minimize the deviations. However, public transport companies point out that there is no model solution in Poland, which could support such analyses.

The aim of this article is to identify punctuality problems in public transport and description of the analysis of data from punctuality measurements conducted at a selected public transport company. The research was carried out on the basis of the literature and direct interviews and observations conducted at the selected company.

2. PROBLEMS OF RESEARCH ON PUNCTUALITY OF SERVICES

The timeliness index for the performance of the service is one of the basic parameters of the assessment of the efficiency of logistics system operation. It determines the reliability of transport in the individual branches of transport [1], but is also the subject of measurements in other logistics systems [e.g. 2]. The authors of the article focused in their research on measurements of punctuality of services due to the importance of this parameter in the assessment of functioning of transport companies.

The results of surveys of passenger preferences carried out in Polish cities nearly always identify punctuality as one of the three most important and also most recognizable features which describe the functioning of public transport in a city [3]. In accordance with definition presented by [4], punctuality is defined as a feature involving reaching, passing or leaving a pre-set point on the line (a stop) by the vehicle at the time specified in the published timetable within specified tolerance limits. Each failure to comply with the timetable outside the

adopted tolerance limits is defined as an early or delayed service in respect to the planned departure from the stop. According to Bauer [5], the simplest method of punctuality is deviation from the timetable expressing the difference between the timetable and the actual departure time.

Punctuality as an element of the assessment of service quality is the subject of numerous studies in Poland. The achievements of Wyszomirski and his team [inter alia 6] and Starowicz and his team [inter alia 7, 4] deserve special attention. It is also a topical issue in other countries, which is often considered in a broader assessment referring the measurements of reliability of provided services. This reliability is defined as the ability to provide services in accordance with the plan and is usually expressed as the proportion of the "lost" passage caused by factors, such as traffic intensity or mechanical failures of the vehicle to all services planned in the timetable [8]. Early research in this area was presented, amongst others, by Sterman and Schofer [9] and by Turnquist [10]. In their studies, Abkowitz and Engelstein [11, 12] researched factors influencing the service time for vehicles on specific routes and methods of keeping the regularity of transport services. They concluded, amongst other things, that the average service time depends heavily on the length of the route, boarding and alighting passengers and traffic lights. Bates [13], on the other hand, conducted research aimed at defining basic practices concerning the measurement of punctuality for bus services. Based on interviews carried out among 146 transport companies, he concluded that there are significant differences in the measurement of punctuality results, although the majority of systems use an allowable standard deviation within the range between 1 minute early to 5 minutes late. Model research prepared by Strathman and Hopper [14] proved that the probability of a failure to maintain timeliness of services increases during afternoon rush hours, together with increased passenger activity. They also noticed that drivers employed half-time tend to fail to keep with the timetable more often. Similar conclusions were drawn by researchers from Malaysia who, on the basis of measurements, concluded that the timeliness index of services changes during the day, but mostly due to increased traffic in the streets [15]. In 2004, Yin with his team [16] developed a general approach using simulation to assess the reliability of services considering interactions between the efficiency of the network and passenger behaviour as regards route selection. As a result, they defined three types of reliability specified from the point of view of society or administration responsible for the organization of transport, namely: travel time reliability in the entire system, reliability regarding the timetable, reliability towards the direct time of waiting for departure. Also Chen with his team [17] developed three types of service reliability measurements considering the assessment of reliability on the route, at the stop and at the network level.

3. PROBLEMS OF SERVICE PUNCTUALITY MEASUREMENTS AT A PUBLIC TRANSPORT COMPANY

Punctuality of provided transport services does not only depend on factors occurring the moment such services are being provided, but also on the entire process of preparations preceding the service (examples of research in this area can be found in [18, 19, 20, 21]). Also, the assessment of services in public transport is closely related to the problems of planning passenger services at a transport company. Planning is a part of the transport planning system [22] and it can be divided into various subproblems: the timetable, vehicle scheduling, crew (drivers) scheduling and services' duty hours. Detailed problems related to these issues were described, amongst other things, in [23, 24, 25,26].

The service punctuality index is a measure for assessing services provided by the carrier. For this reason, it is subject to periodic assessments both by the management board of the company and by the public transport organizer ordering this service from a transport company. Service punctuality depends on many factors. On the basis of literature studies, Salicru et al. [27] have composed a list of elements that affect punctuality to a greater or lesser extent. This list includes aspects, such as: traffic conditions, distribution of lanes for exclusive or preferential use, the possibility of overtaking, ease of boarding and alighting at bus stops, priority at traffic lights, lane blockages due to special circumstances, trip length, number of stops, intervals between stops, different driving habits, discipline on leaving the terminal and relief shifts, availability of vehicles and drivers,

number of passengers, occupation of the buses, uniform demand at each stop, control and regulation strategy for incident recovery, adapting of timetables, and time spent recovering from incidents. In the research, the authors, using the list developed by Salicru et al. and their own experience, distinguished the following factors influencing the punctuality of services in the analysed agglomeration and divided them into categories:

1. **Carrier- or organizer-dependent factors:**

- improvement of the selection of the trip times between individual stops (depending on the time of day);
- divisions of the timetable in the types of days and time zones within a given type of day (the so-called timetable hours, which allow differentiation in the duration of trips between stops, depending on the variability of actual trip times caused, amongst other things, by changes in traffic intensity in the city);
- discipline of drivers as regards compliance with the timetable;
- the driving method resulting from the driver's individual characteristics;
- waiting time duration at terminals (aimed, amongst other things, at compensating for delays);
- the number of stops along the route and their location;
- number and coordination of traffic lights in the city;
- assigning priority to public transport at selected intersections;
- the condition of the rolling stock and transport infrastructure.

2. **Factors which do not depend directly on the carrier or organizer:**

- traffic intensity at individual times of the day or on individual days of the week;
- frequency of the occurrence of traffic incidents;
- breakdowns of vehicle, which influence the performance of the transport service;
- the occurrence of the so-called bottlenecks in the transport network, i.e. places where the throughput for public transport vehicles is not sufficient;
- the passenger exchange time at bus stops (depending on passenger streams and the passengers' motor abilities);
- the number of special passengers (who require, for example, lowering the floor level or unfolding the ramp);

This list does not exhaust all factors influencing the time of each individual trip but, in the authors' opinion, these are significant elements from the point of view of their research. While preparing the timetable, the influence of the aforementioned factors on the time of the trip between stops should be taken into account. The possibility of examining the characteristics of services along each route and to define the degree of repeatability of service times at each section within individual time ranges.

4. MEASUREMENT OF PUNCTUALITY OF SERVICES AT A PUBLIC TRANSPORT COMPANY

The investigated public transport company provides transport services in one of large Polish agglomerations. It is a limited liability company operating as a single-member Municipality Company. The company employs over 2000 persons and carries nearly 200 million passengers a year. In a year, the company's vehicles, trams and buses, travel approx. 34 million kilometres in total.

For the purposes of transport planning and within inspections of the operations, the company monitors punctuality of its services. The frequency of periodic measurements depends on the critical importance of the route, which depends on its importance in the city's transport network and on deviations which has occurred so far. Data for measurements are collected from on-board computers, which register selected operational parameters of the vehicle, including departure times from each stop. The registered data are exported to a spreadsheet and analysed. Data pertaining to one route are exported to one spreadsheet, taking into account all trips in the analysed period of time. First, the data is ordered and trips, for which data is missing or any other diagnosed errors occur, are not included in the further stages of the analysis. For punctuality analysis,

the following data from the on-board computer are used: the line number, the trip number, trip description, vehicle number, team number, stop numbers, trip descriptions, time according to the schedule, the actual time of leaving the stop.

In the investigated transport company, the deviation from the timetable is defined as the difference between the actual time of departure from the stop and the time specified in the timetable. Negative deviation values correspond to early departures while positive ones to delayed departures.

In the spreadsheet for analysing punctuality, the function of excluding trips, which do not meet the assumed conditions, is pre-defined. These are usually trips, for which the deviation from the timetable at any stop is outside the (-10; +60) range or trip times between individual stops and times of travelling the entire route do not fall within the range from “the average trip times minus 3 of standard deviation” to “the average trip time plus 3 of standard deviation”. Owing to this procedure, non-representative data is eliminated, which should not be used for timetable adjustments. Only trips which have been verified successfully are accepted for further analysis.

Data analysis includes several aspects.

1. Comparison of the time moment of leaving the stop by the vehicle with the so-called timetable time. The adopted allowable standard deviation from the timetable is (-1; +3). Departures with deviations within the adopted range are considered punctual.
2. A comparison of actual average times of trips between stops and times adopted in the timetable. The times are calculated as the difference between time moments of departures from consecutive stops, thus they include all events which can occur in this time (e.g. exchanging passengers, waiting tie resulting from traffic lights etc.).
3. A comparison analogous to point 1 with the assumption that the trip started on time. The actual trip times between stops are maintained; however, time moments of departures from stops are calculated on the basis of the assumption that the departure from the first stop on the route occurred in accordance with the timetable (without any deviations).

The tasks described above are performed for each stop within each trip - for point events or for each pair of stops - for continuous events. In this way, actual data with the highest possible degree of detail is obtained and not only global information for the entire trip (counted on the basis of the total time registered from the starting point to the last stop). Such an analysis allows for identifying the place on the route, where the vehicle accelerates/is delayed at individual times of the day. These sections of the route are then monitored in detail in terms of the repeatability of passages and deviations referring to the times assumed in the timetable. It is a good idea to consider sections longer than ones between two stops. The timetable is created with an accuracy to a minute, while actual trip times are measured with an accuracy to a second. It rarely happens that the actual trip time between adjacent stops accurately fits the timetable framework (i.e. it is closed to full minutes). For this reason, it is important to analyse the following spaces between stops. For example, if the average actual trip times for two consecutive sections between stops are 1.5 minutes, the total trip time for such a section is three minutes and it is adopted in this way in the timetable. Due to the timetable structure, the time of the trip must be, however, assigned to each pair of stops separately. A trip time amounting to 1 minute is assigned to the first pair of stops and a two-minute time is assigned to the second pair. This order results from the fact that slight delays are much easier to accept by passengers than early departures (before the timetable time). Therefore, the average time delayed by approx. 0.5 minute will be more advantageous for the passenger than the departure taking place 0.5 minute before the scheduled time. Statistically, the departure from the third stop should occur with a slight deviation from the timetable. If all sections are analysed separately, there is a high risk of erroneous selection of timetable times, which could amount to one minute for individual sections or two minutes for individual sections.

Additionally, the punctuality level at the beginning of the trip is significant information, which can be obtained. If trips begin with a considerable deviation from the timetable, their global punctuality will be low, even if the

inter-stop times have been selected properly. For such cases, it is important to define the reason for such deviations. If there are delays occurring during an earlier trip, and the duration of the break between trips does not make it possible to compensate for this delay, break extension is a solution (which, unfortunately, often makes it necessary to use a larger number of vehicles on the line).

The analysis performed allows for determining the values of the following indices:

- the percentage of punctual departures from stops;
- the percentage of delayed departures from stops;
- the percentage of early departures from stops;
- the punctuality index calculated for each stops of the trip with division into the times of the day in accordance with the timetable,
- the number of analysed trips;
- the average duration of the trip between stops, divided into the actual and timetable times;
- the average deviation of actual times of trips between consecutive stops in relation to the times provided in the timetable;
- the average time of entire trip.

For all indices, values would be achieved with the assumption that the departure from the first stop along the route would be consistent with the timetable time.

The results of analyses are presented in tables and graphs to increase their legibility. Based on these results, decisions are made about changes in timetables. If an in-depth analysis reveals that deviations from the timetable duration of the trip are repeatable and that they depend on factors independent of the company, an application is filed to the City Hall with a request to introduce changes in, for example, the frequency of trips on a given line or the divisions of the timetable times.

5. CONCLUSION

The measurement of punctuality of trips is of key importance in the timetable improvement process. As presented in the article, public transport companies are looking for solutions, which would support their control actions in this area. The managerial staff need tools, which will not only allow them to assess the degree of timely transport services, but which will also facilitate an analysis of factors influencing the trip duration and examine the repeatability of occurring deviations. The research presented in the article is a part of a larger study carried out by the authors in the field of punctuality measurements in public transport. Subsequent analyses will be targeted at the assessment of the influence of selected factors on the trip duration and the occurrence of deviations from the timetable.

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