Pricing Policy After the Implementation of Electronic Ticketing Technology in Public Urban Transport: An Exploratory Study in Poland

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Abstract. Systems used for selling paper tickets for the use of public urban transport services have specific limitations, not only those concerning collection of data on demand, but mainly regarding the possibilities of differentiating prices and developing fare systems. The type of fare used depends not only on social expectations and income policy, but also on the technical possibilities of differentiating fares. Thus, worldwide as well as in Poland, automated fare technologies in public urban transport that are ever more widely implemented, are most often based on electronic cards. The aim of the paper is to compare e-ticketing systems implemented in the largest Polish conurbations, to deal with payments for the use of public urban transport, as well as to present directions of changes in the pricing policy.

Keywords: Pricing policy · Electronic tickets · e-ticketing systems · Public urban transport · Smart cards · Price differentiation

1 Introduction

Development of efficient fare policy is a very complex and has many dimensions, as it requires taking into account not only economic factors, but also social ones. Prices are a key factor for competitiveness of public urban transport services, as well as for sustainable development of towns, as properly conducted public transport pricing policy can improve modal shift and sustainable urban mobility. Contemporary automated fare technologies create a chance to use the potential resulting from new possibilities of price differentiation, and to develop such a functionality of electronic tickets (e-tickets), which will constitute added value for the passenger.

The research conducted extends the knowledge concerning pricing policy in urban public transport, particularly in the aspect of various possibilities created by modern technologies of electronic tickets. The paper makes an in-depth analysis of e-ticketing systems implemented in five biggest conurbations in Poland. The results of exploratory study create an avenue for further research, particularly in the area of international comparisons.

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2 Urban Public Transport Fare Policy

Prices of public urban transport services perform various functions, also the expectations and preferences differ: of institutions that decide the prices, those who use public urban transport, and those who manage public urban transport. Prices of public urban transport are subject to substantial regulations, as they are subsidized from budgets of public entities [1]. In the process of price development, also the social factor is of particular importance, namely being accustomed to the scope of services provided, which often is the case, and which reduces the possibilities of fare change. It is expected that prices of urban public transport tickets shall provide appropriate income, yet at the same time shall be an incentive for using public transport services. Of importance here is the re-distribution of funds among various social groups, which is manifested by the substantial percentage of people who are authorized to use public transport free of charge or for a reduced fare [2].

Broadly speaking, economic results are expected from public urban transport services, which may be grouped into three categories [3]:

- impacts on the transport system itself, assessed in terms of transport service performance (accessibility, modal split, congestion, efficiency),
- impacts on environment and health (air quality, noise levels etc. for which transport is responsible)
- impacts on the economy and society, which can be estimated through the assessment of income distribution effects, equity and welfare effects of pricing policies.

Transport fares are constructed, in practice, by means of specific price differentiation tools, referred to as differentials. Two types of differentials are distinguished: vertical and horizontal ones. Vertical differentials reflect the distance and route along which transport services are provided. Horizontal differentiation of prices occurs when the price differs depending on who/what is transported and organization of the transport process (e.g. modes of transport, route, speed, time of day). In public urban transport, three types of fares are used most frequently [4]:

- flat fare, also referred to as uniform fare (no vertical differentiation of ticket prices, e.g. single tickets),
- section-based fare (prices differentiated depending upon the number of sections travelled), which has two variants: distance-based and time-based systems,
- zonal based system (prices depend upon the number and type of zones, for which the ticket is valid, sometimes additionally the criterion of validity in time is introduced, which leads to the zone-and-time fare.

Contemporary fare systems in public urban transport are characterized by being substantially differentiated, which takes into account both the type of the area being served, its population, as well as specific transport needs. It results from research conducted in Europe, that zonal-based fares dominate in public urban transport [4]. Zone boundaries are delineated in various ways, they may be the administrative borders of towns, town districts, or arbitrarily determined – having in mind the perspective of public urban transport. The advantages of zone based systems include making the fare

dependent (to a certain degree) on the distance travelled, having also a fairly simple fare, in which it is easy for the passenger to calculate the fare [2].

The type of fare used depends, on the one hand, on the expectations, on the other hand on the technical feasibility of application a particular differentiation of fares, provision of efficient ticket distribution systems, keeping the ticket sales system within the assumed cost limits, securing ticket availability and easy use of the fare systems [5].

Tickets can have paper or electronic form. Ticket distribution systems based on paper tickets have numerous limitations, concerning mainly the possibility of price differentiation and collection of data concerning demand, along with high maintenance costs [6]. Thus, automated fare technologies have been ever more widely used worldwide, they are expected first of all to enable more efficient price management in public urban transport [7].

3 E-ticketing Systems for Urban Public Transport

Electronic fare collection systems are the main element of intelligent transport systems (ITS) and ever more often used tool for price management in urban transport, and a basis for integrated ticketing [8]. The automated fare systems presently implemented enable, among other things, automatic selection of the best fare for the passenger, differentiation of prices depending on the time of day, line, mode of transport, or various reduced fares passengers are entitled to. In public transport, three types of e-ticketing systems are in use worldwide at present [8, 9]:

- magnetic stripe cards,
- mobile ticketing,
- contactless smart cards.

First electronic tickets appeared with the development of the technology of cards with a magnetic stripe London in 1964 [10]. It is a relatively simple and cheap technology, but magnetic stripe cards and tickets require a physical swipe and, unfortunately, do not allow for collection of data concerning demand, the cards can be easily read and copied and are not re-programmable [5]. At present, this technology is considered obsolete and it is slowly going out of use.

In case of mobile ticketing, the mobile phone, smart phone, tablet or personal digital assistant (PDA) is used as an electronic version of a ticket. Such a ticket may be purchased at any place. The role of mobile phones and the Internet in everyday life has been increasing continuously, it is predicted that their use in public transport ticketing will continue to increase. There are three different possibilities for mobile ticketing [8]:

- premium SMS based transactional payments – the user pays fare with the next phone bill or pays the fare using funds available on prepaid telephone card,
- optical character recognition (OCR) – the user receives a special code for example QR code that contains all needed information,
- Near Field Communication (NFC) - a process that is very similar to OCR technology, yet in case of NFC the information is stored in the NFC memory of the phone.

In case of contactless smart cards technology passengers use plastic cards, which are provided with chips, storing the most important information. This type of cards requires only holding it near the electronic reader, which can read it from a distance up to about 10 cm, with which the card gets connected by high-frequency waves similar to Radio Frequency Identification (RFID) [11]. Presently, it is the most popular technology of electronic ticketing in the public urban transport. First smart cards began to be used on a large scale in the 1980s. Nowadays they are in common use in banking, health care, government and transportation. The microprocessors presently used in contactless smart cards are produced on the basis of standards of EMV technology (the acronym for Euro pay, MasterCard, and Visa) [8, 11]. It provides huge possibilities as regards processing of information and management of transactions, which is of much importance in case of dynamic settling of costs and travel time in urban public transport.

Each of those technologies creates specific possibilities concerning vertical and horizontal differentiation of prices, using additional functionalities that make up added value for the passenger, as well as other possibilities for data collection from the market, e.g. concerning demand. In Table 1 we have compared the three technologies of e-ticketing for urban public transport, from the point of view of selected functionalities for price differentiation and other passenger conveniences.

The "best fare" policy consists of limiting the total amount that the passenger may pay in a defined time. For example, the singles fares paid in one day shall not exceed the price of a day ticket. Distance-based fares and real-time origin fares and destination

Table 1. Selected functionalities for pricing, available in three e-ticketing technologies [7]

Potential Applications	Magnetic stripe	Smart Card	Open Payment System/NFC
Discounts by passenger class (senior, student)	X	X	X
Daily, monthly passes	X	X	X
Seamless intermodal transfer*	X	X	X
Distance-based fares	X	X	X
Time-of-day based fares**		X	X
Real-time origin and destination data		X	X
"Best fare" policy		X	X
Use of fare card as debit/credit card		X	
Use of fare media for retail purchases, parking, tolls, bike sharing		X	X
Passenger top up cards, check past transactions online		X	X
Personalized marketing	Limited***	X	X

*Passenger can transfer between different modes of transport without acquiring a ticket or other proof of payment.

**It could be accomplished with a magnetic stripe system, but it would preclude other functions.

***It is limited to passengers who pay by automated debit, for example when setting up automatic payments for yearly passes.

data collection, in all three technologies analysed require the passenger to swipe or tap (very often called "tag") at the entry and egress or only at egress [7].

Section-based fare, distance-based fare, and time-based fare are examples of fares in which, thanks to modern e-ticketing technologies, one deals with dynamic settlement of the costs and time of travel, sometimes referred to as the "Pay as you go" fare, which requires identification of getting on and off the vehicle. Three technologies of identification of boarding and leasing the vehicle are distinguished [8]:

- Check-in/Check-out (also called CICO, Tap-In/Tap-Out or Touch-In/Touch-Out): it requires the passenger to physically register the entrance to the vehicle and leaving it, by placing a smart card or mobile phone in front of a reader. The system then calculates the fare due and debits the passenger account with it [12].
- Be-in/Be-out: it does not require the passenger to register her/his presence in the vehicle, as the system automatically detects the presence of smart cards (or other fare media) in the vehicle. The system automatically calculates the fare which is most advantageous for the passenger. Passengers pay afterwards for example on a monthly basis [12].
- Walk-in/Walk-out: it functions much like Be-in/Be-out, the difference being only in the fact that passenger's presence in the vehicle is detected when s/he enter the door of the vehicle [13].

What is interesting, the research conducted indicates that a very frequent phenomenon worldwide is the parallel application of various technologies of e-ticketing in urban public transport, not only in one region, but also in one town/city, often parallel to the use of paper tickets [14].

4 Urban e-ticketing for Public Transport in the Largest Conurbations in Poland

E-ticketing systems for urban public transport are ever more often implemented in Polish cities and towns. Most of the big conurbations in Poland either already implemented such systems, or are in process of implementing them. It results from the research conducted that almost all e-ticketing systems for urban public transport in Poland are based on the contactless smart cards technology and mobile ticketing. They differ in functionalities, first of all as regards the possibilities to differentiate prices, to collect data on demand, and the scope of services available with the card. Moreover, which is worth stressing, in most Polish cities the e-ticketing systems function in parallel to the paper tickets distribution systems. Rare are the cases where organizers of urban public transport decide to completely give up paper tickets. In Poland this happened only in Rybnik. Table 2 provides a comparison of selected e-ticketing systems for urban public transport, implemented or being implemented in the biggest Polish conurbations.

At present, one of the biggest systems based on contactless smart cards, and undergoing implementation, is the project of Silesian Card of Public Services (ŚKUP).

Table 2. Comparison between e-ticketing systems for urban public transport in the largest conurbations in Poland [own study]

Item	Poznan Electronic Card for Agglomeration (PEKA)	Warsaw City Card (WKM)	Urban Card Wroclaw	Cracow City Card (KKM)	Silesian Card of Public Services (ŚKUP)
Started	2014	2001	2010	2005	2015 (planned)
Technology	MIFARE	MIFARE	MIFARE Plus	MIFARE	MIFARE DESFire
Scope of city-related services	public transport, parking, libraries, electronic signature, prepaid payment card (micropayments up to 50 PLN without pin code)	public transport, parking	public transport, parking, culture-related services, sports and recreation services, prepaid payment card (micro-payments up to 50 PLN without pin code)	public transport, parking, prepaid payment card (micro-payments up to 50 PLN without pin code)	public transport, parking, payments in municipalities, libraries, culture-related services, sports and recreation services, electronic signature
Dynamic settling of costs „Pay as you go"	Yes distance-based fare, fare calculated for each stop	No	No	No	Yes (all types of fare: time-based fare, zonal-based fare, time-based fare)
„Best fare" policy	Yes	No	No	No	No
Single-journey tickets available on smart card	Yes T-purse (funds converted into points, passenger pays using points)	No Single journey tickets cannot be encoded on the card	No Single journey tickets cannot be encoded on the card	No Single journey tickets cannot be encoded on the card	Yes ePurse (electronic money)

(*Continued*)

Table 2. (*Continued*)

Item	Poznan Electronic Card for Agglomeration (PEKA)	Warsaw City Card (WKM)	Urban Card Wroclaw	Cracow City Card (KKM)	Silesian Card of Public Services (ŚKUP)
Multi- journey tickets and season tickets available on smart card	Time- and zonal-based fare (3 zones) or season tickets for a definite number of stops. Season tickets can be valid for any number of days (minimum 14 days).	Time-based fare, season tickets for a long period of time only, in fixe fare, with strictly defined validity (30 or 90 days, or yearly tickets)	Time-based fare and differentia-tion because of type of line, with strictly defined validity (e.g. 7 or 90 days)	Time-based fare, differentia-tion due to number and type of lines, validity expressed in months (1 to 12 months)	Time and zonal-based fare, differentiation due to presence or absence of limit as to the number of trips
Journey registration requirement	In case of "Pay as you go" Check in required, check Out – cost of trip settlement	No	No	No	Check in obligatory in each case (all types of tickets and all types of fare), Check Out – cost of trip settlement in "Pay as you go".

(*Continued*)

Table 2. (*Continued*)

Item	Poznan Electronic Card for Agglomeration (PEKA)	Warsaw City Card (WKM)	Urban Card Wroclaw	Cracow City Card (KKM)	Silesian Card of Public Services (ŚKUP)
Possibility to pay for another person with a single card	Yes	No	No	No	Yes
Mobile ticketing	Yes (single-journey tickets)	Yes (time-based, season tickets, e.g. valid for 20 min, and weekend passes)	Yes (single-journey tickets and time-based, season tickets, e.g. valid for 30 min or 72 h)	Yes (single-journey tickets and time-based, season tickets, e.g. valid for 20 min and for 7 days)	Yes (time-based and zonal-based, single journey tickets)

It is a project implemented by the Municipal Transport Union of the Upper Silesian Industrial District (KZK GOP) – the biggest public urban transport organizer in Poland and one of the biggest in Europe. KZK GOP currently comprises 28 municipalities from the central part of the Province of Silesia [15]. ŚKUP card will be a carrier of electronic money, which will enable paying not only for public transport, but also for culture-related services, sports and recreation services, library services, and parking. Thanks to the electronic purse (ePurse), dynamic settlement of trip costs will be possible, in the "Pay as you go" system, in various fare systems [16].

The "Pay as you go" functionality is also available in case of the Poznan Electronic Card for Agglomeration (PEKA) [17]. In this case, however, passengers do not use ePurse, as the funds are converted into points, which are used for paying fares for each section travelled, measured by the number of stops. In both cases analysed, maximum fare for a given router is accrued when entering the vehicle, upon leasing the vehicle and Checking out it is corrected to the amount due for the section actually travelled.

The requirement to register trips in the Check in – Check out system is particularly important from the perspective of managing the transport offer, as it allows to identify passenger flows, identify revenues from tickets, and – in case of integrated tickets – to make settlements between various parties. In the ŚKUP system, as opposed to analysed systems (see [18–20]), the requirement for trip registration will also be in place for all types of multi-journey and season tickets.

5 Conclusion

E-ticketing systems constitute an important IT tool assisting pricing policy and optimization of transport offer. Those systems create substantial possibilities for price differentiation, defining rebates, or management of promotions, while a more efficient fare policy is an important instrument for enhancing competitiveness and attractiveness of public urban transport. Automated fare technology allows for dynamic settlement of trip costs, on the basis of various fare systems and application of "best fare policy", which is of much advantage for the passenger. Smart cards are more and more often used also for paying for other municipal services, which will in future allow to conduct integrated municipal policy.

However, having seen the implementations made in Poland so far, it can be stated that not always the possibilities provided by smart cards technology are fully utilized. The above concerns in particular price differentiation and possibilities of obtaining information about demand. Also the passenger's choice is limited, as regards the possibilities of defining the validity of season/multiple journey tickets, as in a decisive majority of cases electronic tickets are but a copy of paper ones. One can risk making a statement that a barrier for more efficient pricing policy is not technology any more, but legal or organizational constraints, or economic factors.

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