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NEW PRICING THEORY OF INTELLIGENT FLEXIBLE TRANSPORTATION

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Abstract. In the paper, possible pricing structures of flexible transport systems have been investigated. After a brief introduction into demand responsive systems, the currently used pricing systems have been analysed. Having reviewed the conventional pricing methodologies – in line with the average cost and marginal cost based methods – the advantages and the disadvantages of particular systems are presented. What is more, that traditional pricing theory enabled to order costs of flexible transportation systems only approximately to passengers in proportion to their demanded transportation performance, thus traditional pricing framework is not able to fully meet the principle of fairness. For reaching the highest level of fairness loops a fictive unit of individual trips is introduced as the base of pricing. When applying individual loops is gives a unique approach to describe unit cost of the operators especially considering that empty runs are taken into account in a fair way. Beside fairness, it is also an essential objective to represent economies of scale and the preference of early bookings in the pricing methodology. Accordingly, the below presented 'mixed price system' had good results in the reduction of average fares related to new travellers and also in the improvement of attraction related to 'early birds'. Therefore, the goal of this research was to define the direction and the aspects of the development process related to the pricing methods of flexible transportation.

Keywords: price; transport expenses; sustainable transport; intelligent transport system; public service.

Introduction

It is well known today how flexible transport systems are capable of combining the advantages of traditional, regular bus and taxi services, while maintaining the economical feature of public transportation and the flexibility of taxi services (Horváth *et. al.* 2013). Numerous types of flexible transport systems are known which can be basically categorised according to three aspects: route, timetable and users due to which the flexibility of the systems may vary. Such services are not designed to substitute local or inter-urban public transport but rather to complement conventional modes. In accordance with this, Demand Responsive Transport (DRT) systems are mostly used for the supply of people with limited mobility, furthermore as a tool for education-oriented or work-oriented transport processes (usually in sparsely populated areas) (Diana *et al.* 2007). So, the aim of DRT is to minimize unutilized capacities and maximize cost-effectiveness. Beside this, the research shows that DRT systems have more preferable emission parameters as well (Jakubauskas 2008; Lazauskas *et al.* 2012; Szendro *et al.* 2012). Nowadays, almost 60% of the European citizens are living in cities and approximately 85% of the European gross domestic product is produced within urban areas. The demand of urban transport is spatially distributed and it is vital for the transport planner to detect areas presenting common travel, behavioral and socioeconomic characteristics (Gavanas *et al.* 2012).

DRT is an innovative form of public transport; however, researches focusing to this type of transport service can be traced back to the seventies. Several substantial studies and projects emphasized the success of DRT in Europe, Australia, UK and US (FAMS, SAMPO, SAMPLUS, etc.) (Mageean, Nelson 2003), however it has to be emphasized that US (e.g. zone services) has significantly more experience with FTS than any other country or region of the world (Mulley *et al.* 2012).

The main result of these studies is that DRT is a suitable transport solution in particular areas and can achieve community building objectives. Beside the successful pilot projects, other good practices can be mentioned, for instance: 'UCall', which is a good example from UK. The story of 'UCall' started in 2002, when Nexus won a bid to the Government's Urban Bus

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Challenge competition for funding to establish a DRT service, marketed as 'UCall', within the outer west area of Newcastle. It is also worth mentioning that the fare structure of the 'UCall' service was the same as local bus services and reflected the straight line of travelled distance. There was an additional fare, 50 pence, for the door-to-door service (Mulley, Nelson 2009).

Flexible Transport Services (FTSs) have to be considered as a new market opportunity for public transport (Nelson, Phonphitakchai 2012). FTSs have been introduced as DRT service, which are able to broaden a niche market. According to this approach, telematics-based FTSs have the scope to bring public transport closer to the flexibility and convenience of private transport, whilst retaining a fare structure more in line with public transport journeys as opposed to the most flexible – but costly – private hire and taxis. FTS is an emerging term, which covers public transport services that are flexible in terms of route, vehicle allocation, vehicle operator, type of payment and passenger category. The flexibility of each element can vary along a continuum of demand responsiveness from services where all variables of a fixed considerable time before operation (e.g. a conventional public transport bus route) to services whose constituent variables are determined close to the time of operation (Mulley, Nelson 2009).

In accordance with the development orientation of the above mentioned research studies the objective of the paper is to investigate and define a more effective pricing structure of flexible transport systems. In the next chapter the currently used pricing systems are analysed. Having reviewed the conventional pricing methodologies – in line with the average cost and marginal cost based methods – the advantages and the disadvantages of particular systems are presented. After this, the paper focuses on the new theory, which is introduced through two basic explaining examples.

1. Pricing Systems

Fares are essential to the operation of any public transport system because of forming a major source of income to operators. The effects of increasing or decreasing fares come from the relationship between fares and patronage as represented by the demand curve. Fare elasticities are dynamic, varying over time for a considerable period following fare changes (Paulley *et al.* 2006). Another point of view is the simplicity of the fare system (Jansson, Angell 2012). People have more trust in those systems they see through and understand well. According to Borndörfer *et al.* (2012) fare planning (with its interdependences between passenger behavior and costs) can have a significant impact on passenger behavior and, in particular, travel choice.

Planning and developing the pricing systems of flexible transport systems is a rather complex task, since they determine both the designed systems' competitiveness and revenues. To satisfy the demand for flexible payment process related to DRT systems as it was drawn up by Mulley and Nelson (2009) a more flexible pricing systems should be introduced. This consideration makes it necessary to examine the currently used pricing methods, and especially the applicability of the examined method.

The average-cost based method uses the calculated unit cost of the transport system based on previous traffic data. Among the average cost basis systems, certain pricing systems can be listed which determine the average specific cost based on one factor of the variable cost. For such purpose, regarding passenger transportation, the passenger-kilometre can be applied, for instance. In the case of such pricing systems the cost depends on the extent the passengers use the service. The total revenue depends greatly on the market situation of the transportation company (Nelson, Phonphitakchai 2012).

In case of marginal cost pricing – compared to average cost pricing – a newly consumed product or service costs as much as total cost is raised by its production. To calculate the average cost of a product or the marginal cost of a newly consumed product or service, cost driver factors have to be defined, which can reliably characterise the investigated process. In case of passenger transportation, this factor can for instance be the passenger-kilometre.

To evaluate the different cost, drivers firstly stake holders have to be identified. The next step is the interpretation of the mechanism between the different stake holders and their relationship, which in the long-term makes it necessary to identify system components and processes (Deflorio 2011).

Flexible transportation systems cannot be clearly classified into the above mentioned groups, since flexibility causes certain costs which cannot be defined in advance. The demand driven feature leads to several situations in which special pricing solutions are needed, e.g. congested urban traffic often explains complex structure of time and distance based pricing. However, the developed new pricing methods, which improve the competitiveness of flexible transport systems with enabling fair and proportional pricing – will only be presented through the basic example to support the lucidity of the theory.

To discuss the implementation possibilities of flexible transportation systems, the system has to be examined in terms of stakeholders, system processes and costs of other relevant processes. According to Davison *et al.* (2012), stakeholders in the current task environment have a significant effect on DRT provision and the markets served. Their classification is more chiselled but in main lines it is similar to the followings.

From the interested parties point of view, DRT systems do not differ decisively from traditional transportation systems. First of all, stakeholders have to be differentiated depending on whether they are inside or outside of the system (having direct or indirect connection to the system). Therefore, the following components of a system can be defined:

1) Internal elements of the system:
   a) DRT operator;
   b) DRT user.

2) External elements of the system:
   a) Road operator;
   b) Road users;
   c) Society/National Economy.

Understanding the objectives and the role of stakeholders strongly determines the success of the system planning process. Table 1 presents system processes that occur among the stakeholders. Only 15 procedures have been examined (although 25 processes could be defined between the five parties) since the effects of the omitted processes on the pricing system is considered to be negligible. Summing up, Table 1 includes system processes, which are investigated in the authors' example. These transport processes generate costs. The model is planned to be as simple as possible to support lucidity, however in a real application, more system process and cost factors can be considered as well.

It is assumed that DRT operators offer transport service to DRT users and the service is characterized by the travel time and the comfort level. In the meantime the DRT operator can provide the road operator and road users with information on traffic, for instance, from floating car data. In addition, DRT as a transport subsector has a beneficial effect on modal shift (it reduces modal split of individual transport), thereby it offers an indirect service to road operators (it reduces road operation cost), the road user and society. It has to be emphasized that in lower demand environment flexible transport is more environment-friendly than alternatives (Jakubauskas 2008).

DRT users' effect on each other induces negative externalities: new passenger's booking decreases the comfort of other passengers, while their travel time due to the route modification increases. DRT users provide information for road operators, e.g. the information about their choice in reference to DRT service instead of individual transport let the short-term change in modal-split be dynamically estimated (Horváth 2012). From the road users' point of view DRT can cause a reduction in the level of traffic, while from a social point of view it brings on an indirect improvement of living standards (pollution, noise, and decrease in the number of accidents).

Similarly to DRT users, road users affect each other negatively. Since the appearance of a new individual road user can lead to increased travel time and reduced comfort for other road users (e.g. more travellers can cause more stops and longer routes). From a social point of view, they appear as agents of decreasing living standards due to air pollution, noise and accidents caused by them (Deng, Nelson 2013).

Society and the national economy appear as 'suppliers' by providing space and other resources for the operators. On the other hand, they are mostly the victims of negative externalities.

At the present stage of research external factors will be ignored and the internal system components will be further investigated.

In the following analysis, only those processes are examined, which connect DRT operators and DRT users; however the system can be expanded in the future, if necessary. Accordingly, Table 2 presents only those cost factors, which are related to the internal operation process of a DRT system, based on Table 1.

Table 1. The system processes of a DRT system

System processes			Beneficiary				
			Internal actors		External actors		
			DRT operator	DRT user	Road operator	Road user	Society/National economy
Supplier	Internal components	DRT operator	–	1. Transport service (comfort level, travel time)	2. External service: floating car data; modal shift	3. External service: floating car data; modal shift (decrease of travel time)	4. External service; modal shift (pollution, noise, fall accidents)
Supplier	Internal components	DRT user	–	5. E.g. the acceptance of the decrease of transport service quality (comfort level, travel time)	6. Modal split: gives information by choosing DRT instead of individual transport	7. E.g. Choosing DRT instead of individual transport → accepting the decrease of transport supply quality (comfort level, travel time)	8. E.g. Choosing DRT instead of individual transport → accepting the increase of standard of living (pollution, noise, fall in accidents)
Supplier	External components	Road operator	9. Road capacity: quality, travel time	10. Information: current modal split	–	11. Information: current modal split, current modal shift (comfort level, travel time)	12. Information: curent modal shift (pollution, noise, accidents)
Supplier	External components	Road user	–	–	–	13. E.g. Causing the decrease of transport service quality (comfort level, travel time)	14. Causing the decrease of standard of living (pollution, noise, increase of accidents)
		Society/National economy	–	–	15. Providing land	–	–

Source: research by the authors.

Table 2. Costs generated by the inner elements of the DRT system

Components	Processes	Costs	Independent variable	
DRT operator	DRT operator supplies for the DRT user: transportation service (comfort, reaching time)	Fuel	Vehicle km	Traffic density → the beginning of the journey
		Tyre deterioration	Vehicle km	Traffic density → the beginning of the journey
		Car operation	Vehicle km	Traffic density → the beginning of the journey
		Road toll	Depends on the type of road toll	
		The general costs of controlling a company	Fix	
		Site rents	Fix	
		Office rents	Fix	
		Human resources	Fix	
		Information costs	Number of passengers	Informational channel
DRT user	DRT user generates for another DRT user: e.g. the acceptance of the decrease of transport service quality (comfort, travel time)	Costs for booking in advance	Change of the travel time (change of the schedule)	

Source: research by the authors.

Going deeper into these cost elements is essential because the two main goals of DRT services is minimizing costs and maximizing flexibility (Carotenuto *et al.* 2012).

In Table 2 costs are differentiated in the first column according to whether they can be related to services carried out by the operator towards users or they can be related to effects caused by users to each other. The related internal processes are in the second column; these are taken from Table 1. Some cost items of the introduced processes are presented in the third column of Table 2, however these costs present only examples and they are proposed to be extended in case of a real project. The fourth column includes the main variables upon which the cost items in the given rows are dependent. In case of single or constant items, it has no meaning to identify independent variables, since costs are fixed. Additional columns describe such supplementary factors, which can also be defined as independent possible variables since they strongly affect costs (e.g. traffic density can directly affect fuel consumption through congestion). Beside the number of cost items, the number of independent variables is also extendable; since one cost item can be dependent upon more variables (e.g. fuel consumption can be depended upon travelled vehicle kilometres as well as on the traffic density). During the introduction of the new pricing theory vehicle kilometre is being assumed as the only independent cost driving variable, which affects travel cost. However, it has to be kept in mind that in case of a realistic pricing system, moreover in case of the urban transportation, a vehicle hour has to be an important factor in the pricing system as well.

The costs are classified into two categories: fix costs and variable costs. For example the cost of purchasing the vehicles, the land, managing the company, operating the scheduling centre, the site rents and the office rents are considered to be fix costs. Theoretically, 'fix costs' affect the expectable length of the payback period of the project rather than its feasibility, since it can be expected that a profitable project will sooner or later pay back the value of the investment. Contrarily the feasibility of a project is much more significantly affected by the relationship between variable costs and returns. Hence, the price strategy of a DRT service should rather be based on the variable costs, which are driven by the occurred demand. It is important to be mentioned that the introduced independent variables based on the decisions of the operator (e.g. how many vehicles the DRT supplier operates, when the DRT supplier start the vehicle to avoid peak hour, which routes are used by the supplier to avoid road toll, what kind of information channels are used by the operator, etc.).

These kinds of variable costs can be broken down into three groups. Information flow related costs depend on the number of passengers and (or e.g. on the number of applied information channels – internet, mobile network, etc.). 'Rolling' costs (fuel, vehicle operation) depend on travelled distance, road tolls, and traffic density (and for instance costs can even be indirectly affected by the time of departure due to peak time effect). The third investigated cost factor is caused by DRT users themselves to each other. For example, if a newly booked passenger's destination makes it necessary to change the planned route of the common loop then this modification can cause changes in the travel time of those users who booked earlier.

The introduced variable costs should be the base of the applicable pricing system. Firstly, transport performance should be ordered to the occurred/estimated demand and only after defining the required capacity shall pricing strategy be defined. The demand side is represented in the fifth column of Table 2 by the decision variables of the users. The unified representation of decision variable based costs theoretically ensures the possibility to define a marginal cost based pricing system, since, with this, decisions (so demands) can be described based on the price of an additionally consumed unit of 'good' (e.g. travelled distance in kilometre).

2. A New Pricing Approach in Case of a DRT System

The task of this chapter is to define an adequate pricing method for a DRT system. Although the Commission of the EU launched more and more research projects that encourage the use of marginal costs in the transport sector, and itself provided a wide range of solutions for the scheme, average-cost methodology related to public transport service is still difficult to be avoided (Nelson, Mulley 2013). However, for the aim of 'using the existing facilities at the optimal utilisation level' (according to the neo-classical welfare theory) the marginal cost based prices seem still to be the most adequate solution (Milne *et al.* 2000). In the following part of the chapter authors investigate the applicability of traditional methods in reference to DRT and the possibility of introducing a newly developed pricing model (Palmer *et al.* 2008).

Firstly, the average cost based pricing has to be mentioned. In case of an average cost based pricing system, fares are defined by the proportion of the costs of operator and the estimated travel demands. This kind of pricing system has too large inertia for DRT systems, since it can only adapt prices to demands (based on users' decision variables) after the end of the validity period of the defined pricing interval can be further broken down to separate consumer segments in the case of DRT (e.g. based on spatial, temporal or social aspects) (Deb, Filippini 2011).

If travel fares are previously not determined, but a specific unit price is used based on some measurable cost factors of an average route, then the pricing system can be defined as an average variable cost based system. In such a system travel fares are determined by the proportion of the costs of operator and the total estimated performance. In this case, every trip will have a different fare.

If a certain case related to the average variable cost based system is examined, our conclusions will be more reasonable in reference to the operation of the system. It has to be assume that a given passenger would like to use our average cost based DRT system, and would apply it for a journey. If he/she is not the first then he/she has to orient to a previously defined route. If the passenger should not adapt to a previously ordered journey, for example, in case of taking a cab, than this system would have the highest flexibility level. However, let us assume now that the passenger has to adapt to others and can only be transported through a longer route than the shortest between the departure and the arrival point. In this case, according to the basic principles of the average variable cost, this passenger would pay more than the cost of his/her shortest route. If the passenger has to pay more, this means that the others cause him some sort of extra cost. The problem can be tackled in many ways.

Another question arises concerning the fairness of the average variable cost based system. When a passenger books a longer journey close to the centre, and another one books a short journey far from the centre, the first passenger pays several times more than the second one, although the bigger part of the vacant bus route is caused by the second passenger (Tirachini *et al.* 2014).

Usually marginal cost based systems are more sophisticated than average cost based systems, since in this case costs are derived from units of the used service, even if it is difficult to define units of a service. In the field of flexible transportation marginal cost can be defined as the extra cost caused by new registrations due to route alternations. So, in case of pure marginal cost based pricing (1) all passengers pay as much as their trip increases the cost of the operator:

$$MC = \frac{dTC}{dQ}, \tag{1}$$

where: MC is the marginal cost; TC is the total cost; Q is the quantity.

In case of a public transport service the quantity can be, for example, the number of passengers (and dQ is a new passenger incrementally admitted to the system – so after a new booking $dQ = 1$). By this, if there is a service round consisting of n journeys which are inserted with one new booking, then the journey's marginal cost is the deviation between the service round with $n + 1$ journeys and the costs of the service round with n journeys.

In this system, users are interested in late bookings, since the first passenger is charged as if he/she was the only passenger to be transported, which seems to be rather expensive. To the contrary, if someone makes a booking just before the trip and the new passenger's route exactly corresponds with the set route then his/her cost can be zero. This characteristic of marginal cost based pricing does not coincide with the operator's interest.

Beside this, another case when a new booking causes more extra operational cost (marginal cost) for the existing journey, than the cost of separating it needs to be examined (so make 2 journeys with 2 vehicles). Though in the case of overcapacity, it can be solved by adding another vehicle to the system, however if surplus capacity characterizes the network then the above mentioned problem may turn out to be a determining point of conflict.

The contradictions of the pricing systems can be resolved by developing a mixed pricing system. The new pricing system can be basically traced back to the average variable cost based pricing system, however in this case the base of the average cost is given by the loop cost. Individual loop cost refers to the cost of the shortest loop that starts from the terminal, goes to the passenger's origin, then his final destination, and finally back to the terminal. In case of a real problem, it also has to be considered if one or more terminal is necessary to satisfy demands in the most efficient way, however this question is beyond the objective of the research.

So, according to the new pricing method the costs of a complete route are divided in the proportion of the individual loop costs. All problems, which were mentioned above, are solved, except the one. Costs of vacant routes are distributed since the individual loops include the vacant routes. Passengers are motivated to suggest the service to other passengers as their expenses might decrease with the newcomers.

However, if the marginal cost of the complete route (collecting loop) due to the new user is bigger than the given passenger's individual loop cost, than the other passengers' expenses can even increase. To solve this problem, further correction needs to be applied. It is clear that every passenger causes some amount of externality to the others, since with more passengers the travel time and the level of comfort differs from travelling alone. In the next chapter three examples will be presented below to explain how it is possible to apply the examined pricing systems in practice (however, the applied sums are not real life values; they are simply used to demonstrate how the user charges develop in comparison to each other).

3. Introduction of the Newly Developed Pricing Method

First of all, that case should be examined in which the marginal cost of the last passenger is bigger than the cost of his individual loop. Case No. 1 is introduced by Figs 1–3, how passengers check-in. Table 3 introduces that the average cost of the passengers can be defined with dividing total cost equally between passengers (the collective loop cost is divided by the number of the passengers). Now the system is based on 'trip unit' as a pricing unit, since, as it was mentioned before, it would have the same effect, if it was based on passenger kilometres or travel time. To present the advantage of the newly developed mixed pricing system it is practical to describe the problem in Tables 3 and 4, which represent that in case of the mixed pricing system, the appearance of a new passenger (passenger No. 4) might cause cost reduction for other passengers. When a new passenger would increase the costs of other passengers (counting with traditional average cost based pricing) marginal cost based and mixed pricing systems would be preferred (since average cost based pricing cannot handle adequately the costs, which are caused by users to each other because total cost is divided equally). However, in case of marginal cost based pricing, new bookings do not affect other passengers' charges. Beside this, it can happen that a new passenger's marginal cost is higher when he joins to others compared to his individual loop cost (travelling alone seems to be cheaper but of course it is not realistic). Therefore Tables 3 and 4 describe together that mixed pricing system can be fairer (e.g. in case of a short route far away from the previously planned common loop). Furthermore, it is discernible that passenger No. 3 who has a larger individual loop cost pays less than passenger No. 2 (in the case of reversed booking order passenger No. 2 would pay less – therefore, for passenger No. 3 it is better to book as late as possible).

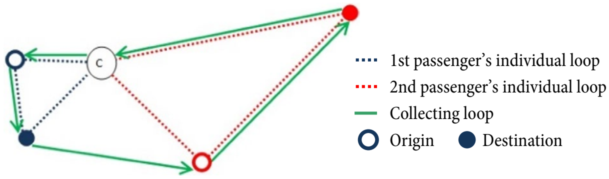

Fig. 1. The illustration of the first step of case No. 1 (*source:* research by the authors)

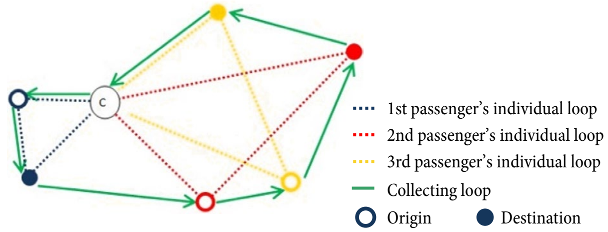

Fig. 2. The illustration of the second step of case No. 1 (*source:* research by the authors)

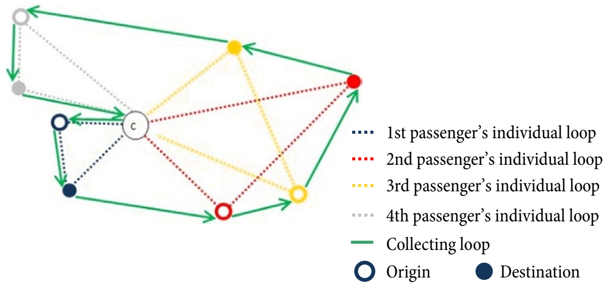

Fig. 3. The illustration of the last step of case No. 1 (*source*: research by the authors)

Table 3. Costs in the different pricing systems (the second step)

Pass. No.	Individual loop cost	Collecting loop cost	Marginal cost based pricing	Mixed pricing	Average cost based pricing
1	4	4	4	3.58	5.67
2	7	11	7	6.26	5.67
3	8	17	6	7.16	5.67

Source: calculation by the authors.

Table 4. Cost table for the pricing systems in case No. 1 (last step)

Pass. No.	Individual loop cost	Collecting loop cost	Marginal cost based pricing	Mixed pricing	Average cost based pricing
1	4	4	4	3.83	5.75
2	7	11	7	6.71	5.75
3	8	17	6	7.67	5.75
4	5	23	6	4.79	5.75

Source: calculation by the authors.

The introduced certain pricing methods can be represented by the formulas below. The formulas are referring to the definition of individual loop cost, which is directly proportional to the length of the given passenger's individual loop. Accordingly collecting loop cost is directly proportional to the length of the collecting loop. The pricing formulas (2–4) are below:

$$MC_i = CLC_i - CLC_{i-1}, \quad (2)$$

where: MC_i is the marginal cost based price of passenger No. i; CLC_i is the actual collecting loop cost at passenger No. i; CLC_{i-1} is the actual collecting loop cost at passenger No. i–1.

$$Mix_i = CLC_n \cdot \frac{ILC_i}{\sum_{i=1}^{n} ILC_i}, \quad (3)$$

where: Mix_i is the mixed price of passenger No. i; CLC_n is the latest collecting loop cost with n passenger; ILC_i is the individual loop cost of passenger No. i.

$$AC_i = \frac{CLC_n}{n}, \quad (4)$$

where: AC_i is the average cost based price of passenger No. i; CLC_n is the latest collecting loop cost with n passenger.

The reason why the new system is called 'Mixed' is the following. For every newcomer the system defines these prices (based on individual loops) and compares them with the prices before the newcomer's appearance. If any price of it increases then the newcomer's price will be his/her marginal cost and for the others it will be the same as before. If there are no increases, the new prices will be the individual loop-based prices (case No. 2). So, the system can ensure that a newcomer will never increase the other's costs but often decrease. Thereby, the 4 passengers-version in case of No. 1 would pay the mixed prices (Table 5).

Table 5. Mixed prices paid by passengers in case No. 1

Pass. No.	Price
1	3.58
2	6.26
3	7.16
4	6

Source: calculation by the authors.

However, it should be further investigated, that in case No. 1, if another passenger comes to our system, how the system can define mixed prices. The solution can be the following. Prices have to be defined according to Table 4, but at the end the comparison should be based on the prices of Table 5. If any of the passengers should pay more, than before, prices will be taken from Table 5. in other cases new prices will be shared proportional to individual loop lengths.

In the next case (case No. 2) the marginal cost of passenger No. 4 is lower than his/her loop cost. It is noticeable (in Table 6) that in the mixed pricing system all charges have decreased compared to the 3 passengers-version (Table 3). In this case, if marginal cost pricing was used, passenger No. 4 would pay less than everybody although his/her loop cost is not the least and he registered last. So, it is clear that marginal cost pricing would not be fair.

Table 6. Cost table for the pricing systems in case No. 2

Pass. No.	Individual loop cost	Collecting loop cost	Marginal cost based pricing	Mixed pricing	Average cost based pricing
1	4	4	4	3.83	4.75
2	7	11	7	6.71	4.75
3	8	17	6	7.67	4.75
4	5	19	2	4.79	4.75

Source: calculation by the authors.

It can be recognised that the mixed pricing method motivates passengers to order the service as early as possible because if they are in the first few volunteers the probability of being a passenger who should pay marginal cost is less. They can always count with that every newcomer might decrease their price. Moreover, at this point the system reached another important advantage: passengers are motivated to advertise the DRT system and invite other people to use this service because it is economically better for them.

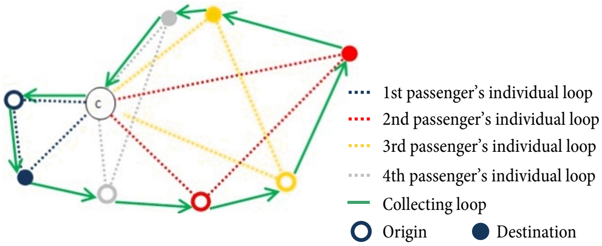

Fig. 4. The illustration of case No. 2 (*source*: research by the authors)

Conclusions

DRT systems fully meet the expectations of sustainable transportation and indirectly they also facilitate social attempts directed at increasing resource-efficiency.

The newly developed method (mixed pricing based on individual loops) makes it possible to apply marginal cost theory in the field of flexible transportation. The innovative idea behind the presented solution was the newly defined unit of marginal cost pricing in case of flexible transportation, namely the individual transport loop (instead of transported volume, e.g. passenger kilometre, etc.).

However, still some questions need to be answered. The common answer to the questions is a mixed pricing system based on the individual loop cost, of which parameters, advantages and disadvantages were discussed in this paper. The future goal of this research is to validate the pricing system in practice and to conduct related cost-benefit analysis. Beyond the above mentioned research topic, defining the necessary number of terminals is also an important scientific development orientation, especially considering the conditions of the efficient operation (Chevrier *et al.* 2012).

Traditional transport pricing models do not specifically support flexible transport solutions, since these models do not include the possibility to apply proportionality and to recompense calculability and reliability. However, the fact that the new model is based on the mentioned principles makes it suitable to enhance the competitiveness of flexible transportation.

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