Theses for a doctoral thesis (PhD)

SUSTAINABILITY AND ECONOMIC ISSUES OF URBAN PUBLIC TRANSPORT

Szabolcs Tóth

Thesis Supervisor:

Dr. habil Adrián Szilárd Nagy

Associate Professor

UNIVERSITY OF DEBRECEN

Károly Ihrig Business and Management Sciences

Doctoral School

Debrecen, 2023

1. BACKGROUND, OBJECTIVES AND HYPOTHESES OF THE RESEARCH

The aim of my research work within the doctoral programme of the Károly Ihrig Doctoral School of Business and Management is to continue and deepen the analyses I started during my Master's programme, in order to meet the requirements of scientific research. My research focuses on the economic and sustainability issues of urban public transport in Hungary. My choice of topics can be considered complex, with themes that are related to several academic fields.

Nowadays, travelling in large cities is becoming increasingly challenging for the people living there, and it takes more and more time to reach the chosen destinations. The number of vehicles on the roads in cities is exploding, while the existing road network cannot keep up with the same dynamics (EKÉS, 2020). In Hungary, the number of road vehicles has increased by about one third in the last decade, steadily approaching the higher population levels in EU Member States (KSH, 2021b). This suggests that more and more people in Hungary are opting for individual mobility and using private cars on urban roads, which is leading to an increasing number of unforeseen and unpleasant traffic situations. In addition to increased and unpredictable travel times, air pollution and the quality of urban life are also deteriorating significantly. The problem is multifaceted and finding a satisfactory solution is a major challenge both for those responsible for organising and maintaining urban transport and for the residents using these services.

The importance of sustainable urban public transport has become increasingly important as urbanisation processes have emerged in parallel with the global population growth (EURÓPAI BIZOTTSÁG, 2020). With the further expected increase in the proportion of the population living in cities, a renewed focus on public transport is clearly forecasted (UITP, 2020). However, maintaining and continuously improving the quality of service is essential to encourage people to choose public transport over private transport. Setting and implementing mobility targets in this direction can also greatly enhance the attractiveness of cities for the labour market, improve the quality of urban life, reduce environmental pressure and improve the well-being of the population. City leaders are of course aware of the importance of this, and most cities have strategies and transport plans in place, which are set out in so-called Sustainable Urban Mobility Plans (SUMP).

Based on my previous research for my thesis at the University of Debrecen, Faculty of Economics and Business Administration, Master of Business Development, it was found that there are several solutions and different methods for the sustainable operation and financing of urban public transport not only among cities in European countries, but also among cities in Hungary.

In my current research, I will examine the European standards of public transport, its operational and organisational structure, the composition of revenues in several Hungarian cities and the domestic subsidy systems that are essential for its maintenance. For the selected cities, the research will analyse whether local public transport is sustainable without an appropriate subsidy system, and whether the fare revenues paid by passengers using the service can cover the costs of operation on their own. The level of contribution and support required from the organisations responsible for the service, the municipality, the ministry responsible for transport and the state to maintain the quality and safety of the service.

Research to date has shown that the current funding structure in many cities not only hinders necessary and timely improvements but may even jeopardise the continued maintenance of the service. Existing funding problems may fundamentally hinder the maintenance of safe operations and the implementation of improvements that are essential to meet the objectives of the smart city concept and declared in the European Commission's White Paper, which, in addition to reducing the environmental burden on cities, could generate more residents using public transport and higher fare revenues from passengers, thus promoting sustainability (EURÓPAI BIZOTTSÁG, 2011).

In many cases, the problems of the domestic support and funding system can also be traced back to inadequate operational and organisational structures. The aim of my research is to explore as broadly as possible the problems inherent in the financing of domestic public transport and to identify the operational options that would enhance sustainability. A more detailed analysis of the revenue side and the current subsidy structure is of particular importance.

As a professional of this field, I believe it is essential to examine the role of the municipalities and the state in maintaining the service. I also consider it essential to examine and understand the various operating models from the point of view of the person who bears

the revenue and operational risk. In the domestic funding environment, the research will look at the proportion of revenue provided by the state, the cities and the passengers using the service to cover the expenditure needed for operation and development.

The transport sector, including urban passenger transport, has been significantly affected by the pandemic. Even before the virus outbreak, the European Union was already experiencing a shortage of skilled labour, which in Hungary was characterised by a large-scale emigration of workers, with a significant proportion of the population seeking employment outside the country's borders. The shortage of drivers in the passenger transport sector has made it even more difficult to maintain a smooth service over the period, with minimal disruption to services.

In the passenger transport sector, the use of public transport was already gradually shifting towards private transport even before the virus outbreak. With the spread of the COVID-19 virus and the changes in travel patterns during the pandemic, as well as the measures taken by the government to protect against the virus, there have been radical changes in the use of public transport. Teleworking and distance learning, the expansion of free travel and the introduction of restrictions have changed travel demand, with a parallel sharp reduction in the number of passengers paying for the services. In our country, the introduction of mandatory mask wearing and distance rules have further reduced the demand for public transport.

Main objectives of the research

Objective 1 (O_1): The EU and national institutional system will be analysed. Identify the legal and regulatory framework for public services and how these requirements are reflected in domestic public services. As a practitioner, I consider it essential to examine the role of local authorities and the state in maintaining the service. I also consider it essential to examine and understand the different operating models from the point of view of the person who bears the revenue and operational risk.

Objective 2 (O_2): To analyse whether the subsidy system for local public transport in our country adequately ensures sustainability. The contribution and support of the organisations responsible for the service, the municipality, the ministry responsible for transport and the state to maintain the quality and safety of the service will be examined. The problems of the

domestic support and funding system can in many cases be traced back to inadequate operational and organisational structures. The aim of my research is to look as widely as possible at the problems inherent in the financing of domestic public transport and to identify the operational options that would enable sustainability. A more detailed analysis of the revenue side and the current subsidy structure is of particular importance.

Objective 3 (O_3): My aim is to carry out a detailed analysis of whether the fare revenues paid by passengers using the service can cover the costs of operation on their own. By looking at the domestic funding environment, the research will include the proportion of revenues provided by the state, subsidised by the cities, and by passengers using the service, which can be used to cover the necessary expenditure for operations and improvements. The basic aim of the research is to identify the options that will ensure sustainability on the service provider side, the highest quality of public transport service for the urban population and the lowest financing burden for those responsible for maintaining public transport.

Objective 4 (O_4): My research will investigate the relationship between sales volumes and hence fare revenue trends and the number of active cases of the virus. The transport sector, including urban passenger transport, has been significantly affected by the pandemic. Even before the virus outbreak, the European Union was already experiencing a shortage of skilled labour, which in our country was also characterised by a large-scale emigration of workers, as a significant part of the population sought employment outside the country's borders. The shortage of drivers in the passenger transport sector has made it even more difficult to maintain a smooth service over the period, with minimal disruption to services.

In the passenger transport sector, the use of public transport was already gradually shifting towards private transport even before the virus outbreak. With the spread of the COVID-19 virus and the changes in travel patterns during the virus outbreak, as well as the measures taken by the government to protect against the virus, there have been radical changes in the use of public transport. Teleworking and distance learning, the expansion of free travel and the introduction of curfews have changed travel demand, with a parallel sharp reduction in the number of passengers paying for services. In our country, the introduction of mandatory mask wearing and distance rules have further reduced the demand for public transport.

Objective 5 (O_5): My aim is to identify innovative ways to increase the modal split in the city.

Urbanisation processes are making urban transport an increasing problem for people living in cities. One obvious solution is to increase the modal share of public transport. In order to make this form of mobility an attractive alternative for the population, it is necessary to maintain it and to develop it continuously, using innovative solutions that passengers also expect. To examine this objective, it is necessary to understand the expectations of the public.

Objective 6 (O_6): Examine the role of modern passenger information facilities and digitalisation.

The questionnaire filled in by passengers will be used to investigate the possibilities for modern passenger information based on the responses to the travel habits. The research will look for innovative solutions to facilitate travel planning, optimise travel time, provide passengers with as much information as possible and offer complex solutions to make their journey more comfortable.

The research hypotheses

The study of sustainability and economic issues in public transport covers a fairly broad area. The domestic operation of the sector alone raises many questions, but the pandemic and war period of recent years, as well the resulting economic impacts and changes in travel patterns, also justify the formulation of several hypotheses that need to be examined.

On the basis of the themes and objectives outlined above, the following hypotheses are formulated in advance of the research work:

Hypothesis 1 (H_1): The institutional system of public transport in our country is capable of ensuring sustainability.

Hypothesis 2 (H_2): The support system for public transport in our country is capable of ensuring sustainability.

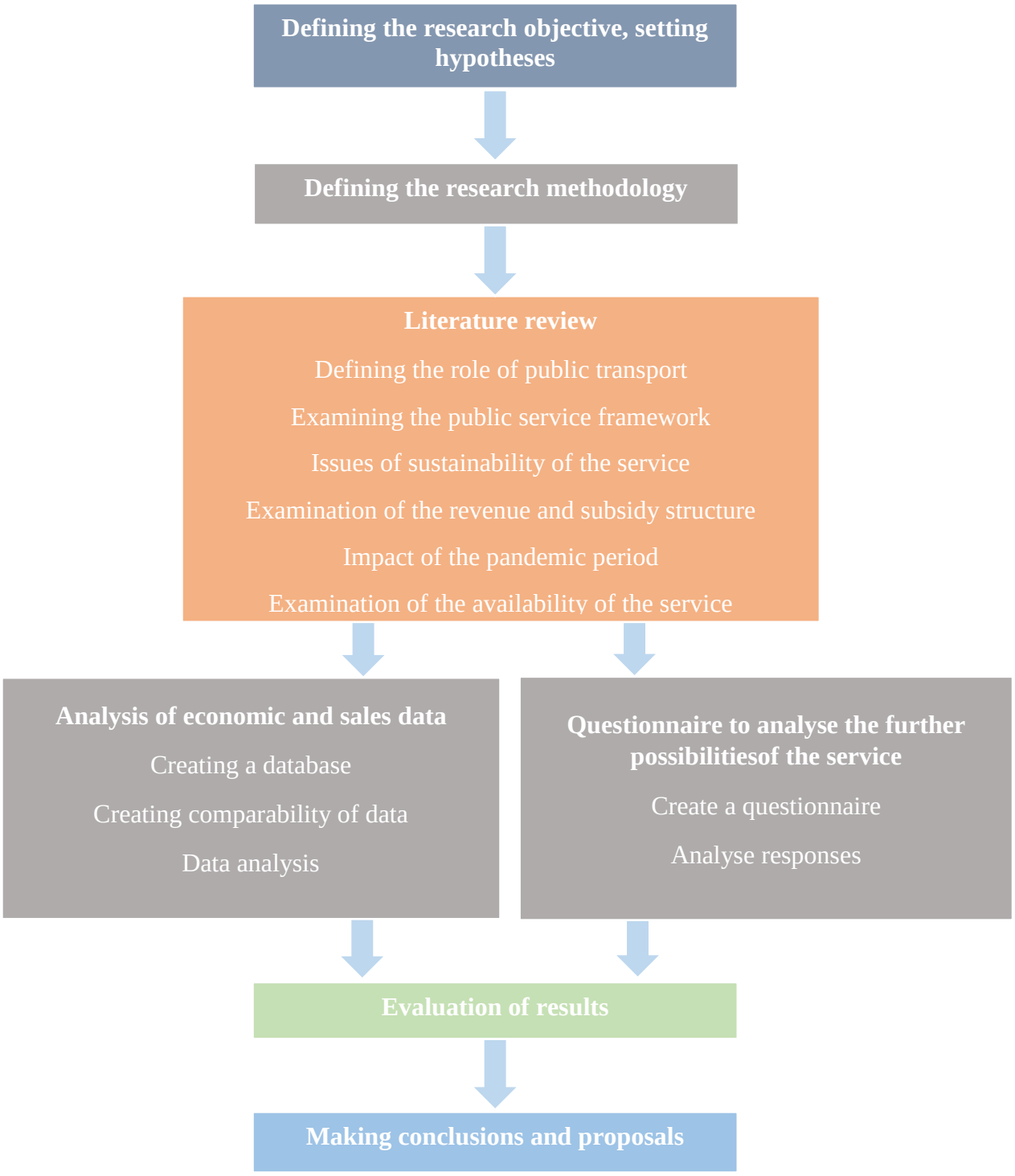
Hypothesis 3 (H_3): Urban public transport in the cities studied cannot be financed solely by fare revenues from passengers using the service.

Hypothesis 4 (H_4): Revenues from passengers were influenced by the evolution of the active case numbers of COVID-19 virus.

Hypothesis 5 (H_5): Continuous innovation in public transport is needed to ensure that the population uses these means to reach their destination.

Hypothesis 6 (H_6): The role of advanced journey planning and real-time travel information systems is of paramount importance to users.

In order to achieve the aims and objectives set out in the thesis, and to test the hypotheses put forward, I followed the following research agenda (1. Figure):



1. Figure: Research programme

Source: own editing, 2022

2. DATABASE AND METHODS USED

2.1. Method of data collection

During the research I collected both secondary and primary data and information. Access to domestic sources was possible thanks to the cooperation of professional organisations and the reporting requirements under the Accounting Act. Access to foreign data is based on annual reports available on the Internet. Secondary information is collected through statistical publications, international and national scientific publications and textbooks, which provide a theoretical and legal background of public transport in close relation to sustainability issues. Due to the nature of the topic, I can rely on the reports of the persons responsible for the management of public transport services, the accounting documents of the responsible organisations and the annual reports of the transport service providers. Direct enquiries and data collection via the Internet provide a more detailed insight into operating models, management and maintenance data.

2.2. Definition of stakeholders

To examine the institutional system and support structure, it is necessary to identify the stakeholders. The success of a service and the directions in which it can be developed are greatly influenced by the way in which service providers can identify their stakeholders. The extent to which and how stakeholders benefit or contribute to the success of processes is important. The need for this analysis is also unquestionable in the context of the sustainability and development of public transport. Stakeholders are identified through the interpretation of legislation, based on the published reports of those responsible for services and operators.

2.3. Methodology for the economic analysis of transport operators

To collect the quantitative data, I used published data from state and municipal budgets and annual reports, available on the Internet, as well as data on operations, and conducted personal interviews with several city managers, transport experts, and managers and economists of the service providers.

In order to examine the level of revenue from fares paid by passengers and the level of subsidies to compensate for expenditure not covered by revenue, economic data from the

annual accounts and related annexes of the public transport operators in the cities and, in their absence, of the actual public operators operating in those cities were examined and compared. These revenue and subsidy data have been assessed not only on a territorial basis, but also in relation to the previous year, the period before the pandemic, thus excluding possible periodic economic spill-overs in a given year. The economic data of the providers were assessed by economic analysis, comparing revenue and subsidy ratios. The correlation calculation may allow to exclude unrelated indicators from further analysis.

The primary data collection was based on data from transport service providers and a questionnaire survey of the population. In order to ensure comparability, an economic analysis was carried out to examine the revenue and the different types of subsidies provided by the state and the public authorities. In addition to identifying the range of subsidy providers, the system of concessionary travel entitlements mandated by the government, its subsidy structure and methodology are analysed.

Face-to-face consultations, information available on electronic platforms, professional studies and reports will be of considerable help in preparing the appropriate analysis.

Among the major cities in Hungary, the cities of Budapest, Debrecen, Miskolc, Kaposvár and Pécs were examined. Several factors influenced the choice:

1. in the selected cities, the revenues and expenditures of urban public transport operators can be separated from other activities and transport services in other cities.
2. the public transport systems in these cities are different in that some of them have only bus services, but many also have fixed-route services. In the case of Budapest, fixed rail activities also include metro and suburban transport. Debrecen also offers a complex local transport service for its inhabitants, with trolleybus and tram services in addition to bus services. In the case of Miskolc, bus services are also complemented by tram services, while Pécs and Kaposvár have only bus passenger transport.
3. the vehicle mileage emissions associated with the public service function also differ between cities, so that starting from a small urban transport system, the management data associated with the operation of the capital city can be examined.
4. in the selected cities, external and internal service models and combinations of these are found differently, and intermediate contracting organisations are also present.

I examine the development of ticket and season ticket sales in the city of Debrecen in particular detail, at the level of the higher volume value coupons, for the years before and during the pandemic. The research looks for the strength of the correlations between revenue and the evolution of the waves of the virus situation and the decisions taken by the government.

Several major European cities have introduced free local public transport in recent years, and the analysis of the operational and financing experience and the economic analysis of the feasibility of introducing it in domestic cities is also at the forefront of ongoing research (BUCSKY, 2018). The research area is complemented by an analysis of the feasibility of introducing free travel in the domestic operational and legislative context, in addition to the economic and sustainability issues identified above.

2.4. Methodology for the analysis of time series data

When analysing the sales volumes of local public transport before and after the pandemic, the different types of vouchers were divided into 4 main groups. The sales data were examined for the city of Debrecen, focusing on the correlation between the impact of the virus pandemic and government measures and the evolution of the volume of value tickets.

In the 4 main groups, tickets and passes were categorised according to their nature and group of use as shown in (1. Table):

1. Table: Grouping of value sections

1. Tickets
Single ticket
Mobile ticket
Driver ticket
Group ticket
Small group ticket
1-hour ticket (mobile)
1-day ticket
3-day ticket
7-day ticket
Group ticket 1 day
Family ticket 3 days
2. Supplementary passes
Supplementary student monthly combined pass

Supplementary general monthly combined pass
3. General season tickets
Monthly
Half month
Monthly without photo
Annual
4. Discounted season tickets
Student monthly combined pass
Pensioner monthly combined pass
Monthly combined pass for small children

Source: own editing, 2022

For the time series belonging to the four groups of value segments, it is clear that they are additive time series. The additive model assumes that both the seasonal effect and the random term have constant fluctuations independent of the trend.

Stochastic time series analysis was used to analyse the relationship between the evolution of sales volumes of fare vouchers and the active case numbers of COVID-19 virus. This method was chosen due to the availability of a relatively short time series, in this case the 24-month period between 01 January 2020 and 31 December 2021. On the other hand, it was assumed that random effects and stresses on the process are built into the phenomenon and play a process-building role in the longer term.

In a first step, the stationarity of the data series was investigated. The Augmented Dickey-Fuller (ADF) test was used to assist in this. The null hypothesis of this test is that the time series has a unit root and is therefore not stationary. The ADF test yielded significant results for all travel entitlements, and the null hypothesis was rejected, indicating that the processes are stationary. The values of the stationary time series fluctuate around a constant mean value with a constant standard deviation, with no trend effect.

In the analysis of time series, the so-called autoregressive and moving average processes (ARMA) have gained importance over the last 50 years and are widely used. The name autoregressive (AR) refers to the fact that the process can be described as a linear regression on its own past. The name moving average (MA) expresses that the "error term" of the linear regression is the moving average of the white noise εt, i.e. the linear combination of the

present and the finite past. ARMA models are also excellent for modelling steady-state processes.

In a model for the study of sales volumes, the active case rate can be included as a regressor. Its coefficient shows how the COVID-19 virus case rate affects the sales of different travel entitlements.

The first-order ARMA (1, 1) model with regressor (R) is of the following form:

$$y_t = C + \varphi_1 y_{t-1} + \beta R_t + \varepsilon_t + \theta_1 \varepsilon_{t-1}$$

where:

y_t: Amount of travel entitlement for the t-th date

C: Intercept

φ_1: Coefficient of autoregressive term

y_{t-1}: amount of travel entitlement for date t-1

β_1: Coefficient of active case numbers

R_t: Active case numbers at time t

ε_t: Error at the t-th time

θ_1: Coefficient of the moving average

ε_{t-1}: error term of the t-1-th time.

To my knowledge, the use of the ARMA model to investigate the relationship between volume changes in public transport and active case numbers of the virus has not yet been investigated. Examples of the use of the model to predict COVID infection case numbers and to analyse passenger traffic data in public transport can be found.

2.5. Methodology for the questionnaire survey

A questionnaire survey was carried out in 2022 as part of the primary research to identify possible directions for improvement in the quality of service expected by passengers. The data was collected online in a self-completion format, completed voluntarily and anonymously. The questions covered the use of public transport in general and specific to the city of Debrecen.

The questionnaire consisted of four main groups of questions:

Part 1: revealed the socio-demographic characteristics of the respondents,

Part 2: respondents were asked to answer questions about their transport habits and how much a change in each factor would influence them towards choosing public transport,

Part 3: the SERVQUAL model was used to assess consumers' expectations of public transport,

Part 4: measuring the experiences of existing users of public transport in Debrecen.

When choosing the sampling method, the main criteria was to make the questionnaire as easily accessible as possible and to complete it as quickly as possible. These specifications clearly favoured electronic convenience sampling, so the questionnaire was completed on-line by respondents.The questionnaire was made available online in May 2022 and was completed by 241 respondents, with a total of 239 respondents completing the questionnaire (2. Table).

2. Table: Socio-demographic distribution of respondents (N= 239)

Distribution of respondents by gender	**Answers**	**Ratio**
women	128	53.6%
men	110	46%
I do not wish to reply	1	0.4%
Distribution of respondents by age group	**Answers**	**Ratio**
under 18	33	13.8%
19-25	69	28.9%
26-40	58	24.3%
41-64	74	31%
over 65	5	2.1%
Distribution of respondents by education	**Answers**	**Ratio**
below primary school	0	0%
primary school (8 primary)	33	13.8%
upper secondary school (vocational school, upper secondary vocational school, gymnasium)	89	37.2%
higher education (college, university)	110	46%
postgraduate	7	2.9%
Distribution of respondents by labour market status	**Answers**	**Ratio**
active worker	146	61.1%
inactive worker (on childcare leave, unpaid leave, long-term sick leave, unemployed)	5	2.1%
student	83	34.7%
pensioner	4	1.7%

other	1	0.4%
Distribution of respondents by place of residence	**Answers**	**Ratio**
capital	12	5%
place of residence	138	58%
small city	61	25.6%
village	24	10.1%
other	3	1.3%
Distribution of respondents by car ownership	**Answers**	**Ratio**
yes, I use it regularly	122	51%
yes, but not regularly	12	5%
no, but my close relative (family member, partner) does	81	33.9%
no	24	10%
Distribution of respondents by mode of transport within the city	**Answers**	**Ratio**
car (as driver or passenger)	105	43.9%
motorbike	4	1.7%
bike	33	13.8%
pedestrian	15	6.3%
Public transport (bus, tram, trolleybus, metro)	79	33.1%
Other (scooter, electric scooter, etc.)	3	1.3%
Distribution of respondents by smartphone ownership	**Answers**	**Ratio**
yes	239	99.6%
no	1	0.4%
Distribution of respondents by use of digital solutions	**Answers**	**Ratio**
fully	115	48.1%
rather yes	50	20.9%
both yes and no	53	22.2%
rather not	16	6.7%
not at all	5	2.1%

Source: own editing, 2022

3. MAIN FINDINGS OF THE THESIS

The hypotheses were tested based on a literature review, using the methodology detailed in the Methodology, and by evaluating the time series analysis and questionnaire responses.

3.1. Results of the analysis of the domestic institutional and support system

In order to test **hypothesis H1**, the EU and the domestic institutional system, described in detail in the literature section, were analysed separately.

3.1.1. The domestic institutional system in public transport

As can be seen at EU level, the legal framework for Community transport services is regulated by Regulation (EC) No 1370/2007 (EURÓPAI UNIÓ, 2007). In Hungary, in line with the EC Regulation, the requirements of the service are set out in Act XLI of 2012 on regular passenger transport services (MAGYAR KÖZTÁRSASÁG ORSZÁGGYŰLÉSE, 2012). Taking into account the provisions of the regulations and the law and the mandatory content of the latter, the public service contracts for the provision of the service are drawn up by the operators responsible for the service and the transport service providers (IFUA et al., 2012). This document clearly sets out the conditions for the provision of the public service:

- the way in which the service provider is selected,
- the choice of the service provider, the method of selection of the service provider and the time frame for the provision of the public service,
- the tariff and timetable requirements,
- the expected quality of service,
- the average age and technical characteristics of the vehicles involved in the service,
- the minimum mileage (usually expressed in terms of passenger capacity),
- maximum level of cancellations,
- requirements for keeping separate accounting records for the public service task,
- the method of calculating the net financial impact,
- the method of reimbursing justified costs not covered by revenue,

- the determination of reasonable profit,
- the method of reporting,
- service standards and methods of financial control.

Transport service providers or contracting entities are generally required to report monthly, quarterly, and annually to the contracting municipality or intermediate contracting entity, with detailed reports broken down by division:

- the planned and actual scheduling performance for the year,
- the reasons for cancellations,
- cumulative mileage of vehicles,
- the number and age composition of vehicles,
- the investments made to ensure the safe maintenance of the service,
- the management of passenger receipts and complaints,
- the operation of customer service activities,
- the revenue from fares and subsidies affecting the service,
- costs incurred in connection with the service,
- the calculation of the net financial impact by division, to be determined on the basis of separate accounts,
- the determination of the amount of compensation and reasonable profit.

The audits relating to public service tasks are generally carried out by a designated department of the municipality or by the intermediate contracting body. The final approval of the accounts of the service providers and, where appropriate, of the contracting entities, and the award of compensation are the responsibility of the assembly of local authorities (IFUA et al., 2012).

As is the case in European forms of organisation and operation, in our country, too, there are already effective solutions in several cities, in which the client's tasks and obligations can be well separated (WRIGHT, 2015). The emergence and gradual spread of customer organisations, the way in which transport service providers are designated, and the

emergence of competition could help to improve service quality (ODIS, 2023; TFL, 2023). It can be seen that the emergence of transport alliances can promote the coordination of urban, suburban and interurban transport systems and the effective implementation of intermodality, for which there are still only a few examples in Hungary (BKK, 2023;TÜKE BUSZ, 2023; SZKT, 2023; KEKO, 2023).

Another factor that can improve the quality of service is where incentive schemes are already included in public service contracts, encouraging operators to operate efficiently and sustainably and to meet passenger expectations at the highest possible level.

In the light of the above, it can be concluded that the domestic institutional system regulates the conditions and requirements of public service provision in line with EU requirements, thus the **hypothesis H1 is fulfilled**.

3.1.2. The domestic support scheme for public transport

Hypothesis H_2 is tested by a detailed analysis of the current support system in Hungary. State involvement in interurban transport has been significant year after year, the main reason being that the state is responsible for the provision of interurban rail, bus and suburban transport. As shown in Table 3**Hiba! A hivatkozási forrás nem található.**, in the year before the pandemic, support reached HUF 350 billion, while in 2021 it exceeded HUF 433 billion. The budget for 2022 is also HUF 442.6 billion, so it can be said that the state's involvement in this sector is significant, with the level of funding increasing further in the event of a virus outbreak (3. Table).

3. Table: Support of public transport services (in million HUF)

	2015	2016	2017	2018	2019	2020	2021	2022
Compensation for the operation of the railway network	72.970	74.138	74.805	93.071	98.113	106.104	127.000	130.000
Compensation for public passenger transport services by rail	154.400	154.400	154.400	164.997	168.372	173.000	193.500	206.000
Compensation for public passenger transport services by coach and bus	33.505	41.049	42.000	65.300	65.300	90.000	98.400	93.000
Settlement of previous compensation for the	12.072	4.000	6.000	5.554	4.748	460	0	0

reimbursement of the costs of rail passenger transport								
Reimbursement of urban public transport costs	0	0	9.000	13.444	12.997	14.259	14.900	13.600
Settlement of expenditure incurred in the past in respect of the reimbursement of the costs of public passenger transport services by coach and bus	4.528	6.627	0	0	0	0	0	0
Subsidy for compulsory local public transport (Capital)	24.000	18.000	15.000	12.000	12.000	12.000	12.000	12.000
Subsidies to municipalities for local public transport	2.015	2.050	2.050	2.050	2.050	0	0	0

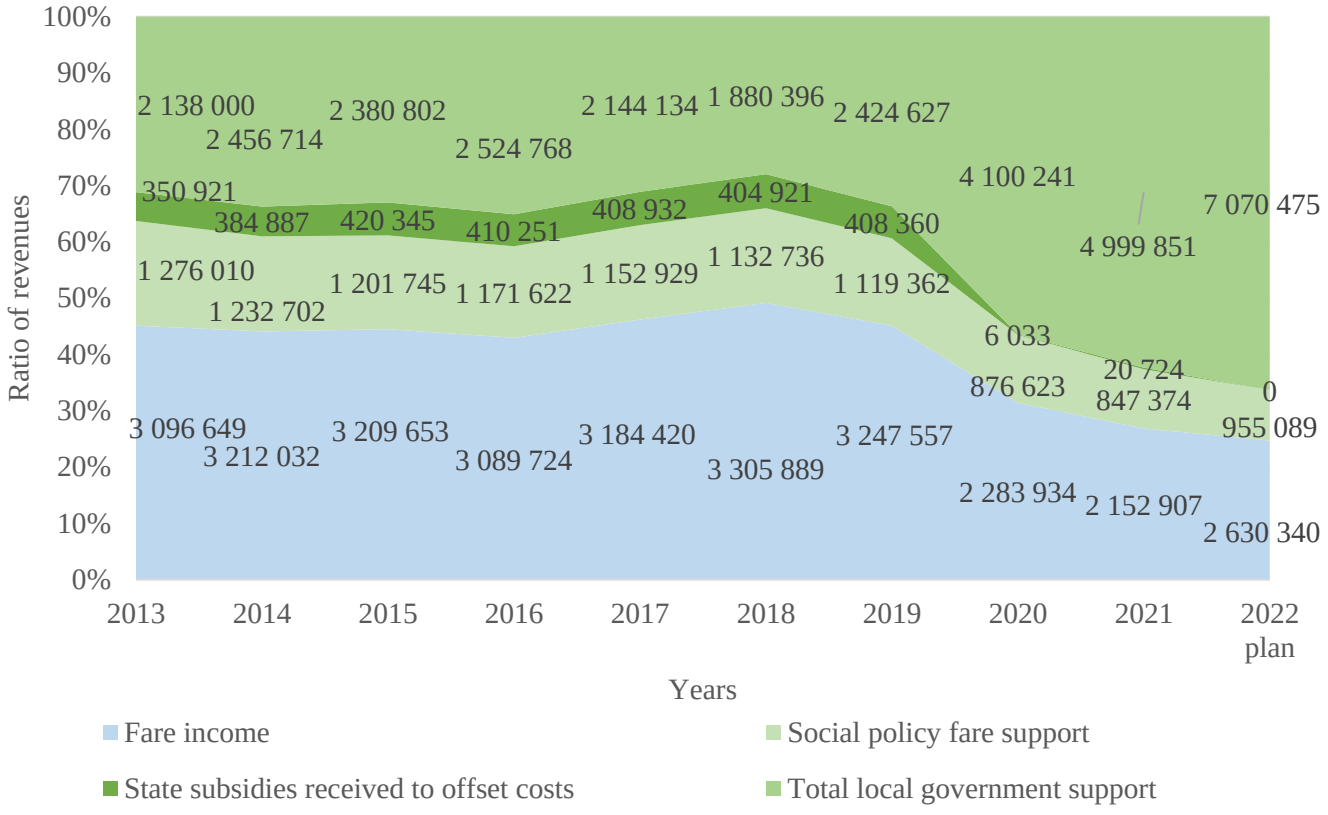
Source: own editing, based on the central budget of Hungary (2015-2022), 2022

At the same time, the literature review suggests that the public support structure for local transport would require significant changes. The government's annual budget allocation to local authorities for local public transport was already relatively low in the years before the pandemic, with a total annual allocation of HUF 2,050 million in those years. The number of municipalities maintaining local transport and applying for subsidies from the allocated budget exceeds 80, which means that the level of public subsidies available is proportionally only of marginal help in financing the maintenance of public services. In the years of the pandemic, this aid was withdrawn, leaving the municipalities to bear the full cost of maintaining the public service (BORBÉLYNÉ, 2021).

In the case of the capital, there has also been a significant reduction in the state budget, but unlike in rural cities, there is still a budget allocation for support during the pandemic.

Revenue and subsidy datas for the city of Debrecen 2. Figure also confirms that while in the years before the pandemic the state subsidy helped to finance the service to a significant extent, the withdrawal of subsidies and the reduced fare revenue in the virus situation has resulted in the municipality having to bear a significant share of the maintenance costs.The level of municipal subsidies in the city has doubled from 2019 to 2021, which in 2019 meant an additional funding requirement of more than HUF 2.5 billion (DKV, 2019; DKV, 2021). In 2022, there will be a further upward trend in costs, as the increase in fuel prices, the multiple increase in energy costs, the maintenance costs due to the impact of inflation, and

the large change in the interest rate environment will lead to a further significant increase in the municipal subsidy.



2. Figure: Revenues of DKV Debreceni Közlekedési Zrt (thousand HUF)

Source: own editing based on the accounts of DKV Zrt according to the Accounting Act, 2022

As a result of the analysis, it can be stated that the previous bipolar subsidy system for local public transport in Hungary has not been functioning properly in recent years. In addition to lower fare revenues due to changing travel habits, unchanged social-political subsidies, rising energy and fuel prices and operating costs, the maintenance of the service is placing an increasing financial burden on local authorities. This means that the **hypothesis H_2 is not fulfilled** in terms of domestic subsidies, and the current subsidy system does not sufficiently support the secure sustainability of public services.

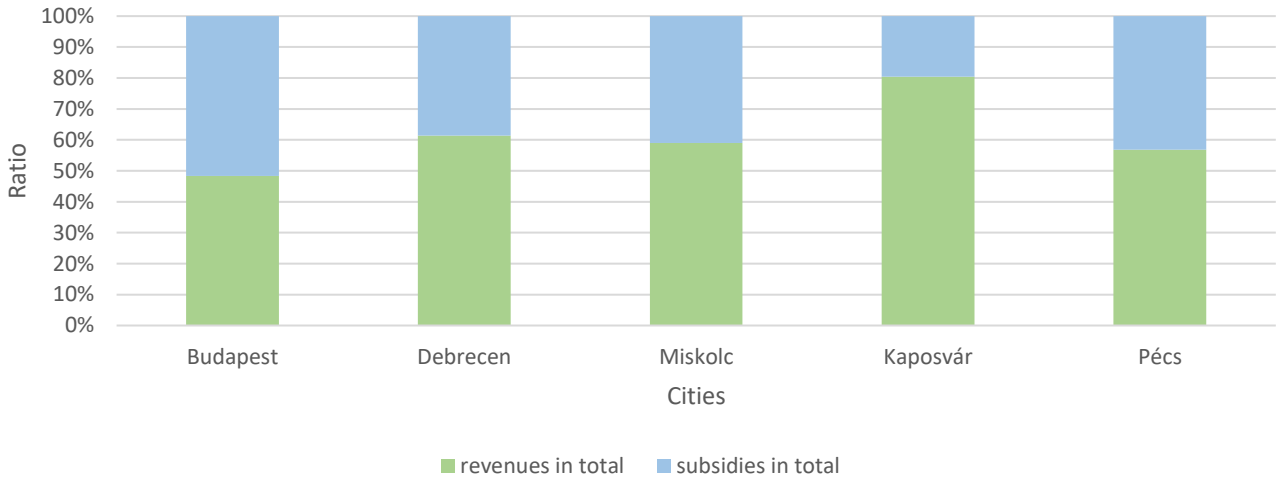
3.2. Results of the analysis of funding sources

Hypothesis H_3 is tested by analysing the revenues generated by the operation of local public transport in the selected 5 domestic cities using data for the year before the pandemic and the year 2021.

3.2.1. Service revenues from passengers in the pre-pandemic period in Hungary

The hypothesis H_3, that public transport in Hungary cannot be fully financed by the users, was tested by analysing the reports of public transport operators. The cities of Budapest, Debrecen, Miskolc, Kaposvár and Pécs were examined. There were significant differences between the pandemic period and the years preceding it, based on the data analysed in the research. Therefore, to ensure comparability, data from both the pre-pandemic and the post-pandemic periods were analysed, including passenger fare revenue paid by passengers, as well as other revenue from state and municipal subsidies and compensation.

The results of the research show that passengers, as the end-users of public transport services, are also the main financiers of public transport services. In Hungary, in the cities surveyed, around 50-60% of local public transport revenues were generated by passenger fares in the years preceding the pandemic (TÓTH, 2021). Similar results were found when analysing the 2019 reports, as detailed in 3. Figure:



3. Figure: Share of subsidies and revenues for domestic operators in 2019

Source: own editing, based on reports from service providers, 2022

It can be seen that there is a rather large variation in the results obtained. In the case of the city of Kaposvár, which provides bus-only transport, 80% of the revenues needed to ensure the operation were paid by passengers. In the case of the cities with county town status, the share of fare revenues ranges between 57% and 61%. Among the cities surveyed, the capital city has the lowest share, not exceeding 50%. (BKK, 2019).

When evaluating the data, it is important to note that the development of fare revenues is strongly influenced by the quality of the service provided, the frequency of services, the timetable design and the extent to which public transport is an alternative to private transport in terms of journey times and accessibility. The cost side is strongly influenced by the share of fixed rail modes, as rail track and overhead line systems are more expensive to maintain. In terms of specific costs per kilometre, these modes are more expensive than bus services, as they lack infrastructure. Another important cost factor is the ability of operators to finance the purchase of the necessary equipment for their operations through non-reimbursable subsidies or through their own investment, possibly through leasing or rental contracts (operators' reports).

The number of passengers carried in the large rural cities has stagnated in the years preceding the pandemic period, in some places falling slightly. The level of fare revenue is affected not only by changes in sales volumes but also by changes in the level of fares. The evolution of fares is influenced by a number of factors, one of which is political, as the level of fares and the design of the discount scheme are factors that influence public sentiment. On the other hand, it is influenced by the level of benefit at which it is still worthwhile for the population to choose public transport over other alternative modes of transport. An analysis of the fares applied in our country shows that fares in our rural cities are similar, with no significant differences between them, as shown in 4. Table.

4. Table: Urban operators' tariffs for the highest volume of fare vouchers sold in 2019

HUF/piece	**Budapest**	**Debrecen**	**Miskolc**	**Kaposvár**	**Pécs**
single ticket in advance	350	330	300	260	350
single ticket at the driver's desk	450	400	400	390	500
student season ticket	3 450	3 800	3 900	3 150	3 710
pensioner season ticket	3 330	3 800	3 900	3 150	3 710
employee season ticket	9 500	6 600	7 000	6 480	6 940

Source: own editing, based on reports from service providers, 2022

In our country, it is the competence of the responsible body to set the tariffs and change them. Based on the experience of recent years, it can be said that a major change in fares has a major impact on the number of passengers. Transport operators also place great emphasis on ticket and pass control activities. Besides the revenue side, ticket control

activities have a major impact on passenger compliance. An ineffective control system also has a major impact on the volume of sales of vouchers.

The development of fare revenues is also strongly influenced by demographic trends in our country. Over the last 15 years, there have been significant changes in the number and composition of Hungary's population. During this period, the population of the country has steadily decreased, while the number of people aged 65 and over has increased dramatically, resulting in an increase in the number of people entitled to free travel. The number of people aged between 7 and 64 has decreased by around 500,000, which also leads to a further decrease in the number of paying passengers (KSH, 2020a). As a result of working in other European countries, hundreds of thousands of Hungarian citizens live outside our borders, which also results in a steady decrease in the number of paying passengers.

3.2.2. Impact of the coronavirus on public transport

An unexpected change in the lives of people around the world has been brought about by the appearance of the Covid virus at the end of 2019. Our lives have changed overnight, and our habits have changed dramatically. When the virus emerged, its lingering effects were not anticipated. The virus situation has presented unexpected challenges to the world economy, with factories shutting down due to severe problems in the supply chain.

The logistics and transport sector has been hit exceptionally hard over the past two years, with significant declines in both freight and passenger traffic. In addition to international transport, domestic transport, including urban transport, has also experienced an unprecedented drop in volumes. In Hungary, the proportion of people using public transport at the start of the pandemic fell to around 30% of the previous period, with an annual average of 70% (MVK, 2020; SZKT, 2020). Transport experts predicted a rapid "bounce back" following the fall in passenger numbers. However, the recent period has seen a prolonged period of slow growth and new surges have created a continuing challenge for operators. The measures taken to deal with the virus situation have also had a major impact on the previous users of public transport. The introduction of atypical forms of employment, distance learning in educational institutions and curfew restrictions have all reduced the number of users. The introduction of specific rules on the use of public transport, the compulsory use of masks and the minimum distance to be maintained have led to a shift

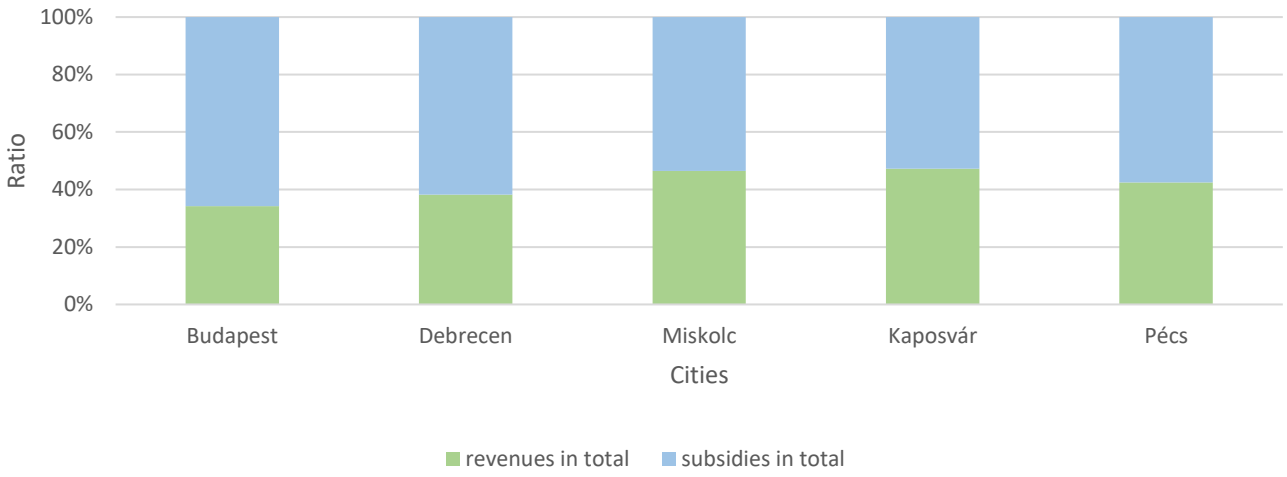
towards private transport. A further measure affecting public transport was the extension of free travel, which greatly reduced the number of paying passengers (TÓTH, 2021).

3.2.3. Revenue of the service during the pandemic period

Travel patterns during the pandemic period, the measures taken by the government in general to slow the spread of the virus and those specific to public transport have changed the economic situation of operators. The curfew, distance learning, the rise of home-office working, the use of masks, the obligation to keep a distance and the fear of being in confined spaces have led to a significant drop in the use of public transport. Driver ticketing has been discontinued in order to minimise personal contact, and contactless, online payment methods have been introduced.

Transport operators have introduced various changes to timetables and optimisation of routes in response to reduced travel demand. However, in addition to these cost-cutting measures, they have also had to carry out occasional screening and disinfection of vehicles and public places to slow down the spread of the virus (DKV, 2021).

Due to radically changed travel habits and reduced willingness to travel by public transport on the part of the population, the volume of fare revenue from passengers has fallen significantly over the past 3 years, to levels of up to 30-40% at the beginning of the pandemic, during the period of distance learning and curfew (SCHULEK, 2021). Despite their efforts to minimise costs, service providers were unable to compensate for the sudden loss of revenue, thus requiring proportionally higher compensation.



4. Figure: Share of subsidies and revenues for domestic operators in 2021

Source: own editing, based on reports from service providers, 2022

Analysing the data 4. Figure, it can be stated that the average 50-60% revenue share from fares and social-political fare subsidies in public transport in the Hungarian cities under study has significantly decreased from the pre-pandemic level of 50-60% in the years before the pandemic. In the capital city this was about 35%, in the rural cities 40-45% for the year 2021. A large share of the loss of revenue is due to the non-payment of fares by those who are not required to pay a fare due to the temporary extension of free travel entitlement, but who are in fact users of public transport (DKV, 2021; MVK 2021).

The government has banned any changes to the fare and voucher structure for public transport during the virus outbreak by special decree. This prevented operators from passing on to passengers the cost increases resulting from the inflationary effect of the epidemic response.

Comparing the data for 2021 and 2019, it can be observed that in each of the cities studied, there was a significant increase in the level of subsidies required for operations (MVK 2019). In none of the periods and cities studied did the revenue from passengers cover the operating costs of the service, thus it can be stated that **hypothesis H_3 is fulfilled**, that the fares paid are not sufficient to maintain the service.

In order to avoid the need for state or municipal subsidies to maintain the public service, passengers would have to pay the costs in fares. This would mean an increase in ticket and season ticket prices and fare subsidies for concessionary and free travel of the order of 120-180% on top of the current subsidy rates of 35-45%. Such an increase would mean that the cost of a monthly season ticket for employees would be at least HUF 20 000, and the cost of a monthly season ticket for students would be more than HUF 10 000. For an average family with 2 children, this would amount to a monthly expenditure of HUF 60,000, which would already represent a significant proportion of the families' monthly budget. In this case, additional transport options would arise, which would reduce the share of public transport use.

3.3. Analysis of the impact of Covid-19 virus case numbers on revenues

In the test of **hypothesis H_4**, the correlation between the number of cases of the COVID-19 virus epidemic and the development of fare revenues in the city of Debrecen was analysed using the mathematical model described in the methodology section. The study was

complemented by an analysis of the impact of government measures taken in our country during the virus outbreak on revenues.

3.3.1. Analysis of sales data for the period affected by the pandemic

As noted, the period prior to the virus outbreak was characterised by stagnant, slightly declining public transport ridership in the city (TÓTH, 2021). The changes in travel patterns caused by the virus, similar to those experienced in major cities around the world, have had an impact on life and transport in Debrecen.

Community operators have continuously adapted to reduced travel demand in order to minimise their operating costs and have introduced several timetable changes depending on the evolution of the epidemic wave. However, the government measures taken in response to the epidemic situation have not always allowed for greater optimisation of routes. In order to ensure to keep distance in public transport, as laid down in the government decree, operators sometimes had to increase the capacity of the seats allocated, thus limiting to some extent the scope for cost reduction.

From 2020, the withdrawal of the public normative subsidy for local public transport also added to the problems of the sector, which is still facing significant financing difficulties today.

In addition to the impact of the pandemic on public transport, the extension of the scope of mandated fare-free travel entitlements in Hungary was a major factor in the development of passenger fare revenues. Under Government Decree 505/2020 (17.11.20), a number of existing fare-paying passengers were able to use local services in Hungarian cities without paying a fare. Due to the tightening of epidemiological measures, the introduction of online schooling over several periods and the increasing frequency of working from home, the demand for travel in Debrecen has also fallen dramatically during the period. The curfew period introduced on 23 November 2020 also saw a sharp drop in passenger numbers (KSH, 2021c).

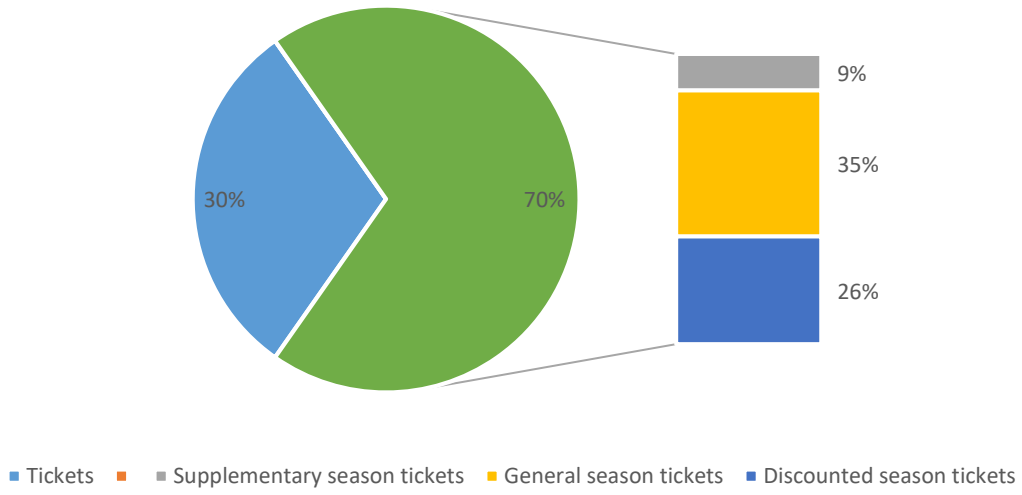
The lower volume of fare-paying passengers in the first three quarters of 2021 was still significant compared to 2019. A slower upturn was only observed from the last quarter, but sales volumes were still well below the same period in 2019. However, in 2022, there was a further increase in fare-paying passenger numbers, which was also affected by the

abolition of the emergency fare-free travel options from 15 June 2022. Rising fuel prices in our country, higher service charges due to increased inflation, will make it increasingly costly to maintain a private car, and more people are expected to turn from private transport to public transport.

3.3.2. Impact of active caseloads on sales

An analysis of the local public transport in the city of Debrecen for the pandemic period between 01 January 2020 and 31 December 2021 (DKV, 2021). To test the hypothesis, i.e. whether a correlation between the number of infected cases and the development of ticket and season ticket sales can be detected, stochastic time series analysis was used. The autoregressive moving average (ARMA) model was used for this purpose. The model was regressed on the active case numbers of the COVID-19 virus, with a coefficient showing how the evolution of sales volumes was influenced by case numbers.

The analysis of token types was divided into four main groups. As can be seen from 5. Figure, tickets represent about 30% of the revenue, while season tickets account for 70%. It can be said that general season tickets represent the largest share (35%) of the total revenue, discounted season tickets account for 26%, while supplementary season tickets represent the lowest share, at 9%.



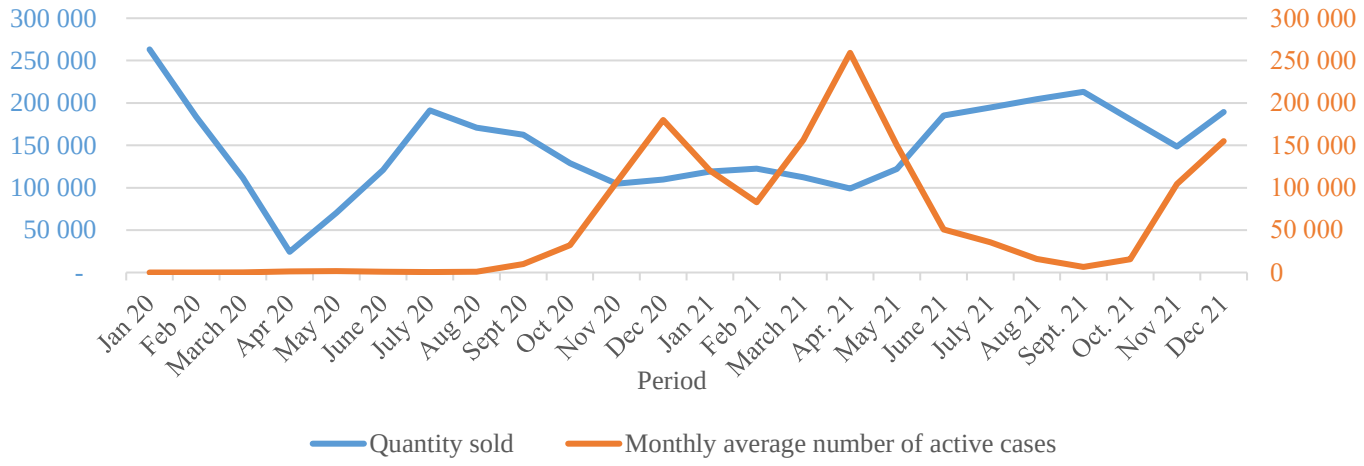
5. Figure: Distribution of DKV Zrt. sales revenues by voucher in 2021

Source: own editing, based on DKV Zrt. sales data,2022

The ARMA model was used for the mathematical analysis of the relationships between the evolution of sales and the number of cases, and the parameters obtained are shown in the following analyses, broken down into value coupon groups. The most relevant for the analysis is the value of β1, which is the coefficient of the active case numbers. If the value of β1 is negative, the change between the sales volume and the value of the case numbers is in the opposite direction. This means that as case numbers increase, sales volumes decrease. If the value of the coefficient of the autoregressive term φ1 (Pr) does not exceed 10%, the value is not significant (*significance level P<0.10), i.e. the active caseload did not influence the sales volume.

3.3.3. Examination of correlation for ticket-type fare vouchers

Value vouchers of this type include ad-hoc, single, small or large group or day tickets. Sales of these vouchers dropped significantly at the onset of the virus and at the peak of subsequent waves.



6. Figure: Evolution of the number of tickets sold by DKV and the monthly average number of COVID-19 virus cases

Source: own editing based on DKV sales data and data from (WORLDOMETERS.INFO, 2022), 2022

When examining 6. Figure, we can see that the sales volume trend reached its lowest point in the month following the first wave, in April 2020, down by around 22% compared to March. In the following months, there was a slow recovery, but during the period under review, sales did not reach pre-pandemic volumes. From the second wave onwards, the fall in sales volumes relative to the higher case numbers was not as large as in the first wave.

When analysing the time series of ticket sales numbers and active case numbers in the ARMA model, the parameters shown in 5. Table are observed.

5. Table: Parameters of the ARMA (1,1) model describing the effect of the number of cases on ticket sales

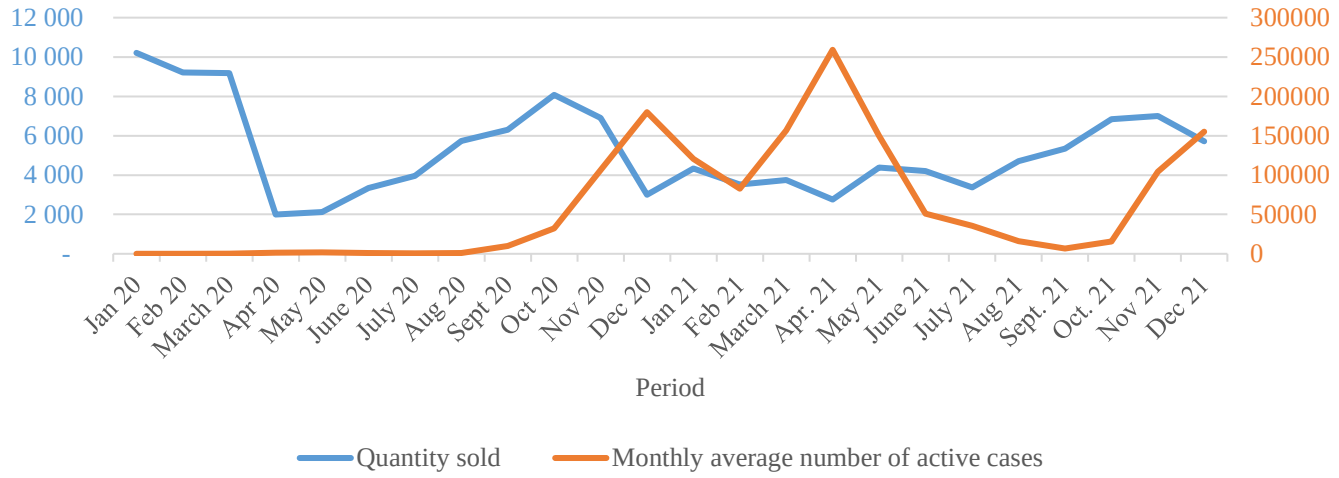
Coefficient	Estimated value	Standard error	t-value	Pr (>|t|)[1]
Intersection	172138.927	24398.210	7.06	<0.0001*
φ_1	0.603	0.206	2.93	**0.0083 ***
β_1	**-0.199**	0.127	-1.56	0.1333
θ_1	0.390	0.170	2.29	0.0328*

Source: own editing, 2022

From 5. Table the coefficient β1 takes a negative value (β1 = -0.199), which implies that the shift is opposite between the number of sales units and the number of active cases. However, the value of the coefficient of the autoregressive term φ1 (Pr) does not exceed 10%, so the relationship is not significant. This means that the hypothesis H3 for ticket sales did not hold for the period under study, and the active case counts of COVID-19 virus did not significantly affect ticket sales.

3.3.4. Examination of correlation for supplementary season tickets

The next grouping of fare vouchers is the so-called supplementary season tickets. The introduction of this type of season ticket in Debrecen was justified by the need to facilitate travel for a large number of people arriving in the city from the surrounding agglomeration. The supplemantory season ticket can be purchased by a passenger holding an interurban season ticket, a train and/or a bus season ticket valid for the same period for local transport, the starting or final destination of which is the city of Debrecen. It can be purchased in the form of a student or employee pass at a reduced price compared to the general student or employee pass. The name 'supplementary pass' thus basically means that this voucher is not available on its own, but only to holders of an interchange pass.



7. Figure: Evolution of DKV Zrt. supplementary season ticket sales and monthly average number of COVID-19 cases

Source: own editing based on DKV sales data and data from (WORLDOMETERS.INFO, 2022), 2022

In the case of additional season tickets, the first wave of the COVID-19 virus spread 7. Figure shows the change in volumes, which fell by around 8,000 units in April compared to the previous month, to 22%. In this case, the recovery from the first wave to around 80%, due to the resumption of attendance training, is clearly visible. This was followed by a larger drop in sales in the second wave, due to the impact of the new restrictive measures taken, after which sales figures stagnated and only started to "bounce back" after the third wave. The trend in the number of supplementary season tickets is negative in the periods affected by distance learning, since the majority of this product is purchased by students. The ARMA model shows the following parameters for supplementary season tickets:

6. Table: Parameters of the ARMA (1,1) model describing the impact of the number of cases for supplementary season tickets

Coefficient	Estimated value	Standard error	t-value	Pr (>|t|)[1]
Intersection	5812.682	909.627	6.39	<0.0001*
φ_1	0.484	0.266	1.82	**0.0840**
β_1	**-0.054**	0.007	-0.83	0.4193
θ_1	0.2083	0.253	0.82	0.4199

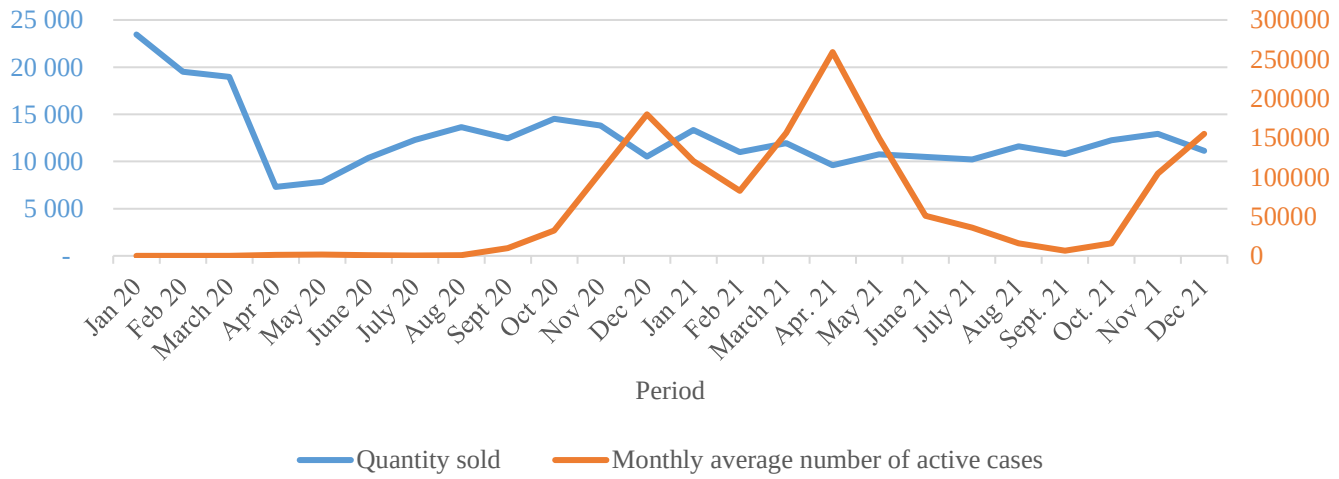
Source: own editing, 2022

When examining the relationship between the sale of supplementary season tickets and the number of cases, the results are detailed in 6. Table. The coefficient β1 also takes a negative

value for these season tickets (β1 = -0.054), so that the shift in the relationship between sales and caseload is also in the opposite direction for supplementary season tickets. The value is non-significant (Pr<0.10), thus it can be concluded that the evolution of the active case numbers of COVID-19 virus in our country did not influence the sales volume of additional season tickets in the public transport sector in the city of Debrecen.

3.3.5. Correlation analysis for general season tickets

General season ticket holders are people who commute to work every day and who may or may not be eligible for a preferential season ticket for one reason or another. These customers usually use their season tickets several times a day, but the pandemic period has brought significant changes in this case. With the spread of the virus and the introduction of restrictions, as well as changes in employment patterns and home-office working, travel patterns have changed for this customer segment. A shift towards private transport is more possible in this case, as this group is self-employed, it is easier to choose this mode of mobility by buying and maintaining their own car, and it is more difficult to return to the use of public transport.



8. Figure: Evolution of DKV Zrt. general season ticket sales and monthly average number of COVID-19 virus cases

Source: own editing based on DKV sales data and data from (WORLDOMETERS.INFO, 2022), 2022

An analysis of 8. Figure **Hiba! A hivatkozási forrás nem található.**shows that the biggest drop in volume occurred in the first wave period, falling to around 38% from March to April.

The peaks of the following waves also show decreases, but not as large as in the first wave period. When analysing the sales trend, it can also be observed that the previous volume has not even nearly recovered , with the number of units falling back to around 10-15 thousand units compared to the 20-24 thousand units sold per month previously. This trend also suggests that this segment is returning to public transport more slowly or not at allor is becoming ad-hoc passengers and not buying monthly season tickets. They are likely to travel by private car or other personal means, only occasionally using public transport with a season ticket.

Sales volumes have also been negatively affected by the extension of the scope of the free travel entitlement and its maintenance for most of the pandemic period.

The ARMA model used to test the correlation gave the following parameters 7. Table for the period under study:

7. Table: Parameters of the ARMA (1,1) model describing the effect of the number of cases for general season tickets

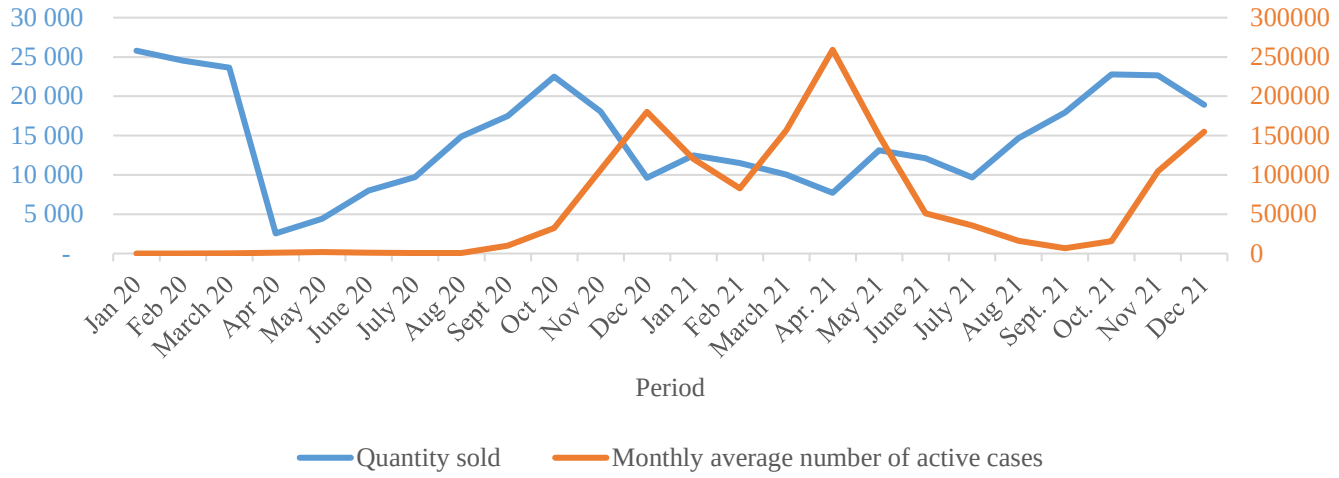
Coefficient	Estimated value	Standard error	t-value	Pr (>|t|)[1]
Intersection	13486.750	1761.697	7.66	<0.0001*
φ_1	0.635	0.2691	2.36	**0.0285** *
β_1	**-0.005**	0.0107	-0.49	0.6296
θ_1	0.067	0.2371	0.28	0.7795

Source: own editing, 2022

The β1 coefficient is also negative in this case (-0.005) and not significant. For general season ticket, it can also be concluded that the change in sales volume was not primarily influenced by the change in the number of active cases.

3.3.6. Correlation analysis for concessionary season tickets

Discounted season tickets are available to students, pensioners and mothers with young children. During the period of the COVID-19 virus, the purchasing behaviour of this group was influenced by several factors. The introduction of online education for students, who make up the largest proportion of the season ticket group, and the higher risk of being infected by the virus for pensioners and mothers with young children have led to changes in travel behaviour. The imposition of curfews has also had a major impact on sales volumes.



9. Figure: Evolution of DKV Zrt discounted season ticket sales and monthly average number of COVID-19 cases

Source: own editing based on DKV sales data and data from (WORLDOMETERS.INFO, 2022), 2022

The biggest drop in the volume of discounted season ticket sales among the four groups was observed in the first wave period, with volumes falling from 11% fromMarch to April (9. Figure). However, it is also the case that the biggest recovery occurred with the start of school in September, with sales reaching 95% of March figures. Here too, the measures introduced in the second wave in November 2020, including the reintroduction of distance learning, have had an impact, with sales volumes falling to 50% of their original levels on average. A steeper increase will only be observed with the start of school in September 2021, when no new restrictive measures will be taken in the country due to the evolution of the number of cases. There were also no major restrictions at the start of the fourth wave, so sales volumes resumed their upward trend. The mathematical model used to relate case numbers to sales figures gave the following parameters:

8. Table: Parameters of the ARMA (1,1) model describing the impact of the number of cases for concessionary season tickets

Coefficient	Estimated value	Standard error	t-value	Pr (>|t|)[1]
Intersection	16382.925	2604.826	6.29	<0.0001*
φ_1	0.457	0.259	1.76	**0.0932**
β_1	**-0.016**	0.018	-0.87	0.3968
θ_1	0.307	0.264	1.16	0.2578

Source: own editing, 2022

The coefficient β1 for concessionary passes also has a negative sign 8. Table, which is also low at -0.016. The coefficient obtained is not significant, so the hypothesis is not fulfilled for the sales of discounted season tickets, i.e. no correlation can be shown for the effect of the domestic case numbers of COVID-19 virus on the evolution of the number of sales of public transport in Debrecen.

In conclusion, hypothesis **H_4 is not confirmed**, as the coefficient β1 was not significant for any group of season tickets, so it is highly probable that the active case rate did not influence the evolution of sales volumes during the pandemic period.

3.3.7. Analysis of the measures taken during the pandemic

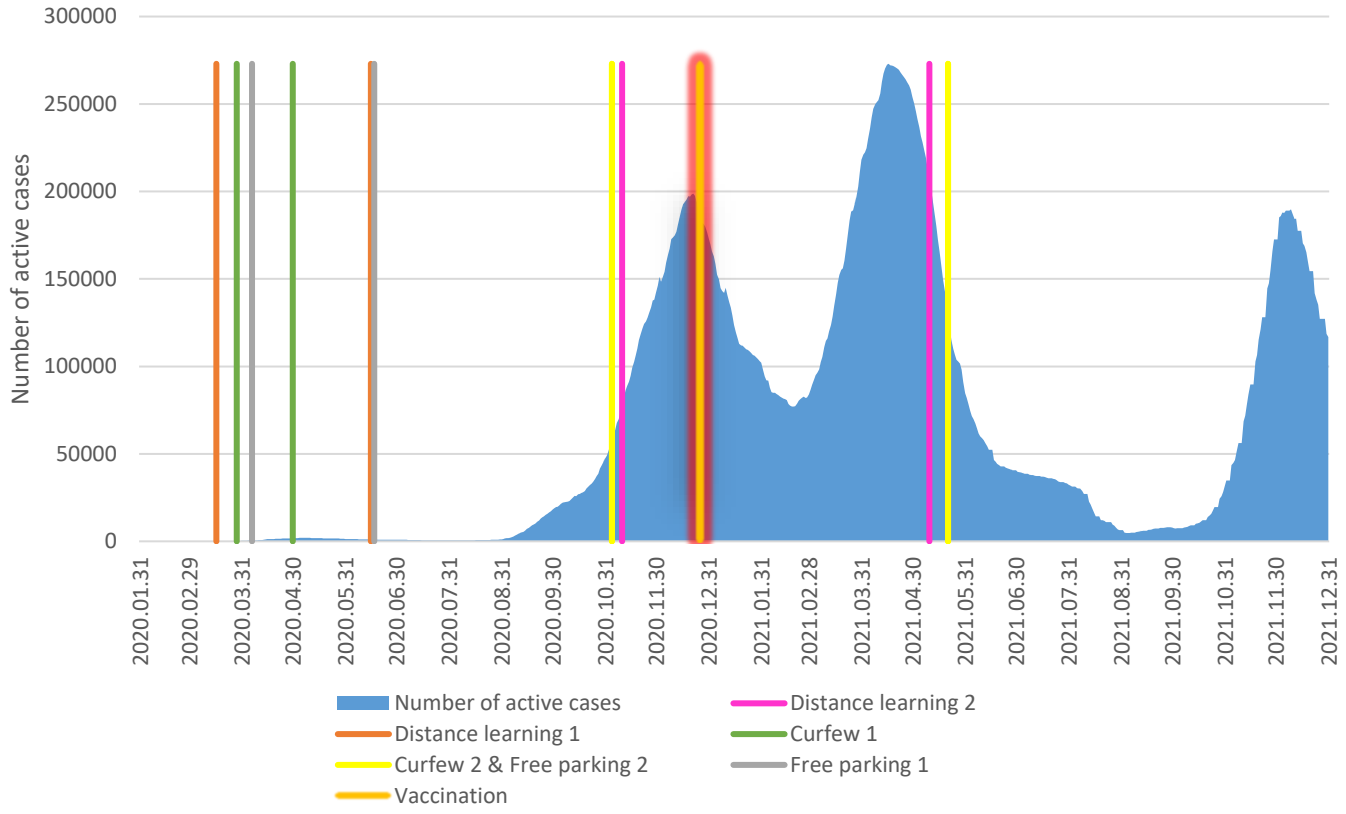
As can be seen from the literature review, a number of measures have been taken by both government and local government to control the spread of the virus. Many of the measures taken have had an impact on travel patterns, the most relevant of which are detailed in 9. Table.

9. Table: Government measures affecting public transport during the pandemic

Measure	Date of effect	End of effect	Government Decree No
Distance learning	16 March 2020.	15 June 2020.	1102/2020
Lockdown	28 March 2020.	30 April 2020.	71/2020
Masking	1 May 2020.	26 June 2021.	168/2020
Extension of free travel	1 April 2020.	15 June 2022.	486/2020
Free parking	6 April 2020.	17 June 2020.	87/2020
Lockdown	4 November 2020.	21 May 2021.	479/2020
Free parking	4 November 2020.	21 May 2021	478/2020; 512/2020
Distance learning	10 November 2020.	10 May 2021.	depending on the level of education
Mask wearing	21 November	7 March 2022.	597/2021

Source: own editing based on the Hungarian Gazette, 2022

In hindsight, the measures may seem excessive in terms of case numbers, but without them, the evolution of active case numbers would certainly have been worse. The mandatory wearing of masks on vehicles has certainly had a negative impact on travel patterns, but the measure has probably had a major impact on preventing the spread of the virus and also on the safer provision of the service by protecting drivers from infection. In addition to the disinfection of vehicles, service providers during this period also introduced additional measures such as the suspension of ticket sales to drivers, no front door boarding, and cordoning off traffic areas and seats close to the driver.



10. Figure: Evolution of active COVID-19 cases and control measures taken

Source: own editing based on data from the Hungarian Gazette and (WORLDOMETERS.INFO, 2022), 2022

As shown in 10. Figure the first wave included several strict measures affecting public transport, such as distance learning, curfews and free parking. In this time band, the number of passengers fell significantly, with the largest drop in the number of paying passengers, as already observed in the previous four fare voucher groups.

Measures with a significant impact were also introduced during the second wave in the autumn. In addition to curfew restrictions and the new introduction of distance learning, parking is again free. These factors have also led to a shift towards private transport and a significant reduction in the number of public transport users.

It is also noticeable that after the vaccinations started, there were no more restrictions on public transport with a negative impact, but several remained in force. The longest-lasting provision was the extended free travel option, which was maintained continuously during the emergency and will remain in force until 14 June 2022.

It can be seen from the restrictions imposed to protect the population, the evolution of the number of cases during the waves of the virus and the evolution of public transport revenues

that the measures had a significant impact on the sharp drop in sales volumes during the first and second waves. Basically, these government and municipal restrictions have changed the travel habits of the population and have had an impact on the evolution of the number of paying passengers.

3.4. Results of the study on the role of innovation and passenger information

The analysis of the results obtained from the responses to the questionnaire helps to test **hypotheses H_5 and H_6**. In addition to a detailed analysis of transport habits and service expectations, the questions asked in the questionnaire aimed to obtain answers on the need for innovation in public transport and the importance of modern travel planning and information systems for passengers.

3.4.1. Evaluation of the questionnaire

A questionnaire was prepared to assess the public's expectations and experiences of public transport. It took respondents a short time to complete, was anonymous and was processed in aggregate. It is important to note that the data were collected using a convenience sampling procedure, so the sample is not representative and conclusions cannot be generalised.

3.4.2. Socio-demographic characteristics of respondents

The first part of the questionnaire asked respondents to answer socio-demographic questions. In terms of gender, the respondents were almost equally divided between women (54%) and men (46%). In terms of age groups, the most active respondents were aged 41-64, slightly ahead of the other age groups, with the exception of those aged 65 and over. A total of 5 people from this group responded, presumably due to the online nature of the survey, as this age group is less likely to use social media and more difficult to reach through these channels. In terms of educational attainment, the majority of respondents had a degree (46%), with those with a high school education (37%) slightly behind but represented a significant number of respondents. Some 61% of respondents were active workers, while nearly 35% were students. This is significant for the sample because, based on sales data, more than 90% of actual users of public transport services are from this group. They are the ones who use these means most on a daily basis, have the most experience and therefore

have the most reasonable expectations of the service. In terms of place of residence, around 63% of the respondents live in a county town or in the capital, i.e. a large city. While around half of respondents use private cars regularly, the remaining respondents are potentially more frequent users of public transport. The results of the urban mobility mode question roughly mirror the proportions in the modal split, with around 30% of this sample using public transport. While the proportion of car users is high, the proportion of environmentally friendly modes is welcome, with the proportion of walking, cycling and micro-mobility modes reaching 21% of the sample. The result of the question on the existence of smart devices was in fact predictable given the level of technological development of our time, as these types of devices have become part of our social existence. They are essential for our work, for keeping in touch and for daily communication. We are also increasingly using smart devices to achieve our planned travel goals, depending on the individual and the mode of mobility. The majority of respondents rely on digital solutions for their transactions, which is a clear sign of the direction of development for transport services. From the passenger's side, digital solutions are and will continue to be a clear priority, both for the sale of fare products and for efficient and fast passenger information and travel planning.

3.4.3. Analysis of issues related to community transport patterns

The second part of the questionnaire asked respondents about their public transport habits.

Around 28% of respondents use public transport daily, but a significant proportion use it on a weekly basis. The results show that 6% of respondents do not use the service at all. The target group for improving the service, in addition to retaining regular users, may be the group of less frequent users, as after a good experience of a journey, the option of public transport may arise more often as an alternative.

Asked about the purpose of using public transport, respondents were given the opportunity to indicate several answers. The main reasons given by most respondents were leisure activities and administration. A noteworthy finding is that fewer people use public transport to go to school and work. This could be due to several reasons, as for most families, the morning commute to work and school start are close in time, allowing families to travel together. In such cases, in a metropolitan environment, the use of private cars can be a time and cost competitive alternative.

3.4.4. Analysis of issues influencing the choice of Community instruments

The next section asks how much a change in each of these factors would influence respondents' choice of public transport, followed by an assessment of consumers' expectations of public transport using the SERVQUAL model.

For transport professionals and city managers, creating sustainable urban transport is a key challenge. To this end, a continuous analysis of the factors that may lead the public to favour the use of public transport is essential. In a large city, the definition of a transport strategy and the direction of service development can be based on the results of public opinion surveys.

In the evaluation of the questionnaire, the top three factors in the ranking of the 5 "definitely" answers are faster journey times, the introduction of rapid transit and real-time passenger information. Apart from this, in analysing the responses to the present questionnaire, I have considered the "definitely" and "rather yes" questions as factors whose modification could have a radical impact on the change of travel behaviour when ranking the answers.

Based on this methodology, overall, changes in travel comfort ranked first. In addition to the accessibility of stops, comfort and convenience of vehicles, this factor is also strongly related to the smoothness of the organisation of the journey, the payment of the fare and the overall management of the journey. All the elements of the service must work perfectly to ensure that the passenger is satisfied at the end of the journey and chooses this alternative for his or her next trip. Almost as important as the previous aspect is real-time passenger information, which is nowadays essential to plan a trip accurately and find the right alternative.

The next most highly rated factor was the improvement of journey times. Faster journey times and the introduction of rapid transit to reduce journey times were the main factors associated with this change in travel habits. Closely linked to these aspects is the improvement of transfers and connections, which refers to the possibility of linking public transport with each other and with other means of mobility. The location of stops as close as possible to departure and destination points is also important, but it should be noted that in most cases their location is already given, and for various reasons it is not possible to change their location. When planning their location, professionals take into account walking

distances, the number of inhabitants in the surrounding neighbourhood and the accessibility of institutions. These considerations also influence the shortest possible door-to-door journey times.

Densification also helps to improve service availability, travel predictability and safer travel, even in the event of cancellations. This factor is also a priority in the ranking, followed by fleet improvements that support improved comfort, safe access and shift-free travel.

The next category, which received the same rating, can be basically summarised as the development of applications on digital devices, including online payment and the availability of travel planning in an app. Identical in ranking with these types of solutions is the factor of line network improvements, an increasing demand from residents and employers in dynamic growing metropolitan areas.

The introduction of school bus services, the extension of operating hours and the availability of on-board wifi are less important. The lack of a significant shift to public transport due to rising fuel prices and the increasing popularity of micro-mobility devices and linking public transport are also not ranked highly. Despite being one of the focal points of transport development today, the introduction of autonomous means of transport is ranked last in the ranking of respondents to the questionnaire. On the basis of the assessment of this block of the questionnaire, grouped together, the ranking of factors identified is as follows (10. Table):

10. Table: Ranking of factors influencing the choice of public transport

Answer options	**5 -for sure**	**4 - rather yes**	**Ranking scores**
More comfortable travel conditions	93	90	**183**
Availability of real-time informative data	104	75	**179**
With the introduction of express services (reduction in travel time)	105	69	**174**
Faster travel time	106	65	**171**
Development of connection options (reduction of transfer time)	91	78	**169**
Condensation of lines	90	72	**162**
Vehicle park development	80	75	**155**
Designing closer stops	74	76	**150**
Line network development	82	66	**148**
Development of digital solutions	71	77	**148**

The possibility of paying the fare online	78	70	**148**
Development of travel planning applications	77	70	**147**
Development of passenger information	73	61	**134**
Availability of Wi-Fi service on the vehicles	72	59	**131**
Extension of operating time (lines 0-24)	81	48	**129**
Introduction of school buses	74	50	**124**
The possibility of transporting individual means of transport (e.g. scooters, bicycles).	60	57	**117**
Further increase in fuel prices	51	49	**100**
Connection options for micro-mobility devices (e-roller, e-bike points).	38	56	**94**
Introduction of driverless vehicles	15	21	**36**

Source: own editing, 2022

3.4.5. Analysis of issues related to expectations of public transport services

In the analysis of passengers' expectations of service quality, the ranking was based on the aggregation of the first two categories (very important and rather important), as in the previous methodology.

According to the ranking, the main expectation of service is punctuality, followed by real-time passenger information with almost the same score. These two factors are fundamental to passengers' needs, as predictability of the journey and knowledge of the current position of vehicles are essential when choosing a mode of mobility. These factors are also linked to the expectations of timetables and passenger information, which are also highly valued. The technical condition and cleanliness of vehicles, linked to travel comfort, also scored highly. The design of an adequate line network and the proper functioning of applications are also highly rated.

Ticket and season ticket prices alone are the 5th ranked aspect, but ranked lower. Connectivity and digital solutions are overall ranked at the level of fare expectations. Expectations of the service provider's staff alone also scored highly, suggesting that the quality of face-to-face encounters is an important factor even in today's digitalised world.

Passenger check-in handling, app availability and payment are also expected, but do not feature highly in the ranking. The environmental friendliness and comfort of the vehicles, the cleanliness and design of the stops are also not high on the list of service quality

expectations. The dress and appearance of the staff providing the service is also low on the list of expectations.

The ranking of passengers' expectations of service quality is shown in **Hiba! A hivatkozási forrás nem található.**

11. Table: Ranking of factors expected from the service

Answer options	5- very important	4 – rather important	Ranking scores
Punctuality (keeping to schedule)	176	56	**232**
The real-time passenger information system (time remaining	176	54	**230**
Cleanliness of vehicles	161	64	**225**
The schedule	158	66	**224**
The passenger information system (e.g. timetable)	156	67	**223**
The technical condition of the vehicles	142	76	**218**
The right line network	135	76	**211**
Operation of applications	146	65	**211**
Connection options	126	82	**208**
Digital solutions (payment, schedule viewing, vehicle	120	88	**208**
Ticket and pass prices	157	51	**208**
Behavior of inspectors	141	62	**203**
Availability of applications	117	84	**201**
Payment methods	115	84	**199**
Management of passenger reviews	116	81	**197**
Behavior of drivers	130	66	**196**
The comfort of the vehicles	86	109	**195**
The cleanliness of the (bus/tram/trolley) stops	121	72	**193**
Behavior of customer service staff	135	58	**193**
Design of (bus/tram/trolley) stops	100	90	**190**
Environmentally friendly nature of the vehicles	100	77	**177**
Availability of the customer service office	94	73	**167**
The points of the terminus	80	86	**166**
Accessibility of vehicles	72	57	**129**
The dress and appearance of the inspectors	53	61	**114**
Dress and appearance of customer service staff	43	54	**97**
The dress and appearance of the drivers	36	53	**89**

Source: own editing, 2022

3.4.6. Analysis of issues related to public transport services in Debrecen

The final, fourth part of the questionnaire measured the experiences of people who already use public transport in Debrecen. As can be seen from the results, nearly 92% of the

respondents had already used the public transport services of DKV Debreceni Közlekedési Zrt, of which almost half are regular users.

Basically, the respondents were most satisfied with the appearance of the drivers, their dress, the condition of the vehicles, their comfort, their accessibility and the design of the stops. Payment methods also score high, thanks to the availability of fare vouchers in Debrecen on a wide platform, including kiosks, ticket machines, online and mobile platforms, cash and credit card payments, in addition to cash desks. The cleanliness of vehicles comes next in the ranking, followed by the behaviour and dress of the inspectors. The environmental friendliness of the vehicles, the line network and the passenger information system also show higher satisfaction. However, it is worth noting that even more people were satisfied with digital solutions. The overall satisfaction ranking is as follows (12. Table):

12. Table: Ranking of satisfaction with DKV services

Answer options	**5- very satisfied**	**4 – rather satisfied**	**Ranking scores**
With the dress and appearance of the DKV drivers	37	94	**131**
With the technical condition of DKV vehicles	21	104	**125**
With the comfort of DKV vehicles	22	103	**125**
With the accessibility of DKV vehicles	36	86	**122**
By creating the (bus/tram/trolley) stops	21	101	**122**
With the behavior of DKV drivers	29	90	**119**
With payment methods	41	75	**116**
With the cleanliness of DKV vehicles	19	92	**111**
With the behavior of DKV inspectors	25	86	**111**
With the dress and appearance of DKV inspectors	26	81	**107**
With the environmentally friendly nature of DKV vehicles	21	82	**103**
With the DKV line network	17	85	**102**
With the DKV passenger information system	17	85	**102**
The points of the DKV terminal stations	18	80	**98**
With the DKV timetable	14	83	**97**
Digital solutions (payment, schedule viewing, vehicle location viewing)	30	66	**96**
With the connection options	11	77	**88**
With the behavior of DKV customer service staff	19	67	**86**
With the dress and appearance of the DKV customer service staff	21	64	**85**
With the cleanliness of the (bus/tram/trolley) stops	14	70	**84**
With the availability of DKV Application(s).	23	61	**84**

DKV with real-time passenger information system (time remaining until arrival, traffic situations, etc.)	17	65	**82**
Punctuality (keeping to schedule)	16	64	**80**
With the operation of the application	19	59	**78**
DKV with ticket and pass prices	18	60	**78**
With the contact information of the DKV customer service office	18	53	**71**
By managing passenger reviews	21	50	**71**

Source: own editing, 2022

Responses were also examined in terms of which factors respondents were most dissatisfied with. Before starting the analysis, it was found that only a smaller proportion of respondents expressed dissatisfaction than those who were satisfied with the service. This resulted in the following ranking (13. Table):

13. Table: Ranking of dissatisfaction with DKV services

Answer options	**2 – rather dissatisfied**	**1 -very unsatisfied**	**Ranking scores**
Punctuality (keeping to schedule)	52	34	**86**
With the DKV timetable	56	22	**78**
With DKV's real-time passenger information system (time remaining until arrival, traffic	47	26	**73**
DKV with ticket and pass prices	39	20	**59**
With the cleanliness of the (bus/tram/trolley) stops	41	17	**58**
With the cleanliness of DKV vehicles	43	8	**51**
With the operation of the application	27	22	**49**
With the DKV passenger information system (schedule display, e.g.)	35	12	**47**
With the technical condition of DKV vehicles	37	6	**43**
With the availability of DKV Application(s).	26	17	**43**
With the connection options	33	9	**42**
With the behavior of DKV drivers	29	8	**37**
With the environmentally friendly nature of DKV vehicles	27	10	**37**
With the DKV line network	29	8	**37**
Digital solutions (payment, schedule viewing, vehicle location viewing)	23	12	**35**
With the behavior of DKV inspectors	24	8	**32**
By managing passenger reviews	26	6	**32**
With the contact information of the DKV customer service office	17	9	**26**
By creating the (bus/tram/trolley) stops	19	5	**24**
With the comfort of DKV vehicles	19	3	**22**

The points of the DKV terminal stations	15	7	**22**
With payment methods	14	6	**20**
With the accessibility of DKV vehicles	14	5	**19**
With the behavior of DKV customer service staff	14	4	**18**
With the dress and appearance of DKV inspectors	8	6	**14**
With the dress and appearance of the DKV drivers	2	3	**5**
With the dress and appearance of the DKV customer service staff	2	2	**4**

Source: own editing, 2022

The majority of respondents were dissatisfied with punctuality, timetables and real-time passenger information. The next highest ranking was ticket and pass prices, followed by cleanliness of stops and vehicles. In terms of service, it is clear that both passenger information and the proper functioning of the app are essential. The behaviour of staff and the availability of customer service and the handling of passenger enquiries are also highlighted.

3.5. The need for innovation in public transport

Hypothesis H_5 assumes the need for continuous innovation in public transport and can be tested by analysing the responses to the questionnaire. The second part of the questionnaire focuses on the aspects that might lead people to use public transport. Although a significant proportion of respondents put more comfortable travelling conditions first, the next most innovative factor was the availability of real-time travel information. From the passenger's point of view, it is therefore of particular importance when planning a journey to be able to see the current position of the vehicles in addition to the static information announced in the timetable in order to get there as quickly as possible, which can also help to plan a journey. While journey information is primarily available on on-board and at-stop passenger information devices, it is nowadays a basic requirement to be accessible from home on computers and mobile devices.

The third way to reduce journey times is the introduction of fast services, which are also the result of innovative solutions. Today, the utilisation of transport services is being monitored using on-board passenger counting systems instead of manual counting. These devices can be used to accurately measure the number of passengers boarding and alighting, as well as the occupancy of stops. The processed data can also be used to filter out stops that are

affected by the route but have lower passenger volumes, allowing for the planning of their omission from the timetable, even at different times of the day, broken down by individual service. Using this data, fast services can be introduced either at the start of the school day or at the workplace for shift changes or to reach busy interchanges as quickly as possible.

The development of digital solutions, the possibility to pay fares online and the development of travel planning applications were also high on the list of innovative options for respondents. The need to be able to plan our journey to our destination and pay the fare in an easily accessible and fast way is an expected demand of our times. This can usually be facilitated by applications on websites or available on mobile devices, combined with multi-operator fare products, local and inter-urban travel entitlements. Improvements to make it easier to pay fares are also coming to the fore as people increasingly prefer to buy services quickly and without cash. In public transport, mobile payment methods have therefore become available alongside credit card purchases. Fare products from most domestic operators are now available on this platform. The use of electronic tickets is becoming increasingly popular and they represent a growing share of ticket sales. With the location-based functionality of mobile devices, charging systems linked to the actual distance travelled have also been developed.

The innovative solutions preferred by the questionnaire are the development of passenger information and the availability of on-board wifi services. Modern passenger information is essential for the availability of the service, as it is based on accurate travel data and journey times that we choose our mobility mode. This requires the use of state-of-the-art platforms that provide easy-to-use and easy-to-understand information, whether at the stop, on board the vehicle or on an electronic device. Wi-fi also helps us to travel comfortably, to do our work or correspond while on the move. When the user logs in, he or she can also receive advertising revenue from the service provider or find out about travel habits through a questionnaire.

The responses to the questionnaire show that the continuous improvement of public transport in line with modern requirements is a fundamental expectation of passengers. **Hypothesis H_5 is fulfilled**, the importance of innovative solutions is a key factor in the public's choice of public transport, as assessed by the respondents.

3.6. The role of real-time passenger information in public transport

To test **hypothesis H_6**, I used the questionnaire to find out passengers' expectations of the service. Evaluating the responses received, the following conclusions can be drawn:

The basic expectation of the population regarding urban mobility is to reach the destination in the shortest possible time, at the lowest possible cost and in the most convenient way. This is helped by a high level of information for passengers so that they can plan and optimise their journeys. In today's fast-paced world, traditional passenger information systems are limited in their ability to meet these needs, and thanks to technological advances, complex applications are now available that offer additional convenience functions beyond trip planning, including the ability to manage trip fares. Real-time travel information even offers additional opportunities for travellers and transport operators.

The analysis of the questionnaire showed that the majority of respondents considered it a priority to receive accurate, real-time information about their flight. To be informed about the current status of the selected vehicle, possible delays, so that they can accurately track their journey and reschedule it if necessary. This service is nowadays a basic expectation of passengers, which operators must provide in order to make public transport more attractive, **thus fulfilling hypothesis H_6**.

4. CONCLUSIONS AND PROPOSALS

Public transport plays an essential and growing role in urban mobility. The smooth operation and continuous improvement of service quality are necessary to ensure that urban populations use these means of transport. In recent years, there has been a shift in travel patterns in many parts of the world towards the use of private transport (NAGY and TÓTH, 2019). The pandemic situation has exacerbated this trend, with a sharp drop in passenger numbers in cities due to the virus situation. In Hungary, the emergency measures taken by the government and local authorities have also led the population to use private transport, as the mandatory use of masks, the need to keep a distance and free parking have led to passengers choosing private cars or other private transport.

The combined effect of all these factors is to create significant congestion in cities, especially in the morning and afternoon, which are peak traffic hours. In order to maintain the quality of urban life, it is essential to address this situation and to redirect people towards public transport in order to maintain urban mobility. To this end, it is essential to improve the accessibility of the service and to provide the quality of travel that residents expect. Passengers expect and demand that operators should be able to plan their journeys in terms of time and geography.

In order to examine how public transport can be an alternative to private transport, it is necessary to analyse the factors that influence consumer behaviour. In the case of mobility, our decisions are fundamentally influenced by the distances we have to cover and the frequency with which we have to do so. What are the local topography factors, thestructure of the settlement, and what is infrastructure available. Of course, another important factor is our financial means, whether we can afford to buy and maintain our own car. Can we adapt to our fellow human beings and to the fact that community facilities are not able to meet individual needs fully, or only partially, with compromises.

Our decision also depends on our daily schedules and habits. Our health and physical condition, and whether walking and cycling can fit into our lives. The comfort of the journey, the availability of a suitable travel environment, is also an important factor, and the additional means of transport that can be used to reach our destination, whether it is the possible parking place, the possibility of micro-mobility or the distance of walking.

We need to find the most optimal solution for us, taking into account all the influencing factors, which, given our transport conditions and possibilities, can meet our needs in the most convenient, cost-effective and predictable way, and preferably in the shortest possible time.

5. NEW OR NOVEL RESULTS OF THE THESIS

Based on the research objectives, the results of the hypotheses and the conclusions, the main findings and new and novel results of the thesis are summarised below (14. Table):

14. Table: Summary of novel findings

Objectives	Hypotheses	Hypothesis test results	New results
O_1	H_1	Fulfilled	R_1, R_2, R_3, R_4
O_2	H_2	Not fulfilled	R_1, R_3, R_4
O_3	H_3	Fulfilled	R_5
O_4	H_4	Not fulfilled	R_6
O_5	H_5	Fulfilled	R_7
O_6	H_6	Fulfilled	R_7

Source: own editing, 2023

Result 1 (R_1): besides the adequacy of the institutional system, I have demonstrated through a detailed analysis of the financing and subsidy structure that the financing system of local public transport in Hungary is currently outdated, the state compensation does not cover the costs justified by the actual utilisation rate, and the review of the social-political subsidies for free and concessionary travel and their valorisation is essential to ensure sustainability.

Result 2 (R_2): An analysis of European examples shows that the sustainability and efficient coordination of the public transport system of a municipality and its conurbation can be achieved by setting up a regional commissioning body to coordinate interurban rail and bus services, suburban and urban transport, to establish timetable links and to develop a common passenger information and fare system.

Result 3 (R_3): Based on the literature review, I have concluded that it is not possible to rely solely on revenue and cost analyses when assessing the sustainability of public transport. Generally speaking, it is necessary to examine and quantify the social, environmental and livability dimensions of public transport, in addition to the financial aspects. The combined effect of these factors justifies the continued maintenance of public transport.

Result 4 (R_4): A definition of sustainable local public transport based on the findings of the study:

A transport alternative that is adapted to the specificities of the locality and its agglomeration environment and that meets the travel needs in the most optimal way, and whose coordinated, simple and predictable accessibility allows the daily mobility of the population to be efficiently managed. The source of funding for the development of the service and its smooth operation is shared between the local authority, the region concerned, the State and the users of the service. In addition to the economic factors, particular attention will be paid to maintaining the liveability of the city, achieving environmental ambitions and using innovative options.

Result 5 (R_5): I have confirmed the hypothesis that the maintenance of local public transport in the cities studied cannot be covered by revenue from passengers alone and requires an adequate level of support from the State and the customer. Charging passengers entirely for the cost of the service would lead to a diversion of the population to other modes of transport.

Result 6 (R_6): Using the ARMA mathematical model, I confirmed that the relationship between the evolution of COVID-19 virus case numbers and the decrease in fare revenue is not significant. The change in travel behaviour, and thus the negative trend in revenues, was significantly influenced by the measures taken to control the spread of the virus.

Result 7 (R_7): The evaluation of the questionnaire showed that, in addition to the three factors defined in the literature as the price of the service, the comfort of the journey and the journey time, the provision of innovative public transport solutions has become increasingly important for the public when choosing a mobility option. For the general public, the static information on timetables that has been available until now is no longer sufficient. Efficient ways of planning and implementing journeys are essential to improve the availability of the service. Applications, also available on smart devices, will help citizens to reach their destinations in the most optimal way by providing complex options. Fast and flexible journey planning, accurate real-time tracking of the selected flight, thus predictable and potentially shorter journey times, and the possibility to settle fares online are key expectations of today's passengers.

6. PRACTICAL UTILITY OF THE RESULTS

1. The results show that domestic public transport is properly regulated in accordance with the relevant Regulation (EC) No 1370/2007 and Act XLI of 2012 on regular passenger transport services. At the same time, it can be concluded that efficiency can be improved by applying European organisational and operational examples from the literature analysis. By separating the roles of client and service provider, funding and operational tasks can also be separated. A key requirement for sustainable urban transport is the coordination of transport systems and the implementation of intermodality. This requires improving the links between private and public transport, including the use of micromobility and ride-sharing. These efforts can be reflected in the coordination of local, conurbation and interurban services within public transport, with a common tariff system to improve accessibility. A common ticketing and season ticketing system will provide convenience for passengers and easier access to travel entitlements. The development of intermodal connections and transfers is also a key factor in improving competitiveness, shortening journey times and ensuring predictability.
2. The results of the evaluation of the issues arising from the institutional and financing system behind the free and reduced fare travel facilities and the issues involved show that the government regulations that define the conditions for the operation of the fairly long-established framework in our country need to be reviewed. The valorisation of the level of these subsidies is essential to ensure the sustainability of the service and to keep down the actual fees paid by the beneficiaries.
3. In order to ensure the sustainability of the service, it is necessary to increase public involvement, because just as local public transport cannot function properly without intercity public transport, the reverse is not true either. Effective maintenance of public transport is possible through proper coordination between national and regional systems and local transport. The elimination of duplication of transport and the coordination of timetables promote sustainability as well as cost-effectiveness, the implementation of which is one of the key factors in the introduction of a uniform tariff system.

4. It can be concluded that, in addition to travel comfort, punctuality and accessibility, the use of innovative solutions is a priority for passengers. The ability to plan journeys, accurate and continuous passenger information, availability of timetables and online payment of travel entitlements are among the main needs of the public. Real-time passenger information plays a key role in reducing journey times and making travel more comfortable. If such a system is introduced, more people will be able to choose public transport, making urban mobility sustainable and reducing congestion and environmental pressures.

7. LITERATURE USED FOR THESIS

BKK. (2019). *2019 éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: Budapest: https://e-beszamolo.im.gov.hu/oldal/kezdolap

BKK. (2023). A BKK-ról. Letöltve: https://bkk.hu/magunkrol/

Borbélyné, d. S. Á. (2021). *Közösségi közlekedési szolgáltatások finanszírozása, minősége, kihívások*. Letöltve: https://www.ktenet.hu/uploads/2021/Konferenciak/Uj_megoldasok/BorbelynedrSzaboAgnes.pdf

Bucsky, P. (2018). Az észt fővárosban ingyenes a tömegközlekedés, és így is nyereséggel jönnek ki belőle. *g7.hu*. https://g7.hu/kozelet/20180909/az-eszt-fovarosban-ingyenes-a-tomegkozlekedes-es-igy-is-nyereseggel-jonnek-ki-belole/

DKV. (2019). *2019. éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: https://e-beszamolo.im.gov.hu/oldal/kezdolap

DKV. (2021). *2021. éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: https://e-beszamolo.im.gov.hu/oldal/kezdolap

Ekés, A. (2020). *Költségtakarékos és hatékony intézkedések az alacsonyabb státuszú közösségi közlekedési rendszerek megmentésére*. Letöltve: http://sump-network.eu/fileadmin/user_upload/downloads/innovation_briefs/PROSPERITY_Innovation_Brief_Inexpensive_and_Efficient_measures_for_PT_HU.pdf

Európai Bizottság. (2011). *Útiterv az egységes európai közlekedési térség megvalósításához – Úton egy versenyképes és erőforrás-hatékony közlekedési rendszer felé* (COM (2011) 144). Brüsszel: Európai Bizottság, Letöltve: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:HU:PDF

Európai Bizottság. (2020). *Fenntartható és intelligens mobilitási stratégia – az európai közlekedés időtálló pályára állítása*. (COM/2020/789 final). Brüsszel: Európai Bizottság, Letöltve: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0789&from=EN

Európai Parlament (2007). Az Európai Parlament és a Tanács 1370/2007/EK rendelete (2007. október 23.) a vasúti és közúti személyszállítási közszolgáltatásról, valamint az 1191/69/EGK és az 1107/70/EGK tanácsi rendelet hatályon kívül helyezéséről, (2007).

IFUA, H. P. K. – Városkutatás Kft. – Közlekedés Fővárosi Tervező Iroda Kft. – Közlekedéstudományi Intézet N. Kft. (2012). A Debreceni Agglomeráció integrált városkörnyéki közösségi közlekedés 2020-ig tartó fejlesztési tervét; valamint közlekedési

szövetség létrehozásának előkészítését, és hosszú távú működési modelljének meghatározását megalapozó tanulmány.

KEKO. (2023). Kecsekeméti Közlekedés cégtörténet. Letöltve: https://keko.hu/cegtortenet

KSH. (2020a). Népesség korév és nem szerint, január 1. (1980–)*. Letöltve: 2020. október 18., https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_wdsd009.html

KSH. (2020b). *A személygépkocsik ezer lakosra jutó száma országonként [darab]*. Letöltve: https://www.ksh.hu/stadat_files/sza/hu/sza0048.html

KSH. (2021c). *A helyi személyszállítás országos és budapesti forgalma közlekedési módok szerint*. 24.1.1.21. Letöltve: https://www.ksh.hu/stadat_files/sza/hu/sza0021.html

2012. évi XLI. törvény a személyszállítási szolgáltatásokról, (2012).

MVK. (2019). *2019. évi éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: Miskolc: https://e-beszamolo.im.gov.hu/oldal/kezdolap

MVK. (2020). *2020. évi éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: https://e-beszamolo.im.gov.hu/oldal/kezdolap

Nagy, A. S. – Tóth, S. (2019). Helyi közösségi közlekedési szövetségek és szolgáltatói modellek Európában. *Limes, 6*, 291-298.

ODIS. (2023). Dopravní infocentra. Letöltve: https://kodis.cz/info-centers

Schulek, T. (2021). A közösségi közlekedés lett a koronavírus vesztese. *Közlekedés Világ, V.* (1), 28-29.

SZKT. (2020). *2020. évi éves számviteli törvény szerinti beszámoló és kiegészítő melléklete*. Letöltve: https://e-beszamolo.im.gov.hu/oldal/kezdolap

SZKT. (2023). Szegedi Közlekedési Társaság cégtörténet. Letöltve: https://szkt.hu/tarsasagunkrol#cegtortenet

TfL. (2023). About TfL. What we do. Letöltve: https://tfl.gov.uk/corporate/about-tfl/what-we-do

Tóth, S. (2021). A városi közösségi közlekedés fenntartása. *Regiókutatás Szemle, 6*(1). doi:10.30716/RSZ/21/1/12

Tüke Busz. (2023). Tüke Busz története. Letöltve: http://www.tukebusz.hu/tartalmak/Tortenetunk

UITP. (2020). Cities for people: public transport for better lives. *Advancing Public Transport*, (May), 6. https://cms.uitp.org/wp/wp-content/uploads/2020/06/Policy-Brief-CitiesForPeople-web.pdf

Worldometers.info. (2022,). Coronavirus Hungary. *daily*. Letöltve: https://www.worldometers.info/coronavirus/country/hungary/

Wright, S. (2015). A European Model for Public Transport Authorities in Small and Medium Urban Areas. *Journal of Public Transportation*, *18*(2), 45-60. doi:10.5038/2375-0901.18.2.4

8. PUBLICATIONS ON THE SUBJECT OF THE THESIS

Foreign language scientific journal

1. Tóth, S., Bittner, B., Kovács, T., Nagy, A.: Digital Transformation Possibilities in Public Transportation in Debrecen. Issues in Information Systems. 22 (3), 305-319, 2022.
2. Nagy, A., Tóth, S., Bognár, I., David, F.: Industry 4.0 and Innovation. Int. Sci. J. Innov. 10 (1), 3-5, 2022. 2021

Hungarian language scientific journal with foreign language abstract

1. Tóth, S.: A városi közösségi közlekedés vonzóbbá tételének lehetősége = The possibility of making urban public transport more attractive. Régiókut. szle. 7 (1), 58-66, 2022.
2. Tóth, S.: A városi közösségi közlekedés fenntartása = Sustainment of local public transport. Régiókut. szle. 2021 (1), 133-142, 2021. 2019
3. Tóth, S.: A helyi közösségi közlekedés finanszírozásának környezete = The operating and financing environmental of local public transport. Int. J. Eng. Manag. Sci. 4 (3), 190-196, 2019.
4. Nagy, A., Tóth, S.: A helyi közösségi közlekedés finanszírozási modelljei = Financing modells of the local public transport. TAYLOR. 11 (3), 90-99, 2019.
5. Nagy, A., Tóth, S.: Helyi közösségi közlekedési szövetségek és szolgáltatói modellek Európában. Limes. 6 291-298, 2019.

Conference Bulletins

1. Tóth, S.: A közúti vasúti és trolibusz közlekedés fejlesztésének irányai Debrecen városában. In: City Rail Konferencia Kiadvány / [közr. a BKV Zrt. és a Közlekedéstudományi Egyesület], Közlekedéstudományi Egyesület, Budapest, 50-61, 2021. ISBN: 9789638121943