

Short thesis for the degree of doctor of philosophy (PhD)

**Optimal effects of intermodal transport systems in
urban and transport development**

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INTRODUCTION

Due to the transformation of society and economy in the 21st century, cities are facing new challenges and new expectations are being set for transport, especially public transport. The most important of the expectations are the following: shortening the transfer time for travellers between different modes of transport, the possibility to spend waiting time usefully, increasing comfort, and reducing the areas required by travel in cities. In response to these challenges, public transport around the world has moved towards an intermodal approach, especially in Europe (EC 2007, 2010, 2011, 2019) (EC 2012, 2015).

European cities, regardless of their size, are seeking to use the tools of intermodality in public transport, and intermodal public transport hubs have a key role to play in this process. The European Union has laid the foundations for intermodal transport development with a view to optimising the role of hubs in the transport system (EC – CORDIS 2012, Green–Hall 2009, Pitsiava-Latinopoulou et al. 2008, Pitsiava-Latinopoulou–Iordanopoulos 2012, Lucietti et al. 2016). These are the nodes of the entire public transport system, a kind of integrating interfaces (Stewart, 1995) in which travellers switch between different modes of transport and whose function goes far beyond transport. European examples also illustrate that central development is not an island-like intervention, but in many cases a starting point for related urban structure interventions or major city-level projects such as a complex smart city development.

With the establishment of the intermodal centre, the outstanding Hungarian transport development of the forthcoming European Union programming period can be realised in Debrecen. The importance of the project is adequately reflected in the fact that, among the key projects of the city (i.e. all other projects influencing development), the development of the centre is one, if not the most important. Due to its cost, expected duration, size and local impact of the investment, the project has been and will continue to be addressed by a number of feasibility studies and analyses. At the same time, I did not find any works that would place the development of the intermodal centre and the related urban structure interventions in the context of the development of Debrecen.

Several previous studies provide a clear picture of the conditions for the development of intermodal passenger transport centres (Stewart 1995, Fleischer 2006), the patterns found, design rules (Peek et al. 2006) the need for basic services (Pitsiava-Latinopoulou et al. 2008, 2012), and the criteria set for the centres (Rivasplata 2001). However, due to the serious

past, vomiting present and significant future potential of the development of intermodal transport systems and community centres, as well as the aforementioned shortcomings in the preparation of the Debrecen investment, I considered it necessary to conduct further research on the following objectives.

OBJECTIVES

The main goals of the research and the subgoals within them (their reasons and the tasks to be performed in order to achieve the goals) are the following:

1.) Interpretation of intermodal public transport centres and exploring settlement development and transport sector issues related to their feasibility.

1/a) subgoal:

Examining the background of the development of the intermodal centre as a concept and formulating the main findings related to it. Categorisation of intermodal centres. Interpretation of terms used in the literature. Defining the general characteristics, principles and mechanisms of action of intermodal centres, grouping them according to different aspects. Different methods and different contents are associated with the concept of intermodal public transport hubs in the literature (Rivasplata (2001), Pitsiava-Latinopoulou et al. (2008), Pitsiava-Latinopoulou – Iordanopoulos (2012), de Neufville – Odoni (2003), MAÚT (2012), Dohány – Kádi (2016)). In order to achieve the subgoal, the intermodal public transport centre is defined as a concept in a terminological approach, also on a theoretical level, at the model level and in a functional context. Based on the work of Pitsiava-Latinopoulou et al. (2008) (2012) and de Neufville et al. (2003), the research also details the categorisation of centres as a function of the characteristics of the area in which the centre is located, the associated modes of transport and the characteristics of the passengers using the centre. In the course of the study, I intend to categorise intermodal centres at different levels (international, regional, local, and district).

1/b) subgoal:

In accordance with the objectives of the Intermodal Public Transport Centre Design and Evaluation Guide (MAÚT 2021) issued by the Hungarian Road Association in 2012, to review the rationale and regulatory background for the implementation of intermodal centres

reflecting the following dichotomy: some cities in Hungary are integrated into a complex urban system as a very emphasised subsystem, while other cities see the implementation of intermodal transport centres only as a transport sector issue.

In order to achieve the subgoal, I examine the optimal transport and urban development effects of the centres, of which I highlight two very important and current segments, namely the rationale for the establishment of the centres and the regulatory background.

2.) Gathering a set of experiences based on international patterns and creating a general profile picture based on the characteristic patterns that emerge in this way to support or refute the design logic in Hungary.

2/a) subgoal:

Creating a programme plan or recommendation to be followed with the help of international research works and existing examples, based on the transport policy, transport developments, implemented intermodal centres of different cities, and their positive and negative effects.

In the 2014–2020 European Union programming period, transport development based on outstanding intermodality in Hungary can be implemented in Debrecen. A number of feasibility studies have been conducted in connection with the investment, but these have not analysed the effects on the development of the city.

In order to achieve the subgoal, I examine the expected or assumed impact of the development of centres and related urban structure interventions on the position of Debrecen in the city network and everyday life in general by collecting and using foreign and Hungarian studies, research and case studies.

2/b) subgoal:

Comparison of one or more selected international examples and the comparison of the Debrecen Intermodal Public Transport Centre in order to support or refute the planning logic in Hungary.

The exemplary international investments made in recent years show that the implemented intermodal centres will become one of the most important spatial and urban image-forming elements of the city, while providing both transport and non-transport functions. The City of Debrecen intends to implement a transport centre similar to the European examples.

In order to achieve this subgoal, I would like to present the details, technical solutions and innovations of the centres closest to the

intermodal centre in Debrecen, and at the same time give an insight into the life of this transport development project in Debrecen.

3.) To give an idea of the possible development effects of the implementation of intermodal centres by collecting and analysing demonstrable results.

3/a) subgoal:

What is the impact of intermodal centres on the diversion of commuters towards sustainable modes of transport, the development of the affected urban fabric, the complex development of some cities.

3/b) subgoal:

Determining the impact of intermodal centres on urban spatial structure, socio-economic life, agglomeration and the settlement of various functions (logistics, trade, catering, office, administration, etc.). The work of Erdősi (2002) provides a suitable basis for this study, in which he points out that in addition to the significant elements of transport infrastructure, in his opinion, production companies appear, the young, qualified, creative workforce intensifies, trade and production cooperation increases, information flow, the range and intensity of services is expanding.

3/c) subgoal:

Predicting the impact of the implementation of the Debrecen Intermodal Public Transport Centre on transport and urban development, as well as on its agglomeration.

MATERIALS AND METHODS

Due to the complexity of the topic, it was necessary to use a diverse methodological arsenal to provide appropriate answers to the questions.

1. In order to write the theoretical chapters, I analysed the available Hungarian and English transport literature sources on the topic.
2. As a secondary source I used some works published in auxiliary sciences (architecture, urban planning, sociology, regional science).
3. The chapter on the examination of the transport strategy background was based on the EU and Hungarian state and local (county and local government) regulations, strategic documents and programmes

- on transport development and general regional and settlement development, which I also analysed in detail and topic-specifically.
4. My study was based on a self-sampling intermodal centre database of 100 elements - 67 European, 21 North American, 9 Australian and 3 Japanese. During the sampling, I examined the following characteristics of cities and centres:
 - 1) the population of the city and its agglomeration;
 - 2) the area of the city;
 - 3) the urban structure position of the intermodal centre;
 - 4) year and nature of construction;
 - 5) the cost of the construction of the intermodal centre;
 - 6) types of related modes of transport;
 - 7) the number of incoming (related) services;
 - 8) number of tracks;
 - 9) the existence of an international transport link;
 - 10) the level of connection of the modes of transport (horizontal/vertical);
 - 11) the volume of passenger traffic;
 - 12) types of background functions;
 - 13) the existence of the associated P + R car park;
 - 14) the presence of cycling infrastructure;
 - 15) the presence of freight traffic.
 5. During the selection of the case studies, I examined the geographical, regional and urban structure characteristics of the cities, while the architectural functional, operational and sociological characteristics of the centres were also examined. Special attention was paid to the comparison of the characteristics of settlement-level integration as well as transport integration.
 6. Collected data were represented on a map, in tables and also in diagrams.
 7. In order to select the relevant samples, I considered it necessary to apply cluster analysis. The normality test was based on the Kolmogorov – Smirnov test.
During the study, I used hierarchical cluster analysis according to the Ward method.
 8. When examining the development plans set by Hungarian cities and their feasibility, the feasibility studies and plans of urban intermodal centres were analysed in detail by analysing the individual initial abilities, and I set up the so-called contact inventory of Hungarian cities based on intermodality.
 9. The functional territorial analysis of the intermodal centre in Debrecen was carried out with accessibility studies characteristic of

classical quantitative geography, examining separately the situation formed on the basis of the characteristics of the road network and the accessibility conditions obtained with the operation of public transport systems.

10. Based on the synthesis of the planned parameters of the Debrecen intermodal centre and the characteristics of the city, I mapped and personally examined the closest intermodal centres in Graz and Linz (both Austria) and Poznań (Poland), as well as the urban intermodal transport connections in Ljubljana. and Burgas (Bulgaria). In addition, of course, all intermodal centers and aspirations in Hungary were searched.

I used a Microsoft Excel spreadsheet program to process and represent the quantifiable data, and the GPS Visualizer IT software to create map illustrations. I used IBM SPSS 24 software for both cluster analysis and normality testing.

RESULTS

In the course of the research, I analysed the questions I thought were important along four hypotheses. At the end of the analyses, I came to the conclusion that intermodal centre development can basically have effects of three different strengths (weak, medium, strong), and that effects can occur at local level (Debrecen), at regional level (at least Hajdú-Bihar County), national level (within national borders) and international level (mainly for Romania and Ukraine).

Based on the results, the following five theses were set in the topic.

Thesis 1: The ideal design concept for intermodal centres in Central and Eastern Europe is the development of a railway station integrating local and intercity bus and rail modes and individual motorised and non-motorised modes of transport, mainly located in the city centre and typically based on vertical connections, retaining local architectural values but creating new commercial and catering background functions. Typically, these developments take place along transport networks between the cities and agglomerations of Central and Eastern Europe and local urban travel. The level of transport integration covers all modes of transport present, including individual modes of mobility. Commercial and catering background functions may include the following defining functions: cafes, shops, restaurants, fast food

restaurants, shopping centres, super and hypermarkets, newsstands, bakeries, tobacco shops.

In order to answer the questions, I carried out literature research in the framework of a secondary research method on the conceptual and content interpretation, division, and characteristics of intermodal centres, the background of the development of the concept, as well as the systemic characteristics, principles and mechanisms of action of the centres. My thesis was based on the creation of an intermodal centre database of 100 elements based on my own sampling. The study was completed with the analysis of samples from Europe, North America, Australia and Japan. In order to support my thesis, I focused mainly on analysing the European samples. The analysis covered, among others, the geographical, regional and urban structure characteristics of cities, the architectural, functional, operational and sociological characteristics of the hubs, and the comparison of the characteristics of settlement level and transport integration. The distribution of the samples by their characteristics was determined using map diagrams created with a GPS Visualizer IT software.

Thesis 2: The central position of Debrecen in the agglomeration will strengthen further thanks to its medium level administrative functions. The administrative functions, however, hardly extend beyond the agglomeration of Debrecen (i.e. do not even cover Hajdú-Bihar county) therefore the effects can be regarded rather local with moderate strength as neighbouring towns may have extractor effects.

The research was focused on answering the question of whether Debrecen would be able to strengthen its central position against other nearby cities in respect of certain medium-level administrative functions thanks to the intermodal centre.

In order to answer the questions, I carried out primarily literature research as a secondary research method on the change in the absolute weight of Debrecen as an employment centre.

In order to prove the hypothesis, I carried out a comparative analysis of the implementation of the government customer service to be established in the centre as a medium-level administrative function. The analysis was carried out according to accessibility by car, bus and train, based on the distance of and the time required by the travel, and the frequency of public transport services. Data necessary for the analysis were provided by the existing timetables on the official websites of the public service providers. The time interval of the study, taking into account the opening hours of the government customer service, was a weekday from 8:00 a.m. to 6:00 p.m. The research was performed for eight settlements: Ebes,

Bocskai kert, Hajdúsámson, Monostorpályi, Hosszúpályi, Hajdúbágos, Mikepércs, Sáránd.

The results of the research (Figures 1 and 2) showed that the inhabitants of Hajdúsámson (opposed to Nyíradony), Mikepércs and Hajdúbágos (opposed to Derecské), and Ebes (opposed to Hajdúszoboszló) would potentially choose the government customer service to be built in the centre in Debrecen.

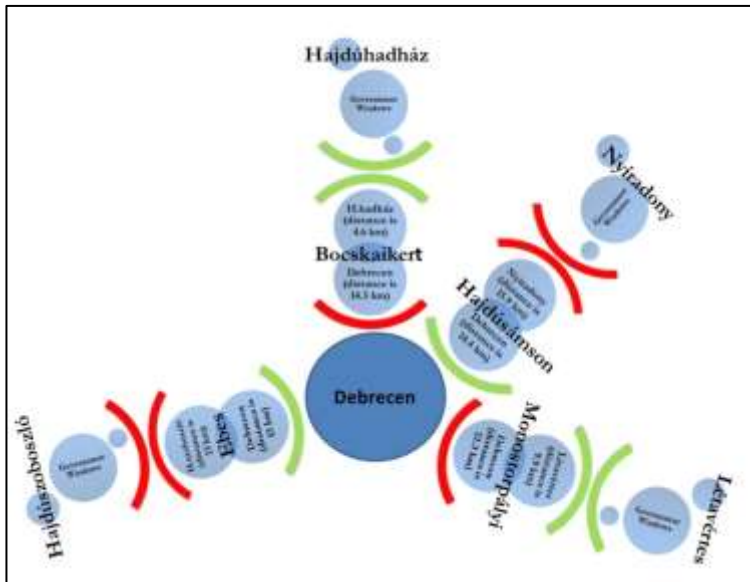


Figure 1: The most probable selection, distribution of government customer services regarding the settlements in the northern attraction district of Debrecen, 2018

Source: own editing based on the effective timetables accessible on the official websites of the public service providers

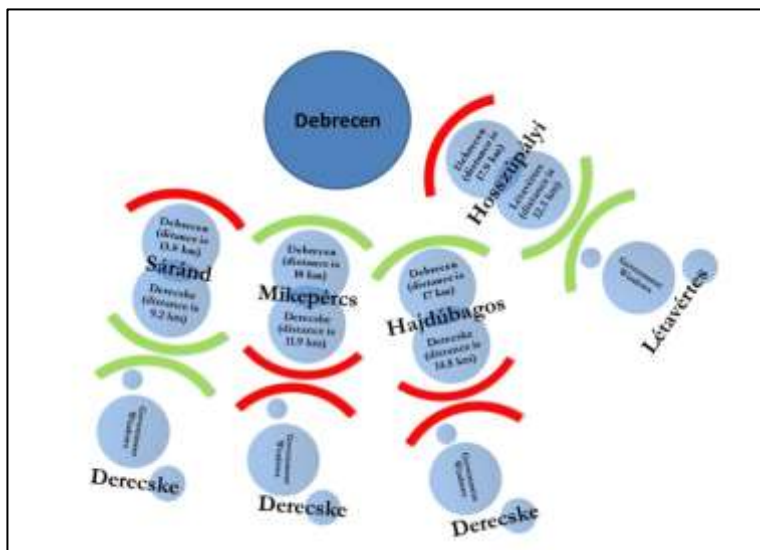


Figure 2: The most probable selection, distribution of government customer services regarding the settlements in the southern attraction district of Debrecen, 2018

Source: own editing based on the effective timetables accessible on the official websites of the public service providers

Thesis 3: The intermodal transport centre has a regional-level impact on the change in the competitiveness of Debrecen at the most, and its strength can be considered weak. The fundamental reason for this is that the hub itself does not affect the change in rail transport (frequency, speed, comfort), but Debrecen can be reached basically from Budapest and from almost every large city by motorway as well. Furthermore, the competitiveness of Debrecen is determined by the presence of an international airport compared to cities at a similar level in the city network (e.g. Kecskemét, Miskolc, Szeged or even Oradea), and not by the existence of an intermodal hub.

In order to answer these questions, I carried out literature research, as a secondary research method, on the relationship between regional competitiveness and transport infrastructure development, including intermodal transport solutions.

After that, the transport development and economic development strategies of Debrecen were analysed. With an empirical examination, the past, present and specifics of transport in Debrecen were comprehensively studied, as well as the development of the local economy as a basis for local transport development.

The results of the research led to the conclusion that the intermodal centre on its own does not contribute to the improvement of the competitiveness of Debrecen, or only to a weak extent. It was also shown that the International Airport of Debrecen and its development are becoming more and more important in the urban transport development plans. According to the documents examined, in addition to the airport, the trimodal logistics centre linking the modes of transport involved in freight transport (air, rail and road) will also receive outstanding attention, which would also be developed in accordance with the development of the airport and in its immediate vicinity.

Thesis 4: The development of the urban functions of Debrecen (trade, education, human services) and the local economy (especially tourism) can be influenced by the intermodal transport hub across borders, and the strength of the impact is medium.

The international character arises because the hub provides an opportunity for those from abroad, especially Romania, to continue their journey through the city by means of public transport after parking their vehicle, and consequently Debrecen can become an even more attractive destination. Of course, the same is true for those arriving in Debrecen from other Hungarian settlements, especially those who commute to Debrecen on a daily basis, either because they work, study in the city, or because they use the city services. On average, I rate the intensity of the effect as medium, since the functions of the hub are important for those coming from abroad, students and tourists (parking, fast transfer), in their case the existence of the hub can even have an attractive effect.

However, there is no significant connection between the use of urban services (except, of course, administrative functions) and the intermodal centre, or the connection is very weak. A non-local resident who has to use a service in Debrecen (whether it is a medical institution or a shopping centre) has to get into the city in any case and then reach its destination, whether the hub exists or not. For them, therefore, the hub is more of a means of streamlining transport and making forced travel more comfortable. For economic operators, the development of the hub is likely to have a neutral effect, as the current railway station also fulfils the important basic functions (of course, the services provided by the railway are independent of this), and the choice for the site of premises is mainly determined by the presence of a motorway and an international airport.

The intermodal centre is demonstrably related to the development of five segments of Debrecen: the local (productive) economy, trade, tourism, administrative functions, human services (education, health). To prove the

hypothesis, I examined tourism, trade and human services from these segments with situational analysis and the identification of trends.

In all three areas, I carried out the necessary literature research and explored the capabilities of the centre in relation to the studied topics by presenting in detail the plan of the Intermodal Centre in Debrecen.

Thesis 5: The only field where the impact of the intermodal transport centre – although much more the associated urban structural interventions – is considered to be strong is the decentralisation of culture. Debrecen has a strong cultural attitude even at national level, and it is no coincidence that the city is also looking for positions on the international cultural scene through, for example, the European Capitals of Culture project, for example. Cultural attractions can, of course, be found in the city (City Centre and Great Forest), but they are already overloaded and probably could not bear the increased stress that a European-level cultural project entails. However, the community space in front of the station, which is large even on an urban scale, can be the perfect venue for large-scale cultural attractions, which, in turn, may positively change the function of the area.

In order to answer these questions, I carried out literature research, as a secondary research method, on the relationship, and then I dealt with the processing of the city's cultural strategy, the examination of urban development documents and, last but not least, the distribution of cultural investments in the city. It became apparent to me that Debrecen is committed to creating a decentralised culture, and the city involves an increasing number of action areas in its cultural developments.

To prove my hypothesis, I had sampling and case studies examined according to primary research methods, which are the backbone of my thesis. The study was based on an intermodal centre database of 100 elements – 67 European, 21 North American, 9 Australian and 3 Japanese – based on own sampling. In the course of sampling, I examined cities and their centres on the basis of fifteen different characteristics. In the criteria for the selection of case studies, I considered it important to explore the geographical context, the similarities and to compare the characteristics of settlement-level integration and transport integration.

In order to select the relevant samples, I considered it necessary to use cluster analysis. In the 4-cluster study, the distribution of the samples showed that Graz, Linz and Poznań, assumed to be the most optimal samples, were placed in the same cluster as Debrecen. That is why I selected these cities for detailed analysis (Tables 1 and 2).

Table 1: Characteristics of transport integration

Intermodal centre	International connection	Number of methods	Connection of methods	Presence of P+R	Presence of Freight traffic
Graz Hauptbahnhof	yes	6 (1)	horizontal, vertical	yes	yes
Linz Hauptbahnhof	yes	6 (1)	horizontal, vertical	yes	yes
Poznań Główny	yes	6 (1)	horizontal, vertical	yes	yes
Intermodal Centre in Debrecen	yes	6 (1)	horizontal, vertical	yes	yes

Source: own editing based on the data of the 100 samples

Table 2: Characteristics of settlement-level integration

Intermodal centre	City	Attraction district (million people)	Urban structural position	Type of construction	Public role
Graz Hauptbahnhof	Graz, AT	Styria Austrian province, 1.2	middle field	transformation	present
Linz Hauptbahnhof	Linz, AT	Greater Linz conurbation, 0.27	central	transformation	present
Poznań Główny	Poznań, PL	Greater Poland Voivodeship, 3.4	central	transformation	present
Intermodal Centre in Debrecen	Debrecen, HU	Northern Great Plain Region, 1.5	middle field	transformation	present

Source: own editing based on the data of the 100 samples

Later, I explored the capabilities of the centre in relation to the studied topic and the similarities related to the selected three case studies by presenting in detail the plan of the intermodal hub in Debrecen.

SUMMARY

This dissertation was aimed at examining the optimal transport and urban development impact of intermodal transport systems and community centres. I tried to present the development effects of the centres in this regard via the example of the intermodal centre in Debrecen. The results of the dissertation provided satisfactory answers to the three main basic research questions and to a number of sub-objectives. In addition to informing the scientists examining the topic, the new and innovative results of the thesis provide practical guidelines for relevant professionals and policy makers in the preparation and accomplishment of projects for the implementation of intermodal public transport centres. Furthermore, they help to make transport development a profitable urban investment. In summing up my research carried out in connection with the Debrecen case study, it can be concluded that the development of the intermodal public transport centre and the significant urban structural interventions surrounding it, although multilevel and variable in strength, can certainly have a positive impact on the long-term development of Debrecen (Table 3).

Table 3: Summarising evaluation of the effects of the development of the intermodal public transport centre and the associated changes in the city structure, 2018

Topic	Local	Regional	National	International
	effects			
Strengthening central position of Debrecen in the agglomeration	medium			
Changes in the competitiveness of Debrecen		weak		
Changes in the social and economic fundamentals of Debrecen				medium
Strengthening of the cultural polycentricity of Debrecen	strong			

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List of publications related to the dissertation

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