Evaluation of railway surrounding areas: the case of Ostrava city

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Abstract

The status of railway stations depends not only on a nodal position in the transport network, but also on the conditions, structure and capacity of its local surroundings. The level and potential of railway stations surroundings is studied on the case of Ostrava, the third largest city of the Czech Republic. Various data sources are used in the context of the Bertolini node-place model to reach a complex evaluation. The original methodology was adapted to national conditions due to significant differences in transport behaviour of passengers between post-communist countries and highest-ranked economies. The place aspect of the Bertolini's methodology is considerably enlarged. Parameters of buffers around all railway stations respects original values (700 metres long perimeter, etc.), but other features are properly adjusted. The place conditions are analyzed mainly from the socio-demographical (population, unemployment, etc.), economical (structure of companies, retail, etc.) and urban (land use, land price map, etc.) points of view. The node aspect is described by various transport indicators as number of departing trains, parking capacity, accessibility of stations by urban transport, etc. Also other factors which helped to start the regeneration process of important European railway stations are discussed. The results show significant differences among these localities, different temporal trends and requirements for regeneration which lead to optimization of transport services. The adapted methodology with extended and adjusted range of place and nodal indicators seems to provide satisfactory inputs for re-engineering of transport nodes essential for further successful development of any city.
Keywords: railway station, place index, node index, Ostrava, city.

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1 Introduction

The increased level of individual car transportation causes serious problems for daily commuting to any big city in the Czech Republic similarly to other European countries. Congestions during rush hours, demands for parking facilities and also decreasing live quality of residents in the central parts of the city, which leads to depopulation out of this areas, are not longer a problem only in the case of cities with monocentric patterns of transport system (Prague, Brno, Pilsen) but also in the case of the biggest post-socialistic cities in old industrial regions (Ostrava, Ústí nad Labem). These cities and their hinterlands are typical (historically) by their polycentric patterns of transport system.

The population of Ostrava was 306,006 in 2010 and it is the centre of the biggest old industrial region in the Czech Republic – Ostrava-Karviná agglomeration (700,000 people). Ostrava can be considered as a member of deindustrialized cities based on wide industrial basics with complicated conversion to post-industrial society (Rumpel *et al.* [2]). Similarly, as in other industrial cities, the development of housing and service functions avoided historical areas of medieval towns. The role of the city centre is significantly weakened by the existence of another two isolated and heavily populated residential areas with own service functions. These were built and developed during the communism era. Thus, the role of the city centre is being difficult and the threat of another potential residential suburbanization increases the pressure on the transport system, because the offer of vacancies for services increases continuously.

The integrated system of public transportation has been gradually implemented in the urban agglomeration since 1997. Most municipalities joined the system during this first phase which lasted over 10 years when the whole system was significantly extended and tariffs were unified. The next phase (since 2008) brought additional improvement of quality and functionality of the system including implementation of interval timetables, unification of ticketing (especially between urban and suburban transport) and gradual efforts of the complex integrated transport policy (implementation of parking policy, first parking facilities for P+R, etc.). The important role in the public transport system is given to a railway transport. There are two main problems of railway transport in this region – 1) inappropriate localization of railway nodes (significant railway stations are located on the edge of settlements) and 2) long transfer distances between railway stations and stations of other modes of public transport. Both of these factors influence walking distances of commuters (Ivan [3], Givoni and Rietveld [4]). In some cases it is necessary to use connecting transport; thus the necessity of transfer again negatively influences the final number of users (Hine and Scott [5]).

Ostrava is actually serviced by 11 stations of railway passenger transport (Fig. 1). These stations do not cover the city area regularly but they were established historically along main railway links and based on the demand of big industrial companies. In old industrial (polycentric) regions, passenger public transportation use the railway network which is mostly developed according to requirements of dominant production structures (Zapletalová [6]). Today this network shows typical signs of an out-date railway infrastructure. The importance of railway stations has been significantly decreased under influences of deindustrialization processes (Hruška-Tvrdý *et al.* [7]). Their oversized hall devoid of any use and they deteriorate or are used only marginally. Other stations are expected to have dynamical development of their importance within the railway network as well as the city function of their surroundings. Thus this research is focused on the basic comparison of railway stations in Ostrava according to the methodology of node-place model to determine a possible development potential for the redevelopment of particular railway stations.

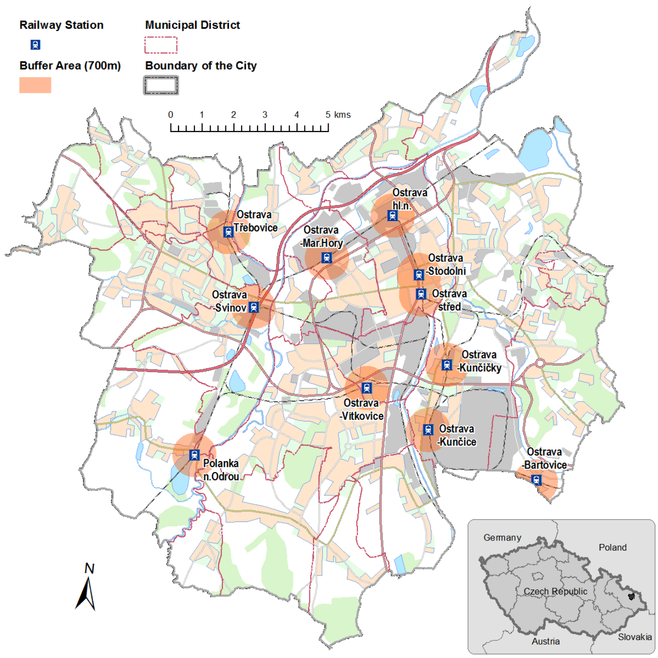

Figure 1: Railway stations and their surroundings in Ostrava.

The node-place model (Bertolini [1]) is usually used for evaluation of mainly large scales urban projects which are realized in the relation to revitalization of railway station itself (Bertolini and Spit [8], Pol [9]). Some studies are also focused on the role of particular actors (Priemus [10]) participating in the redevelopment process of railway stations and their surroundings, where a shift in relationships and decision-making procedures among public, private and nonprofit sector are mostly monitored (*i.e.* the shift from government to governance; Oosten [11]). The redevelopment of stations is usually coupled with effects on urban space which is expressed in the place index more than in the node index. Various projects and their evaluations are focused on urban design (Trip [12]), on the change of locality image (Glover [13]) or on the change of property value in surroundings reflecting the distance-decay effect from a central business district (Bowes and Ihlanfeldt [14]). Debrezion *et al.* [15] pointed out the different effects among different types of property (commercial and residential) in surroundings of railway stations. Similarly, Cervero and Duncan [16] proved that commuter railway stations have bigger impact on the rise of property value than other railway stations (heavy rail, urban light rail, metro).

The node-place model is constructed using various time and geographical perspectives. Large stations with a great potential for commercial activities (Bertolini and Spit [8]) or stations within the urban regions (Bertolini [1]) are mutually compared or the dynamics of the temporal changes are analysed (Bertolini [17]). Reusser *et al.* [18] used the node-place model for the comparison of all railway stations in Switzerland and they classified them in five clusters based on the cluster analyses. They concluded that medium-sized stations out of the city centre but in urbanized areas increase their potential of the place index without any progress of the node index.

The presented research is focused on evaluation of current potential of urban railway stations in a central city of the biggest old industrial region in the Czech Republic. Therefore it is methodologically close to Bertolini's study [17], although specific conditions of transforming post-socialist countries bring different challenges and problems in urban and regional development. The land-use and transport planning on the local level is still not integrated in the Czech Republic and this fact issues into wrong political decisions creating conflicts between stakeholders and do not lead to sustainable development of transport systems. The basic motivation of this study is the verification whether the node-place model is useable in city (transport node) with prevailing commuting function.

2 Methodology of the comparison

The node and place indices are constructed for selected localities (railway stations with surroundings) using multicriteria evaluation. Both indices have been used in various studies and adjusted according to national conditions. Similar adjustments had to be implemented also in the case of Ostrava. In addition, an availability of useful data sources has a significant influence on the node-place model in particular countries (Reusser *et al.* [18] – the case study of Switzerland).

Due to data availability the pilot area is restricted to Ostrava city. As mentioned above evaluated localities represent 11 railway stations and surroundings which is defined as a buffer zone within 700 metres from a main pedestrian entrance of the station, according to the Bertolini's methodology (Bertolini [1, 17]). A straight distance seems to be more appropriate against others variants of distance measurements (based on road network, time, price, etc.) because the influence of the railway stations does not mirror a road network but is spread equally from the station in all directions. Moreover, people's walking is not restricted to a road network and a detailed footpath network is not available.

The micro-level of this kind of studies brings various problems, mainly the source of data for indicators to describe the local situation around stations. The node index is constructed with utilisation of various transport indicators from valid timetables. This data source is commonly used. In conditions of the Czech Republic, the census provides many information useful for the place index, but due to the year of the last census in 2001, it is not possible to use such data. Thus various alternative data from some quite unique sources had to be used (Table 1).

Table 1: The list of used data sources, their providers and validity.

Name	Validity	Provider
Timetables	1/3/2011	CHAPS, Ltd.
Population register	31/3/2010	Statutory City of Ostrava
Price map	31/12/2010	Statutory City of Ostrava
Land use	31/12/2010	Statutory City of Ostrava
Registration of unemployed	1/4/2010	Labour Office in Ostrava
Structure of main employers in Ostrava (25+ employees)	2010	Labour Office in Ostrava
Register of Enumeration Districts and Buildings	1/7/2010	Czech Statistical Office

Particular indicators used for the construction of node and place indices are discussed in next chapter. The resulting node-index and place-index were evaluated using weighted linear combination (WLC). WLC is a process of combination a set of spatial parameters controlled by two sets of weights – criterion score and factor weights. The criterion score represents a standardized value of each factor in the given place. The factor's standardization is necessary because of different scales upon which criteria are measured. We apply a linear scaling method using the minimum and maximum values as scaling points for standardization. The output values ranges between 0 and 1.

The factor weights are opinion-based scores, which determine the degree of trade-off of one parameter against another (Ayalew *et al.* [19]). When the number of factors exceeds three it may be difficult to develop factor weights directly. Analytic hierarchy process (AHP) facilitates the weighting process breaking the information down into simple pair-wise comparisons in which only two factors can be considered at a time. This technique was described by Saaty [20, 21] and Saaty and Vargas [22]. The weights are derived through a principal eigenvector of a square reciprocal matrix of pair-wise comparisons between factors. Since the matrix is symmetrical in nature, it is needed to fill in the diagonal and the lower triangular half of the matrix. The relative importance of one factor to another is determined on the basis of a 9-point scale, where each step is represented by a linguistic expression and the corresponding numerical value (see Table 2). These linguistic expressions help to express the opinion about the relative importance of factors. Assigned numerical values are used for calculation of the principal eigenvector representing a final vector of weights.

The result consists of the factor weights and a consistency ratio. The consistency ratio (CR) indicates the probability that the matrix ratings were

Table 2: Pair-wise comparison according to Saaty [20, 21].

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely
less important				equal	more important			

randomly generated (Mahini and Gholamalifard [23]). Matrices with CR greater than 0.10 should usually be re-evaluated.

3 Node index

The node index describes the transport activity and connectivity of the railway station to other places of interest. Based on the Bertolini [1] methodology, the node index is described by nine indicators like accessibility by train (number of directions served, daily frequency of services, amount of stations within 45 minutes of travel), by bus, tram and underground (number of directions, daily frequency), by car (distance from the closest motorway access, parking capacity) and by bicycle (number of freestanding bicycle paths, parking capacity). Reusser *et al.* [18] used seven of Bertolini's indicators and added other two indicators for conditions of Switzerland based on experts' opinions. Under different conditions of the Czech Republic and Ostrava, some indicators used in previous works are quite unfitting for our study. A use of bike and ride system remains very rare and unusual and therefore indicators focusing on bicycle access and parking are not significant. Similarly small significance has also the proximity of highway exit. Finally, the node index in present research is described by four eligible indicators (see Table 3). The valid timetables were used as the only data source and car parking capacity was calculated based on the field survey.

The railway transport role of particular stations is described only by the number of trains departing from the station. Other indicators used in previous studies (directions or number of reachable stations in a time distance) are not

Table 3: Indicators used for calculation of node index.

Indicator	Calculation	Weight
Frequency of train services	Number of trains departing from the station on Tuesday, 1/3/2011[a]	0.5173
Daily frequency of urban transport	Number of urban transport buses, trams and trolleys departing from the station on Tuesday, 1/3/2011[b]	0.3061
Daily frequency of suburban buses	Number of suburban buses departing from the station on Tuesday, 1/3/2011[c]	0.1371
Car parking capacity	Number of public and legal car parking places near the station	0.0395

[a] including all arriving trains terminated in analysed railway station.
[b] including all arriving terminated urban transport vehicles.
[c] including all arriving terminated suburban buses.

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important for the city of such size like Ostrava where differences in reachable stations are negligible. The importance of this indicator is significantly higher than others, what is reflected in the weight setting (0.5173) – this indicator is considered to have approximately the same weight as all others indicators together. The second most significant indicator is the accessibility of stations by urban transport with weight equals to 0.3061. This mode of transport is the most common to access railway stations and continue the journey by train. Also this indicator provides sufficient informational value and there is no need to include some other indicator as the number of directions. On the other hand one new indicator was incorporated in the calculation – accessibility of railway stations by suburban buses. This transport mode is often used by people who travel to or from location close to Ostrava but without any possibility to travel there by train (out of the railway network or without any connection in appropriate time). The weight for this indicator is 0.1371. The last indicator used for node index calculation was car parking capacity. Generally, a proper infrastructure for regular using of park and ride system has not been developed in Ostrava yet and so the importance is expressed by a small weight (0.0395). Many railway stations, especially the smaller ones at the periphery, have absolutely no possibility to use this system of travelling or commuting because there is no parking place at all (case of 4 railway stations) and almost all other car parking are paid what does not inspire people to change the mode and to use trains for the rest of the journey. The consistency ratio for the weight matrix is 0.10 which is acceptable for calculation of the node index. Before the calculation of node index all indicators were rescaled to have a minimum of 0 and a maximum of 1. The node index was defined as the sum of all standardized indicators multiplied by particular weights.

4 Place index

The place index describes the quantity and diversity of possible activities in the surroundings of the railway station (area with perimeter 700 metres as defined above). Bertolini [1] used for the node index calculation several indicators – number of residents in the area and number of employees per each of four economic clusters (retail/hotel and catering, education/health/culture, administration and services, industry and distribution) and the degree of functional mix. In addition, Reusser *et al.* [18] considered these variables as the most important indicators for the place index calculation. But due to problematic availability of data they finally used only the numbers of workers in the secondary and in the tertiary sectors. Their study extends the list of used indicators for calculation of place index about several new ones – presence of conference rooms and educational facilities expressed by number of full time workers; distance to the town centre and presence of various commercial services as grocery stores, restaurants, pharmacy or florist. In addition based on their questionnaire survey, they present various possibilities of next extensions of this index but again due to problems with availability of data or with operationalisation respecting the place index they decided not to use them (attributes of station buildings, size and arrangements of station arrangements, etc.).

The presented place index uses almost all already mentioned indicators and adds several new ones. Finally seven of them were used for the place index calculation. Number of residents and number of employees were considered as the most important indicators. Employees were additionally divided in two groups – employed in the service sector and the rest of workers created the second group. The functional mix was not included in the calculation because it was substituted by other indicators. These new indicators cover the land use and land prices, the number of flats and the specific rate of unemployed people with low education in surroundings of particular stations. The size of population and employees in service sector within the analyzed area should have similar high influence on the place index and thus the weight for these indicators were mutually equal (0.2931) and they are more significant than all others indicators together. A small significance is assigned to the number of workers in the secondary sector (nowadays potential of regeneration of railway station areas and urban fabric is led mainly by service sector) and thus the weight is almost about a half smaller (0.1696). The built-up area for housing and services defines one of new indicator. As it is written in the introduction, there are many railway stations which were developed primarily to provide transport services to big industrial factories in Ostrava. These, from today's point of view, oversized stations are surrounded often by brownfields or are very close to still running factory. This indicator should define the size of stations potential and it is decreasing with increasing size of industrial or transport built up area or greenery and the weight is equal to 0.1066. The land price map provides slightly different information about the attractiveness of land. It is important to notice that financially valued land makes only 70% of total area within 700 m of the railway station. This area consists mainly of housing or small commercial buildings. The significance is about a half smaller than in case of core urban area (0.0514). Another new indicator works with number of flats in the analyzed surroundings. The people, who live in flats close to station, should use trains for commuting or non-daily travelling more often. This indicator was incorporate also due to the fact that the population indicator covers only permanent residents and not persons in rent. The significance is very similar as in case of land prices (0.058).

The last new indicator evaluates the social conditions of surroundings areas. Houses close to stations are often inhabited by socially disadvantaged people. The proposed indicator is using the rate of unemployed people with low education from the total number of unemployed and proved to be reliable in locating of these areas. Unfortunately there is negative correlation between this rate and place index because with increasing rate the place index should be smaller. Thus, the inverse value was used as the indicator. The suggested significance is the smallest from all indicators, so the weight is only 0.0283.

Also in the case of place index, the consistency ratio for weight matrix is equal to 0.10 which is acceptable for further calculation and all indicators were rescaled to have a minimum of 0 and a maximum of 1. The place index was

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Table 4: Indicators used for calculation of the place index.

Indicator	Calculation	Weight
Population	Number of residents within 700 m of the railway station	0.2931
The number of workers in service sector	Number of workers within 700 m of the railway station in the tertiary sector	0.2931
The number of workers in secondary sector	Number of workers within 700 m of the railway station in the secondary sector	0.1696
Core urban area	Built-up area for housing and services within 700 m of the railway station	0.1066
The number of flats	Number of flats within 700 m of the railway station	0.0579
Land prices	Weighted average of land price within 700 m of the railway station defined as $\frac{\sum(area_i * price_i)}{\sum area_i}$	0.0514
Rate of unemployed with basic education	100-rate of unemployed people with basic and lower education from the total number of unemployed within 700 m of the railway station	0.0283

defined, similarly to the node index, as the sum of all standardized indicators multiplied by particular weights.

5 Conclusions

The scatterplot depicts resulting relationships between the node index and the place index for all railway stations. In general, five stations with very low scores for both indices have only minimal local impact. Some further investments to increase place or node index are very questionable because these stations have not even significant potential – some of them are surrounded by garages or industrial buildings (Třebovice, Mariánské Hory, Kunčičky) and the other two stations (Polanka, Bartovice) belong more to members of small village stations (city periphery).

The rest of stations have more significant influence and so there should be conducted efforts to expand their potential. Ostrava as the typical polycentric city has not any typical central railway station as other similar big cities in the Czech Republic (Prague, Brno). Two major stations are Ostrava hl.n. (main station) and Svinov but both of these stations have more significant the node index than the place index. The node index of Svinov is quite extreme, it has only the transport role and this station miss any background. There are discussions about development of this station but only in relation to a new and better accessibility to public transport (near tram links).

Ostrava-Stodolní station lies completely on the other side of this evaluation. It has almost absolute place index and very small node index. This station is the

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newest one in Ostrava (the end of 2007); it is the closest to city centre and the main role is to provide better accessibility of the city centre by commuter trains. This station has quite a big potential mainly because its position is on the railway between Ostrava and two big cities (Frýdek-Místek and Havířov – together almost 150,000 people). The main problem of this station is missing connection to the urban transport system, because there is no urban transport stop nearby the station.

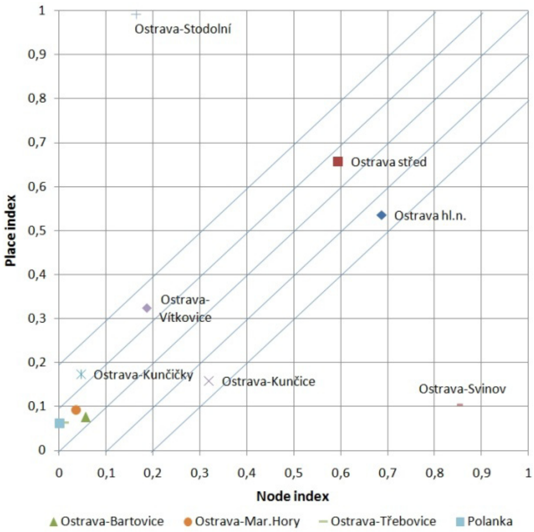

Figure 2: Node-place model of Ostrava.

Ostrava střed is a historical part of “the Mining railway”; the good node index is supported by great accessibility for urban transport and suburban buses (it is situated close to central bus station). The transport potential primarily of this station and secondary of main nodal stations has the development of new city centre Karolina which is located just over the railway tracks. Unfortunately, there is no clear connection between this station and the new developing area in existing plans. The certain effect will be on the place index which will increase its significance (similarly as Ostrava-Stodolní which is also quite close).

Ostrava hl. n. (main station) has similar balance position as Ostrava střed. The location of this station is unfortunately on the edge of the city centre with low place index. During the communist era, this formerly prosperous part of the city centre was declining and nowadays, there live mainly socially excluded people with lower income. From the transport point of view this station provides a mix of long-distance and commuting transport and the future development of place index strongly depends on the development of this part of the city centre.

Ostrava – Kunčice and Ostrava – Vítkovice are members of stations which historically provided transport connections to main industrial employers in these areas. Today, both stations have not a significant place index because they are too large relative to their transport role. Mainly Ostrava-Vítkovice has large unused space around the station, good location in relation to public transport and it is close to highly populated city parts.

The evaluation of urban railway stations in Ostrava proved that the stations closer to the city centre have bigger potential for development of the place index. These stations are mainly used for daily commuting from hinterland of the agglomeration. Their further development in the hierarchy of urban railway stations in the context of the node-place model is supported by the development of the new part of the city centre in their proximity and by continuing modernisation of regional railway network (electrification of the railway to Frýdek – Místek or the realisation of the train-tram between Ostrava and Havířov). However the potential of main long-distance railway stations is so far used minimally.

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