TAMÁS DUSEK

The effect of the reduction of the Hungarian railway network in 2009 on accessibility*

There are two aims of this study. Firstly, to give a quantitative overview on the changing railway accessibility due to the reduction of the railway network in 2009 in Hungary. Secondly, to discuss various forms of detour indices, the main method of analysis. From previous quantitative analyses of the Hungarian railway network, Csaba Kovács's (1973) study is to be noted, in which he analysed the geographical location of 197 settlements on the railway network. Gábor Szalkai's (2001) study included dynamic comparisons in addition to the static characteristics of the railway network at that time. In addition, it described the impacts of unmounting the circular railway network due to the Treaty of Trianon after the First World War, of mutilating the branch line network after 1968, and of a potential new Kecskemét–Dunaújváros–Szolnok line on accessibility. The present study diverges primarily in two aspects from these analyses. On the one hand, it concerns a smaller railway network after the reduction of railway network in 2007 and in 2009. As the study also aims to analyse the impact on accessibility of closed branch lines after the schedule change in December 2009, it deals with two networks (smaller than the ones examined in earlier studies). However, it does not deal directly with the impact of restarting some lines in June and December 2010. On the other hand, the set of data used is wider in the sense that it uses actual schedule data regarding temporal accessibility between stations.

The study is concerned both with descriptive analysis of situation and temporal comparison; however, it does not deal with economic, cost-effective, environmental, schedule and other concerns of railway transport, but focuses solely on its supply-side. Traffic data would be interesting for weighted calculations with the particular network elements, but these are not available. I do not touch upon conceptual issues of accessibility, which are well described in Tamás Fleischer's two studies (Fleischer 2008a, 2008b). In the present analysis, accessibility means whether a given settlement can be approached by train, and if so, how far it is from the other settlements.

Analysis database

Data regarding the length of the railway network differ to some extent in various sources of information; a completely accurate number also cannot be expected due to methodological reasons. The network used for passenger transport was approximately 8 000 kilometres in 2008. As a consequence of schedule changes at the end of 2009, transportation has ceased on a section of 868 kilometres according to the data indicated in the schedule (Table 1 and Figure 1). From the branch lines, 10 are feeder lines, that is, of

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its two end-points, only one has connection or continuation to a national base network or sub network, and the other one has not. Some 15 branch lines have connections or continuations on both ends. Due to reduction of branch lines, the accessibility of 202 previous stations (or stops) has ceased. On the Veszprém–Zirc line, transportation was available for three train pairs a day on weekends only, from December 2009 to its restart in July 2010, and was not available on weekdays. I employed the weekday (Thursday) schedule in the analysis. In Table 1, the number of the directly concerned population means the total population of settlements having a discontinued station. The number of actually, directly concerned people may be lower owing to the disadvantageous position of certain train stops in terms of passenger traffic, and the number of those indirectly concerned may be higher. A more accurate definition of concern would be impossible, or difficult.

Table 1

Passenger transport has ceased according to time schedules on 13 December 2009, on the following lines

Line	Length, km	Number of stations	Number of cancelled stations	Number of inhabitants directly concerned[a)]
	Feeder lines			
Mezőfalva – Paks	40	7	6	35.1
Godisa – Komló	19	7	6	29.2
Pécs – Pécsvárad	23	9	8	7.4
Sáránd – Létavértes	20	5	4	17.2
Fehérgyarmat – Zajta	25	8	7	5.8
Csenger – Kocsord alsó	33	8	5	11.4
Kisszénás – Kondoros	6	2	1	5.7
Körösnagyharsány – Vésztő	32	6	5	8.0
Nyíregyháza átrakó – Balsa-Tiszapart[b)]	39	21	21	14.9
Herminatanya – Dombrád[b)]	28	10	10	19.3
Sum	*265*	*84*	*74*	*154.0*
	Not feeder lines			
Almásfüzitő – Esztergom-Kertváros	42	15	13	28.6
Szilvásvárad – Putnok	35	8	6	5.1
Abaújszántó – Hidasnémeti	30	10	8	8.2
Lajosmizse – Kecskemét	25	13	11	0.0
Székesfehérvár – Komárom	82	17	15	39.6
Körmend – Zalalövő	23	4	2	2.1
Balatonszentgyörgy – Somogyszob	59	10	7	21.7
Börgönd – Sárbogárd	30	8	6	8.7
Galgamácsa – Vácrátót	15	4	2	1.2
Karcag – Tiszafüred	44	10	8	10.8
Ohat-Pusztakócs – Tiszalök	65	13	11	21.8
Kecskemét– Kiskőrös[b)]	54	20	18	9.8
Törökfái – Kiskunmajsa[b)]	44	14	13	8.2
Hódmezővásárhely – Makó	34	7	5	3.3
Veszprém – Zirc	21	3	1	0.5
Sum	*603*	*160*	*128*	*169.6*
Total sum	*868*	*244*	*202*	*323.6*

a) Explanation in the text.

b) Narrow-gauge line.

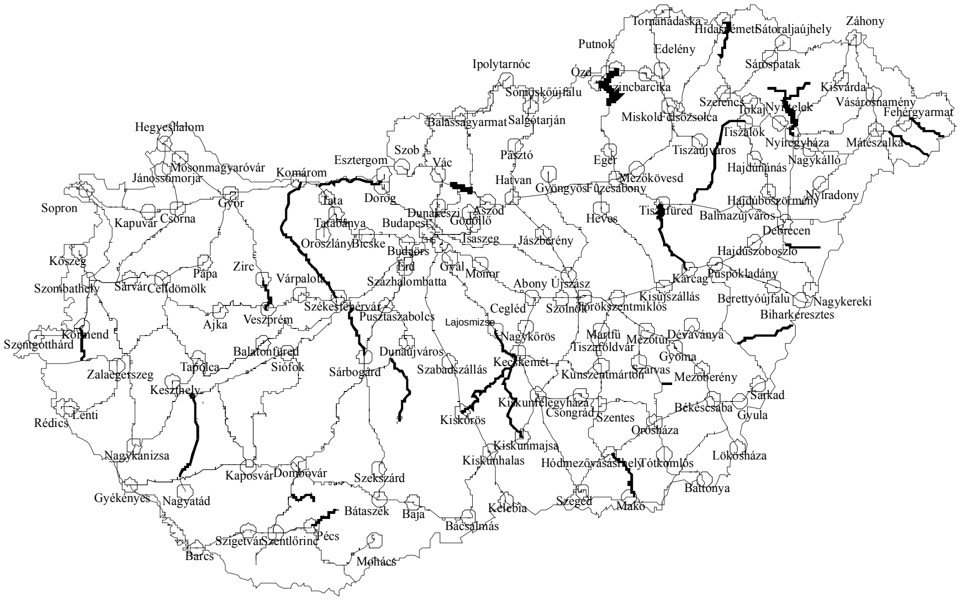
Source: schedule of Hungarian State Railways.

In the course of analysis, a mid-size network containing 143 settlements has been analysed. In selecting the 143 settlements, their size and their position in the railway network has been taken into consideration. Based on the latter aspect, network end-points and terminals of feeder lines have been included, independently from the size of settlements. Based on the two criteria, the settlements are distributed evenly in the country, as there are no significant differences in the density of the railway network on a regional level either.

For the examination, matrixes of railway network distance (in kilometres) and time distance (in minutes) were created between the selected settlements. Data are from the schedule of Hungarian State Railways; in the case of time distances, the option of the shortest time has been chosen from the options offered by the "Elvira" for each connection. The kilometre distance matrix is symmetrical, however, the interval is not, predominantly due to transfers and less due to the direction dependence of journey times. An example of the latter is that the (schedule) journey time of trains going to Budapest is mostly longer with one, two or three minutes than that of trains leaving from Budapest. Overall, (together with transfer impact) the difference between the average journey time of trains leaving from Budapest and of trains arriving in Budapest is 2.3 minutes on average.

Figure 1

Passenger transport has ceased according to the time schedule on 13 December 2009, on the following lines (heavy lines) and the settlements in the analysis



Source: own drawing according to schedule of Hungarian State Railways.

As a reference, the air distance matrix was created between train stations based on the coordinates of the Uniform National Projection. By comparing it with network distances, it has become evident that kilometre distances of schedules sometimes slightly differ from the actual data for stations close to each other. Altogether, it is most obvious in 23 cases, where air distances between stations are greater than those indicated in the schedule. For instance, the Abony–Szolnok distance is 11 kilometres according to schedule, 12.16 km according to the geographical coordinates of train stations, and 12.198 km based on the coordinates of the Uniform National Projection. Some further examples: Budaörs–Budapest South railway station (10.33 km in air distance, 10 km according to the schedule, the actual network length measured from the UNP map is 14 km), and so forth. Based on further random measurement the errors are not so significant that they would obstruct the analysis, and they do not play a role in temporal comparison in any case. In the 23 cases, network distances have been increased to the smallest whole number that minimally exceeds air distance.

Impact of the network reduction on accessibility

The reduction of the network affects accessibility in three different ways. First, certain settlements become completely inaccessible by train (e.g. Kisbér or Kondoros). Secondly, still accessible settlements can be accessed from fewer settlements. Thirdly, distances between accessible settlements may also change. The discontinuation of feeder lines has no impact, only those lines, where both end-points are connected to the national network. For example, the impact of the discontinuation of the Fehérgyarmat–Zajta feeder line is that railway accessibility of settlements between Fehérgyarmat and Zajta has decreased to zero, but the discontinuation of this network element does not influence the accessibility relationship between still accessible settlements. At the same time, discontinuation of the line between Tiszafüred and Karcag not only makes the settlements along the railway line between the two locations inaccessible but it also has an impact on accessibility between Tiszafüred and Karcag or Füzesabony and Püspökladány which are still accessible but only with a detour compared to the earlier state. The analysis involves only the settlements accessible at both dates; therefore, the aim of the present study is to quantify the third level of impact.

Methodological questions in the calculation of the detour index

The detour index in the most general case is the ratio of network distance and air distance between two points of interest. Its minimal value is 1, if the route between the two points is in a straight line. The detour index can be calculated between two points in only one way, but it is possible to calculate it for a set of points in several ways. In Csaba Kovács's paper and Gábor Szalkai's calculations on railway and public road networks (Szalkai 2001, 2003, 2004), it was computed in the following way:

$$H_i = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{n} dh_{ij} /(n-1)}{\sum_{\substack{j=1 \\ j \neq i}}^{n} dg_{ij} /(n-1)}$$

The numerator[1] of the formula comprises the average network distance of a given settlement from the other settlements; its denominator contains the average air distance.[2] Tamás Fleischer (2002) used the reciprocal of the formula with regard to the public road network. This procedure of calculation is distance weighting, that is, it gives greater weight to larger distances and smaller weight to smaller distances. In the formula giving a unit weight for every pair-wise detour index, the averages of pair-wise detour indices are presented:

$$H_i(b) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{dh_{ij}}{dg_{ij}}}{n-1}$$

At the same time, based on the consideration that the relationship between settlements located closer to each other may be stronger than the relationship between settlements situated farther from each other; smaller distances may also be given greater weight. The simplest way to do this is weighting by the reciprocal of distance:

$$H_i(c) = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{1}{dh_{ij}} * \frac{dh_{ij}}{dg_{ij}}}{\sum_{\substack{j=1 \\ j\neq i}} \frac{1}{dh_{ij}}} = \frac{\sum_{\substack{j=1 \\ j\neq i}}^{n} \frac{1}{dg_{ij}}}{\sum_{\substack{j=1 \\ j\neq i}} \frac{1}{dh_{ij}}}$$

Another possibility is to weight either by the reciprocal of the detour index itself, or by the square of the reciprocal, or combining the two possibilities, which is better in terms of taking into account the straight-line difference in the case of smaller distances. The present study does not aim to discuss further methodological details; therefore, other versions of different distance weighting are not examined in this instance.

The common problem of the so far described versions of detour indices is that they do not take account of how significant the settlement is. For instance, in the detour index of Budaörs, the Budaörs–Ipolytarnóc and the Budaörs–Budapest relationships have the same weight, while of course Budapest (with almost two million inhabitants) is more significant than Ipolytarnóc (with only 500 inhabitants). To eliminate the problem, we can weight the particular relations. Csaba Kovács used the total quantity of goods sent from or left at the given settlement in his calculation of weighted indicator. In case of no traffic data, the simplest way is to apply population number. The previous three formulas have to be modified in the following way (p is the sign for population):

$$H_i(d) = \frac{\sum_{\substack{j=1 \\ j\neq i}} p_j * dh_{ij}}{\sum_{\substack{j=1 \\ j\neq i}} p_j * dg_{ij}}, \quad H_i(e) = \frac{\sum_{\substack{j=1 \\ j\neq i}} p_j * \frac{dh_{ij}}{dg_{ij}}}{\sum_{\substack{j=1 \\ j\neq i}} p_j * (n-1)}, \quad H_i(f) = \frac{\sum_{\substack{j=1 \\ j\neq i}} \frac{p_j}{dh_{ij}} * \frac{dh_{ij}}{dg_{ij}}}{\sum_{\substack{j=1 \\ j\neq i}} \frac{p_j}{dh_{ij}}} = \frac{\sum_{\substack{j=1 \\ j\neq i}} \frac{p_j}{dg_{ij}}}{\sum_{\substack{j=1 \\ j\neq i}} \frac{p_j}{dh_{ij}}}.$$

1 The average distance of each settlement from all the other settlements computed in different ways is not a significant indicator itself as it will be primarily the function of delimitation of area. In spite of this, the indicator is calculated by different weighting of accessible masses and distance (Tóth 2006, Tóth & Kincses 2007). Its calculation is justified to some extent in the case of totally closed systems with no external spatial connections.

2 dh_{ij}: network distance between i-th and j-th settlements in kilometres; dg_{ij}: air distance between i-th and j-th settlements in kilometres.

Possible differences of the six indicators compared to each other may provide interesting information on whether the accessibility of a given settlement is divergent from closer and farther settlements, or from larger or smaller settlements. For instance, if the versions weighted by population number are lower than the versions not weighted by population number, it indicates that from the given settlement, the accessibility of larger settlements is relatively better compared to smaller ones. The indicators have been computed, but only the first version on a settlement level has been described in detail due to lack of space; in the case of the others, only the most significant differences are highlighted.

Detour indices can also be calculated if the concepts of distance to be compared have divergent measures, for example, time and cost distance can be compared with air distances and network kilometre distances. In this case, given distances have to be expressed as a distribution ratio in proportion to total network distances (or of other more aggregated forms). At this point, unit value of indicator means that the proportion of the two kinds of distances is equivalent within the two types of total distances.

Of course, the set of settlements involved in the analysis has an effect on the value of the indicators; however, significant differences can only emerge between the values of indicators computed with different networks if the spatial distribution of settlements involved in the analysis is very uneven. Uneven spatial distribution has a similar impact to weighting by population number. Liquidation of lines connected to the network at both ends increases the value of the indicator, while liquidation of feeder lines may decrease or increase it.

Choropleth interpolated maps have not been used to describe detour indices, but their values are indicated by numbers next to the settlements involved in the analysis, furthermore, the size of circles marking settlements is also in proportion to their values. Interpolated maps are more spectacular, but their use is methodologically justified if they apply to a phenomenon that is spatially everywhere interpretable (e.g. amount of precipitation, sunlight), the value of which can be recorded only in certain observation points. Railway accessibility can be conceptually interpreted only at railway stations, and combined with other forms of transport it is the lowest at the points of railway stations; moving away from them, it becomes more unfavourable. Consequently, applying traditional interpolation procedures is not justified in this case.

Tendency of some indicators of total network

Total distance of network expressed in kilometres (the sum of distances of each settlement from all the other settlements) has increased by 1.9% as a result of the new schedule (Table 2). Total journey time has increased only by 0.6%, as discontinued lines belong to those of slower average speed; however, favourable schedule changes, such as better transfer possibilities, may have also contributed to the difference. The average of detour indices weighted by population is lower than that of the unweighted ratios, primarily owing to the good accessibility of Budapest, but they would also decrease if we did not take Budapest into consideration. On the other hand, detour indices weighted by population have increased to a smaller extent than their unweighted counterparts, which shows that accessibility has declined towards and between smaller settlements to a greater extent on average, than towards and between larger ones.

Table 2

Some indicators of the whole network

	2009	2010	2009[a)]	2010[a)]	2009[b)]	2010[b)]
Air distance, km	3 561 301	3 561 301	3 476 535	3 476 535	86 163	86 163
Network distance, km	4 953 446	5 047 528	4 828 904	4 893 962	118 402	119 508
Network distance/Air distance	1.391	1.417	1.389	1.408	1.374	1.387
Total running-time, minute	5 236 226	5 266 974	5 052 782	5 056 098	113 917	113 686
Average speed, km/hour	56.8	57.5	57.3	58.1	62.4	63.1
Mean of indicator H	1.393	1.421	1.391	1.410	1.377	1.391
Mean of indicator H(b)	1.454	1.497	1.430	1.458	1.348	1.367
Mean of indicator H(c)	1.447	1.486	1.443	1.468	1.390	1.408
Mean of indicator H(d)	1.345	1.364	1.354	1.369	1.325	1.335
Mean of indicator H(e)	1.383	1.412	1.381	1.400	1.332	1.345
Mean of indicator H(f)	1.362	1.385	1.360	1.375	1.309	1.320

a) Network with 141 settlements, without Lajosmizse and Zirc.
b) Network with 23 towns of county rank.
Source: own calculation according to schedule.

Indicators with different distance weighting show that detour indices on average are higher between settlements located closer to each other than ratios between settlements located farther apart. Although the lowest network ratios are mostly between settlements close to each other, it is also frequent that adjacent straight-line settlements do not have direct connections. In case of settlements far from each other, the impact of unevenness and deficiencies of the network decreases.

In Table 2, two further results regarding smaller networks are shown. Two settlements, Zirc and Lajosmizse became terminals at the end of a feeder line and therefore they have the greatest impact on the results. Studying only towns of county rank, changes have a smaller effect, and temporal accessibility (although to a hardly detectable extent, by 0.2%) has also improved between them. It is clearly shown that the reduction of the network has affected smaller settlements in a more disadvantageous way. Indicators and their changes are spatially uneven, for example, the average of journey times has decreased for 63 settlements, exceeding 5 minutes for 18 settlements. Subsequently, spatial distribution is analysed in detail.

Greatest changes of detour indices

The highest values of detour indices are taken up between settlements that are close to each other in air distance, but do not have direct connection (Table 3). Since there are other transport possibilities besides the railway, these extremely high values of the table rather indicate only theoretical possibilities. The eight-kilometre distance between Biharkeresztes and Nagykereki can be covered faster even on foot than by train (the fastest way is three hours with two transfers).

Table 3

The highest pair-wise detour indices
(according to the time schedule, February 2010)

Settlements	Network distance, km	Air distance, km	Detour index
Biharkeresztes–Nagykereki	147	8.6	17.1
Veszprém–Zirc	197	16.6	11.9
Ipolytarnóc–Somoskőújfalu	181	16.5	11.0
Esztergom–Szob	111	10.6	10.5
Várpalota–Zirc	219	22.1	9.9
Lajosmizse–Kecskemét	157	16.9	9.3
Ipolytarnóc–Salgótarján	175	19.7	8.9
Lajosmizse–Nagykőrös	142	16.1	8.8
Bátaszék–Mohács	184	22.3	8.2

Source: own calculation.

As a result of changes in schedule, detour indices have increased to the greatest degree between Zirc and settlements lying south of it, and between Lajosmizse and settlements lying south-west of it (Table 4). As from the 143 settlements, 129 could be accessed from Zirc in a shorter southern direction via Veszprém (all settlements with the exception of the North Transdanubian ones), the absence of this section affects Zirc in a much more disadvantageous manner than Veszprém. The accessibility of 63 settlements has become longer from Lajosmizse due to the suspension of the Lajosmizse–Kecskemét line.

Table 4

The largeest increase in detour indices

Settlements	Network distance, km		Air distance, km	Detour index		Difference
	2009	2010		2009	2010	
Veszprém–Zirc	21	197	16.6	1.27	11.85	10.58
Várpalota–Zirc	43	219	22.1	1.95	9.91	7.96
Lajosmizse–Kecskemét	25	157	16.9	1.48	9.29	7.81
Lajosmizse–Nagykőrös	40	142	16.1	2.48	8.82	6.34
Siófok–Zirc	114	296	42.0	2.71	7.05	4.33
Székesfehérvár–Zirc	66	242	42.4	1.56	5.71	4.15
Lajosmizse–Kiskunfélegyháza	50	182	41.2	1.21	4.42	3.20
Lajosmizse–Cegléd	58	124	26.5	2.19	4.68	2.49
Karcag–Tiszafüred	45	132	38.4	1.17	3.44	2.27
Esztergom–Tata	51	123	33.7	1.51	3.65	2.14
Dorog–Tata	50	116	31.1	1.61	3.73	2.12
Komárom–Esztergom	53	143	46.4	1.14	3.08	1.94

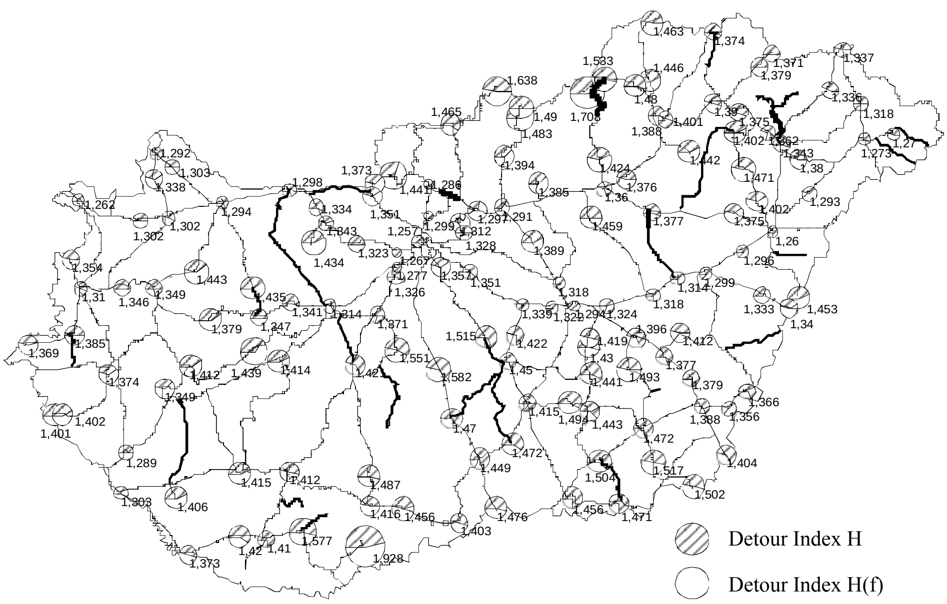
Source: own calculation (for Lajosmizse and Zirc, only the first four settlements).

Detour indices and change of detour indices

The values of detour indices by settlements (H indicator) are shown in Figure 2 and 3, and their changes are indicated in Figure 4. The size of circles is proportional to the value of the indices. The value of detour indices is the lowest along the main lines and settlements located at railway junctions; it is highest at the ends of feeder lines. The orders of magnitudes of indicators computed in different ways are equivalent, but differences between them further refine the picture. If the H and the Hf indicators are equal, the areas of the two sectors of the circle are equivalent. A more significant difference between the H and the Hf indicators primarily emerges for settlements where the accessibility of a nearby city (Budapest or county seats) is considerably worse than the average: Gödöllő, Aszód (although the railway connection is direct to Budapest, the alignment has an eastward direction as far as Pécel, then northward, slightly north-westward as far as Gödöllő), Szob (impact of the Danube Bend), Berettyóújfalu (it has no direct connection with Debrecen, its network ratio with Debrecen is 2.22) and Balatonfüred (its network ratio with Veszprém is 6.04).

Figure 2

Detour indices
(November, 2009)

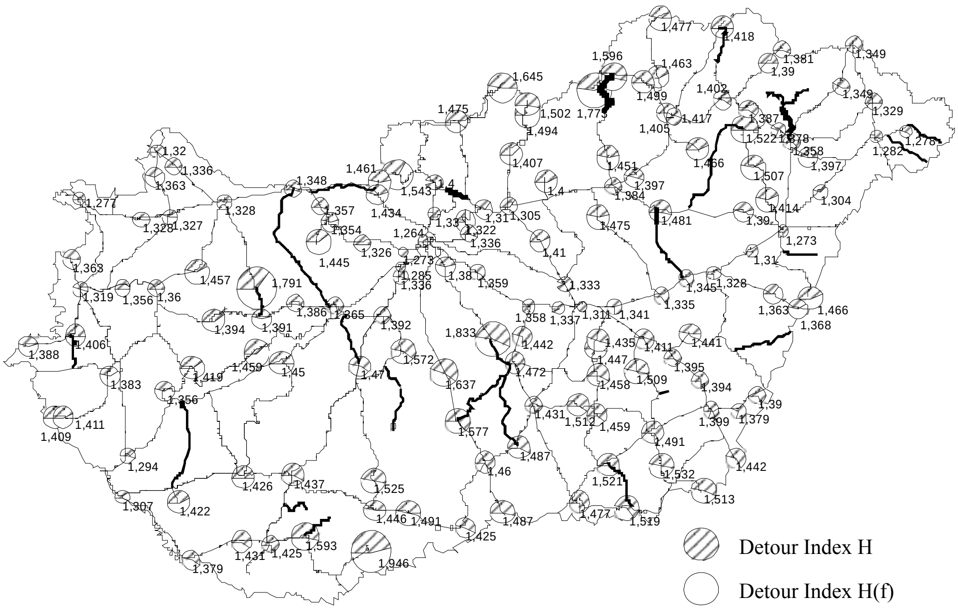


Source: own calculation (beside the settlements the value of indicator H can be seen).

The H indicator has increased on average by 0.028 between the two dates. Detour indices of the previously mentioned Zirc and Lajosmizse have increased to the greatest extent, since the two settlements (provisionally) have become the end-points of a quite long feeder line. Further settlements whose network ratios have changed to an extent exceeding 0.05 are the following: Tiszalök, Vác, Szob, Tiszafüred, Kiskőrös, Esztergom, Dorog, Ózd, Putnok, Szabadszállás, Székesfehérvár and Komárom. Such an important branch line was discontinued near these settlements, that it has made not only relatively close settlements accessible with a considerable detour, but also several farther settlements can be accessed only with a substantial detour compared to the earlier state. On a regional level, the entire North and Central Transdanubia have increased above average (West and Southwest Transdanubia have not). The eastern half of the country does not have continuous regions increasing above the average; however, discontinuation of the Karcag–Tiszafüred line has noticeably raised the indicators of neighbouring settlements. For Székesfehérvár, the impact of discontinuing three branch lines can be summed up accordingly: the Börgönd–Sárbogárd line has made Southeast Transdanubia more distant (not only from Székesfehérvár, but also from settlements lying north-northwest of it); the Székesfehérvár–Komárom and the Veszprém–Zirc lines have made North Transdanubia more remote.

Figure 3

Detour indices
(February 2010)

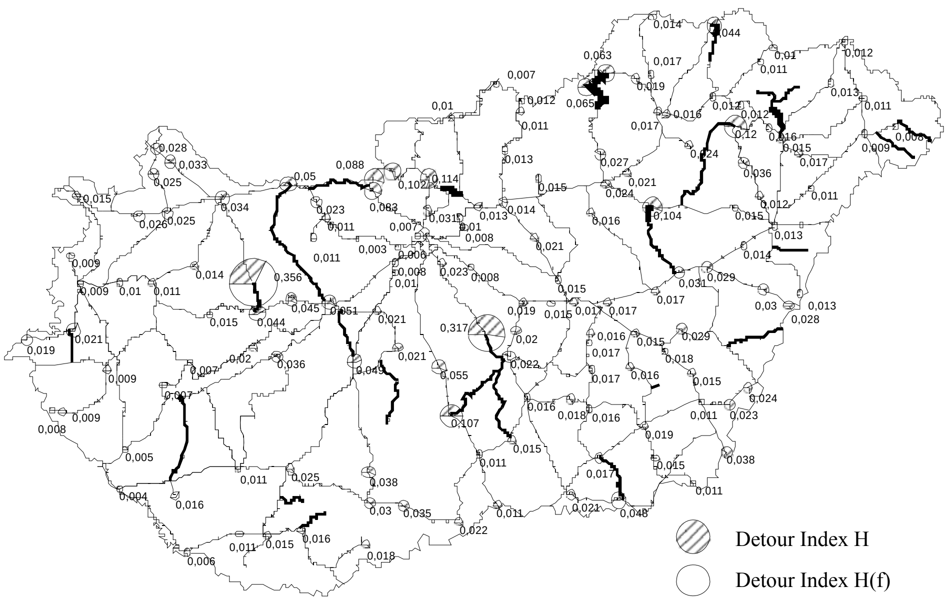


Source: own calculation (beside the settlements the value of indicator H can be seen).

Discontinuation of the Kecskemét–Kiskőrös, Törökfái–Kiskunmajsa, Balatonmária-fürdő–Somogyszob, Makó–Hódmezővásárhely, Körmend–Zalalövő, Abaújszántó–Hidas-németi lines either do not have, or have a minimal spillover impact on further settlements apart from those located at the end-points of lines. Nevertheless, the slight impact of the discontinuation of these lines on regional accessibility does not indicate that problems cannot occur on a local level, due to the liquidation of an earlier existing connection. Discontinuation of the Szilvásvárad–Putnok line has created a peculiar situation as it has made 80% of settlements more distant from Putnok and Ózd in network kilometre distance and correspondingly in cost distance, but not in time distance because the settlements accessible previously in fewer kilometres via Eger and Mezőkövesd, have had the lowest time demand via Miskolc. Even the Putnok–Eger section has been temporally shorter with a maximum of 48 minutes, making a detour to Miskolc rather than on the section via Upponyi mountain; this according to the schedule is shorter by 45 kilometres and can be covered with a (in fact only three-minute) transfer in Szilvásvárad. Suspension of the Lajosmizse–Kecskemét line has a partly similar impact, which has increased accessibility by eight kilometres between Budapest and the South Great Plain. It has not changed temporally either, because the Budapest–Lajosmizse section is 108 minutes, the Lajosmizse–Kecskemét is 35 minutes, while Budapest–Kecskemét is 77 minutes via Ferihegy. The difference is that Lajosmizse has become the end-point of a long dead end in the middle of the country and therefore its railway connection to the South Plain has ceased.

Figure 4

The change of detour indices between November 2009 and February 2010



Source: own calculation (beside the settlements the increase of indicator H can be seen).

Detour indices of several settlements have only imperceptibly increased, the less effected settlements are the following: Bicske, Budaörs, Monor, Budapest, Kiskunhalas, Gyékényes, Kelebia, Isaszeg, and the indicators of a further approximately fifty settlements have only minimally increased.

Temporal accessibility and change of temporal accessibility

The investigation of temporal accessibility raises much more interesting and complex questions than the study of network kilometre distances, as here schedule constraints also have to be taken into account. In the present study, I have calculated in the simplest way, the shortest possible accessibility times from the options provided by the “Elvira” on-line internet timetable search. I am not concerned with the direction dependence of temporal accessibility, as the average of outward and return journeys has been used. Furthermore, the calculations do not deal with the differences of journeys that are the shortest temporally and the shortest in terms of cost[3], with the impact of service frequency and with many further issues.

It has already been shown in Table 2 that despite a reduction of the network, the average temporal accessibility has remained almost unchanged. The accessibility of 42% of settlements has improved, the rest has declined; the greatest changes are indicated in Table 5. From the improving settlements, Ózd has to be noted; its detour index has considerably declined, but as has been mentioned, liquidation of the slow branch line has not influenced temporal accessibility. From the declining settlements, the unfavourable change of Gyula, Sarkad, Lenti and Rédics cannot be explained by network reduction. These settlements are examples for how significant temporal saving, or time margins can result from schedule changes. Apart from this, however, temporal changes do not diverge considerably from that expected due to network changes.

Table 5

The biggest change in temporal accessibility

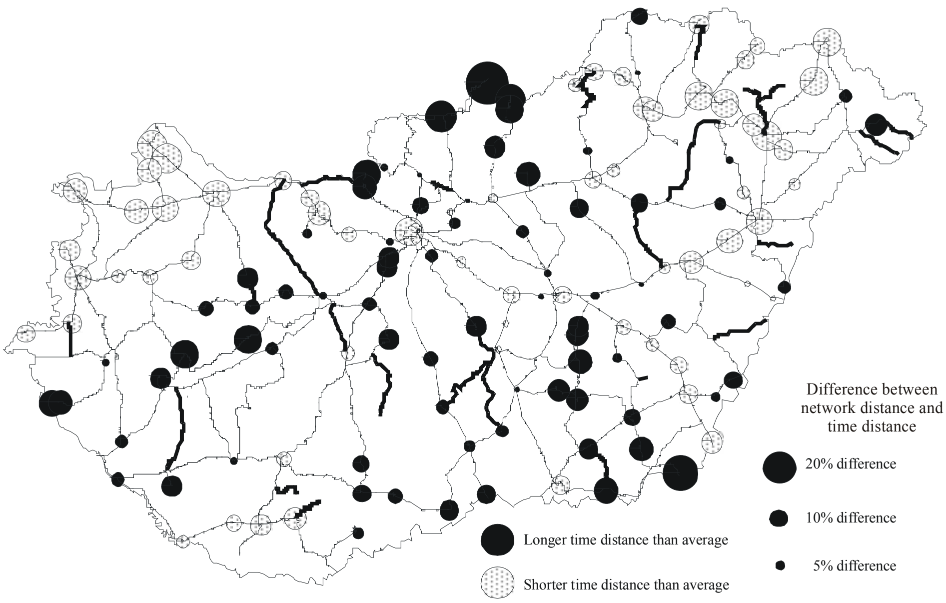
Settlement	Average improvement, minute	Settlement	Average growing, minute
Ipolytarnóc	7.6	Lajosmizse	42.5
Csongrád	6.4	Zirc	32.6
Zalaegerszeg	5.7	Tiszafüred	14.3
Barcs	5.5	Vác	8.6
Salgótarján	4.4	Gyula	7.7
Ózd	4.3	Sarkad	7.1
Várpalota	4.2	Esztergom	6.9
Pusztaszabolcs	4.1	Szob	5.7
Somoskőújfalu	3.6	Lenti	5.5
Szarvas	3.6	Rédics	5.5

Source: own calculation.

3 Its one aspect is that in the case of longer journeys, which direction is it worth going from, i.e. stations where fast trains do not stop if the aim is to minimize time distance (Kotosz 2007, 2009).

Figure 5

The ratio of time distance and network distance
(February, 2010)



Source: own calculation.

The situation in "time space" of each settlement can be compared to the geographical situation (to air distances) and network situation (network kilometre distances). Due to the different measures, I have compared the extent of differences between the rates of distances of settlements computed in different ways within total distance. Figure 5 includes the rates of every time and every network distance according to the state in February 2010. It clearly shows that, apart from the Budapest–Székesfehérvár line planned to be renovated by 2013, the settlements located along main lines are in the best position in temporal accessibility alongside their better network ratios. This is also supported by the positive correlation between the two kinds of ratios (Table 6). The significant exceptions of this correlation include Pécs, Putnok and Ózd in a positive direction (their temporal accessibility is better than their network position) and Fehérgyarmat, Mátészalka, Érd, Százhalombatta, Dunakeszi, Nagykanizsa and Gyékényes in a negative direction. The settlements in the most favourable situation are shown in the top left cell of Table 6, the most unfavourable ones are found in the bottom right cell, the first and last five settlements are indicated in Table 7. It is noteworthy that among the settlements of the most disadvantageous position there are two towns with county rank, namely Dunaújváros and Salgótarján.

Table 6

The number of settlements above the average and below the average according to time distance and network distance

	Time distance compared to network distance		Sum
	under the average	above the average	
	November, 2009		
H below the average	52	27	79
H above the average	20	44	64
Sum	*72*	*71*	*143*
	February, 2010		
H below the average	51	32	83
H above the average	15	45	60
Sum	*66*	*77*	*143*

Source: own calculation.

Table 7

The best and worst settlements from the point of view of time distance (ratios of the shares from the various types of distances, February, 2010)

Settlement	Time distance/ Air distance	Time distance/ Network distance	Network distance/ Air distance
Budapest	72.1	83.1	86.8
Hegyeshalom	76.9	82.6	93.1
Sopron	77.7	86.2	90.1
Debrecen	77.8	86.7	89.8
Mosonmagyaróvár	78.1	82.9	94.2
Nyíregyháza	78.6	82.1	95.8
Kisvárda	79.5	83.5	95.2
Győr	79.6	85.0	93.7
Dunaújváros	121.3	109.3	110.9
Salgótarján	121.9	115.6	105.4
Somoskőújfalu	124.7	117.7	106.0
Balassagyarmat	127.1	122.2	104.1
Battonya	133.4	125.0	106.7
Zirc	137.3	108.3	126.8
Lajosmizse	141.1	109.1	129.3
Mohács	141.2	102.8	137.3
Ipolytarnóc	159.7	137.6	116.1

Source: own calculation.

Conclusions

As a result of network reduction, in addition to a decrease in railway accessibility, differences between the accessibilities of settlements have also increased. Settlements along the main line that had good position earlier, Budapest at the head, have largely further increased their advantage in contrast to the other settlements. However, the completely unambiguous quantification of impacts is not possible, because the results partly depend on the number of settlements symbolising the network, on their position and on the choice of weighting. The detour index computed in the study has also taken account of connections, which rather come up only as theoretical possibilities (such as the mentioned Biharkeresztes–Nagykereki or Jánossomorja–Fehérgyarmat). In the interpretation of results, these constraints have to be considered. At the same time, these calculations have approached accessibility from the supply side; different objective calculation may be possible by knowing traffic data.

Apart from methodological observations and certain general characteristics, owing to the restarted lines from June 2010 (Székesfehérvár–Komárom, Zirc–Veszprém, Karcag–Tiszafüred, Lajosmizse–Kecskemét and Csorna–Pápa which had been suspended since 2007), the presented changes have historical significance and they rather indicate what would have happened in case of permanent or eventual suspension of all discontinued lines. In addition, the analyses have demonstrated that these lines (with the exception of the Csorna–Pápa line, which has not been included in the analysis) have had the greatest impact on the increase in the detour index; therefore, their restarting was actually the most justified from this point of view.

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