SPATIAL GRAVITY CENTRES OF THE DYNAMICS AND THE CRISIS IN HUNGARY

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The transition into market economy in Hungary was coupled with an increase in regional disparities and the restructuring of the spatial pattern of economy. The study presents some spatial processes of the Hungarian transition (1990–2000) by the classic method of the spatial analysis: method of gravity centres. The basic points of the analysis are the settlements of the country. The characteristic geographical location of individual gravity centres – population, income, unemployment, phone lines – and their mobility or stability refer to the fact that the method is suitable not only for the analyses of static features of spatial structures of society or showing long-time, historical trends of movements, but for describing new connections in the examination of periods of radical changes (typically in the transition in Eastern Europe). The investigations prove the dominant role of capital in the spatial structure of transition as well as the sharp West-East disparities.

KEYWORDS: Gravity centres; Regional inequalities.

The transition into market economy in Hungary was coupled with an increase in regional disparities and the restructuring of the spatial pattern of economy. This process has been analysed substantially by using statistical methods as well. Regarding the analytical methods of these studies two characteristic ones can be distinguished: *the classification of regional units* which uses complex mathematical-statistical and multi-dimensional methods (*Faluvégi*; 2000) and the analyses focusing on the tendency in these regional inequalities (latest: *Nagy*; 2002). In an attempt to analyse regional processes this paper works with different methodology: it uses an analogue model applied in physics, the method of gravity centres, which takes demographic and economic gravity centres as the base of the analysis.

THE METHOD

The co-ordinates of the gravity centres in a planar system consisting of n elements can be calculated as the weighted arithmetical means of the co-ordinates of the points in condition that the location of the points in the system of co-ordinates (map) is fixed and all the points are associated with 'weights'. The centre of gravity represents an optimal

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point: the weighted sum of the distances between gravity centre and the basic points is minimal. The calculation of the points of gravity (X, Y) needs co-ordinates of basic points (x_i and y_i) and their weights (f_i):

$$x = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i}; \quad y = \frac{\sum_{i=1}^{n} f_i y_i}{\sum_{i=1}^{n} f_i}.$$

The application of the model in social science roots in social-physics, which was established in the first part of the XXth century (*Stewart–Warntz*; 1958). The applicability of the model is proved by the fact that it can reflect the geographical patterns of population in any spatial unit (county, region), where the basic points are the settlements and the weights are the numbers of inhabitants. The gravity centre of a population is a spatial (geographic) mean of the population pattern. In the calculations the role of weight can be played not only by the population but by any other social or economic variable: growth of economic production, income, number of employed persons (economic centres of gravity), number of votes for parties (political centres of gravity), number of crime events, suicides, accidents (social centres of gravity) etc.

Papers based on the application of this model in Hungary primarily deal with demographic processes. The first contribution was made by *Bene* and *Tekse* (1966) who carried out a comprehensive analysis of this type aiming at the description of the historical changes of spatial population pattern in the period 1900-1960. The shift of the centre of population in the last decades was analysed by *Mészáros* (1995). Both papers conclude that the gravity centre of the total population of Hungary in the XXth century move gradually towards the capital, the motion of the centre of gravity of the urban population is characterised with a South-Eastern–North-Western direction, by contrast the gravity centre of the rural population shifts with a South-Western–North-Eastern vector. The relocation of the demographic centres reflects the pull effect of the capital and the industrial axis with the relative depopulation of the Great Plain, primarily as a result of emigration from the area. *Illés* (2000) used the model for the analysis of the elements of the internal migration processes. The change of gravity points of the industrial production in the (former) socialist countries in the period 1960–1975 was investigated with this model (*Nemes-Nagy*; 1987). The analysis showed a clear shift in economic (industrial) development with a common vector directed in the East for these countries.

The spatial structure of social processes and patterns can be characterised by the distance and direction between the different centres of gravity e.g. the relationship between geometric and population centres of gravity characterises the geographical differentiation of population density, the relationship between the centres of gravity of population and income describes the regional pattern of income inequalities.

The analysis of gravity centres can be undoubtedly regarded as a useful method in the historical investigation of spatial transformation, however it is not applicable in expressing certain type of processes, not even theoretically. Substantial changes in spatial structure can occur without a slight movement of the gravity centre, when the changes (growth or increase) take place symmetrically around the gravity centre. The average,

weighted distance of basic points measured from the gravity centres, the *standard distance* makes the difference among these cases. The smaller the value, the more characteristic is that the given phenomenon concentrates around the gravity centre.

In our analysis a map based co-ordinate system with the capital city in the middle was used. The basic points were settlements, the signed distances measured in kilometres from the capital from West-East or South–North directions give the co-ordinates of their centres. The considered period for the individual indicators are not quite the same. The reason is that data are available on settlement level for distinct years.

In an attempt to analyse the most important processes, we calculated four typical socio-economic gravity centres – for the earliest and latest years of the transition period with data available. These are the following:

1. size of population (permanent population),
2. incomes (volume of taxable incomes),
3. unemployment (registered unemployed persons),
4. supply of phone lines (main phone lines).

The source of data in case of phone lines and the population is the database of the Hungarian Central Statistical Office (TSTAR), in case of registered unemployment and in taxable incomes on settlement level we use the database of the National Employment Office (Foglalkoztatási Hivatal) and the Hungarian Ministry of Finance and the Hungarian Tax and Financial Control Administration (PM–APEH), which is not a public database on settlement level.

Table 1

Regional inequalities between the distribution of population and the analysed economic indicators
(Hoover-indices, percent)

Year	Budapest countryside (*n*=2)	Regions (*n*=7)	Counties (*n*=20)	Micro-regions (*n*=150)	Settlements (*n*=3157)
			Income		
1988	6.9	7.6	7.7	9.1	10.8
1996	9.0	10.1	10.3	12.7	15.2
2000	9.3	11.3	11.5	13.5	15.6
			Unemployment		
1991	17.52	26.35	26.71	30.53	33.16
1996	7.71	12.70	13.57	15.39	18.28
2001	12.01	22.50	22.58	24.30	26.46
			Phone lines		
1992	23.24	17.89	23.59	29.02	34.32
1996	13.26	13.09	13.64	17.31	20.43
2000	7.67	7.50	7.79	9.39	11.10

Note: Hoover-index: $H = \frac{1}{2} \Sigma |x_i - y_i|$, where x_i and y_i are the shares (%) of the i. spatial units (regions, counties, micro-regions, settlements) in the total volume of the compared indicators. $H_{min} = 0$, $H_{max} = 100$.
Source: *Hoover* (1941).

In our paper the population gravity centre has an outstanding importance not only in itself but also in comparison with other analysed economic indicators. We can provide a comprehensive view by analysing the taxable incomes, a description of the spatial characteristics of socio-economic dynamism by using the index of telephone lines supply regarded as a rapidly growing sector, while by using the unemployment data we can make the spatial processes of this crises phenomena. In every case we calculated the gravity centres including all the settlements (3147) as basic points, in the case of the incomes all the cities (251 settlements without the capital) and villages as basic points.

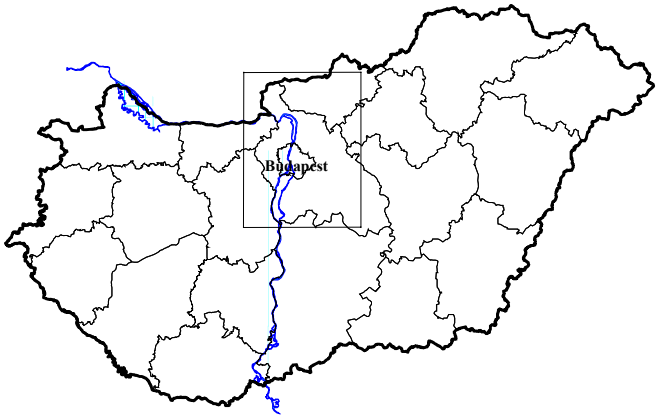
The selection of three indices mentioned previously (income, phone lines, unemployment) is motivated by the fact that they radically differ from each other in their spatial inequality patterns at the end of the XXth century (see Table 1).

At the beginning of the nineties a marked trend in differentiation can be realised, which stabilising itself on a high level resulted a divided income space in the second half of the decade. In contrast in phone lines supply – which is the most dynamically developing sector of the infrastructure – regional levelling is marked, while in the case of unemployment we can see a special waving character of the regional inequalities. Definite spatial directions can be posted to the previously mentioned tendencies by using the gravity centre method.

THE LOCATION OF THE GRAVITY CENTRES

For the interpretation of the location of different gravity centres unweighted (geometric or geographic) centres of gravity and a special centre, called ‘geographic centre of the country’ mean good points to relate to. (The location of the calculated gravity points on the map of Hungary can be seen on Figure 1.)

Figure 1. Calculated gravity points in Hungary



Geometric (geographic) centres

The point mentioned is situated in South-Eastern direction from the capital about 2 kilometres from the centre of Pusztavacs village (Pest county) and its marking was not

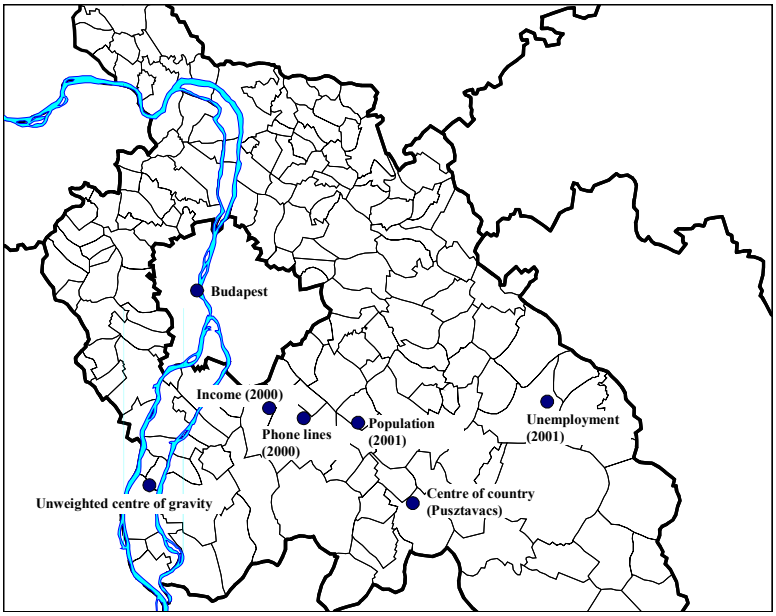
carried out with the gravity centre method, but with taking the average of the longitudes and latitudes bordering the country (*Atlas of Hungary*; 1999 p. 9.). This point is quite near to that gravity centre – though it does not fully coincide with it – which we can get by calculating with all the settlements in the country as basic points taking the public administration area belonging to them as the weight. (The difference between them comes from the fact, that settlements are usually not situated in the geometrical centre of their administration area.)

We get the next interesting 'neutral', unweighted gravity centre if we simply take the average of the place co-ordinates of the settlements in the country. The position of this centre (the gravity centre of the settlements) is quite unique: it is located, not in East-Hungary, but in an isle of the Danube, the Csepel-island (see Figure 2). The reason of it can be attributed to the settlement structure of the country. Though the greater proportion of the area belongs to the Eastern part of the country, Transdanubia has a higher density of settlements, (e.g. large range of regions in West and South Transdanubia is characterised by small settlements), while on the Great Plain we can find fewer (but more populous) settlements.

Location of the gravity centres of the population and economy

During the whole XXth century the economic and population gravity centres of the country were situated mainly in the South-East of the capital city (a characteristic tendency was that they were getting nearer and nearer to the capital first of all because its attracting power of population and economy). At the turn of millennium the situation was the same.

Figure 2. Location of the gravity centres at the end of the XXth century



The population gravity centre in the year 2000 is located near Vasad (33 air kilometres from the 0 kilometre standpoint at the bridge head of Lánchíd in Buda, that is the theoretical centre of Budapest). The income gravity centre of the country has got very close to the capital, and it is the nearest to the centre of the village Alsónémedi community (22.2 kilometres from the capital). Similarly to the income gravity centre, the phone lines gravity centre falls between the capital and the population gravity centre, it is situated at a 26.2 kilometres distance from Budapest, (near Ócsa). The unemployment gravity centre lays far from the other centres, being located to the East of the capital, in a 58.6 kilometres distance from it in 2001. (Near Tápiószele, in Pest county.) The special difference in the location of the distinct gravity centres demonstratively shows the marked regional separation of elements of dynamism and factors of crises (see Figure 2 and Table 2).

Table 2

Location of the gravity centres

Analysed points	Year	Co-ordinates of the gravity centres (kilometre, Budapest = 0;0)	
		West-East	South-North
		Geometric	
Settlements (unweighted points)	2000	-7.58	-31.73
Settlements (weighted by area)	2000	26.61	-35.66
		Population	
Settlements	1988	24.64	-21.54
Settlements	2000	25.03	-21.48
Villages	1988	26.42	-21.90
Villages	2000	25.55	-21.31
Towns (excluded Budapest)	1988	33.22	-29.90
Towns (excluded Budapest)	2000	33.73	-29.39
		Income	
Settlements	1988	17.44	-19.57
Settlements	2000	11.33	-19.06
Villages	1988	18.36	-20.33
Villages	2000	6.60	-19.85
Towns (excluded Budapest)	1988	26.33	-29.71
Towns (excluded Budapest)	2000	19.84	-29.05
		Unemployment	
Settlements	1991	70.28	-13.24
Settlements	2001	60.41	-16.41
		Phone lines	
Settlements	1992	10.62	-16.93
Settlements	2000	16.74	-20.64

Standard distances

In the case of Hungary the gravity centres and the standard distances connected to them are mainly determined by the effect of the capital.

It also originates from this fact that we get the highest value of standard distance just regarding the unweighted settlement gravity centre (140.9 kilometres), as in that calculation the weight of the capital is equal to any other small communities, and this way the gravity centre is not attracted close to the capital. Among the analysed gravity centres the standard distance of unemployment gravity centre situated the farthest from the capital is the biggest. The change of the index follows the movement of the gravity centre related to the capital: when the gravity centre comes nearer to the capital, its value decreases, when it goes farther, its value increases. This fact demonstrates well, that in the case of the unemployment gravity centre the capital has a determining effect, where the unemployment rate is always far under the national average, but regarding the absolute numbers most of the unemployed people have always lived in Budapest. In the case of the other investigated gravity centres the formation of standard distance is basically determined by their position to the capital (see Table 3).

Table 3

Standard distances of different gravity centres

Indicator	Year	Weighted standard distance (kilometre)
Settlements (unweighted points)	2000	140.9
Population	1988	107.4
Population	1996	107.2
Population	2000	107.3
Income	1988	96.0
Income	1996	93.8
Income	2000	92.2
Unemployment	1991	128.8
Unemployment	1996	119.9
Unemployment	2001	126.5
Phone lines	1992	83.7
Phone lines	1996	89.5
Phone lines	2000	96.8

Distances of gravity centres

As a result of the stability of the population gravity centre and the motion of income gravity centre the two gravity centres have moved relatively far from each other (in 1988 7.5 kilometres, in 2000 13.9 kilometres), which, complemented with direct geographical meaning proves unambiguously the growing inequalities of incomes and highlights the role of regional potential factor in the social processes.

In the case of phone lines as well as the population gravity centres – reinforcing the levelling trend of Hoover-indices published in Table 1 – the distance decreased from 15 to 8.3 kilometres in the period 1992–2000 (as the population gravity centre was basically stable, the approaching of the two gravity centres can be attributed to the effect of the growing phone lines supply). Comparing the gravity centres of unemployment and population in 1991 and in 2000 the distances are much bigger (46.2 or 31.1 kilometres), and the decrease, though in a smaller degree, reflects to the more balanced spatial structure of the labour market (see Table 4).

Table 4

Distances between the population centres of gravity and the other analysed centres

Compared gravity centres	Years	Distance (kilometre)
Population-Income	1988	7.5
Population-Income	1996	12.3
Population-Income	2000	13.9
Population-Unemployment	1991	46.2
Population-Unemployment	1996	20.5
Population-Unemployment	2001	31.1
Population-Phone lines	1992	15.0
Population-Phone lines	1996	13.7
Population-Phone lines	2000	8.3

If we do not insist on comparing two years from the beginning and from the end of the transformation period, though we follow through the whole period, the movement of the three economic-well-being gravity centres show further interesting features of the spatial processes.

SHIFT OF GRAVITY CENTRES

The movement of each of the gravity centres demonstrate spectacularly, that the transition processes were accompanied by radical geographical changes.

Income

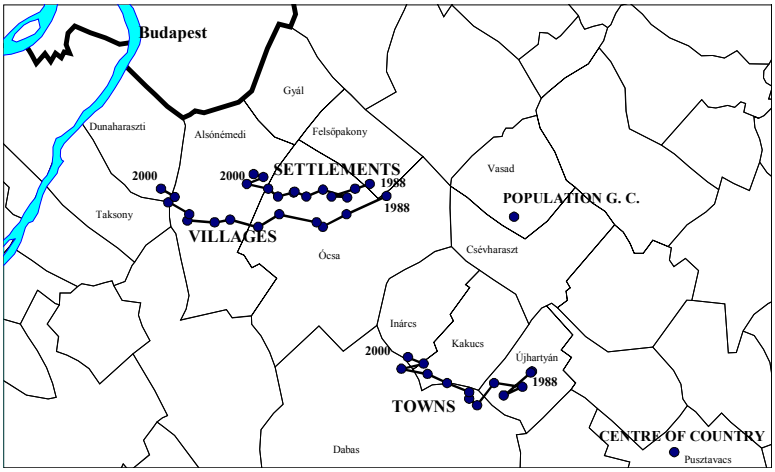
While the population gravity centre in each of the investigated categories of settlements seems to be almost fixed, meaning that at the end of millennium in the macro-regional dispersion of population no definite rearrangement happened, the mobility of the income gravity centres are significant. While the results of the population gravity centres indicate small, only some hundred metres movement, the income gravity centre between 1988 and 2000 moved 6.1 kilometres to the direction of North–West, more dominantly to the West.

The measurement of the movement of two subsets of settlements (towns and villages) represents almost the same scale. It might be surprising, that the most mobile geographical centre of incomes is that of the villages, its shift is about twice as high as in the case of the gravity centre of the income of the 251 cities. This fact shows the relative stability of the network of cities as they serve as ‘economic skeleton’ of the country. The villages comparing to the cities – mainly as a function of their location – took a more different path after the transition.

In Figure 3 one can observe the motion of gravity centres year by year during the whole period and it calls attention to a South direction component in terms of the geographical direction. One can identify a specific geographical and economic development process in that period: the ‘underlevelling’ inside the countryside, which process was basically in connection with the economic shock of North-Eastern–South-Western industrial axis. In this period the development level of the Eastern part of the country (North-

Hungary and the Great Plain) got almost balanced, from an above average position; the first one has radically fallen down, while the latter one has stagnated. In the recent years the income gravity centres have turned to the North again. This refers – at least in the Western part of the country, in the Transdanubian region – to the slow process of re-establishment of the former North–South duality. (This fact can be proved by other data, too, e.g. GDP per capita in a county.) The explanation of it is partly the dynamism induced by the foreign capital in the Northwest, nearby to the Austrian border zone, but one can mention at least with the same weight the mosaic like, steadily deteriorating position of South-Transdanubia.

Figure 3. Shift of the income gravity centres (1988–2000)



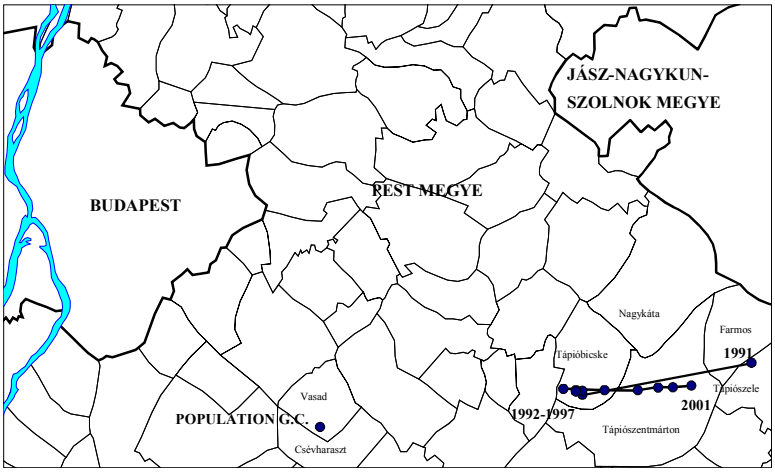
According to our investigations in every settlement category there was a movement away from each other in terms of the income and the population gravity centre between 1988 and 2000, which is a new proof for the fact that the recent income inequalities – independently from the size of settlements – were growing both in the group of the cities and in the villages (about the relation of the location and the settlement structure see *Nemes-Nagy–Jakobi–Németh.*; 2001).

Unemployment

The mass unemployment, the very process of the decade, which caused the greatest shock for the society was characterized by special course both in time and space, and produced mechanism of 'ebb and tide'. In the first phase of the transition process the phenomenon of unemployment – besides becoming a mass symptom – had a definite regional concentration (for the disadvantage of North-East). Afterwards the unemployment crises diffused in the country and later the gravity centre of unemployment came nearer to that of the population, and by now it has again drawn back to its original spatial structure (see Figure 4). The highest unemployment rates today are again in the North-Eastern part of the country. Here, mainly in the rural areas, the labour market has become rigid

without any hope for change, and the younger generation took the place of the permanently unemployed persons after elderly persons got excluded from the labour market.

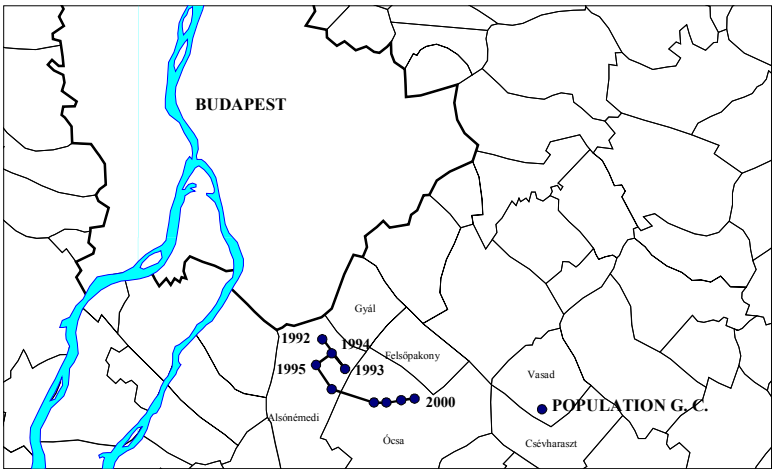
Figure 4. Shift of the unemployment gravity centres (1991–2001)



Phone lines

Between 1992 and 2000 the number of phone lines grew by more than 2 millions, today every third person has a line. Nowadays this development has resulted in a total supply on national level. Though the density of lines – as well as the data of Table 1 show – is rather different among the regions of the country.

5. Figure. Shift of the phone lines gravity centres (1992–2000)



The location of the gravity centres indicates the advantage of the Western part of the country, but in its motion we can recognize two special phases (see Figure 5). In the pe

riod between 1994–1995 and characterized by the building up of regional networks in those areas, which were not supplied, the gravity centre moved almost randomly year by year, its position were modified by the subscriber of a new connected network district. After this period on the basis of the existing network the 'saturating' phase comes. At that time the direction of the movement of the gravity centre suggests that the Eastern and Southern zone of the country having been earlier in a disadvantaged situation started to catch up. In the middle of the 90's as a result of the basically opposite direction in the movement of the income and phone lines gravity centres the two gravity centres got quite close to each other, but the tendencies of the latest years refer to the fact, that the phone lines supply is going to become a basic function, which is independent from the income and therefore the two gravity centres have moved further away from each other.

Conclusions

The study presents some spatial processes of the Hungarian transition by using a special method for the investigation of space, the calculation of gravity centre. The results (the characteristic geographical location of individual gravity centres and their spectacular motions) refer to the fact that the method, nowadays considered as a classic method in spatial investigation, is suitable not only for the analysis of static features of spatial structures of society or showing long-time, historical trends of movements, but for describing new connections in the analysis of periods of radical changes (typically in the transition in Eastern Europe). The investigations prove the dominant role of the capital in the spatial structure of transition as well as the sharp West-East disparities. Though besides these comprehensive effects analyses of the different gravity centres highlight that there are quite different movements in the individual socio-economic segments.

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