ECONOMIC AND DEMOGRAPHIC CENTRES OF GRAVITY IN THE EUROPEAN CMEA COUNTRIES

by
JÓZSEF NEMES NAGY
Department of Regional Geography, Eötvös Loránd University Budapest

Received: 31. 12. 1979.

The statistical indices of regional concentration indicating the differences of regional development levels (regional dispersion, various indices of disproportion or concentration, entropy etc.) when used for geographical analysis have the major shortcoming that although they indicate the quantity of regional disproportion, and although a comparison at two points in time can establish the degree of convergence or differentiation, they do not provide explicit information on the *spatial structure* of a given phenomenon or the *spatial direction* of changes occurring. Clearly, a very vivid picture of spatial change can be made by plotting the comparative time data, but accurate measurements cannot be made merely by visual evaluation, and so it has become necessary to apply new methods. In the unification of the two approaches the statistical analysis of *quantitative* relations and the *visual* representation of the spatial structure by plotting on a map – *analogies taken over from physics* can be of great help in geography. One of them is the *calculation of gravitational centres*, which can be used to describe spatial demographic and economic processes.

Calculation of center of gravity

The co-ordinates of the center of gravity of a planar system consisting of n points, if the location of the points is given in the system and every point has a "weight", can be calculated as the weighted arithmetical mean of the co-ordinates of the points:

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

where x and y are the two co-ordinates of the gravity centre; x_i and y_i are the co-ordinates of the points and f_i indicates the weighting of each point.

Any spatial unit can be described in terms of the above model, be it a *spatial distribution of a country's population*, in which the points on the map correspond to settlements and the number of inhabitants corresponds to

the weight. By calculating the centre of population gravity we arrive at the *mean value* for spatial distribution. Examination of the location and shift over time of this point can produce most interesting conclusions.

The co-ordinates of the points are arrived at from the longitude and latitude of the centres of the settlements or by ad lib drawing of a new orthographic system of co-ordinates. The system of co-ordinates can be arranged in a number of different ways. Generally the origin of the system is placed in the left hand corner of the map, so that all co-ordinates will have a positive value. In the case of Hungary the ideal is to place the origin in the centre of Budapest, so that the signs of the co-ordinates of the calculated centres of gravity immediately show their geographic relationship with the capital.

It is not necessary to represent every single settlement on the map as a separate point when the calculations are required to provide only general guidelines. In such cases the entire population of a regional unit can be shown as a concentration in the calculated demographic centre of gravity of the region or randomly in the administrative centre of the region: fewer points can provide equally good results.

Published examples of the application of the centre of gravity method are found primarily in connection with demographic processes. Of Hungarian studies ones that stand out are L. Bene's (1961) where the method was used to analyse domestic demographic development.* This was also used by É. Ruttkay (1976) in her examination of the Ajka industrial region and as a methodological technique of regional planning in Kulcsár (1972). The aim of the present study is to verify that the method can also be applied to examination of *regional economic development* as well as in the surveys mentioned above which are primarily demographic.

If we use the production value or the national income produced at the basic points (settlements) as the weighting, rather than the number of inhabitants, the result is an *economic* centre of gravity, which will clearly be different from the location of the demographic centre of gravity.

For the calculation we have used the 1:2,000,000 scale map of the European socialist countries. The origin of the system of co-ordinates is Budapest. All the other basic points, i.e. the centres of the administrative areas of the given countries (county: megye, Bezirk, voivodship, kraj, judet, okrug) have been referred to. The system of co-ordinates has been taken on NS – EW axes, one unit corresponding to approximately 80 km (50 statute miles). The number of inhabitants and the production value of the given administrative area have been used for the weighting. Cities being se-

* The demographic centre of gravity of Hungary has in this century shifted approximately along a line between Budapest and Nagykőrös, in a SE – NW direction, gradually approaching the capital: the latest data places it some 30 – 35 km (c:20 statute miles) from Budapest, NE of Dabas. This does not coincide with the geographical centre of the country, which is SE of the demographic centre of gravity, in the village of Pusztavacs, Pest County. The motion of the demographic centre of gravity reflects synthetically the pull effect of the capital and the central chain of hills of the population, and the relative depopulation of the country's Great Plain, primarily a result of emigration from the area.

parate administrational units, such as Budapest, Prague, Bratislava, Bucharest, Sofia, Warsaw, Wroclaw, Poznan, Lodz and Cracow are included within the regional units of which they are neighbours.

The location and movement of the centres of gravity

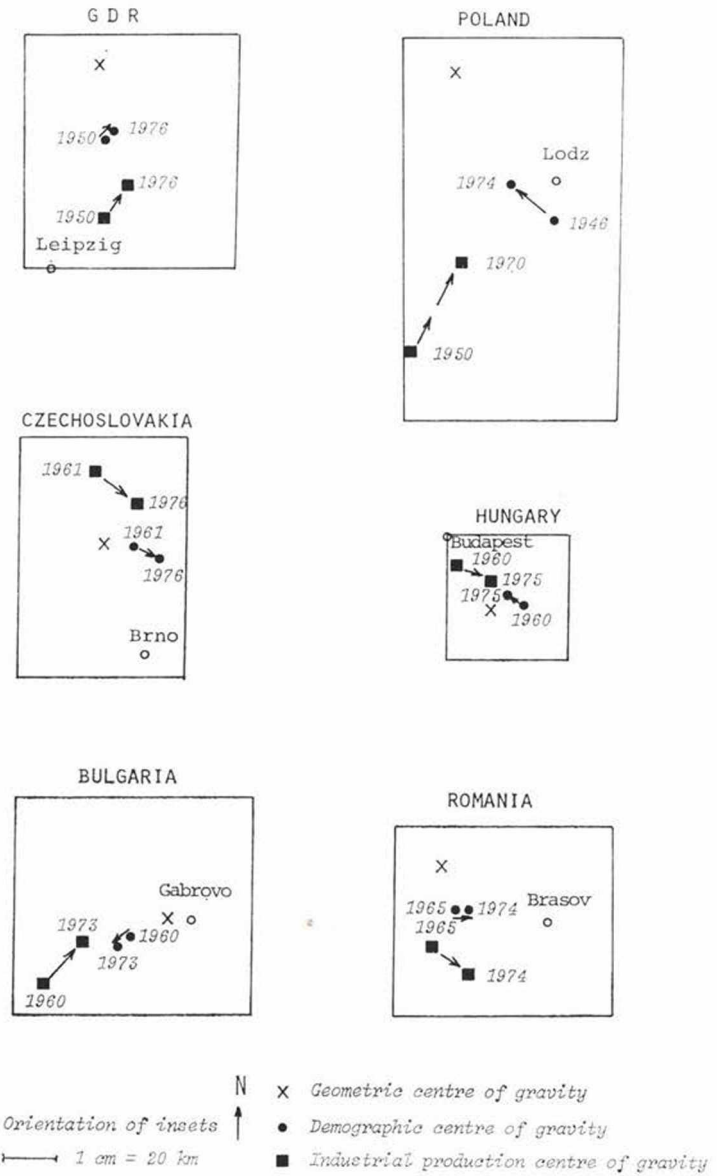
First of all let us look at the location of the demographic and industrial production gravity centres in each country, using data from the mid-1970s. The centres of gravity were located in relation with bigger cities (see illustration). In the GDR the two centres of gravity are located near Leipzig, in Poland near Lodz, in Czechoslovakia near Brno, in Hungary near Budapest, in Bulgaria near Gabrovo, and in Romania near Brasov. The *position* of the demographic and industrial centres of gravity *in relation to the geographical centres* is always revealing in terms of regional population

Country	Number of basic points	Period	Measure of shift of the centre of gravity		Distance between the demographic and industrial centres of gravity
			Demographic	Industrial	
			in units of the system of co-ordinates (1 unit = 80 km)		
GDR	15	1950 – 1976	0.04	0.17	–
		1950	–	–	0.33
		1976	–	–	0.19
Poland	17	1950 – 1970	0.12	0.41	–
		1950	–	–	0.89
		1970	–	–	0.42
Czechoslovakia	10	1961 – 1976	0.10	0.28	–
		1961	–	–	0.37
		1976	–	–	0.20
Hungary	19	1960 – 1975	0.04	0.09	–
		1960	–	–	0.29
		1975	–	–	0.17
Romania	39	1965 – 1974	0.04	0.17	–
		1965	–	–	0.19
		1974	–	–	0.26
Bulgaria	27	1960 – 1973	0.04	0.21	–
		1960	–	–	0.36
		1973	–	–	0.15

Table:

Source: The calculations of the author on the basis of official published statistics. The industrial centre of gravity is calculated on the basis of regional distribution of gross industrial production, except in Hungary, where the values of corrected national income of industrial origin are used for countries, based on a work of Barta (1977). The *direction* of the movements and centres of gravity in relation to each other can be seen on the figure.

THE MOVEMENT OF DEMOGRAPHIC AND INDUSTRIAL CENTRES OF GRAVITY IN THE EUROPEAN CMEA COUNTRIES



distribution. In the case of the GDR and Poland the fact that the two centres of gravity are SE of the respective geographical centres indicates a southerly concentration of economic activity. The situation is very similar in Romania as well, whereas in Hungary, the demographic centre of gravity is N, and the industrial one NE of the geographical centre, reflecting a concentration of productive forces and population diagonally along the central chain of hills. In Bulgaria the demographic and indsutrial preponderance of the western part of the country results in demographic and industrial centres of gravity SW of the geographical centre of the country. If we also measure *the distance from the geographical centre*, in the countries (GDR and Poland) where the densely populated and developed areas create a big, continuous, but not centrally located zone in the country, larger distances can be found. In all the countries except Czechoslovakia, the industrial centre of gravity is at a greater distance from the geometric centre than is the demographic centre of gravity, showing that regional disproportions are greater in industry than in the density of population.

The shift of the gravity centres

Regional redistribution of the population and regional changes in share of industrial production can be traced through the shifts of the centres of gravity. The scale of gravity centre shift can be seen in the table. If we compare the demographic and industrial centres of gravity in each country, in each case *the shift of the demographic centre of gravity* is much *less* than that of the industrial centre of gravity. A relatively bigger shift of the centres of gravity can only be seen in the Polish demographic centre of gravity, to the NE, and in the Czechoslovak centre of gravity, towards the SE. In the case of Poland this can be related to the great migration of the population as a result of the changes in the borders after World War II, and in Czechoslovakia it results from the greater growth rate of the population in the Slovak areas. While longer period is necessary for significant changes to be observable in the demographic map, the relatively more mobile nature of production means and investments result in a bigger shift in the industrial centres of gravity. (A similar conclusion was drawn by Hunke (1969) from his calculations for the Federal Republic of Germany.) Since the periods under discussion differ in each country, the shifts of the industrial centres of gravity can only be compared directly by dividing the total shift value for the period by the number of years, to give an assumed annual value. According to this the greatest shift occurred in the industrial centre of gravity of Poland (NE) followed by Czechoslovakia (SE), Bulgaria (NE), Romania (SE), the GDR (NE), and last of all Hungary, where the shift of the industrial centre of gravity was the slightest, in a south-easterly direction. Since the size of the countries under discussion differs, the scale of shift is scarcely comparable, so no further details of the problem will be discussed in the present study. But obviously, in each country the *direction* of the shift of the industrial gravity centre contains an *easterly* element. This phenomenon can first of all be explained by the intensive cooperation with, and raw material and energy imports from the

Soviet Union, upon which new towns, petrochemical complexes and metallurgical centres have been sited, such as Schwedt, Plock, Leninváros, Burgas, Eisenhüttenstadt, Kosice, Galati. This easterly shift of the industrial centre of gravity deriving from economic changes happily coincides with the dynamic development of what were earlier underdeveloped agricultural areas, such as Slovakia, the Hungarian Great Plain, SE – Romania and the Bulgarian Coast. In parallel with these regional economic processes, it is worth noting that the economic and industrial centres of gravity of the USSR are also shifting towards the east, as a result of the development of the areas beyond the Urals.

The distance between the demographic and industrial centres of gravity can be regarded as the index of existing *regional disproportions in industrial development.* In the countries under discussion (except Romania) the two centres of gravity have been converging, which shows an evening out of regional industrial development. In Poland and Bulgaria the distance had shortened by more than 50% by the end of the period surveyed. The next largest convergences have been in the GDR and Czechoslovakia, while in Hungary the convergence has been smaller. The lessening of the distance between the two gravity centres has occurred in two ways. In one group of countries both main points have shifted in essentially the same direction, with the industrial centre of gravity gradually gaining upon the demographic centre of gravity (GDR, Czechoslovakia). In another group (Hungary, Bulgaria and to an extent Poland) the two centres of gravity have shifted in opposite directions and thus converged. *In Romania* a marked SE shift of the industrial gravity centre in the period under survey has brought it further from the demographic gravity centre, which remained almost static. This illustrates the gradual lagging behind of the NE of the country in terms of industrial development* *

Some practical applications of the gravity centre system

Above we have presented the theoretical use of the gravity centre method. We now consider the practical applications of the method in the regional planning.

Logically the position of the centre of population gravity can be taken into account in *industrial location decisions.* This was the case when the site of the new capital of Brasilia was determined; it was built in the vicinity of the country's demographic centre of gravity. The Australian capital, Canberra, is located approximately halfway between Melbourne and Sydney. In Hungary, the method was recently taken into account in siting the Solt Transmitter Station: that it should be built near the demographic centre of gravity was a major consideration. In these cases the mathematical character in the calculation of the centre of gravity is essential that

** Further details are here not given, but from the position of the gravity centres of investment calculated on the basis of the regional investment ratios, it can clearly be concluded that the two tendencies mentioned – easterly shift and evening out – will continue in the future in the countries discussed in the paper.

the square of the total of its weighted distances from the basic points is less than the square of the total measured from any other point. The *position* of the object or town sited near the centre of gravity from the point of view of accessibility approaches the *optimal* (in the case of a radio transmitter the conditions of reception), with regard to the whole country.

The position of the demographic centre of gravity can also direct the choice of location on less than national scale. The demographic centre of gravity of Budapest was not far from the geometric centre of the city before 1945, near the Great Boulevard. By now it has moved towards the Eastern Railway Station, because of the rapid increase of the population on the outskirts, as a result of the 1950 boundary changes. The position of the demographic centre of gravity (on a town or district level) is also worth considering when a new service project (shopping centre, post office, city council, railway station etc.) is built for the residents. The final decision is of course determined by several other important factors as well, and it frequently happens that a theoretically ideal location has practical drawbacks.

The economic centre of gravity can likewise be used in regional planning, primarily in the theoretical preparations for locating a new industrial unit. Knowing the location of the gravity centre can be very useful in siting a warehouse to supply more than one industrial unit, an agricultural manufacturing plant (e.g. a canning factory), a foundry or a chemical works. But in these cases it is expedient to use transport distances weighted by the costs of transport and not merely straight-line distances, because these may differ accordingly to the goods involved. In such cases the location of the emissive points should be determined in the "space of cost", taking into account transportation routes and costs.

Naturally the gravity centres method can be of great assistance in examining an economic or social phenomenon that can be localized into regions, and its application is not limited to the examples mentioned above. The method introduced above is also suitable, in a simplified form, for use in the practical high school geography curriculum, all the more so since the concept of gravity centres is already a part of school curriculum for mathematics and physics.

REFERENCES

Barta, Gy. 1977: A területi gazdasági különbségek változása 1960 – 1975 között. (Changes in Regional Economic differences between 1960 and 1975). Területi Statisztika/5.

Bene, L. 1961: Magyarország népességi súlypontja (The Demographic Centre of Gravity of Hungary). Demográfia/1.

Hunke, H. 1969: Der interregionale Wohlstandausgleich. "Informationen" 17 – 18.

Kulcsár, V. ed. 1972: Területi tervezés, tanácsi tervezés (Regional Planning, Council Planning). Közgazdasági és Jogi Könyvkiadó Budapest.

NemesNagy, J. ed. 1977: Regionális gazdaságföldrajzi gyakorlatok (Exercises in Regional Geography). Tankönyvkiadó Budapest.

Ruttkay, É – Csorba, Z. 1976: Ajka, az iparból nőtt város (Ajka, the Town that Grew from Industry). Területrendezés.

РЕЗЮМЕ

ЭКОНОМИЧЕСКИЕ И ДЕМОГРАФИЧЕСКИЕ ЦЕНТРЫ ТЯЖЕСТИ В ЕВРОПЕЙСКИХ СТРАНАХ, ЧЛЕНАХ СЭВ-А

Метод вычисления центра тяжести география заимствовала от физики. Используя этот метод, автор анализирует особенности территориального экономического развития европейских социалистических стран, членов СЭВ-а. Результаты расчетов показывают, что во всех странах, центр тяжести промышленного производства перемещается на восток. Можно утверждать, что центр тяжести промышленного производства перемешается быстрее, чем центр тяжести населения. За исключением Румынии, центр тяжести промышленного производства и населения сблизились, что подтверждает тенденцию территориального выравнивания промышленной развитости. Методом «центра тяжести» можно пользоваться при территориальном планировании, а также в процессе теоретической подготовки решений о размещении.