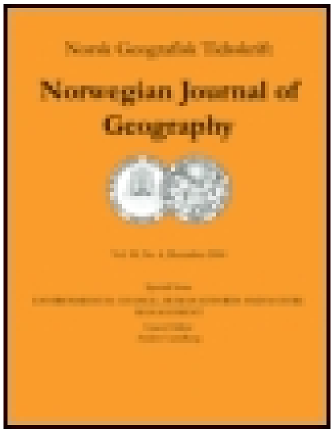


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# The changing economic spatial structure of Europe

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**SHORT ARTICLES – *NOTISARTIKLER***

# The changing economic spatial structure of Europe

GÉZA TÓTH, ÁRON KINCSES & ZOLTÁN NAGY

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Many theoretical and practical works aim at describing the spatial structure of Europe, where spatial relations have undergone continuous change. The article gives an overview of models describing the spatial structure of Europe. The models' diversity is highlighted, without any claim to the completeness of the list of models discussed. The authors describe the economic spatial structure of Europe through bidimensional regression analysis based on a gravity model. With the help of the gravity model, they generate a spatial image of the economic spatial structure of Europe. With the images, the appropriateness of the models based on different methodological backgrounds can be justified through comparison with the authors' results. The authors aim to contribute to understanding the European economic spatial structure through a new methodological approach, rather than to create and show a new model that overwrites existing ones.

Keywords: *bidimensional regression, Europe, gravity model, spatial models*

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## Introduction

Many theoretical and practical works aim at describing the spatial structure of Europe, where spatial relations have undergone continuous change. This article gives an overview of models describing the spatial structure of Europe. Our study aims at describing the economic spatial structure of Europe with bidimensional regression analysis based on the gravitational model. Our goal is not to create and present a new model that overwrites the existing ones, but rather to contribute to understanding the European spatial structure through a new methodological approach.

Some of the theories, models, and descriptions dealing with the economic and social spatial structure of Europe are static, as they focus on the current status and on describing structures. Within the aforementioned group of theories, models, and descriptions, we include the Roger Brunet's concept of the 'European Backbone' (Brunet 1989), including what later became the called the 'Blue Banana' and what Grzegorz Gorzelak called the 'Central European Boomerang' (Gorzelak 2012) (Fig. 1). In addition, the group includes attempts to visualise different polygons (triangles, tetragon) (Brunet 2002).

Among popular spatial structure models are visualisations that highlight potential movements and changes in spatial structure and development. We present some of the models, without any claim to the list's completeness. The growing zone on the northern shore of the Mediterranean Sea corresponds to one such model, called the 'European Sunbelt' by Kunzmann (1992, cited in Kozma 2003), who associates it with one of the rapidly growing southern zones of the United States of America.

The 'Red Octopus' model can be classified as a dynamic model, as it focuses on the future and introduces potential changes in the future, given that this is a vision for 2046 predicting which of Europe's regions will develop the fastest (Fig. 2). In this structure, the body and the western arms stretch approximately between Birmingham and Barcelona toward Rome and Paris. Its form stretches towards Copenhagen–Stockholm–(Helsinki) to the North and towards Berlin–Poznan–Warsaw and Prague–Vienna–Budapest to the East (van der Meer 1998). Unlike earlier visualisations, this model includes the group of developed zones and their core cities, highlighting the possibilities to decrease spatial differences by visualising polycentricity and 'eurocorridors' (Szabó 2009). Development is similarly visualised by the 'Blue Star' model (Dommergues 1992), with arrows to indicate the directions of development and the dynamic areas.

We argue that the description of the 'Bunch of Grapes' model by Kunzmann & Wegener (1991) and Kunzmann (1992; 1996) includes change and the visualisation of development (Fig. 3). By focusing on the polycentric spatial structure, urban development and the dynamic change of urban areas can be highlighted (Szabó 2009). Polycentricity has become an increasingly popular idea and a key part of the European Spatial Development Perspective (ESDP), adopted by the European Union's Council of Ministers Responsible for Spatial Planning, in Potsdam, 10–11 May 1999 (European Commission 1999). It also has had an increasingly important role in the European cohesion policy (Faludi 2005; Kilper 2009). However, at the same time, critical statements have appeared against this type of approach to planning, for example from the point of view of economic efficiency or sustainable development (Vandermotten et al. 2008).



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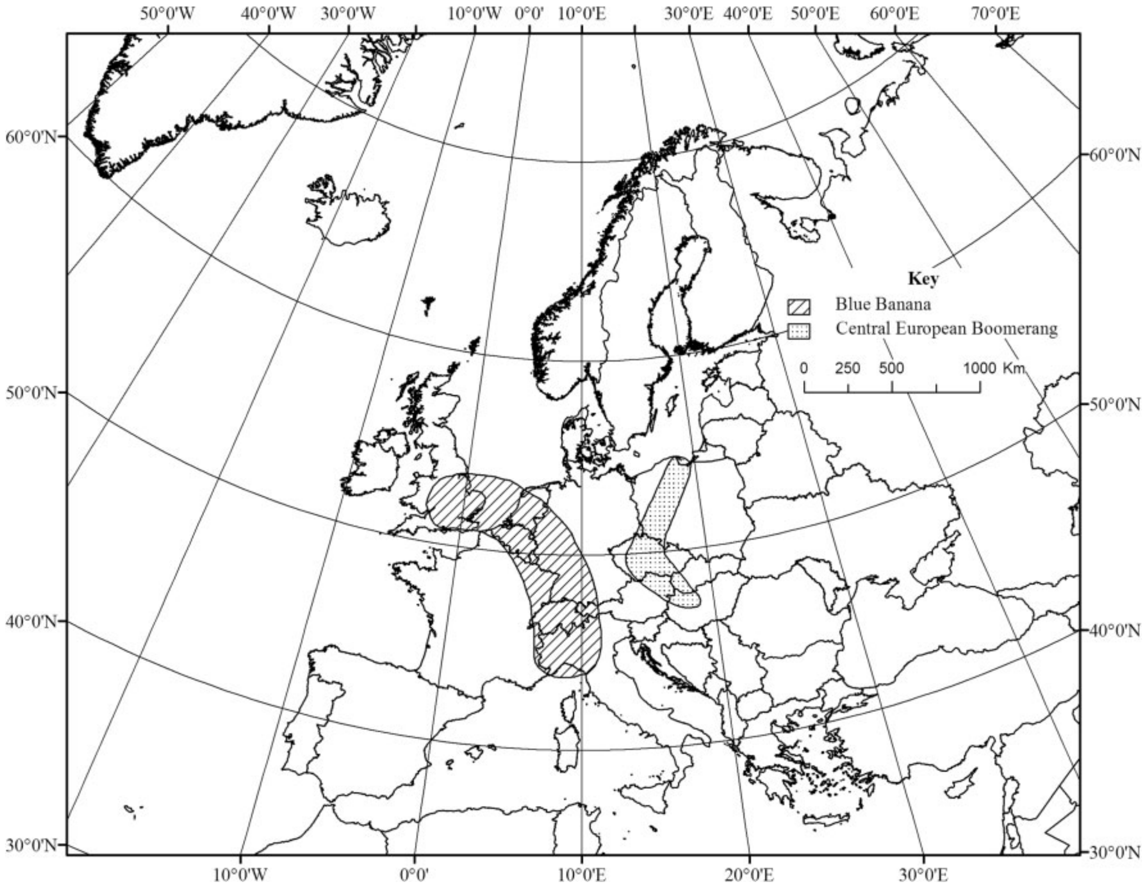


*Fig. 1.* Economic spatial structure models: Blue Banana and Central European Boomerang (based on Brunet (1989) and Gorzelak (2012))

In many cases, it is not the form describing the spatial structure or the quality and extension of the formation (i.e. the static description) that is crucial, but rather the visualisation of the changes, processes, and the relationships among regions. Moreover, it is important to analyse the ways and developments that can create opportunities to utilise advantages and positive effects (Hospers 2003). Dynamic visualisations can help in such analyses.

In the following sections we examine more thoroughly the background of the spatial structural relations and models with the use of the gravity model and bidimensional regression. In all of our examples, we apply gross domestic product (GDP) values as a determining measure of territorial development, as we consider that its use allows a detailed analysis of spatial structure. We apply GDP, as this is the most widely used economic variable. However, similar results could have been obtained if other indicators (such as employment rate) had been used. The results of the two calculations would have differed only slightly.

## Gravity models and examination of spatial structure

Gravity models, which are based on the application of physical forces, are an important method for examining spatial structure. With the approach that we present here, one can assign attraction directions to the given territorial unit that are caused by other units. The universal gravitational law, Newton's gravitational law, states that any two point-like bodies mutually attract each other by a force, the magnitude of which is directly proportional to the product of the bodies' weight and is inversely proportional to the square of the distance between them (Budó 1970) (Eq. 1):

$$F = \gamma \cdot \frac{m_1 \cdot m_2}{r^2} \tag{1}$$

where the proportionality measure $\gamma$ is the gravitational constant (regardless of space and time).

If the radius vector from point mass 2 to point mass 1 is designated by $r$, then the unit vector from point 1 to point 2 is —$r$ and therefore the gravitational force applied on point mass 1 due to point mass 2 is (MacDougal 2013):

$$\vec{F}_{1,2} = -\gamma \cdot \frac{m_1 \cdot m_2}{r^2} \cdot \frac{\vec{r}}{r} \tag{2}$$

A gravitational force field is definite if the direction and the size of gradient K can be defined at each point in the given field. To do so, provided that K is a vector, three pieces of data are necessary for each point (two in the case of a plane), such as the rectangular components $K_x$, $K_y$, $K_z$ of the gradient as the function of the place. However, like the gravitational force field, many force fields can be described in a much simpler way by

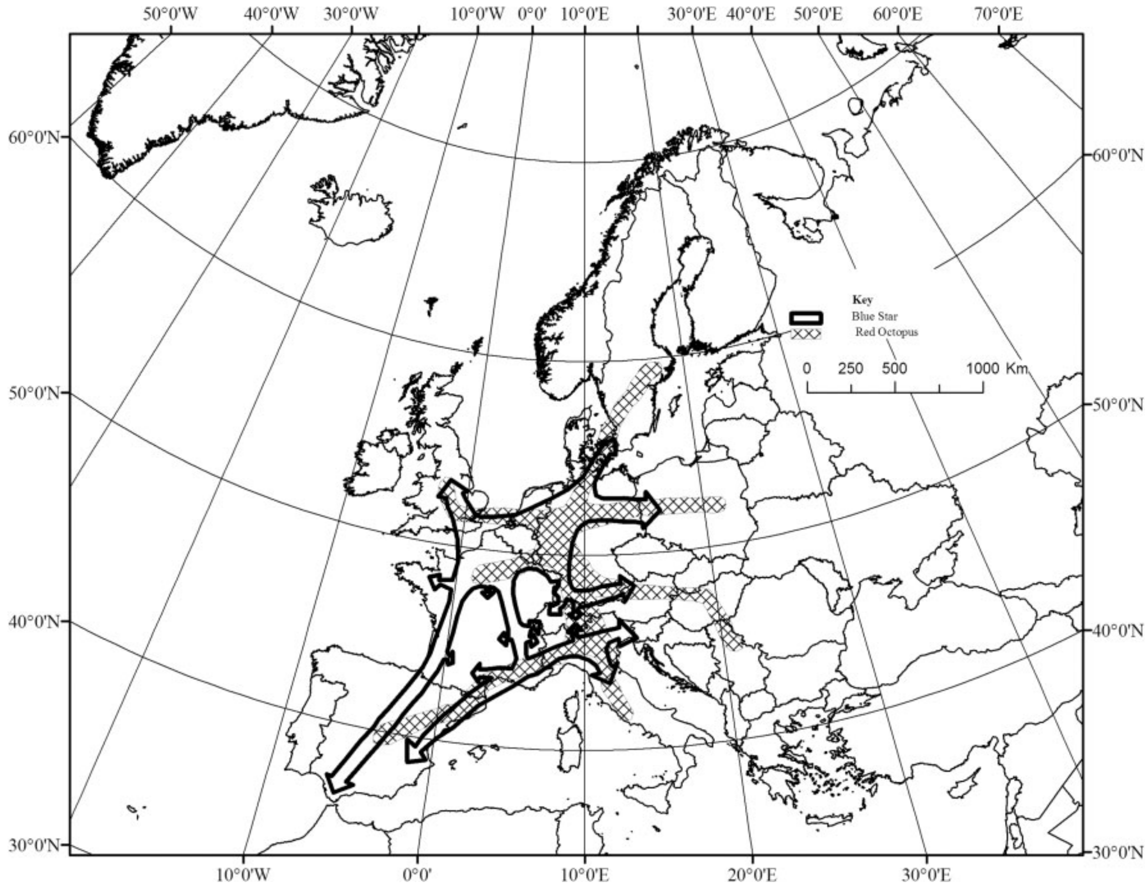


*Fig. 2*. Economic spatial structure models: Blue Star and Red Octopus (based on van der Meer (1998) and Dommergues (1992))

using just one scalar function, termed the potential, instead of using three variables (Fig. 4) (Budó 1970).

Potential has a similar relation to gradient as work or potential energy has to force. If in the gravitation field of gradient K, the trial mass on which a force of $\boldsymbol{F}=m\boldsymbol{K}$ is applied is moved from point A to point B by force $-\boldsymbol{F}$ (without acceleration) along some path, then the work of

$$L = -\int_A^B F_s ds$$

has to be done against force $\boldsymbol{F}$ based on the definition of work. This work is independent of the path from A to B, and therefore it is the change in the potential energy of an arbitrary trial mass:

$$L = E_{potB} - E_{potA} = -\int_A^B F_s ds = -m\int_A^B K_s ds.$$

By dividing by $m$, the potential difference between points B and A in the gravitational space is:

$$U_B - U_A = -\int_A^B K_s ds$$

By utilizing this relation, in most social scientific applications of the gravitational model to date space primarily has intentionally been described by only one scalar function (see, for example, the potential model) (Kincses & Tóth 2011), while in the gravitational law, it is mainly the vectors characterising the space that have an important role, for the main reason that arithmetic operations with numbers are easier to handle than calculations with vectors. In other words, for work with potentials, solving the problem also means avoiding calculation problems.

Even if potential models often show properly the concentration focus of the population or GDP and the space structure, they are not able to provide any information on the direction towards which the social attributes of the other regions attract a specified region or on the force with which they attract it. Therefore, by using vectors we are trying to demonstrate the direction in which the European regions are attracted by other regions in the economic space compared to their real geographical position. We utilise the European Commission's NUTS classification (Nomenclature des unités territoriales statistiques/ Nomenclature of Territorial Units for Statistics) on three levels (NUTS 1, 2, and 3) (Eurostat 2012). We take note of the fact that the NUTS regions – although defined within minimum and maximum population thresholds at each level – vary considerably in geographical size, with the result that in many cases the use of this system (e.g. in the case of Nordic regions) raises the modifiable areal unit problem (Openshaw 1983). In this study

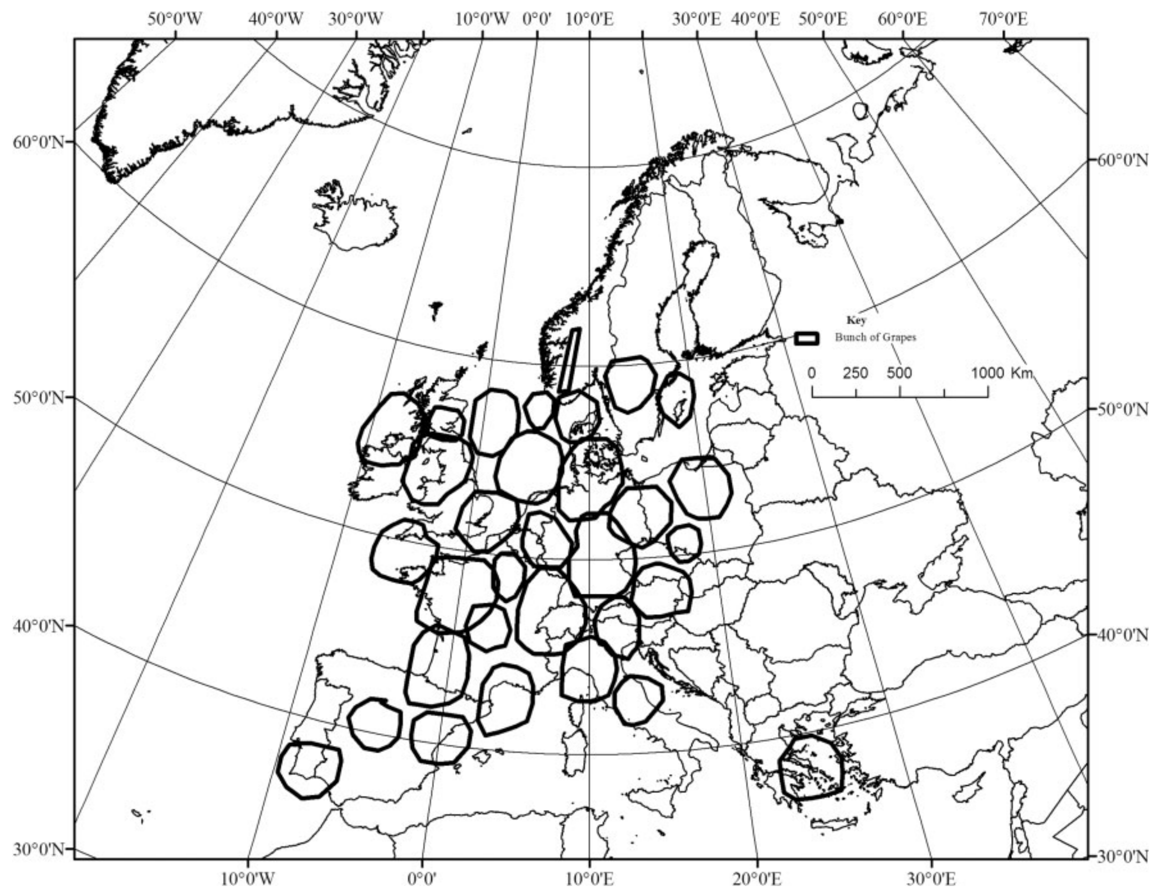


*Fig. 3.* Economic spatial structure model: Bunch of Grapes (based on Kunzmann & Wegener (1991) and Kunzmann (1992; 1996))

makes use of the NUTS system, despite its imperfections. Management of the modifiable areal unit problem could have been done with complex methods, which are beyond the scope of this study. Using our gravity analysis, it is possible to reveal the centres and fault lines representing the most important areas of attractiveness and it is possible to visualise the differences between the gravitational orientation of the regions.

In the traditional gravitational model (Stewart 1948), the 'population force' between i and j is expressed in $D_{ij}$, where $W_i$ and $W_j$ are the populations of the settlements (regions), $d_{ij}$ is the distance between i, and j, and g is the empirical constant:

$$D_{ij} = g \cdot (\frac{W_i \cdot W_j}{d_{ij}^2}) \tag{3}$$

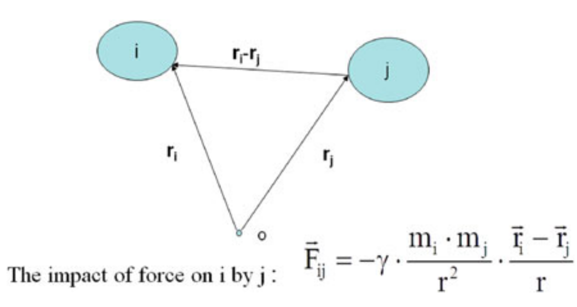


*Fig. 4.* Calculation of gravitational force

With the generalisation of the above formula, the following relationship is given in equations (4) and (5):

$$D_{ij} = \left|\overrightarrow{D_{ij}}\right| = \frac{W_i \cdot W_j}{d_{ij}^c} \tag{4}$$

$$\overrightarrow{D_{ij}} = -\frac{W_i \cdot W_j}{d_{ij}^{c+1}} \cdot \overrightarrow{d_{ij}} \tag{5}$$

where $W_i$ and $W_j$ indicate the masses taken into consideration, $d_{ij}$ is the distance between them and c is the constant, which is the change in the intensity of the interterritorial relations as a function of the distance. With the increase of the power, the intensity of the interterritorial relations becomes more sensitive to the distance and at the same time the importance of the masses gradually decreases (Wilson 1981; Dusek 2003).

With the above-described extension of the formula, not only the force between the two regions but also its direction can be defined. In the calculations, it is worth dividing the vectors into x and y components and then summarising them separately. In order to calculate this effect (i.e. the horizontal and vertical components of the forces), the necessary formulas can be deduced from equations 4 and 5:

$$D_{ij}^X = -\frac{W_i \cdot W_j}{d_{ij}^{c+1}} \cdot (x_i - x_j) \tag{6}$$

$$D_{ij}^{Y} = -\frac{W_i \cdot W_j}{d_{ij}^{c+1}} \cdot (y_i - y_j) \quad (7)$$

where $x_i$, $x_j$, $y_i$, $y_j$ are the coordinates of centroids of regions i and j.

However, if the calculation is carried out for each region included in the analysis, the direction and the force of the effect on the given territorial unit can be defined using equations (8) and (9):

$$D_{ij}^{X} = -\sum_{j=1}^{n} \frac{W_i \cdot W_j}{d_{ij}^{c+1}} \cdot (x_i - x_j) \quad (8)$$

$$D_{ij}^{Y} = -\sum_{j=1}^{n} \frac{W_i \cdot W_j}{d_{ij}^{c+1}} \cdot (y_i - y_j) \quad (9)$$

With equations 8 and 9, the magnitude and direction of the force exerted by the other regions can be defined for each territorial unit. The direction of the vector assigned to the regions determines the attraction direction of the other regions, whereas the magnitude of the vector is related to the magnitude of the force. In order to make visualisation possible, the forces are transformed to proportionate movements in equations (10) and (11):

$$x_i^{\mathrm{mod}} = x_i + \left( D_{ij}^{X} * \frac{x^{\max}}{x^{\min}} * k \frac{1}{\frac{D_{ij}^{X\max}}{D_{ij}^{X\min}}} \right) \quad (10)$$

$$y_i^{\mathrm{mod}} = y_i + \left( D_{ij}^{Y} * \frac{y^{\max}}{y^{\min}} * k \frac{1}{\frac{D_{ij}^{Y\max}}{D_{ij}^{Y\min}}} \right) \quad (11)$$

where $X_i$ mod and $Y_i$ mod are the coordinates of the new points modified by gravitational force, x and y are the coordinates of the original point set, their extreme values are $x_{max}$, $y_{max}$, $x_{min}$, and $y_{min}$, $D_{ij}^{X}$ and $D_{ij}^{Y}$ are the forces along the axes, their extreme values are $D_{ij}^{Xmax}$, $D_{ij}^{Xmin}$, $D_{ij}^{Ymax}$, $D_{ij}^{Ymin}$ and k is a constant, in this case its value is 0.5. We obtained this value as a result of an iteration process.

It is worth comparing the point set obtained by the gravitational calculation (using GDP as a weight) with the baseline point set (i.e. with the actual real-world geographic coordinates, and later with each other) and examining how the space is changed and distorted by the field of force. In such comparisons, not only may the conventional gravitational fields be located as shown in other models, but also the gravity direction can be found. With this analysis, it is possible to reveal the centres and fault lines representing the most important areas of attractiveness and it is possible to visualise the differences among the gravitational orientation of the regions. In order to realise the gravity analysis in practice, bidimensional regression needs to be used.

## Bidimensional regression

It is possible to compare the new point set with the original one through applying this analysis. This comparison can be done with visualisation, but in the case of such a large number of points, this probably does not provide a promising result by itself. Much more favourable results can be obtained by applying bidimensional regression analysis (see the equations related to the Euclidean version in Table 1), which is a

*Table 1.* The equations of the bidimensional Euclidean regression (Sources: Tobler (1994) and Friedman & Kohler (2003, cited in Dusek (2011, 14))

| | |
|---|---|
| 1. The regression equation | $\begin{pmatrix} A' \\ B' \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + \begin{pmatrix} \beta_1 & -\beta_2 \\ \beta_2 & \beta_1 \end{pmatrix} * \begin{pmatrix} X \\ Y \end{pmatrix}$ |
| 2. Scale difference | $\Phi = \sqrt{\beta_1^2 + \beta_2^2}$ |
| 3. Rotation | $\Theta = \tan^{-1}\left(\frac{\beta_2}{\beta_1}\right)$ |
| 4. $\beta_1$ | $\beta_1 = \frac{\sum (a_i-\bar{a})*(x_i-\bar{x}) + \sum (b_i-\bar{b})*(y_i-\bar{y})}{\sum (x_i-\bar{x})^2 + \sum (y_i-\bar{y})^2}$ |
| 5. $\beta_2$ | $\beta_2 = \frac{\sum (b_i-\bar{b})*(x_i-\bar{x}) - \sum (a_i-\bar{a})*(y_i-\bar{y})}{\sum (x_i-\bar{x})^2 + \sum (y_i-\bar{y})^2}$ |
| 6. Horizontal shift | $\alpha_1 = \bar{a} - \beta_1 * \bar{x} + \beta_2 * \bar{y}$ |
| 7. Vertical shift | $\alpha_2 = \bar{b} - \beta_2 * \bar{x} - \beta_1 * \bar{y}$ |
| 8. Correlation based on the error terms | $r = \sqrt{1 - \frac{\sum\left[(a_i-a_i')^2 + (b_i-b_i')^2\right]}{\sum\left[(a_i-\bar{a})^2 + (b_i-\bar{b})^2\right]}}$ |
| 9. The resolution difference of a square sum | $\sum\left[(a_i-\bar{a})^2 + (b_i-\bar{b})^2\right] = \sum\left[(a_i'-\bar{a})^2 + (b_i'-\bar{b})^2\right] + \sum\left[(a_i-a_i')^2 + (b_i-b_i')^2\right]$ <br> SST = SSR + SSE |
| 10. A ′ | $A' = \alpha_1 + \beta_1(X) - \beta_2(Y)$ |
| 11. B ′ | $B' = \alpha_2 + \beta_2(X) + \beta_1(Y)$ |

quantifiable method. In this examination, we apply GDP as weighting variable.

In the equations in Table 1, x and y refer to the coordinates of the independent form, a and b designate the coordinates of the dependent form, $a'$ and $b'$ are the coordinates of the independent form in the dependent form. $\alpha_1$ refers to the extent of the horizontal shift, while $\alpha_2$ defines the extent of the vertical shift. $\beta_1$ and $\beta_2$ are used to determine the scale difference ($\Phi$) and $\Theta$ is the rotation angle. SST is the total sum of squares, SSR is the sum of squares due to regression and SSE is the explained sum of squares of errors/residuals that is not explained by the regression.

To visualise the bidimensional regression, the Darcy program (Vuidel 2009) can be useful. The grid is fitted to the coordinate system of the dependent form and its interpolated modified position makes it possible to further generalise the information about the points of the regression.

## Empirical analysis

The arrows in Fig. 5 show the direction of movement and the grid shading refers to the nature of the distortion. Areas indicated with dark shades refer to concentration and to movements in the same directions (convergence), which can be considered to be the most important gravitational centres.

Our method of analysis can be carried out at NUTS 1, 2, and 3 levels. A comparison of the results between real and modified coordinates with those of bidimensional regression can be found in Table 2. As shown, the lower the level used for the analysis, the smaller the deviation of the gravitational point form from the original structure. This is proven by the correlation and by the sum of squared deviations and their components. Because of the mass differences among the regions, the analyses carried out at different territorial levels show results that are different in their nature even though they are similar in many aspects of their basic structure. Hence, we decided to carry out the analysis at each territorial level in order to examine the different levels of the spatial structure. The regression is greater if the examined spatial level is smaller. We visualised our results and drew the following conclusions.

The analysis carried out at NUTS 1 level contains only the most general relations. However, those general relations are not sufficient to enable a deeper analysis of the spatial structure. Therefore, it is necessary to perform such an analysis at NUTS 2 level. As shown in Fig. 5, regional concentrations can be seen unambiguously, and we consider them to be the core regions. Based on the analysis carried out at NUTS 2 level, three gravitational centres that are slightly related to each other can

*Fig. 5*. Directions of the distortion of gravitational space compared to geographical space for the European NUTS 2 regions)

*Table 2*. Bidimensional regression between gravitational and geographical spaces (r = correlation based on the error terms; $\alpha_1$ = horizontal shift; $\alpha_2$ = vertical shift; $\beta_1$ = regression coefficient; $\beta_2$ = regression coefficient; $\Phi$ = scale difference; $\Theta$ = rotation; SST = total sum of squares; SSR = sum of squares due to regression; SSE = sum of squares of errors/residuals)

| Level | r | $\alpha_1$ | $\alpha_2$ | $\beta_1$ | $\beta_2$ | $\Phi$ | $\Theta$ | SST | SSR | SSE |
|---|---|---|---|---|---|---|---|---|---|---|
| NUTS1 | 0.91 | 0.19 | 0.69 | 0.99 | 0.00 | 0.99 | 0.00 | 20 430 | 19 849 | 582 |
| NUTS2 | 0.97 | 0.04 | 0.15 | 1.00 | 0.00 | 1.00 | 0.00 | 54 121 | 53 484 | 638 |
| NUTS3 | 0.99 | 0.13 | −0.04 | 1.00 | 0.00 | 1.00 | 0.17 | 139 884 | 139 847 | 37 |

be found in the European space. Gravitational centres are the regions that attract other regions and the gravitational movement is toward them. These three centres or cores are: (1) the region including Baden-Württemberg, the western part of Austria, and the eastern part of Switzerland; (2) the region including the Benelux countries and the western part of Nordrhein-Westfalen; and (3) the region including most of England. These core areas mainly have an effect on the regions of the examined area. The three centres also include two concentration spurs. The stronger and undoubtedly the more important one extends from the eastern part of Switzerland through southern France to Madrid, whereas the other somewhat weaker one starts from that point and extends through the Apennine Peninsula.

We find that the key element of the economic spatial structure of Europe – as can be seen at NUTS 1 and NUTS 2 levels – is the structure reflected by the Blue Banana theory. However, at NUTS 2 and NUTS 3 levels, the most important hubs, centres, and focus points clearly emerge in the spatial structure. These elements are in some cases similar to the arms of the Red Octopus. However, it should be pointed out that, as shown clearly by the NUTS 3 level examination, the European economic spatial structure is not uniform but rather a significantly fragmented and somewhat separated economic space. In other words, while at the higher spatial levels the basic structure is clear, that is not the case true when we analyse the structure at a lower spatial level. Rather, the Bunch of Grapes theory becomes relevant in such cases, although we find fewer 'grapes' than the original theory does.

Defining the core regions is easy using gravity analysis, provided that they are defined as regions with converging spatial movements and can be considered the main gravitational centres. Such regions are indicated for 2009 in Fig. 6, within the heavy black line.

In the following section, we try to take into account the change of the structure. For that purpose, the gravity calculations are performed for 1995 and 2009. Due to lack of data, we cannot include the regions of Turkey in the calculation, and therefore the figures for 2009 are slightly different from those represented in Fig. 5. In order to measure changes, we compare and analyse the two gravity sets of points (1995 and 2009). The two-dimensional regression calculations are shown in Tables 3 and 4.

Our results show that there is a strong relationship between the two point systems; the transformed version from the original point pile can be obtained without using rotation (Θ = 0). No essential ratio difference between the two shapes is observed.

In term of change from 1995 to 2009, 15 gravity centres are shown on the map, indicated by shaded ellipses (Fig. 6). The centres show a crucial part of the economic potential of big cities. Such hubs are the hinterlands of Rome, Marseille, Madrid, Vienna, Hamburg, Brussels, Oslo, and Glasgow.

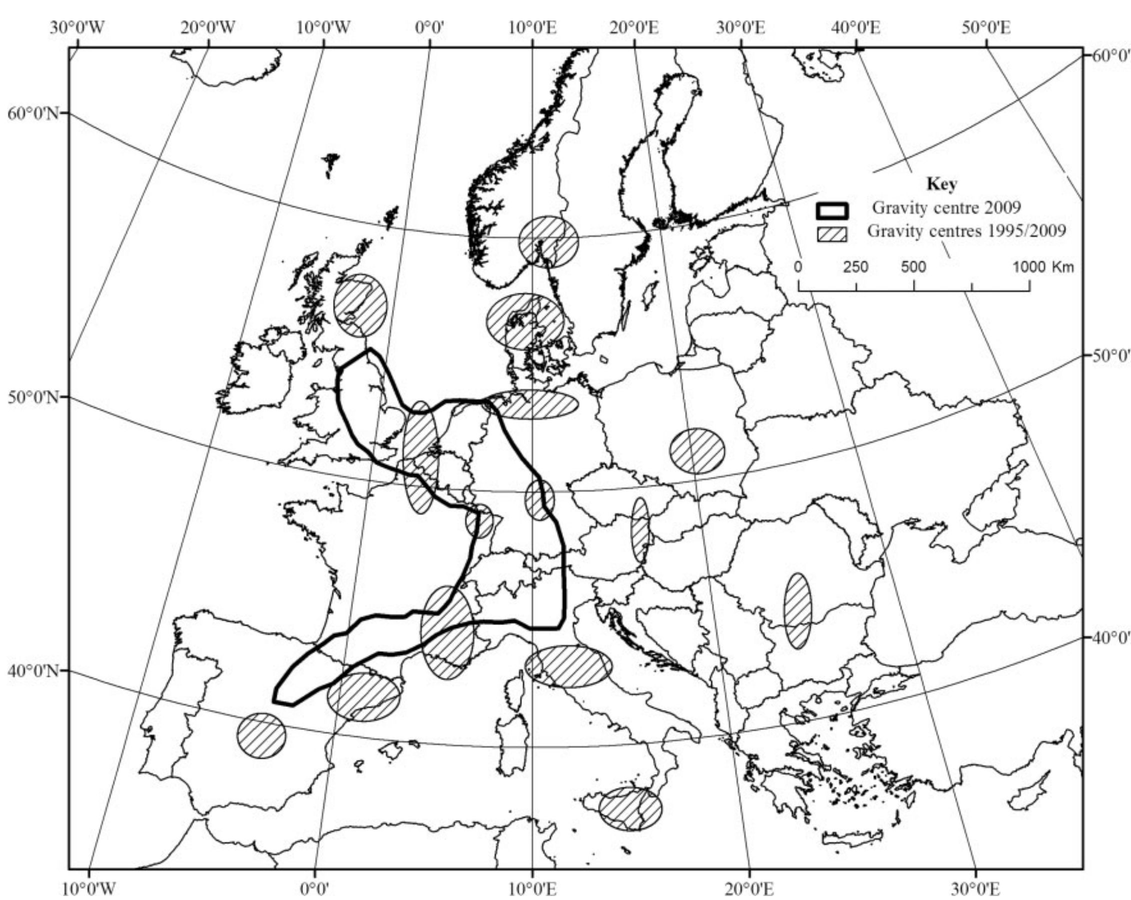


*Fig. 6*. Reresults of the applied gravity model applied by the authors

*Table 3*. Bidimensional regression between gravitational and geographical spaces (r = correlation based on the error terms; $\alpha_1$ = horizontal shift; $\alpha_2$ = vertical shift; $\beta_1$ = regression coefficient; $\beta_2$ = regression coefficient; $\Phi$ = scale difference; $\Theta$ = rotation; SST = total sum of squares; SSR = sum of squares due to regression; SSE = sum of squares of errors/residuals)

| Year | r | $\alpha_1$ | $\alpha_2$ | $\beta_1$ | $\beta_2$ | $\Phi$ | $\Theta$ | SST | SSR | SSE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 0.92 | 0.07 | 0.37 | 0.99 | 0.00 | 0.99 | 0.00 | 65 446 | 62 525 | 2 922 |
| 2009 | 0.92 | 0.05 | 0.26 | 0.99 | 0.00 | 0.99 | 0.00 | 65 632 | 62 811 | 2 821 |

*Table 4*. Bidimensional regression between gravitational spaces (r = correlation based on the error terms; $\alpha_1$ = horizontal shift; $\alpha_2$ = vertical shift; $\beta_1$ = regression coefficient; $\beta_2$ = regression coefficient; $\Phi$ = scale difference; $\Theta$ = rotation; SST = total sum of squares; SSR = sum of squares due to regression; SSE = sum of squares of errors/residuals)

| Year | r | $\alpha_1$ | $\alpha_2$ | $\beta_1$ | $\beta_2$ | $\Phi$ | $\Theta$ | SST | SSR | SSE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995/2009 | 0.99 | −0.01 | −0.06 | 1.00 | 0.00 | 1.00 | 0.00 | 65 632 | 65 607 | 25 |

A gravity 'breakline' can be seen in northern France, northern Italy, Switzerland, and Hessen and northern Saxony in Germany. In general, the change from 1995 to 2009 was not fundamental in the examined period but rather focused on only a few areas. These areas are parts of the Bunch of Grapes fields, which may show the increasing importance of the theory. However, there are fewer nodes or 'grapes' than the model predicts.

As far as the analysis of change is considered, the closest connection is to the Red Octopus model, because 11 of the 15 gravity nodes were directly affected by the 'octopus tentacles'. The analysis confirms the favourable position of certain regions, such as the Sunbelt zone and the Blue Banana. Our results do not confirm the existence of the Central European Boomerang (Gorzelak 2012), and hence we do not consider that the area it supposedly covers would be favourable at the European level.

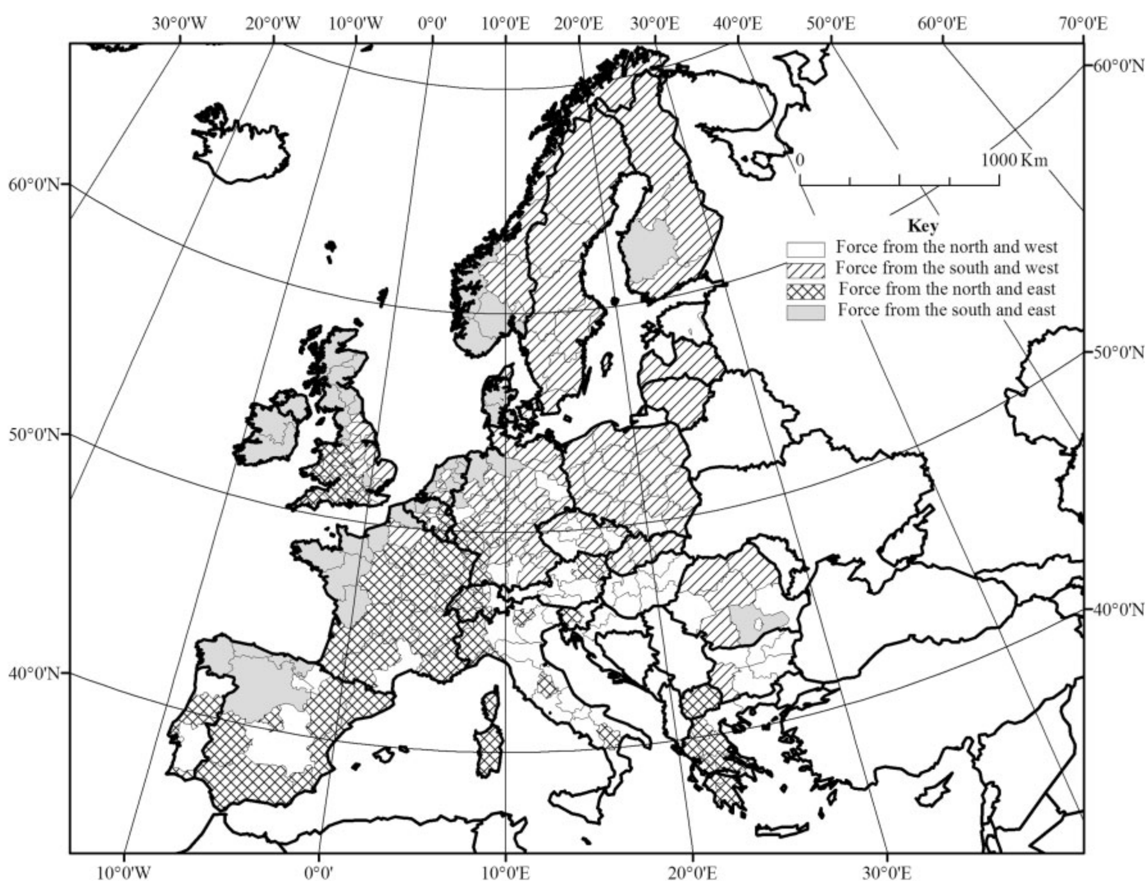


*Fig. 7.* Regions grouped by the direction of force applied to them by other regions in 2009

Based on the obtained results, each of the NUTS 3 level regions can be placed into one of four groups according to the direction of force applied to them by other regions in 2009 (Fig. 7).

On the map, the east–west segmentation appears to be more significant than the north–south one. The change from 1995 to 2009 (not shown here, due to lack of space) is insignificant. The impact of regional centres can clearly be seen in the areas where the direction of forces differs from surrounding regions, (i.e. in the neighbouring areas with different shadings). These nodes mostly overlap the nodes derived from the examination of change from 1995 to 2009 (Fig. 6). As Fig. 7 shows, the barrier lines of different directional forces are similar to those highlighted by the different theories of the economic structural image of Europe.

## Conclusions

In this article we have compared the most important models for investigating the economic spatial structure of Europe with the results of our gravity calculations. Based on the latest GDP calculations, the results verify the 'banana' shape – the European core area still has the banana shape, as also other authors (Brunet 1989; Kunzmann 1992; Kozma 2003) have concluded, but the different analyses highlight the existence of related regions that are moving to catch up.

Our conclusions are drawn on the basis of static and dynamic gravity calculations. Our model mainly justifies the Red Octopus theory (model) in terms of the change in GDP. Our findings clearly outline the banana shape that has long been dominant in the European economic spatial structure. Recent changes have only slightly altered these fundamental spatial relations, and we did not observe any radical modifications.

We conclude that the European economic spatial structure is likely to remain unchanged in the medium term, although we may see more changes in position of the regions than occurred between 1995 and 2009.

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