FACTORS OF ACCESSIBILITY POTENTIAL MODELS

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Abstract

The use of accessibility potential models is widespread in transport geographical studies. In this analysis the connections between the different accessibility models and development conditions are examined. In connection with the use of the models, the problem arises that, due to their complexity, their interpretation may meet some difficulties. In order to solve this problem, a method which is suitable for breaking down the accessibility potentials into factors has been developed. The study analyses the spatial relation between development and accessibility taking as example the EU NUTS3 regions, the factors of the accessibility potential models are presented and the relations between these factors and the components of development are examined. Finally, the population potential in the NUTS3 regions of EU27 is examined according to the nationality of the dominant region influencing it.

Keywords: accessibility potential; regional development, European Union

Introduction

The methods of accessibility modelling have had a long history in scientific literature. The most widespread and most frequently used indicators in the topic are the accessibility potential models. The accessibility potential models (models based on gravitational analogy) have been widely used in urban and geographical studies since the 1940s, the most well-known among them are those in: Stewart (1947), Harris, (1954) Hansen (1959), Ingram (1971), Vickerman (1974), Keeble et al. (1988), Linneker and Spence (1992), Smith and Gibb (1993) Spence and Linneker (1994). After the disjoint, fully covered territorial division, the potential models assess the possibility to access the optionally encircled territories (i) separately in relation to all the other territories (n), within them, those of smaller mass and/or those more remote have a decreasing effect and vice versa (Rich, 1980), (Geertman–van Eck, 1995).

The general form of the accessibility potential model is the following:

$$A_i = \sum_j D_j \cdot F(c_{ij})$$

where A_i is the accessibility of territory i, D_j is the mass of territory j accessible from territory i, c_{ij} is the general travel cost between territories i and j, $F(c_{ij})$ is the impedance function.
In accessibility studies, the authors using different accessibility potential models apply different impedance functions. The reason for applying an impedance function in socio-geographical studies is first of all that spatial separation hinders the cooperation among the different regions, so it is worth quantifying in some way. The simplest application of the model is naturally the use of distances in air kilometres.
The main difference in the application of the accessibility potential model and the physical potential model is that, in contrast to physical space, social space in an everyday sense is typically not continuous but discrete. Socio-economic formations (e.g. settlements, towns) are generally concentrated at a given point of space, and their 'mass' can be connected to this point. As these mass points do not fill the space, it would be difficult to determine the potential value

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of any point of an encircled part of space (e.g. a country), which depends naturally on the effect of all the other points (Tagai, 2007). The mass points' spatial concentrations of different extent induce potential surfaces of different characteristics, the consequence of which is that the distance between the points and thus the impedance function can be described by different functions in the different analyses. That means that the formula of the impedance function used in analyses for different regions, territorial levels or for different numbers of mass points in the same territorial level is different.

Therefore several forms of the impedance function appear in the accessibility studies. The models take into consideration the distance between certain 'masses' also in different ways. Several approaches are known when the researchers apply the reciprocal of the distance or one of its powers (see among others Hansen, 1959; Davidson, 1977; Fortheringham, 1982). Among them, the most 'everyday' solution is provided by the models applying linear impedance function (when determining the potential, the distance is in the first power in the denominator), as here we do not perform any mathematical modification on the duration and cost of access. In models insisting strongly on gravitational analogy, due to the physical demonstration of the model, the second power of distance, duration and the cost are always applied. This, however, is not a rule that must not be broken, so in models based on gravitational analogy there may be other power values as well. In this case, their role is only to quantify the probability of reaching the targets at different distances in the model.

Researchers use the models applying the exponential impedance function essentially in order to specify this objective (Wilson, 1971; Dalvi–Martin, 1976; Martin–Dalvi, 1976; Song, 1996; Simma–Vritic–Axhausen, 2001; Schürmann–Spiekermann–Wegener, 1997). Models applying the impedance function of Gauss (Ingram, 1971; Guy, 1983) or the log-logistic impedance function (Bewley–Fiebig, 1988; Hilbers–Veroen, 1993) are known as well. In similar studies, exponential (see among others Espon, 2007) and linear (Gutiérrez, 2001) impedance functions are used in numerous cases. The present study – especially in respect of the later parts – applied only the linear impedance function, as it was the most suitable for interpreting the results. It is noted, however, that the connection between the specific GDP and the potentials received as a result is by no means the strongest by applying the linear model (Tóth–Kincses, 2007), but, as the aim was first of all to present the methodological possibilities, this model was applied further on.

In the present examination, the regions of France, Portugal and Spain outside the continent were disregarded, so the term amount or average of EU27 regions covers the regions on the continent in case of each variable. Furthermore, the work did not deal with models taking into account competition either (see among others Weibull, 1976; Knox, 1978; Van Wee et al., 2001; Joseph–Bantock, 1982; Fotheringham, 1982).

The accessibility model applied

In the course of applying the potential model, not only the own strength, i.e. the value of the so-called own potential of spatial units can be expressed but, with the value of the internal potential, also the interaction between the masses taken into account. External potential can be demonstrated by taking into account the masses outside the territory observed.

Accordingly, the total potential value is the sum of these three results.

The accessibility potential model applied is the following:

$$A_i = \frac{W_i}{c_{ii}} + \sum_j \frac{W_j}{c_{ij}} + \sum_j \frac{W_o}{c_{io}}$$

Total potential = own potential + internal potential + external potential

where the value of the own potential of point A_i is the quotient of W_i, the own mass of the given territorial unit (in this study the population value) and the distance data ordered to the territorial unit d_{ii} (the simplest way is the length of the radius of the circle equal to its territory).

When calculating the internal potential, the sum of effects of the other spatial units involved in the analysis of the given spatial unit must be calculated. The size of effect depends on the mass of the other points and on their distance from the given spatial unit. The larger the mass of the spatial unit at a nearer distance in space, the higher its value.
The calculation of the external potential is practically the same as that of the internal potential, but here the effects of spatial units outside the territory examined are taken into account.
In the case of internal potential, 1,288 NUTS3 regions of the European Union were taken into account. In the case of external potential, the known territorial units of the EFTA countries, the candidate countries (Croatia, Turkey) as well as further (first of all Eastern) European countries were taken into account. When calculating the external potential, either national data (e.g. Liechtenstein) or data broken down regionally (e.g. oblasts of Russia) were used. The number of territorial units taken into account in respect of external potential is 251.
In connection with the external potential, it has to be noted that each point on the Earth can be considered to be one affecting the potentials of all other points. This naturally does not mean that a researcher takes into account the data of all territorial units; due to practical reasons, the number of points and territorial units considered has to be decreased. On the other hand, each decision made by the researcher when choosing the boundaries of the territory examined can be considered partly arbitrary and this is said to be the central problem of all macroscopic models (Lukermann and Porter, 1960, p 503). Despite the fact that accessibility indicators quantify the accessibility to points in other regions, the total territory examined must be adjusted so that accessibility conditions are influenced not only by the internal accessibility of the region but also by the external points. So, as long as it is possible, it is worth applying as broad an examination territory as possible, where all the target territories relevant in respect of the examination are taken into account. By trying to take into account effects from each country of Europe in a geographical sense for determining the potential of EU27, it was intended to meet this objective.

Dimension	Notes
Source	In the analysis, accessibility is calculated and interpreted from each person's point of view, and no differentiation is made between the social groups or the different travel targets of travellers.
Objective	The objective to be achieved is quantified by the population of the given NUTS3 region.
Resistance	The territorial impedance function means in this case the theoretical accessibility times between the centres of the regions on public roads, in minutes.
Limits	When using the routes between two regions, the limit is the maximum speed in the given area according to the type of road.
Boundaries	When determining the territory examined, the boundaries of Europe were taken into account in a geographical sense.
Way of transport	The analysis did not differentiate the different aspects of passenger and freight transport.
Modality	The analysis calculated unimodal accessibility in respect of public roads.
Regional level	The basic regional level of the research is NUTS3.
Equal chances	The major aims of the research are modelling the centre-periphery differences in the EU27 regions and studying the resulting differences.
Dynamics	In the research, the population and the public road network on 1 January 2007 are taken into account.

Table 1: Dimensions of the analysis

The analysis

The starting point in this study, similarly to other works (Geurs–Wee, 2004), was that accessibility can be used as an economic indicator as well, since improving accessibility improves the productivity and competitiveness of companies. Due to accessibility improving as a consequence of investments, the labour market is affected by positive impulses as well, which results in further advantages in competitiveness (Forslund–Johansson, 1995). Thus, it was deemed worth examining the connection between the accessibility potential and economic development.

The first examination attempted to find an answer to what kind of connection can be demonstrated between the GDP and the population potential of the 1,288 NUTS3 regions of the European Union. In connection with the analysis, it has to be noted that the primary objective of accessibility models is to map the potential probability of movements between certain territorial units and thus to model the spatial fields of force. The probability of movement, however, does not mean movement by all means, and movement in itself is not an evidence of development (or its absence does not necessarily mean underdevelopment). By examining the strength of the connection with a simple regression function, it can be found that population potential accounts for 16.4% of the dispersion of GDP per capita in the NUTS3 regions of the European Union.

The problem of breaking down accessibility potential into factors

Several analyses report on the advantages and disadvantages of the accessibility potential model (Geurs-Ritsema van Eck, 2001; Geurs-Wee, 2004). We, on our part, would have liked to deal first of all with the disadvantages of the model. In this respect, the authors cited herewith, say the following: "Disadvantages of potential measures are related to more difficult interpretation and communicability; the measure is not easily interpreted and communicated as it combines land-use and transport elements, and weighs opportunities (according to the cost sensitivity function). " (Geurs-Wee, 2004 p. 134) The reason for the problem is that accessibility potential models measure the effects of spatial structures, spatial division, the location of a certain spatial domain and the size distribution of masses at the same time. The location of the spatial domain is essentially determined by the geographical location, which is somewhat modified by the accessibility (depending on the way of transport). It means that in case of a certain potential value it cannot be determined whether it is the consequence of the (settlement, regional) structure or the location of the mass sizes, or of the size of the region or the effect of the own mass.

Thus the gravitational space of social masses should be imagined as an optional division of the space (settlement, micro-regional structure, etc.) and then a mass distribution on this division (like masses distributed to the given spatial structure as quanta or counters). The value of the potential at a given point is determined by the sum of these effects (internal potential and external potential) and the effects of own mass and own spatial size (own potential).

The effect of the potential deriving only from the division of the territory at an optional point of the space (briefly spatial structure effect) is the value which would result if the mass were the same in each encircled territorial unit. The mass distribution effect is the difference between the sum of the internal and external potential at an optional point of the space and the value of the spatial structure effect on this point. The value of the total potential is influenced by the size of the given region (in this case NUTS3 region) as well. The effect of the size of the region is the value which would result if the mass were the same in each territorial unit. Subtracting this from the own potential, we get the value of the effect of own mass (Kincses – Tóth, 2011).

The connections described above are as follows:

$$U_i^{total} = U_i^{mass\_distribution} + U_i^{spatial\_strukture} + U_i^{own\_mass} + U_i^{size\_of\_territory}$$

$$U_i^{spatial\_structure} = \sum_j \frac{\frac{\sum_{k=1}^{n} m_k}{n}}{f(d_{ij})}$$

$$U_i^{mass\_distribution} = U_i^{internal+external\_potential} - U_i^{spatial\_structure}$$

$$U_i^{size\_of\_territory} = \frac{\sum_{i=1}^{n} m_i}{\frac{n}{f(d_{ii})}}$$

$$U_i^{own\_mass} = U_i^{own\_potential} - U_i^{size\_of\_territory}$$

After breaking down the potential model, the situation based on the connection between the factors and the GDP per capita is somewhat different. If we examine the connection between the potential models and the specific GDP with multivariable linear regression, as a result of the regression applying more than one variable, the determination coefficient is higher than in case of the basic model. Here, the value of R^2 amounts to 31%. The two factors determining the potential to the greatest extent (i.e. those having the highest standardized beta coefficient) are the territory of the given region and its own mass. It is important to highlight that the effect of spatial structure has the lowest but not significant standardized β coefficient.

Model	Standardized β coefficients
Adjusted R Square	0.311
SPATIAL STRUCTURE	*-0.017*
MASS DISTRIBUTION	-0.271
SIZE OF TERRITORY	0.475
OWN MASS	0.345

Table 2: Connection between the factors of the accessibility potential model and the GDP per capita, R^2 and standardized β coefficients

Characteristics of the factors of the accessibility potential

According to our accessibility potential analyses, the region in the most advantaged situation in the European Union is Paris followed by Seine-Saint-Denise and Val-de-Marne. We can state in general that the central regions of France, South England, the Netherlands, Belgium and the regions of North Italy are in the most advantageous situation. The potential is continuously decreasing from the core area indicated to the peripheries. The lowest potential value is in Värmland (Sweden), Lappi (Finland9 and the Shetland Islands (Scotland). In some respects, our results confirm the Blue Banana spatial structural model (Brunet, 1989), as well as its extension (Kuzmann, 1992).

The effect of the spatial structure is positive in all cases, i.e. it always contributes to the total potential. The effect of spatial structure was the highest in case of Oberhausen, Kreisfreie Stadt; Frankenthal (Pfalz), Kreisfreie Stadt and Rhein-Pfalz-Kreis regions (Germany). By contrast, the lowest values were found in Pohjois-Pohjanmaa, Lappi (Finland), and in Cyprus.

The share of the effect of spatial structure in the total potential is between 71 and 176%. For the former value Bucureşti (Rumania), while for the latter one the Bamberg, Landkreis region

(Germany) can be mentioned. The effect of spatial structure is the most important factor in the total potential for each region.

The effect of the mass distribution – in contrast to the former factor – contributes negatively or positively to the total potential. In 1,224 among the 1,288 regions examined, the sign is negative and it is positive only in the remaining 64 regions. The situation is the worst in those (first of all German) regions, which, by themselves, represent a significant mass, but the masses accessible from them are relatively low. Such regions are: Rhein-Pfalz-Kreis, Bamberg, Landkreis, Frankenthal (Pfalz), Kreisfreie Stadt (Germany). On the other hand, in respect of mass distribution, the regions in the most advantageous situation are: West Inner London, Val-de-Marne, and Seine-Saint-Denis (France).

The share of the effect of mass distribution in the total potential is between -76 and 10%. For the former value, we can point out the regions in Germany with Bamberg, Landkreis region in the lead, while in respect of the latter value we can point out the regions in Southern Europe, especially Guadalajara being in the best situation.

The following two factors are parts of the own potential of the accessibility potential model. The first factor in this part is the size of territory. As when calculating own potential, the territory of the given region, the size of this factor changes along with the territory of the region are taken into account. The sign of the size of the territory is always positive, and its value is the higher, the smaller the territory of the region is. The size of the factor refers first of all to urbanisation, since regions of smaller area are mostly great cities. Accordingly, the maximum value of the territory size factor can be observed in Blackpool (England), while the minimum value in Norrbotten county (Sweden).

The share of the territory size factor in the total potential is between 0.4 and 14%. For the former value Norrbotten county (Sweden), while for the latter one Stralsund, Kreisfreie Stadt (Germany) is an example. It can be highlighted that the share of the territory size factor in the total potential does not even reach 5% in nearly 1,200 regions.

Finally, the last factor is the own mass of the given region. Its sign may also be negative or positive. Due to the method, the sign of regions more populated than the average is positive, while that of sparsely populated ones is negative. The share of the own mass factor in the total potential is between -48 and 22%. Among the negative values, we can mention the Stralsund, Kreisfreie Stadt, Greifswald, Kreisfreie Stadt and Bad Doberan regions (Germany), while among the positive ones Bucureşti, Athens and Paris.

Comparison of the accessibility and development of regions

In the comparison, we followed the method already used by Espon (2003) as well as classification. Based on this, regions can be classified into four groups.

In the first group, those regions are classified which are above the average in respect of both accessibility and development. Here are the regions of South England, Benelux, South Germany, North Italy and North France which are considered the economic engines of the European Union. According to our examination, the range of these regions is somewhat more significant than in the Espon study in 2003. Slightly more than 30% of the regions belong to this category.

The second group includes those regions whose accessibility is more advantageous than the EU27 average, but their state of development is below that. West Germany, some regions of Central European countries having joined the EU in 2004 and some regions of North France are placed in this group. 23% of the regions belong to this second group.

To the third group belong those regions whose accessibility lags behind the average, but whose performance in respect of GDP per capita is above average. First of all, the Swedish, Finnish and Irish regions belong to this category, but most of the regions of North Spain and South and West France, as well as some English, Scottish and Italian regions can be found here. Although many countries are involved in this group, its size is the smallest among the four groups, as only 12% of the regions belong here.

Finally, in the fourth group are those regions which are below the average in respect of both accessibility and state of development. Most of the Central European regions having joined in 2004, as well as many of the regions in Spain, South Italy and Greece can be found in this group. Among the four groups, this one is the most populous, as more than one third of the regions are placed here.

In connection with the spatial image of development and accessibility, we can state that between the two phenomena an essential connection can be demonstrated. The group of regions of high development and good accessibility and that of low development and bad accessibility are the largest groups. These together represent nearly two thirds of all regions.

Connection between the factors of development and accessibility potential

Hereafter, we intended to examine how far spatial distribution of territorial development can be attributed to accessibility and its components. In the interest of deeper analysis, we deemed it practical to break down GDP into parts which can be easily interpreted in their own.

$$\left(\frac{GDP}{Population}\right)=\left(\frac{GDP}{Economically\_actives}\right)*\left(\frac{Economically\_actives}{Active\_aged}\right)*\left(\frac{Active\_aged}{Population}\right)$$

The GDP per capita shows the state of development of regions, which can be broken down into factors according to the above formula. The GDP per economically active persons approaches basically the productivity of the economy in the regions, the proportion of the economically active people in the population gives an estimate of employment, while the proportion of the people of active age in the population can be considered regional resources as a kind of indicator of age structure.

In connection with the linear accessibility potential broken down into factors and the state of development, as well as with its factors, we calculated a correlation matrix (see Table 4). In the matrix, italics indicate the connections which are not significant at a 5% level.

We can state that the total potential is in the closest connection with the effect of spatial structure, which is followed by mass distribution. So, the basic relations of the structure of the potential result from the relations of the spatial structure, i.e. they are “coded” according to these relations, which is somewhat modified by the mass distribution.

On the other hand, the state of development (GDP per capita) depends first of all on productivity. Among the factors of the accessibility potential, the connection is the closest with territory size and spatial structure. The former refers to the high development of regions with small areas, first of all large cities. Similarly, in respect of the spatial structure, the high development of the European central regions and the relative underdevelopment of the peripheries are outlined.

Among the factors of the accessibility potential, the state of development is in the closest connection with territory size and spatial structure. Consequently, we can state that in respect of the European spatial structure of development, accessibility can only slightly modify the productivity and employment conditions basically characteristic of the given region and the general spatial structural conditions characteristic of Europe.

On the basis of our examinations, we can point out that within the European Union, the geographical location of the regions (effect of structure), their central or peripheral character are in relatively close connection with productivity and employment. It is well-known that incomes per capita and economic growth rates are significantly higher in regions which are near the present centres of world economy (Gallup- Sachs-Mellinger, 1999). So we can state that development and economic activity within the European Union will most probably concentrate in the geographical centre regions in the future as well.

Dominance of the potentials of the NUTS 3 regions

The European population potential presented earlier can be further analyzed. Namely, an analysis can be also performed with the NUTS3 regions being classified according to which country's regions had the most significant effect on the establishment of the total potential (Tagai, 2009). The examination is somewhat influenced by the fact that in Europe, apart from the European Union, there is no regional system similar to NUTS. While EFTA countries and candidate countries established their own regional systems very similar to NUTS, this is not the situation in the Eastern European countries. The Eastern European regional units which were included in the calculation of the potential of the EU regions as external potentials are much larger than the limit of 800,000 persons determined for NUTS3 regions (Regulation EC No. 1059/2003 of the European Parliament and of the Council), or in several cases even larger than the maximum of 7 million persons set for NUTS1 level. This fact does not influence the total potential in its merit, but it may affect the determination of dominance in respect of some (above all Eastern) regions, which fact must be taken into account in the analysis.

One of the most important results of the examination is that in the potential of the European regions, the German regions have the most significant effect. In the GDP and the population of the EU27 (only European regions) in 2007, Germany has a share of nearly 20% and 17%, respectively. If we sum up those regions which are influenced the most by the potential of German regions, this share grows by nearly 1–1 percentage point. Following Germany, the second most significant economy of the EU27 is the United Kingdom, representing nearly 17% of the GDP and 12% of the population in the Union. As opposed to the former, though the dominance of the potential extends over the country, the share of the British potential territory does not basically differ from that of the country. The share of France in the GDP of EU27 is 15%, while it is 12% in its population. The share of regions with French dominance is higher by 0.6% and 0.3%, respectively. The share of Italy is nearly 13% in the GDP and 12% in the population of EU27. The share of regions with Italian dominance is by 0.7–0.7% higher.

If we examine which is the country where the socio-economic importance of regions dominated by its potential differs the most from the share of the country in the Union, we can say that the largest difference is in respect of Denmark. The share of Denmark in the GDP of EU27 is nearly 2%, and it is 1% in the EU27 population. On the other hand, this share is by 1.8 and nearly 1 percentage point lower in the region dominated by the potential of the country. A similar difference can be seen in respect of the regions dominated by the Belgian regions.

Conclusions

This study presented a methodological experiment about breaking down the accessibility potential into factors. By examining the connection between the factors and the components of regional development, the structure of reasons for the state of development is outlined. Based on this, it can be stated that the state of development depends first of all on productivity and, among the factors of accessibility, on the size of territory and spatial structure. When comparing the spatial location of development and accessibility, it was possible to demonstrate a close connection in respect of the location of highly developed and easily accessible or underdeveloped and hardly accessible regions. The potentials of the regions according to the nationality of the region having the most dominant effect on them were examined. The most significant result was the demonstration of the degree of German dominance.

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	Regions dominated by the potential of regions in certain countries		
	share in the EU27's		GDP per capita compared to the EU27 average
Countries	GDP	population	
Austria	2.0	1.6	126.4
Belgium	1.8	1.3	142.4
Bulgaria	0.1	0.3	31.6
Belarus	0.1	0.3	23.5
Switzerland	0.3	0.2	116.1
Cyprus	0.1	0.2	81.8
Czech Republic	1.0	1.9	50.4
Serbia	0.3	1.1	31.9
Germany	20.6	17.6	116.8
Denmark	0.0	0.0	135.5
Estonia	0.1	0.1	71.3
Spain	9.1	9.8	93.6
Finland	0.9	0.6	152.5
France	15.8	12.9	122.6
Greece	1.5	1.7	88.2
Croatia	0.0	0.0	55.0
Hungary	0.8	1.8	41.4
Ireland	1.6	0.9	169.9
Italy	13.3	12.7	104.6
Lithuania	0.2	0.4	40.1
Luxembourg	0.0	0.0	95.4
Latvia	0.1	0.3	45.6
Moldova	0.0	0.3	14.9
The Netherlands	4.7	3.5	136.3
Poland	2.2	6.6	33.7
Portugal	1.1	1.8	63.3
Romania	0.7	2.7	24.9
Russia	0.7	1.0	65.2
Sweden	2.8	1.9	144.1
Slovenia	0.2	0.2	90.4
Slovakia	0.4	1.1	40.6
Turkey	0.6	2.6	24.5
Ukraine	0.1	0.2	23.8
United Kingdom	16.6	12.3	134.5
EU27	100.0	100.0	100.0

Table 3: Characteristics of the regions dominated by the regions of certain countries, 2007

Indicators	Total potential	Spatial structure	Mass distribution	Territory size	Own mass	State of development	Productivity	Employment	Age structure
Total potential	1.000	0.931	-0.752	0.485	*-0.040*	0.405	0.381	0.176	*-0.048*
Spatial structure	0.931	1.000	-0.939	0.499	-0.253	0.388	0.351	0.260	-0.117
Mass distribution	-0.752	-0.939	1.000	-0.468	0.376	-0.348	-0.302	-0.310	0.150
Territory size	0.485	0.499	-0.468	1.000	-0.435	0.444	0.420	0.159	*0.003*
Own mass	*-0.040*	-0.253	0.376	-0.435	1.000	*0.040*	*0.052*	-0.150	0.249
State of development	0.405	0.388	-0.348	0.444	*0.040*	1.000	0.966	0.282	-0.139
Productivity	0.381	0.351	-0.302	0.420	*0.052*	0.966	1.000	0.074	-0.195
Employment	0.176	0.260	-0.310	0.159	-0.150	0.282	0.074	1.000	-0.174
Age structure	*-0.048*	-0.117	0.150	*0.003*	0.249	-0.139	-0.195	-0.174	1.000

Table 4: Correlation matrix of the factors examined

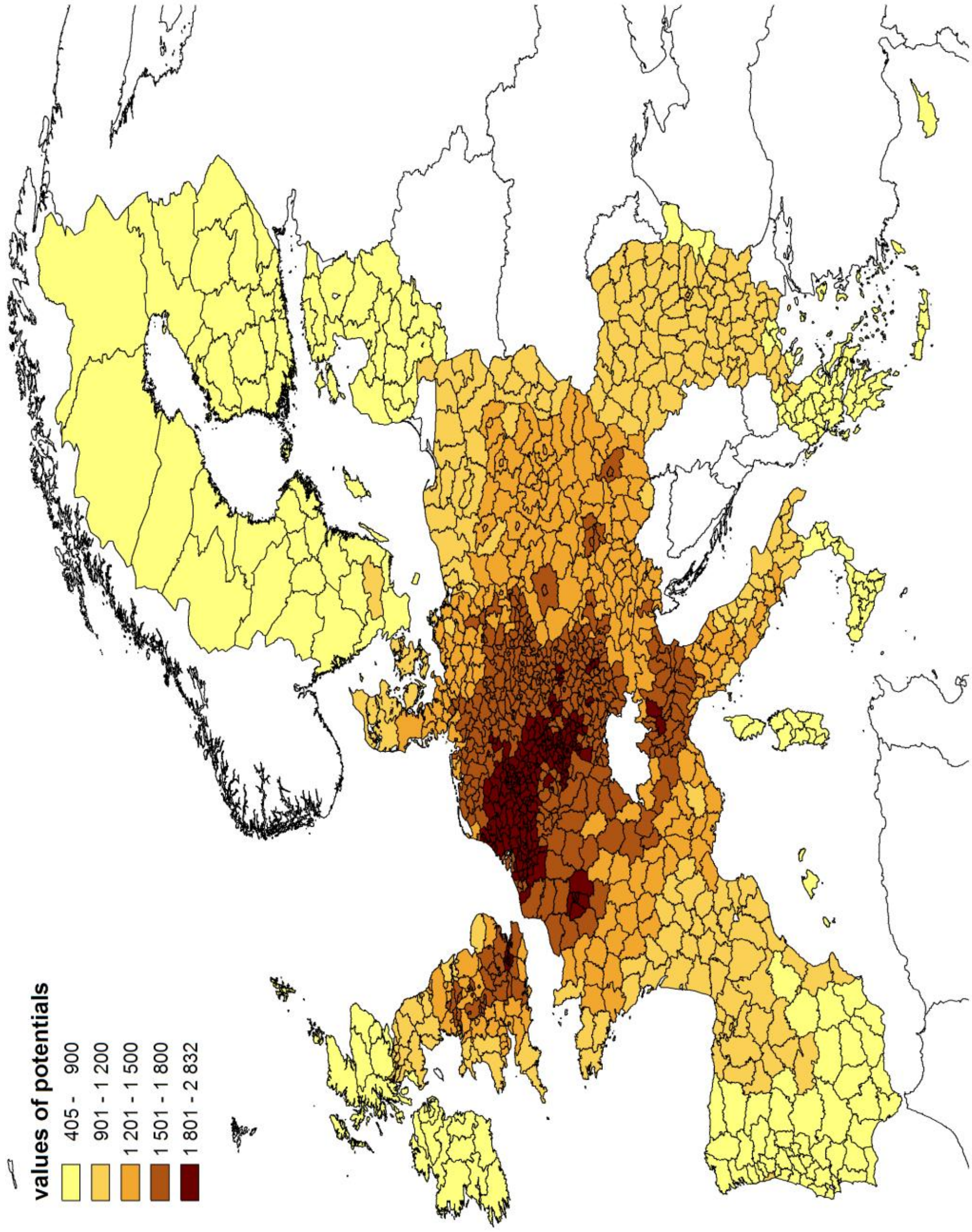

Fig 1: Population potential of the European Union’s regions

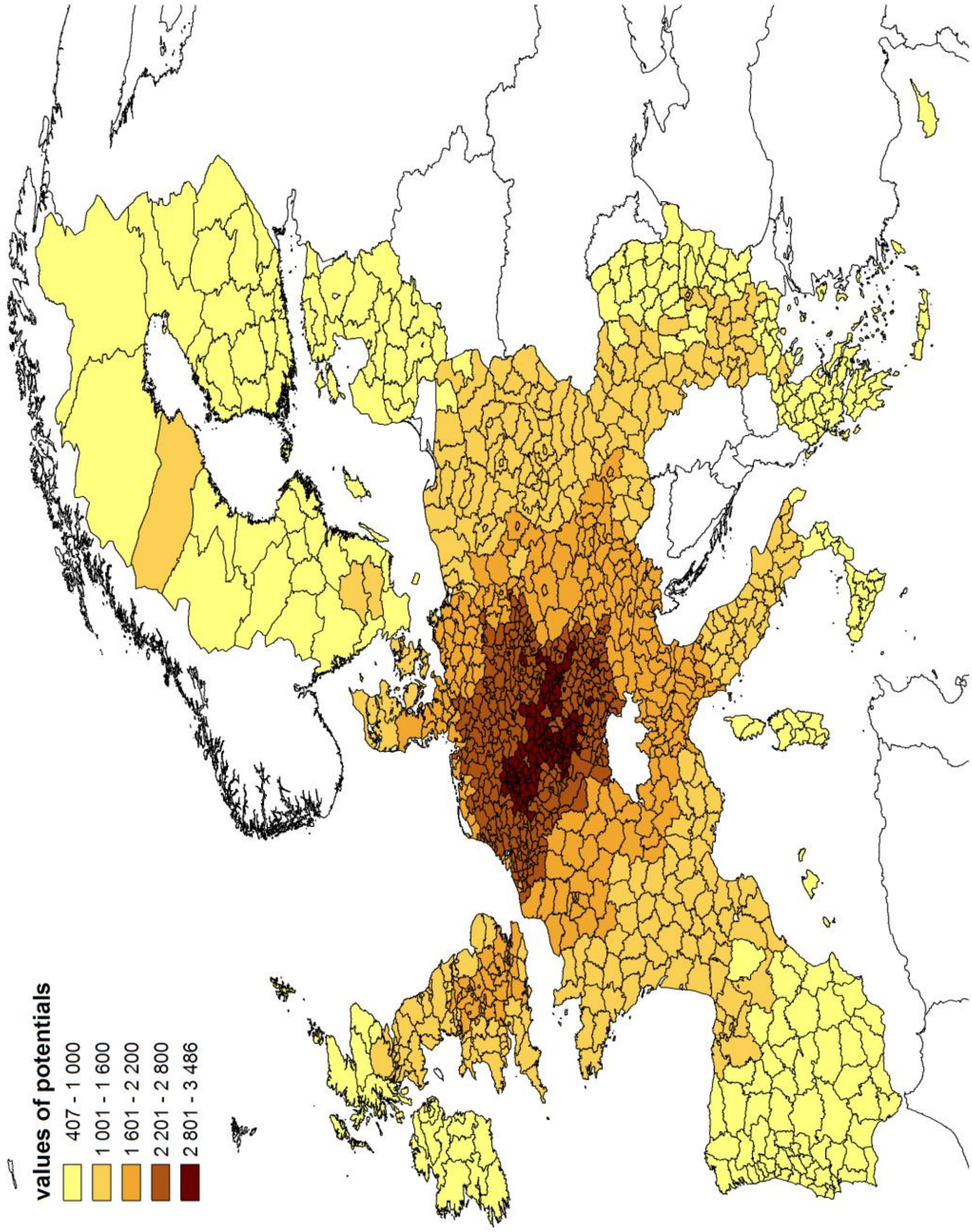

Fig 2: Role of spatial structure in population potential

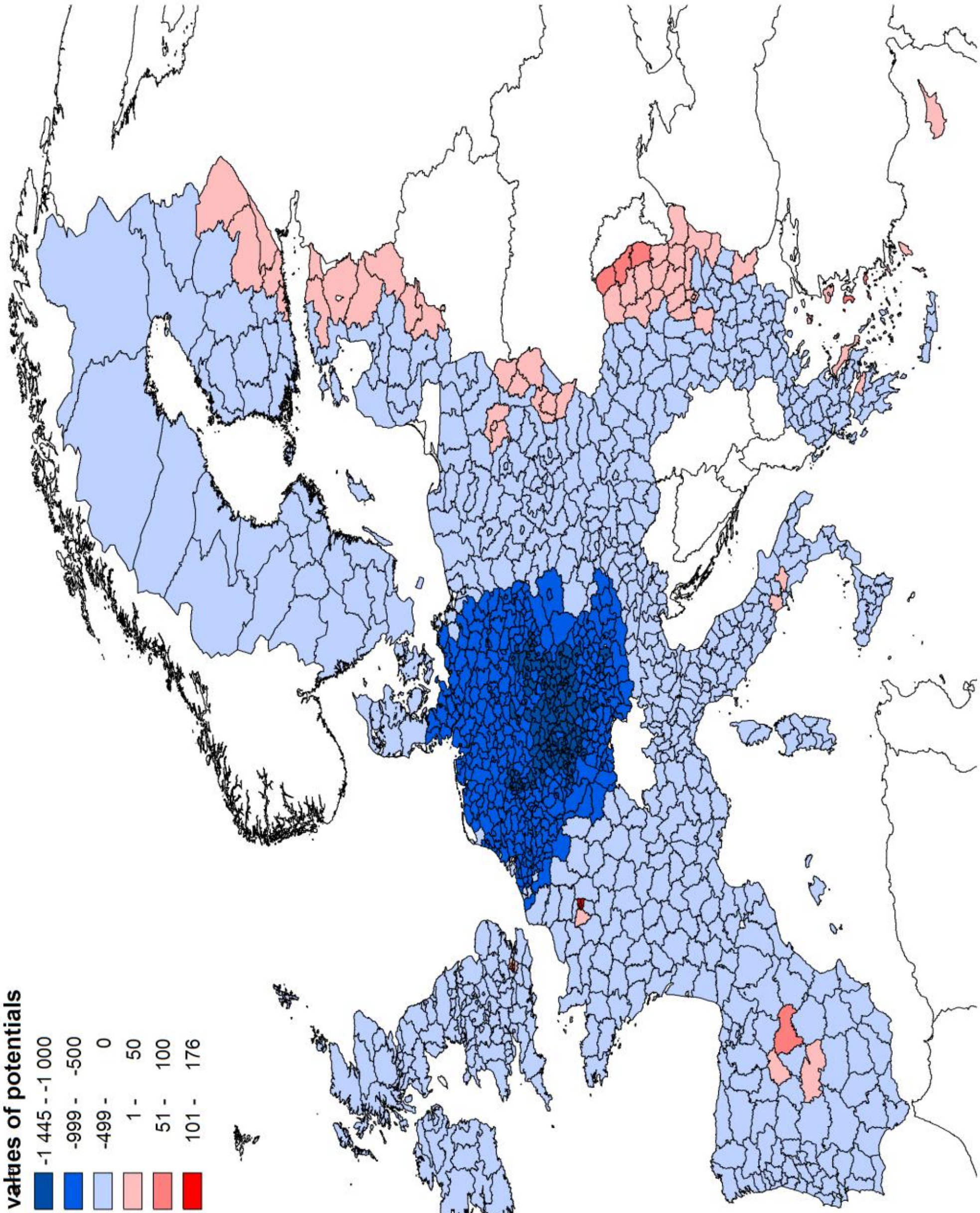

Fig 3: Role of mass distribution in population potential

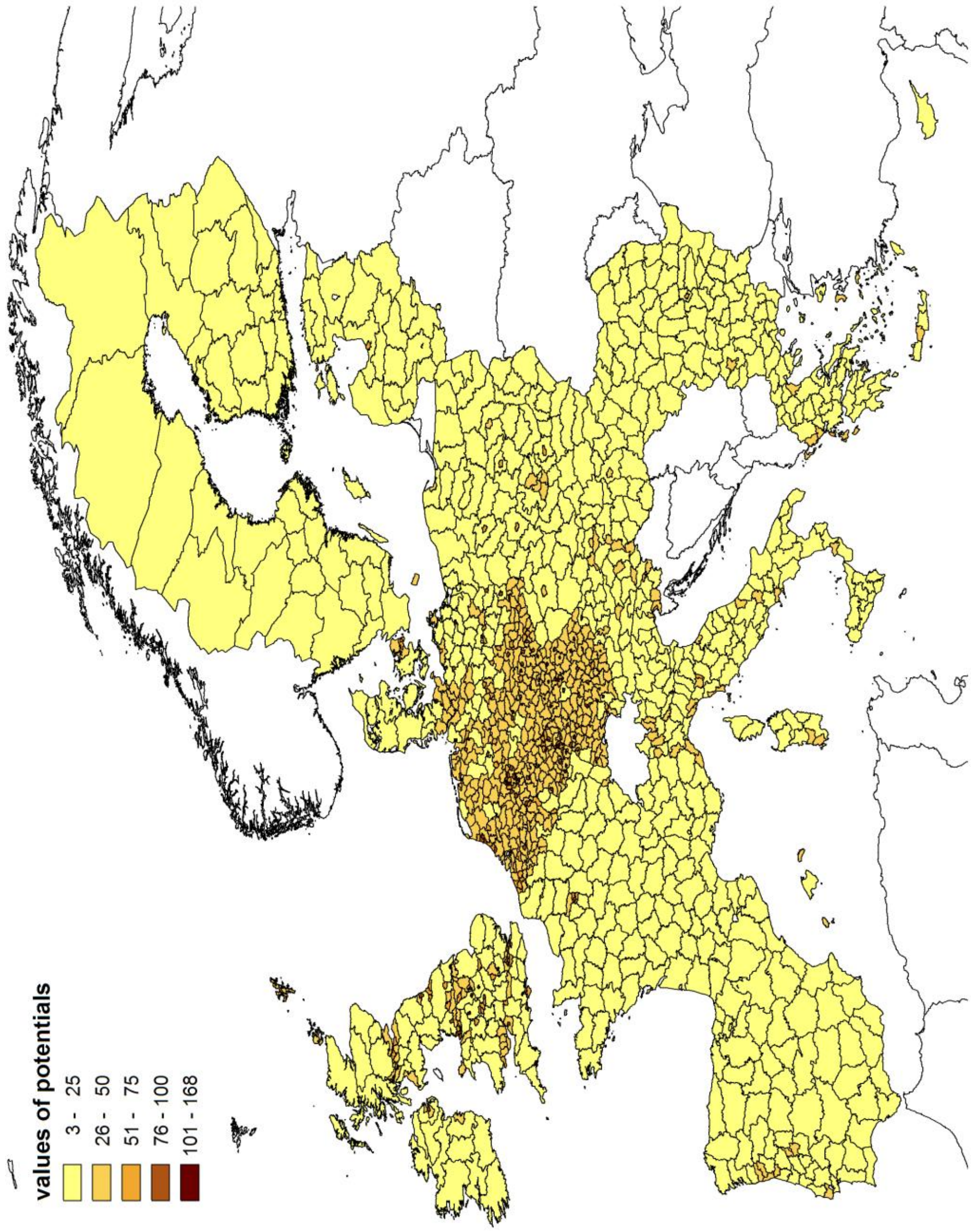

Fig 4: Role of territory size in population potential

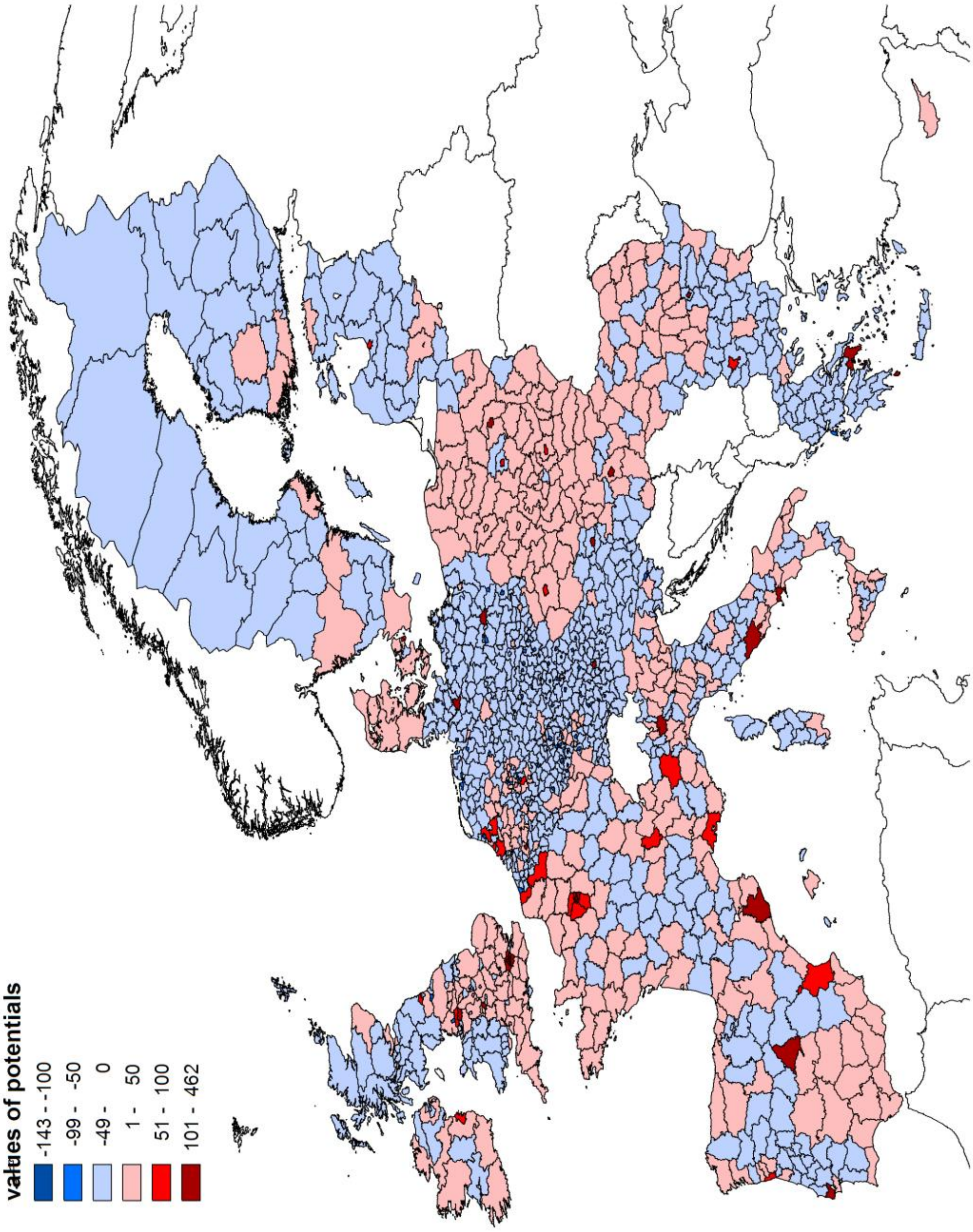

Fig 5: Role of own mass in population potential

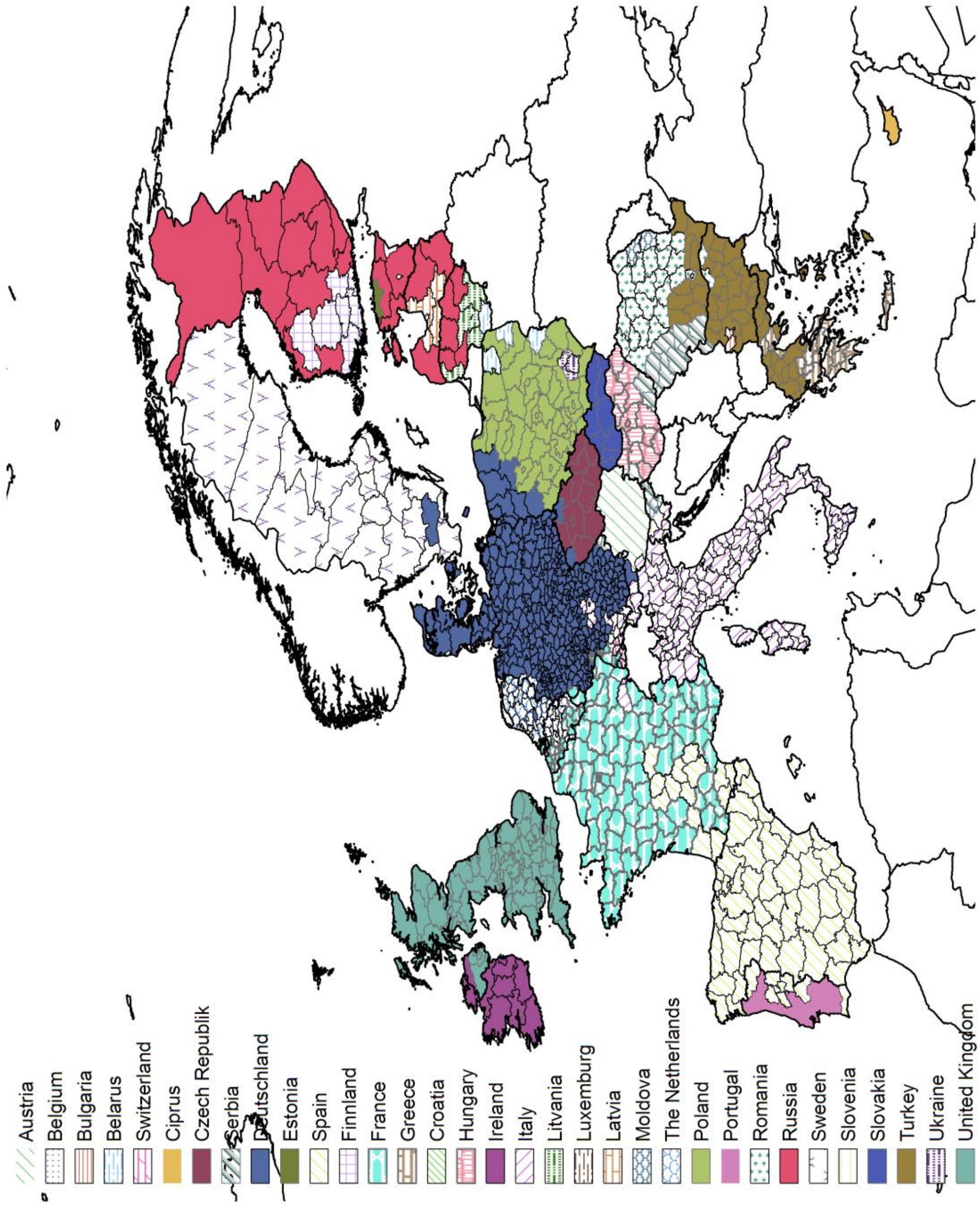

Fig 6: Regions having the greatest effect on the potential of NUTS 3 regions by nationality

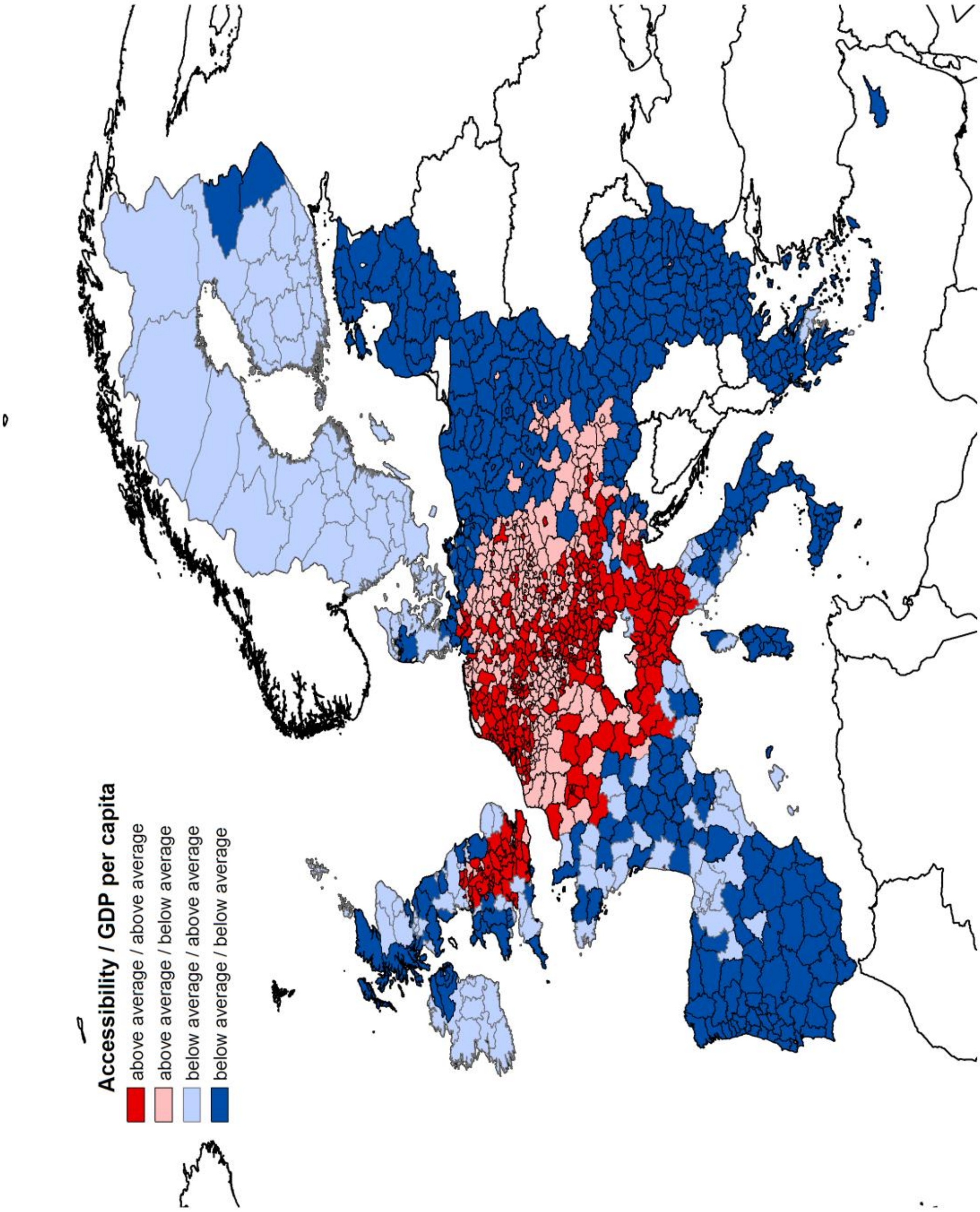

Fig 7: Comparison of accessibility and state of development of NUTS 3 regions