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The European Peripherality Index

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Abstract:

The trans-European transport networks programme is one of the most ambitious initiatives of the European Union. The networks are to link landlocked and peripheral areas with the central areas of the Community. The identification of those peripheral regions, whose accessibility and transport infrastructure systems are to be improved, is becoming of great political importance. This paper presents the result of a *Study on Peripherality*. The objective of this study was the development of an interactive GIS-based software package for the calculation of the *European Peripherality Index* (E.P.I.) in order to identify those peripheral regions, whose geographical location is handicapped. The paper first outlines some theoretical considerations on the relationship between transport network development, accessibility and cohesion; afterwards the dimensions of the indicator system developed are explained briefly. The presentation of the two standard peripherality indicators defined and the discussion of the other dimensions of the indicators will form the heart of this paper. At the end, it concludes with first hints on political implications of the main findings of this study.

1. Background

Article 2 of the Maastricht Treaty states as the goals of the European Union, *inter alia,* the promotion of harmonious and balanced economic development, convergence of economic performance, improvement of the quality of life and economic and social coherence between the member states. A prominent role for the achievement of these goals play the envisaged Trans-European Transport Networks (TETN). They are to link landlocked and peripheral areas with the central areas of the Community. The identification of those peripheral regions, whose accessibility and transport infrastructure systems are to be improved, is becoming of great political importance. This is underlined by the European Commission's *Cohesion Report* (1997) which emphasises that "regions should ensure that policy success is measurable, that results are regularly monitored, and that the public and political authorities are regularly informed of progress."

The TETNs programme is one of the most ambitious initiatives of the European Union. The trans-European transport networks account for about 75,185 km of roads and some 79,440 km of railways, of which 29 percent is still to be build; account for about 381 airports, 273 international seaports, 210 inland ports, as well as traffic management systems. The TETN road network carries about 40 percent of all road freight, and the TETN railway network carries about 60 percent of all rail freight. (European Commission, 2001, 3).

The main objectives of the *New Transport Policy* of the European Commission are to eliminate bottlenecks, changes in modal split, improving the quality and safety, to concentrate efforts on already decided projects, to add only a limited number of new major projects, and finally to make technical changes to the outline plans and environmental provisions (European Commission, 2001, 7).

The purpose of this *Study on Peripherality* was to undertake, for the fifteen EU member states and twelve candidate countries, the calculation of an index of peripherality of the potential type to identify those peripheral regions whose transport infrastructure is to be improved. The economic potential of a region is assumed as the total of destinations in all regions weighted by a function of distance from the origin region. So, the potential for economic activity at any location is a function of both its proximity or ‘travel time’ to other economic centres and its economic size or 'mass'. The economic potential of a given location is found by summing the influence on it of all other centres.

This paper first outlines the relationship between transport networks, peripherality and cohesion from a theoretical perspective, and then reviews the objectives of the EU transport policy; afterwards, the *European Peripherality Index* (E.P.I.) system developed will be explained. An discussion of the different indicators applied forms the heart of the paper. Finally, some hints on political implications conclude the paper.

2. Theoretical Considerations

2.1 Transport Networks and Cohesion

The important role of transport infrastructure for regional development is one of the fundamental principles of regional economics. In its most simplified form it implies that regions with better access to locations of input materials and markets will, *ceteris paribus*, be more productive, more competitive and hence more successful than more remote and isolated regions (see Linneker, 1997).

The two-way interaction between regional economic development and interregional transport is illustrated by Figure 1. The relationship between regional development and transport can be seen as a self-reinforcing positive feedback loop in which regional economic growth creates more traffic and, vice versa, transport opportunities generate regional economic growth, with congestion and prices factor acting as equilibrating negative feedbacks.

The impact of transport infrastructure on regional development has been difficult to verify empirically. There seems to be a clear positive correlation between transport infrastructure endowment or the location in interregional networks and the *levels* of economic indicators such as GDP per capita (e.g. Biehl, 1991; Keeble et al., 1982; 1988). However, this correlation may merely reflect historical agglomeration processes rather than causal relationships effective today (cf. Bröcker and Peschel, 1988). Attempts to explain *changes* in economic indicators, i.e. economic growth and decline, by transport investment have been been much less successful. The reason for this failure may be that in countries with an already highly developed transport infrastructure further transport network improvements bring only marginal benefits. The conclusion is that transport improvements have strong impacts on regional development only where they result in removing a *bottleneck* (Blum, 1982; Biehl, 1991; Fürst et al., 2000).

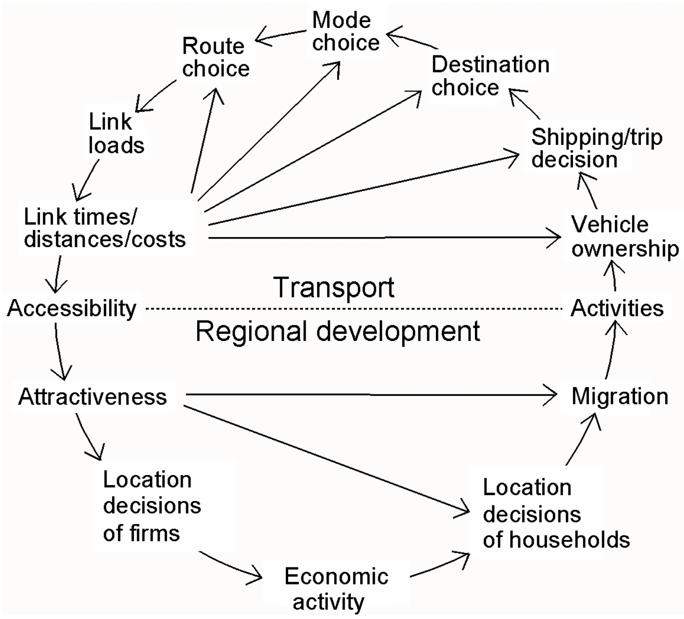

Figure 1. Transport and regional development

While there is uncertainty about the magnitude of the impact of transport infrastructure on regional development, there is even less agreement on its direction. It is debated whether transport infrastructure contributes to regional polarisation or decentralisation. Some analysts argue that regional development policies based on the creation of infrastructure in lagging regions have not succeeded in reducing regional disparities in Europe (Vickerman, 1991a), whereas others point out that it has yet to be ascertained that the reduction of barriers between regions has disadvantaged peripheral regions (Bröcker and Peschel, 1988). From a theoretical point of view, both effects can occur. A new motorway or high-speed rail connection between a peripheral and a central region, for instance, makes it easier for producers in the peripheral region to market their products in large cities, however, it may also expose the region to the competition of more advanced products from the centre and so endanger formerly secure regional monopolies (Vickerman, 1991b; Bundesminister für Verkehr, 1996).

The conclusion is that the relationship between transport infrastructure and economic development has become more complex than ever. There are successful regions in the European core confirming the theoretical expectation that location matters. However, there are also centrally located regions suffering from industrial decline and high unemployment.

On the other side of the spectrum the poorest regions, as theory would predict, are at the periphery, but there are also prosperous peripheral regions such as the Scandinavian countries. To make things even more difficult, some of the economically fastest growing regions are among the most peripheral ones.

2.2 EU Transport Policy

A prominent role for the achievement of the goals stated in Article 2 of the Maastricht Treaty play the trans-European networks in the fields of transport, communications and energy (TEN). Already Article 129b of the Maastricht Treaty linked the TEN to the objectives of Article 7a (free traffic of goods, persons, services and capital) and Article 130a (promotion of economic and social cohesion). In particular the trans-European transport networks were to link landlocked and peripheral areas with the central areas of the Union. These objectives were confirmed in the European Spatial Development Perspective (ESDP 1999, 14). The trans-European transport networks (TETN) are the most relevant in spatial development policy and in financial terms. The TETN absorb more than 80 % of the total TEN budget. A large part of the investments in TETN is currently concentrated on high-speed railway lines, often connecting major conurbations.

In the ESDP document, improvements in accessibility are given a high priority as a policy target: "Good accessibility of European regions improves not only their competitive position but also the competitiveness of Europe as a whole." (ESDP 1999, 69) "The creation of several dynamic zones of global economic integration, well distributed throughout the EU territory and comprising a network of internationally accessible metropolitan regions and their linked hinterland (towns, cities and rural areas of varying sizes), will play a key role in improving spatial balance in Europe" (ESDP, 1999, 20). However, it is admitted that "it is not possible to achieve the same degree of accessibility between all regions of the EU" (ESDP, 1999, 36).

This goal-setting reflects the assertion that improvements in accessibility have positive implications for regional (economic) development. Unfortunately, as shown above, there is no unicausal and straightforward link between these two phenomena, and thus the question remains *a priori* open: upgrading a region's accessibility provides actors in that particular region with improved possibilities to reach destinations outside, but at the same time, they meet increasing competition from outside. The net effect on regional development remains an empirical issue.

3. Peripherality Indicators

In this study, accessibility and peripherality indicators are used in order to identify those regions in Europe whose geographical position is remote and whose transport infrastructure tends to be improved.

Fundamentally, a peripherality indicator can be interpreted as an inverse function of accessibility, i.e. the higher the accessibility, the less peripheral a region is located and *vice versa*. Accessibility indicators can be used to analyse peripherality in several ways: regions can be classified into central and peripheral regions, impacts of different policy measures such as transport investments can be evaluated, or impacts of accessibility on regional development can be analysed.

Accessibility indicators can be defined to reflect both within-region transport infrastructure and infrastructure outside the region which affect the region. For example, the following indicators are often used in literature as basic accessibility indicators (starting from simple to more complex indicators):

- total lengths of motorways, number of railway stations (*infrastructure measures*)
- travel time to the nearest nodes of interregional networks (*travel time indicators*)
- accumulated travel cost to a set of activities (*travel cost indicators*)
- accumulated activities in a given travel time (*daily accessibility*)
- accumulated activities weighted by a function of travel cost (*potential*)

All these indicators are being used to assess the quality of a transport system, or, with respect to infrastructure improvement programmes, to assess which regions are likely to benefit from a certain transport project. By doing this, each indicator has its own strengths and weaknesses, and focuses on certain aspects of accessibility.

The accessibility indicators used in this study are based on the assumption that the attraction of a destination increases with size *and* declines with distance or travel time or cost. Therefore both size and distance of destinations are taken into account. The economic potential of a region is the total of destinations in all regions weighted by a function of distance from the origin region. The potential for economic activity at any location is a function of its proximity $f(c_{ij})$ to other economic centres and of its economic size $g(W_j)$.

$$A_i = \sum_j g(W_j) f(c_{ij})$$

The size of the destination is usually represented by regional population or some economic indicator such as total regional gross domestic product (GDP) or total regional income. This is the main idea of the so called potential accessibility (Hansen, 1959; Keeble et al., 1982; 1988; Schürmann et al., 1997; Schürmann and Talaat, 2000a; Wegener et al., 2000). Potential indicators are frequently expressed in percent of average accessibility of all regions or, if changes of accessibility are studied, in percent of average accessibility of all regions in the base year of the comparison.

In the methodology used here travel time matrices are calculated separately for passenger traffic and freight transport, i.e. the road modes are considered only. These matrices are used to calculate regional accessibility indicators, which are then converted to peripherality indicators. The E.P.I. system developed is capable of calculating a large number of different output indicators, differentiated by the following dimensions:

- *Spatial aggregation*: all calculations of peripherality indices are based on level 3 of the Nomenclature of Territorial Units for Statistics (NUTS) and are then aggregated to levels 2, 1 and 0 of the NUTS for the EU member states and equivalent geographical units as identified by Eurostat for the candidate and EFTA countries (Eurostat, 1999a; 1999b) by averaging over NUTS-3 regions weighted by NUTS-3 region population.

- *Modes*: Since speed limits for cars and trucks differ and statutory drivers' resting periods affect freight transport, all indicators were calculated separately for passenger and freight road transport. Travel time matrices and peripherality indices for cars represent the perspective of service firms and consumers, namely how many opportunities, such as clients, markets or tourist facilities can be reached from a firm’s location. Travel time matrices and peripherality indicators for lorries, i.e. for goods transport, can be interpreted from the perspective of producers on (potential) markets as the answer to the question which location has the highest market potential. Travel time matrices take account of different road types, national speed limits for cars and lorries, speed constraints in urban and mountainous areas, sea journeys, border delays and, in the case of freight transport, statutory drivers' resting periods.

- *Mass terms*: peripherality indices are calculated for each origin region by adding up the mass of each destination region weighted by a function of distance from the origin region. Usually, the mass is measured in terms of gross domestic product (GDP). In this study, also GDP in purchasing power standards (PPS), employment and population are used as mass terms.

- *Type of indicator*: all peripherality indices are derivatives of potential accessibility. Two different types of peripherality indices are defined:
  Peripherality Index 1 (PI1): The region with the highest potential accessibility, i.e. the most central region, is defined to have a peripherality index of zero. The region with the lowest potential accessibility, i.e. the most remote region, is defined to have a peripherality index of one hundred. The peripherality index of all other regions is a linear interpolation between zero and one hundred proportional to their potential accessibility. The higher the peripherality index, the higher the peripherality.
  Peripherality Index 2 (PI2): The average potential accessibility of all regions weighted by regional population is defined to be one hundred. The peripherality index of all regions is calculated as potential accessibility expressed in percent of average accessibility. The higher the peripherality index, the lower the peripherality. Peripherality Index 2 is therefore in fact a standardised accessibility indicator.
- *Spatial scope of standardisation*: the standardisation was done for three different territories: EU member states, EU member states plus five candidate countries (Estonia, Poland, Czech Republic, Hungary, Slovenia) and EU member states plus twelve candidate countries (the five countries above plus Latvia, Lithuania, Slovakia, Romania, Bulgaria, Cyprus, Malta).

Based on the above classification (4 NUTS levels, 2 modes, 4 mass terms, 2 types of indicators, 3 territories), 4 x 2 x 4 x 2 x 3 = 192 possible output indicators were calculated. For this, an interactive GIS-based software package on top of ArcInfo was developed using AML scripts (see Schürmann and Talaat, 2000b).

4. The European Peripherality Index (E.P.I.)

4.1 Standard Peripherality Indicators

Based on other studies and on theoretical considerations, peripherality with respect to population by car and peripherality with respect to GDP in Euro by lorry at the NUTS 3 level were proposed as standard peripherality indices (Schürmann and Talaat, 2000a).

The two indicators refer to different perspectives. Peripherality with respect to population by car represent the perspective of service firms and consumers with respect to how many opportunities such as clients, markets or tourist facilities can be reached. Peripherality to GDP by lorry represent the perspective of producers on potential markets. In both cases, potential accessibility in percent of average potential accessibility of the territory considered, is used (Peripherality Index 2).

Peripherality with respect to population

The peripherality index with respect to population is shown in Figure 2. Regions in the Benelux countries, most of the regions in Germany and regions in northern France show accessibility above average, i.e. can be considered as the most central regions. Regions between the cities of Rotterdam and Antwerp, towards the Rhine-Ruhr-Area and alongside the Rhine river in Germany are the most central ones. Additionally, some regions in England, in particular around London, and in northern Italy nearby Madrid also show above-average accessibilities.

All other regions show accessibilities below-average, i.e. tend to be peripheral. The most peripheral regions are, as expected, located in Scandinavia and Scotland and on the Mediterranean Islands.

Most regions in Spain, Italy and southern France yield peripherality indices between 25 and 100. With very few exceptions in the Czech Republic and in Poland, all regions in the candidate countries have below-average accessibility, i.e. are to be seen as peripheral. Other regions in the Czech Republic and Poland show index values near the average, i.e. they benefit from their relative closeness to German agglomerations, but also from their relatively high self-potential. Peripherality indices for Bulgaria and Romania are as low as in Spain. The Baltic countries are not that peripheral as the Scandinavian countries, but yield also relatively low index values. The further north they are located, the lower are their index values.

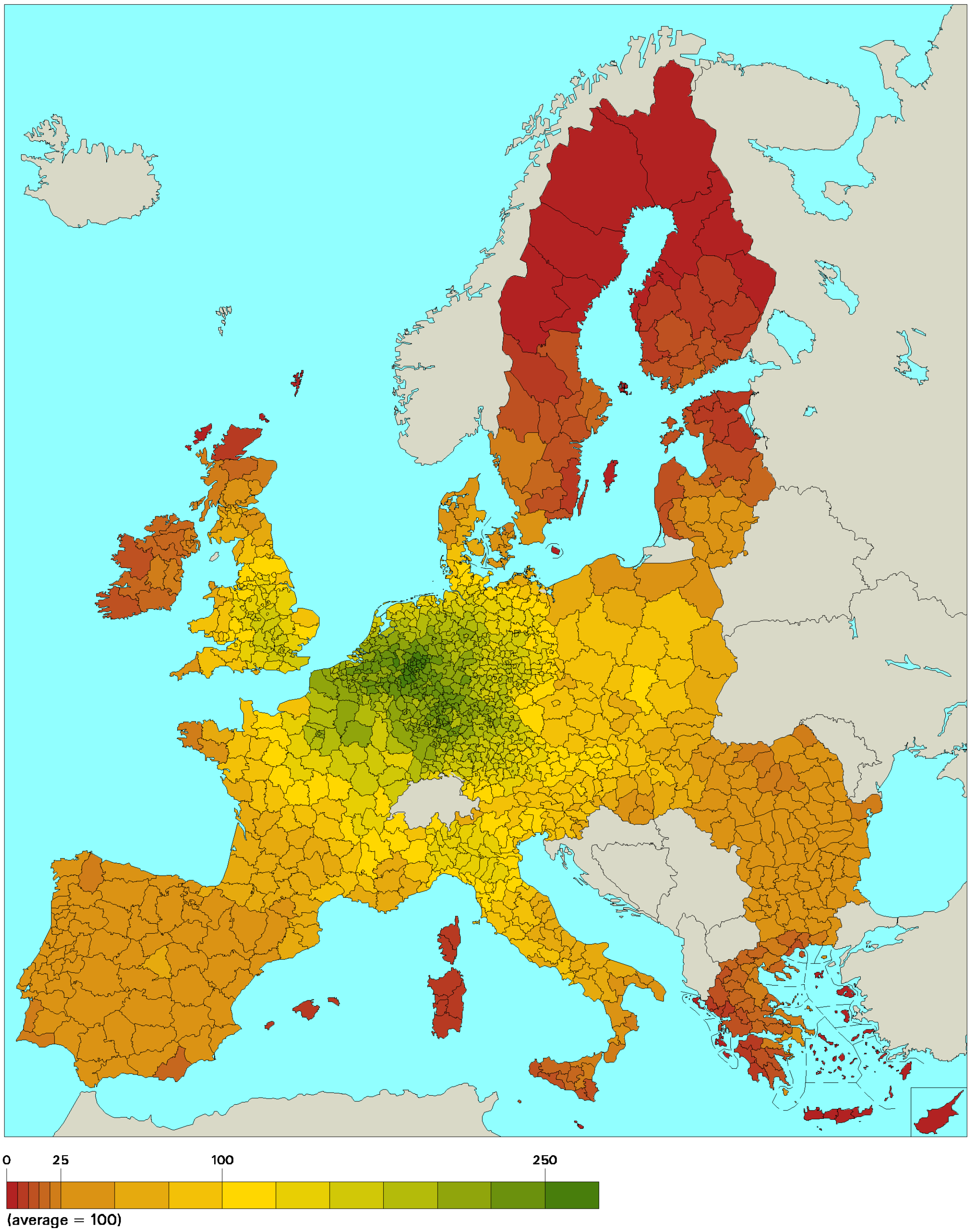

Figure 2. Access to population by car (NUTS 3).

Peripherality with respect to GDP

The peripherality index with respect to GDP is illustrated in Figure 3. The overall spatial pattern is similar to the peripherality index with respect to population. However, the most central and most peripheral regions are much more pronounced. Regions in the

European core show the highest accessibility and so are most central. These regions are located along the 'Blue Banana' in western Germany, Belgium, in the southern parts of the Netherlands, in northern France and in southern England. A band of regions from the Po estuary towards Milan and Lyon up to the Channel coast show above-average accessibility. The differences between Spain and Portugal and between the southern and northern Scandinavian regions are, compared to Figure 2, more pronounced, i.e. among the peripheral regions there seems to be a clear distinction between peripheral, more peripheral and most peripheral regions. Regarding the most peripheral regions, also regions in the Baltic countries, in Romania and Bulgaria show index values of less than 10 due to their - compared to EU member states - still relatively poor economic performance.

Compared to the peripherality index with respect to population, regions directly located at the Channel benefit to a higher degree from the Eurotunnel. This indicates that from a consumer's perspective the Eurotunnel still has a barrier effect, whereas from a producer's perspective this barrier effect can be considered as much lower, if existing at all.

Nevertheless, the number of regions with accessibility values of more than 250 is significantly higher as for car; similarly, the number of regions with accessibility values of less than 10 is also significantly higher compared to Figure 2, since now also Romania and Bulgaria, all the Baltic regions and also regions in Portugal and Greece show up extremely low index values due to their relatively lower economic performance compared to other central European regions. So it can be stated that peripherality with respect to GDP is more polarised than with respect to population by car.

Comparison of Standard Indicators

The correlation diagram (Figure 4) confirms a high degree of similarity of both peripherality indices. Although the overall correlation seems clear, there are some small, but nevertheless important differences between both indices. In general, central regions in Benelux, Germany and France, but also in the UK show comparably higher values for peripherality with respect to GDP than with respect to population. On the other side, regions in the candidate countries have higher accessibility to population than to GDP. This is because most of the candidate countries have relatively poor economic performance but large populations which confirms the observation that peripherality index with respect to population seems less polarised than peripherality with respect to GDP. In other words, if peripherality with respect to GDP is used central regions appear less peripheral, if peripherality with respect to population is used the candidate countries appear less peripheral.

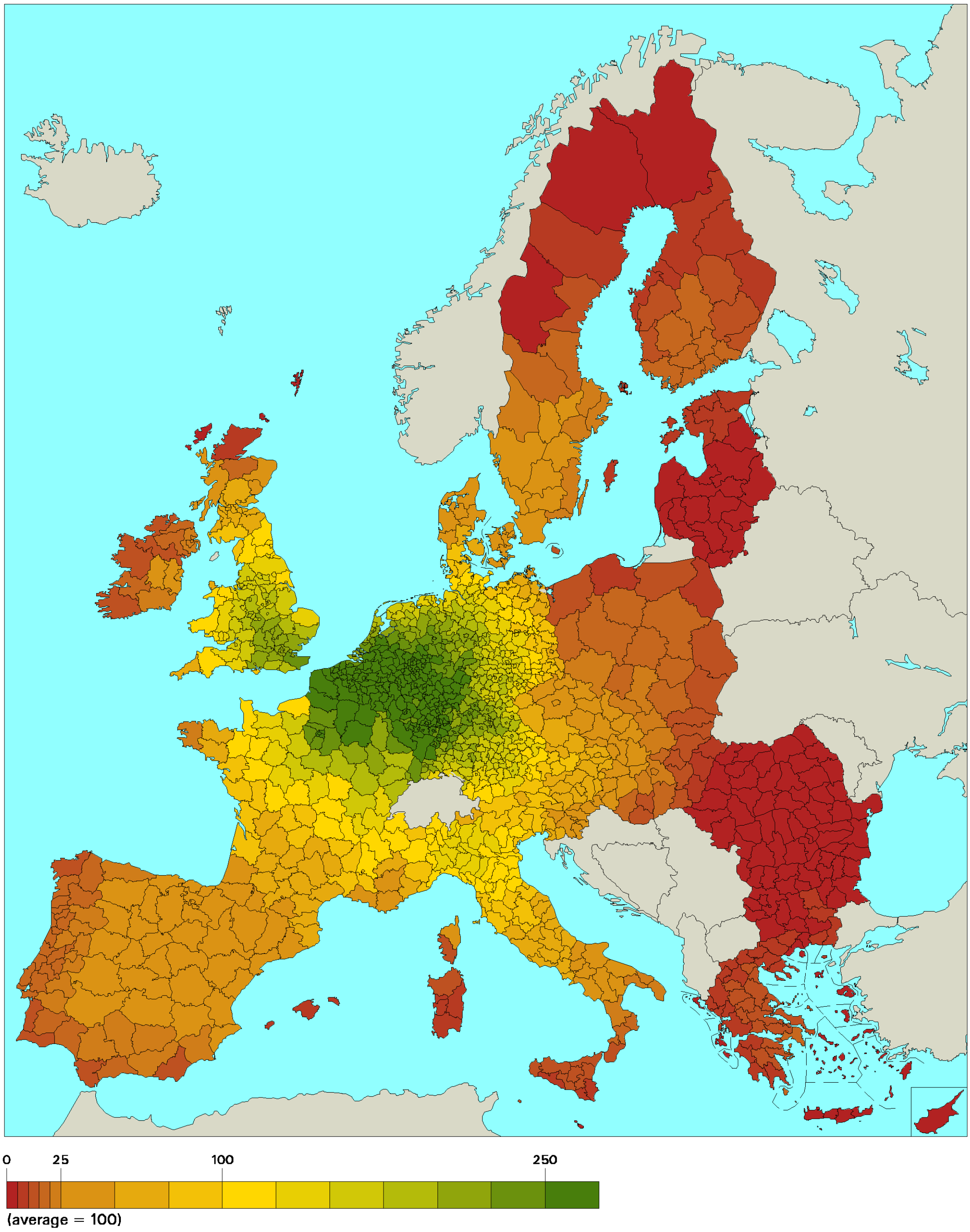

Figure 3. Access to GDP by lorry (NUTS 3).

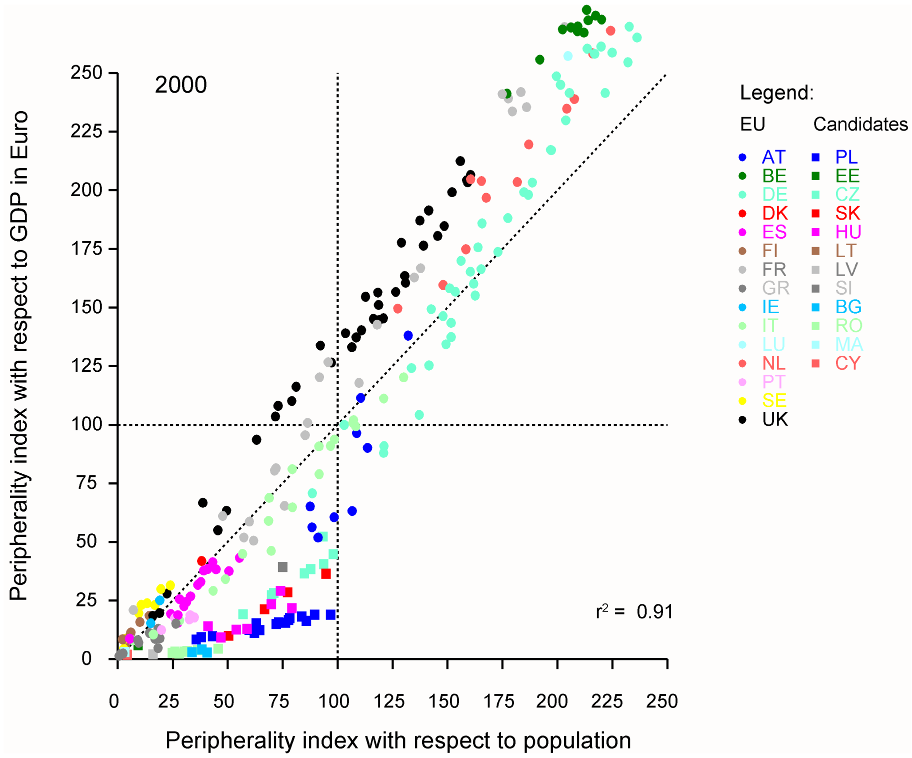

Figure 4. Access to population v. access to GDP (NUTS 2).

4.2. Discussion of Peripherality Indicators

In the following sections, the other dimensions of the peripherality indicators are systematically compared. It can be shown, that the overall pictures are quite similar, but that each indicator emphasis on certain aspects of peripherality. Along with the description, preliminary political recommendations based on the above findings are given.

Spatial aggregation

The higher the NUTS level considered, the greater is the loss in spatial differentiation. Studies based on the NUTS-3 level yield a great number of detail and differentiation between and within peripheral and central regions (Figure 5). This is particularly true for the relatively small German, French and Italian regions. This reflects that accessibility and thus peripherality are very distinct phenomena with respect to their spatial patterns. For example, there might be clear positive economic effects close to new motorway exits, but only few kilometres away from the exit these positive effects cannot be verified. The recommendation then is that for any assessment of transport infrastructure improvements, the smallest spatial unit available should be used, preferable NUTS 3 regions.

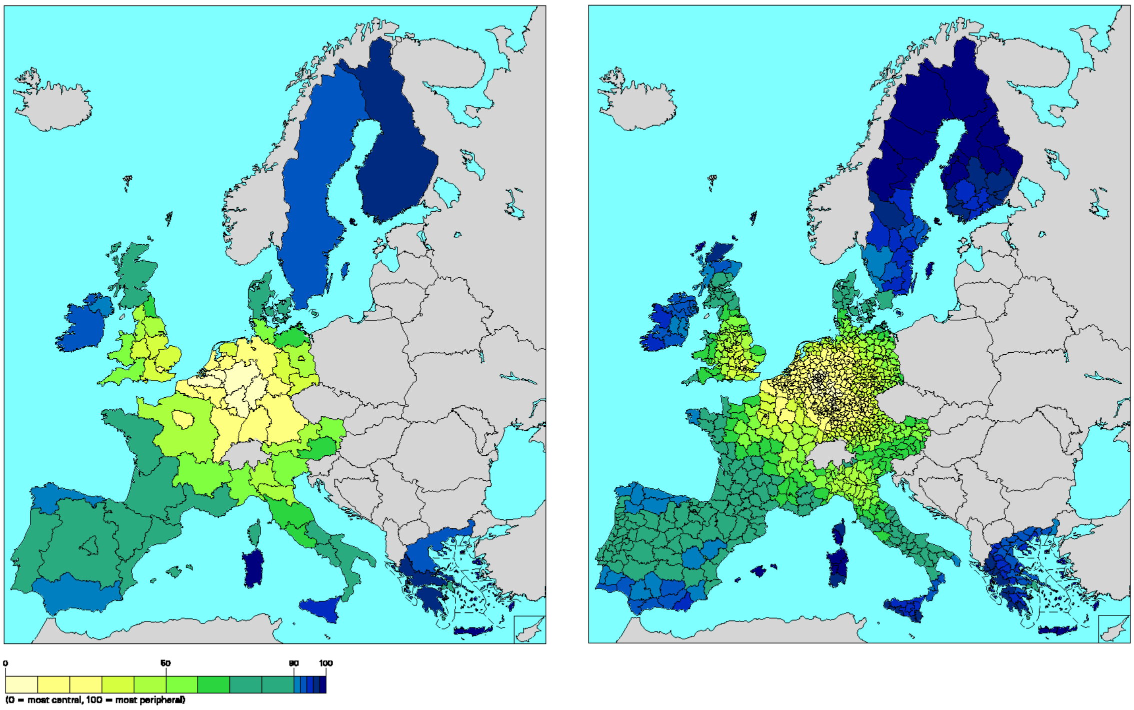

Figure 5. Access to employment by car for NUTS 1 (left) v. NUTS 3 (right).

Modes

Peripherality with respect to population by car is less polarised than peripherality with respect to GDP by lorry (Figure 6).

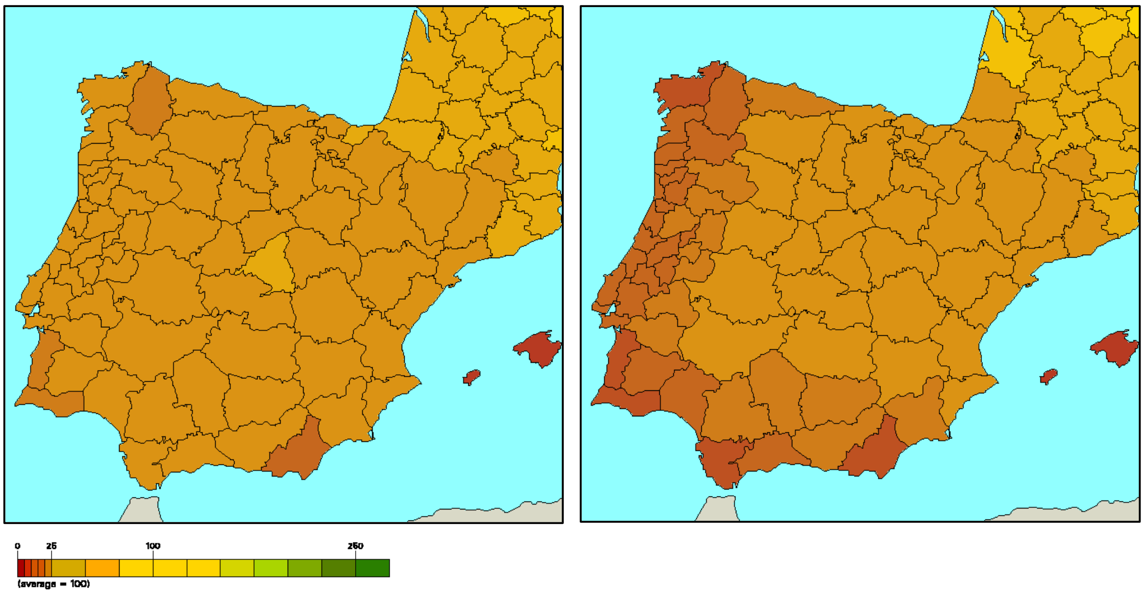

Figure 6. Access to population (left) vs. GDP (right).

This finding reflects that population is more equally distributed across the European continent than GDP. Therefore it cannot be expected that by extending and improving transport systems towards and within remote European regions these regions will catch up in terms of peripherality indicator performances, as long as the performance of the region’s economy is still relatively poor. This observation holds for remote regions within the EU, but also for many regions of the candidate countries.

Another clear distinction between the two modes can be seen on the effect of the Channel Tunnel. Peripherality with respect to lorry favours regions around the Channel coast, since for lorries the ‘barrier effect’ of the Channel is much lower than for cars (Figure 7). This means that producers and business travellers gain benefits from the Channel Tunnel; however, for other private passenger trips (visiting purposes, shopping, vacation trips), the Channel still remains not only a physical, but also a psychological barrier. Other studies indicate that this finding can be translated also to similar cases, for example the case of the Øresund bridge (see Fürst et al., 2000).

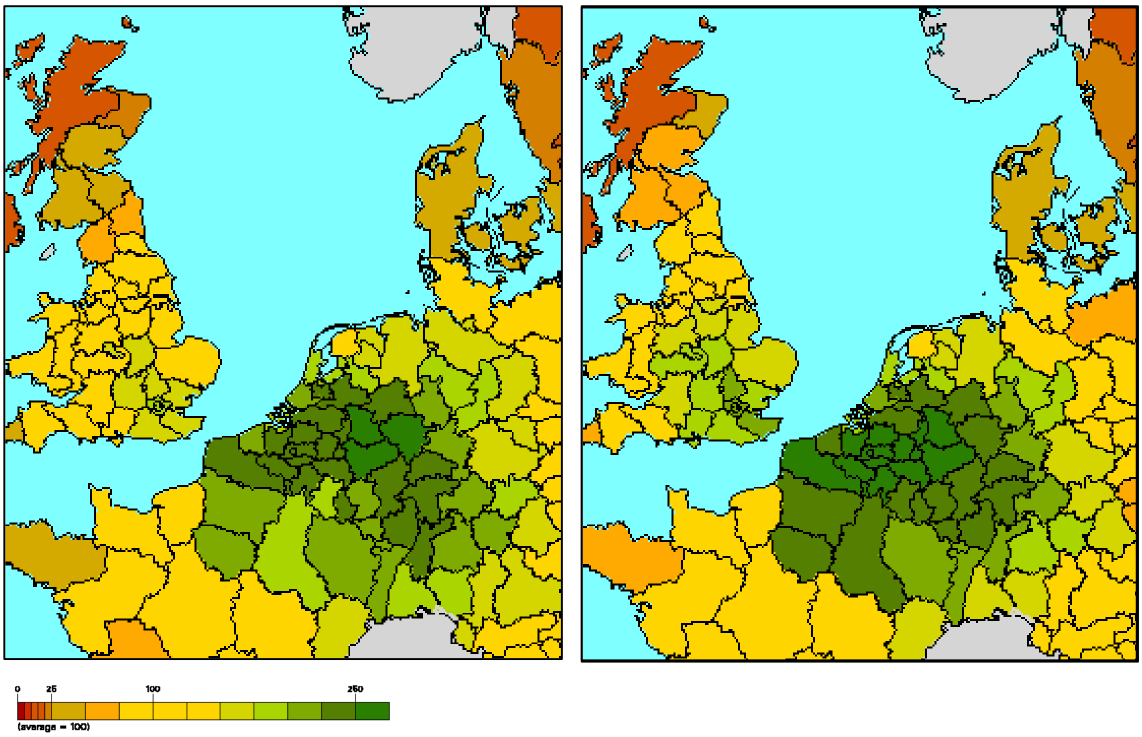

Figure 7. Access to GDP in PPS (NUTS 2) by car (left) and lorry (right).

Mass terms

Candidate countries benefit more if peripherality with respect to population by car is used as indicator; conversely, central European regions benefit more if peripherality with respect to GDP by lorry is used. This is because most of the candidate countries have relatively poor economic performance but large populations. This confirms that the effect of any transport infrastructure enhancements will not be tangible unless effective measures for economic improvement in the candidate countries are taken as well. Moreover, taking GDP in PPS as mass term yields slight balancing effects compared to GDP in Euro, but peripherality with respect to these two remains more polarised than with respect to population or employment.

Type of indicator

The type of the indicator, i.e. the way the accessibility values were standardised to peripherality indicators, has only little influence on the results. Standardisation between the minimum and maximum (Peripherality Index 1) yields slightly more differentiation among peripheral regions, whereas the standardisation on the European average (Peripherality Index 2) yields slightly more polarisation between central regions.

Spatial scope for standardisation

The greater the territory used for standardisation is, i.e. the more candidate countries are taken into account, the lower is the European average, and so the more will regions in EU member states improve their relative position (Figure 8). This hints that for some regions intra-regional peripherality seems to be much more important than inter-regional peripherality, because in many regions all economic, social and family ties are linked to one or two economic centres within the region (or country), but not to that extent to centres abroad. This in turn implies that in some regions it might be more worthwhile to improve intra-regional infrastructure than inter-regional infrastructure (e.g. regions in Portugal or Spain).

4.3 Conclusions

The accessibility indicators and peripherality indices presented confirm previous accessibility calculations (Fürst et al., 2000; Wegener et al., 2000). In summary, for all kind of indicators, regions in western Germany, northern France, Belgium, the Netherlands, southern England and northern Italy show the highest accessibilities and can be considered the most central regions.

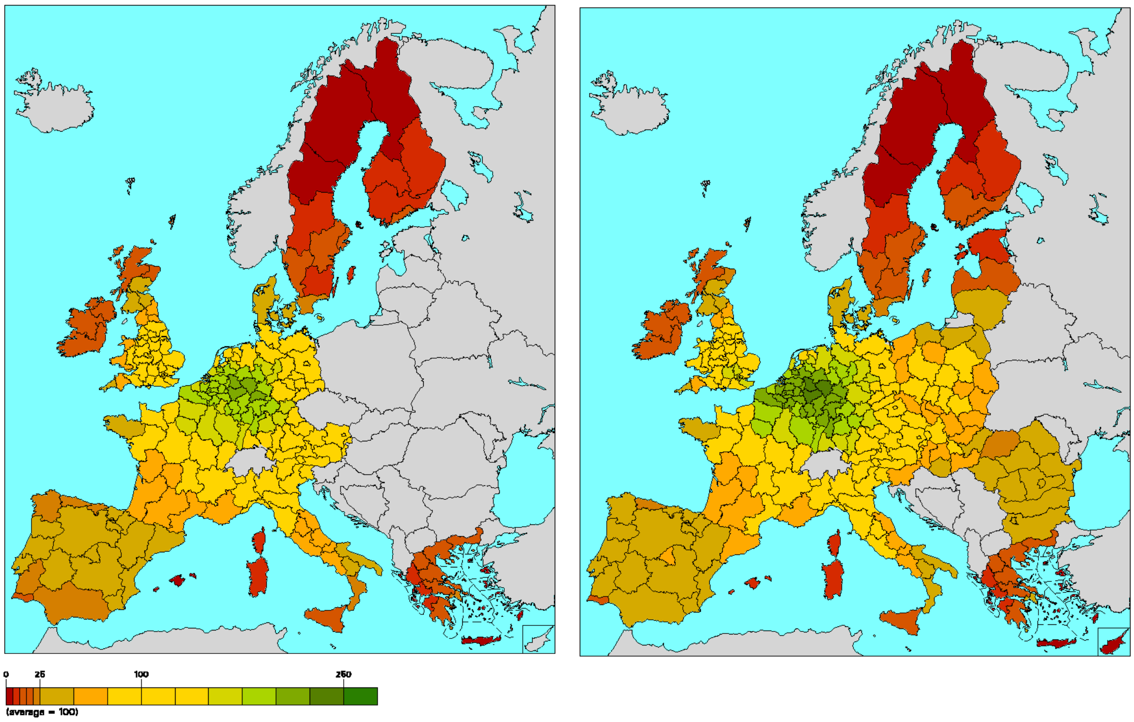

Figure 8. Access to population by car for EU member states (left) and EU member states plus 12 candidate countries (right).

When NUTS-3 regions are considered, great differences in peripherality can be found between peripheral regions, for example in Scandinavia, in Greece and on the Iberian Peninsula. This indicates that it is not appropriate to differentiate between ‘peripheral’ and ‘central’ regions only, but that regions must be treated carefully and very distinct. Of course, when higher NUTS levels are considered, these details partly disappear.

The study also evaluated the peripherality of EU member states and candidate countries by a number of different peripherality indices with respect to NUTS levels, modes, mass terms, types of indicator and spatial scope of standardisation. Comparisons between different peripherality indices show that the choice of indicator has great influence on the results, because each indicator emphasised on certain aspects of peripherality. Based on these comparisons, the following conclusions can be drawn:

- The overall spatial patterns of all peripherality indices are very similar, so correlations between different indicators are rather high. This reflects the fact that, irrespective of the kind of peripherality index used, the distant geographical position of peripheral regions cannot be fully removed by transport infrastructure improvements. Transport infrastructure must, therefore, be seen only as a catalyst to facilitate economic development, but is not a general panacea for remote regions to catch up.

- For a number of regions, effects of infrastructure improvements will not be tangible unless effective measures for economic improvements in these countries are taken as well.
- Producers and business travellers gain benefits from the Channel Tunnel; for other private passenger trips the Channel still remains not only a physical, but also a psychological barrier.
- Transport infrastructure improvements have strongest impacts on regional development only where they remove a bottleneck; however, these improvements affect stronger business trips and goods movements than private passenger trips. Spatially, these effect mainly focus on the regions directly located at the infrastructure project, but can only hardly be measured for the economy as a whole.
- There are hints, that for some regions intra-regional peripherality seems to be more important than inter-regional peripherality, which in turn imply that it might be more worthwhile to improve intra-regional infrastructure than inter-regional transport systems.
- Transport infrastructure improvements lead to significant travel time reductions. These reductions have also positive effects on regional accessibility, but to a lesser degree. The translation of these positive accessibility effects into economic performance of regions sometimes yields only very marginal effects, if there are any positive effects at all, because economic development is not only subject to accessibility but also to a number of other, sometimes conflicting factors (see Fürst et al., 2000).
- Although this study was not intended to answer the question, whether transport infrastructure contributes to regional polarisation or decentralisation, however, the spatial patterns of the peripherality indicators suggest that the transport system existing today tend to lead to further polarisation between regions in Europe.

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