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KLAUS SPIEKERMANN, MICHAEL WEGENER

Trans-European Networks and Unequal Accessibility in Europe

Zusammenfassung

Nach dem Vertrag von Maastricht sollen die transeuropäischen Netze durch die Verbesserung der Erreichbarkeit benachteiligter Regionen die wirtschaftliche und soziale Kohäsion in Europa erhöhen. Allerdings weisen alle Elemente dieses enormen Investitionsprogramms darauf hin, daß im Gegensatz zu den Annahmen des Vertrags ihr wesentlicher Zweck in der Schaffung effizienter Verbindungen zwischen den großen Wirtschaftszentren zur Verbesserung der globalen Wettbewerbsfähigkeit Europas liegt. Es ist daher anzunehmen, daß die transeuropäischen Netze die Erreichbarkeitsunterschiede und damit auch die wirtschaftlichen Diskrepanzen eher noch vergrößern, anstatt sie abzumildern. In dem folgenden Artikel wird die Hypothese der wachsenden Disparitäten in Europa durch die transeuropäischen Netze mittels theoretischer Überlegungen und durch neue Formen der Analyse der Wirkung der transeuropäischen Netze auf die Raumstruktur und die Verteilung der Erreichbarkeit in Europa erörtert.

Résumé

Le Traité de Maastricht prétend que les réseaux transeuropéens, au moyen d'une accessibilité améliorée des régions moins favorisées, conduise à une cohésion économique et sociale augmentée de l'Union Européenne. Pourtant et tout au contraire de ce qu'il prétend le Traité de Maastricht, tous les élements du programme des réseaux transeuropéens, englobant des investissements d'un montant extraordinaire, montrent que le but essentiel poursuivi est de rendre en réseau efficacement les centres économiques principaux afin d'augmenter la compétivité gobale de l'Europe. Pour cette raison il est bien plus probable que les réseaux transeuropéens conduisent à une augmentation des disparités d'accessibilité, et par conséquent de même économiques, entre les régions centrales et périphériques en Europe qu'il ne les réduisent. Le texte suivant se consacre de cette hypothèse des disparités en augmentation en Europe, en tant que conséquence des réseaux transeuropéens, en s'appuyant sur des réflexions théoriques et en présentant des nouvelles approches pour analyser les impacts des réseaux transeuropéens sur la structure territoriale et sur la distribution d'accessibilité en Europe.

Summary

The Maastricht Treaty claims that the trans-European networks are to improve the economic and social cohesion of the Union through increased accessibility of the less favoured regions. However, all features of this enormous investment programme indicate that, in contrast to the claims of the Treaty, its major purpose is to efficiently connect the main economic centres and so enhance the global competitiveness of Europe. It is therefore likely that the trans-European networks will not reduce but widen the differences in accessibility, and consequently also in economic opportunity, between central and peripheral regions in Europe. The hypothesis of growing disparities in Europe due to the trans-European networks is discussed in the paper in theoretical terms and by presenting new ways of analysing the impacts of trans-European networks on the spatial structure and the distribution of accessibility in Europe.

This paper is a companion paper to Roger Vickerman's "Restructuring of Transport Networks" in the previous edition of EUREG. The authors are grateful to Roger Vickerman for the permission to use material from unpublished joint work.

1. Introduction

Article 2 of the Maastricht Treaty states as the goals of the European Union the promotion of harmonious and balanced economic development, stable, non-inflationary and sustainable growth, convergence of economic performance, high levels of employment and social security, improvement of the quality of life and economic and social coherence and solidarity between the member states. However, actual policy making of the Union appears to be predominantly shaped by two major objectives. The first and dominant objective is to increase the competitiveness of Europe as compared with her global rivals, the United States and Japan. The second and mostly secondary objective is to reduce economic and social disparities between the regions and countries of the Union. The inherent conflict between these two objectives is rarely addressed. Policies that stimulate competition for the sake of economic growth reward the more efficient at the expense of the less able, and this necessarily widens the gap between successful and less successful firms, regions and cities.

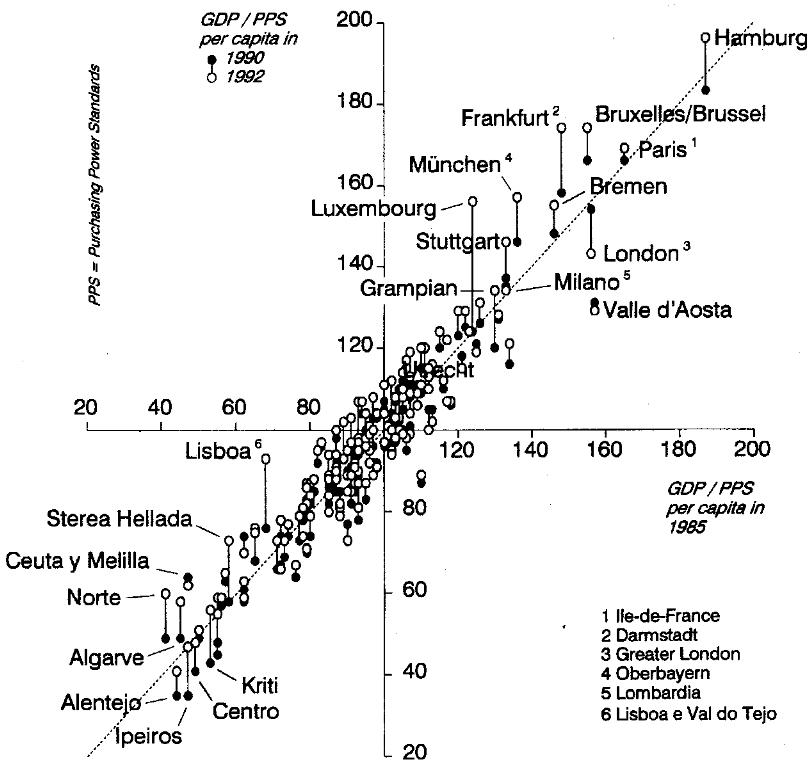
There are large economic disparities at the regional level in the European Union. Regional gross domestic product (GDP) per capita and its development over time are a good indicator to illustrate advantaged and disadvantaged regions. Only in the 1960s and 1970s there was some convergence of regional per-capita GDP in the Community; during the 1980s regional disparities started to increase. Today the ratio between the GDP per capita of the richest and poorest regions in the Community is more than 6:1, about three times as high as that between the richest and poorest states of the United States. Figure 1 compares GDP per capita (adjusted to purchasing power standards) of NUTS 2 (Nomenclature des unités territorriales statistiques) regions between 1985, 1990 and 1992. Even if one takes account of the fact that there are difficulties in regional definition which bias the measures in favour of urban regions, it is evident that the large urban regions have continued to maintain their position as the richest regions in the Community and that the peripheral regions have remained poor. In the early 1990s the asymmetrical regional development is even much more pronounced. With the exception of Greater London, all major agglomerations in the centre of Europe benefit, whereas most of the less favoured regions fall back. Exceptions to this are lagging regions in Portugal, Spain or Greece that received major subsidies from the Structural Funds of the Union, which in some cases account for a large proportion of their growth.

A prominent role for the achievement of cohesion in Europe is played by the envisaged trans-European networks in the field of transport, communications and energy. Article 129b of the Maastricht Treaty links the trans-European networks to the objectives of Article 7a (free traffic of goods, persons, services and capital in the Single European Market) and Article 130a (promotion of economic and social cohesion). In particular, the trans-European networks are to link landlocked and peripheral areas with the central areas of the Community.

In physical and monetary terms, the trans-European transport networks are one of the most ambitious initiatives of the European Community since its foundation. The master plans for rail, road, waterways, ports and airports together require public and private investments of 220 billion ECU until the end of the century, of which the Union is prepared to finance about 20 billion ECU per year (Commission of the European Communities, 1993; European Commission, 1994). At the 1995 Council meeting in Essen a list of 14 specific projects proposed by the Christophersen group was selected for priority implementation.

However, the programme is not undisputed. Critics argue that many of the new connections do not link peripheral countries to the core but link two central countries and so reinforce their accessibility advantage. Only forty percent of the new motorways in the road master plan are in peripheral countries, whereas sixty percent are in countries with an already highly developed road infrastructure. 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, whereas others point out that it has yet to be ascertained that the reduction of barriers between regions has disadvantaged peripheral regions. 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 the large cities, however, it may

Figure 1: GDP per capita (adjusted to purchasing power standards) of NUTS 2 regions in the European Union, 1985, 1990 and 1992 (Source: Eurostat 1990; 1994; 1995)



also expose it to the competition of more advanced products from the centre and so endanger formerly secure regional monopolies.

In addition there are environmental concerns. High-speed rail corridors or multi-lane motorways consume environmentally valuable open space in high-density metropolitan areas and cut through ecologically sensitive habitats and natural regions outside of cities and in addition contribute to the general trend of inducing more and higher-speed travel and goods transport.

The hypothesis of this paper is that the existing differences in accessibility and consequently also in economic opportunity between the regions in Europe tend to increase rather than to be reduced by the trans-European transport networks. The paper discusses this hypothesis by first presenting theoretical arguments on the impact of transport infrastructure on regional development. Then two new ways of analysing the impact of transport network improvements on spatial structure and accessibility are presented.

2. Transport Infrastructure and Spatial Development

One of the fundamental assumptions of regional economics is that regions with better access to the locations of input materials and markets will, ceteris paribus, be more productive, more competitive and hence more successful than regions with inferior accessibility. According to this assumption, the position of a region with respect to major transport networks, and in particular improvements of its accessibility, are essential for its economic development. This has been demonstrated by empirical studies. There seems to be a positive correlation between transport infrastructure endowment or interregional accessibility and the *levels* of economic indicators such as GDP per capita (e.g. Blonk 1979; Biehl 1986; Keeble et al. 1982, 1988). However, this correlation may merely reflect historical agglomeration processes rather than causal relationships still effective today (cf. Bröcker and Peschel 1988).

Attempts to explain *changes* in economic indicators, i.e. economic growth and decline, by transport investment or differences in accessibility have been much less successful. The impact of transport infrastructure investments on regional development has been difficult to verify empirically. One reason for this may be that in countries with an already highly developed transport infrastructure accessibility tends to become ubiquitous and further infrastructure 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 1986, 1991).

What is more important is that there is even less agreement on the direction of the impact. It is still unclear 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 the 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; Vickerman 1996).

However, the way transport infrastructure influences spatial development is affected by fundamental changes in the field of transport and communications that are being accelerated by the increasing integration of national economies by the Single European Market and the ongoing process of normalisation between western and eastern Europe (see Masser et al. 1992):

- The quality and reliability of transport services has replaced transport cost as the most important factor for modern industries. An increased proportion of international freight comprises high-value goods for which the transport cost component of production is much less than for low-value bulk products.
- Transport investments which reduce the variability of travel times, increase travel speeds or allow flexibility in scheduling are becoming more important for improving the competitiveness of service and manufacturing industries and are therefore valued more highly in locational decisions than changes resulting only in cost reductions.
- Telecommunications have reduced the need for some goods transports and person trips, however, they may also increase transport flows by their ability to create new markets.
- With the shift from heavy-industry manufacturing to high-tech industries and services other less tangible location factors have at least partly displaced traditional ones. These include factors related to leisure, culture, image and environment, i.e. quality of life, and access to information and specialised high-level services and to the institutional and political environment.
- The introduction of entirely new, superior levels of transport such as the high-speed rail system creates new locational advantages, but also disadvantages for regions not served by the new networks.

3. Changing Accessibility in Europe

It is now asked whether the expectation of the authors of the Maastricht Treaty is right that the trans-European networks, by linking the peripheral regions to the European core, will stimulate their economic development or whether the sceptics are right that, by primarily linking core regions, they are likely to contribute to spatial polarisation in Europe. A full answer to this question would require a comprehensive forecasting model of all flows of goods, persons and services across these networks and how they would change in response to the new transport opportunities, as well as of the economic impacts this would have on the regions. Such a model based on a multiregional input-output framework has been applied to study the regional impacts of the Channel Tunnel (Fayman et al. 1995; ACT et al. 1996), but such a model is not applied here.

Here it is only asked in which direction the trans-European networks will change the relative locational advantage of different parts of the European continent. If the trans-European networks indeed, as the Maastricht Treaty suggests, improve the accessibility of peripheral regions relative to the regions in the European core, it is possible that the peripheral regions benefit economically, though also the opposite may occur. If, however, the trans-European networks increase the difference in accessibility between the central and peripheral regions, then they will contribute to spatial polarisation.

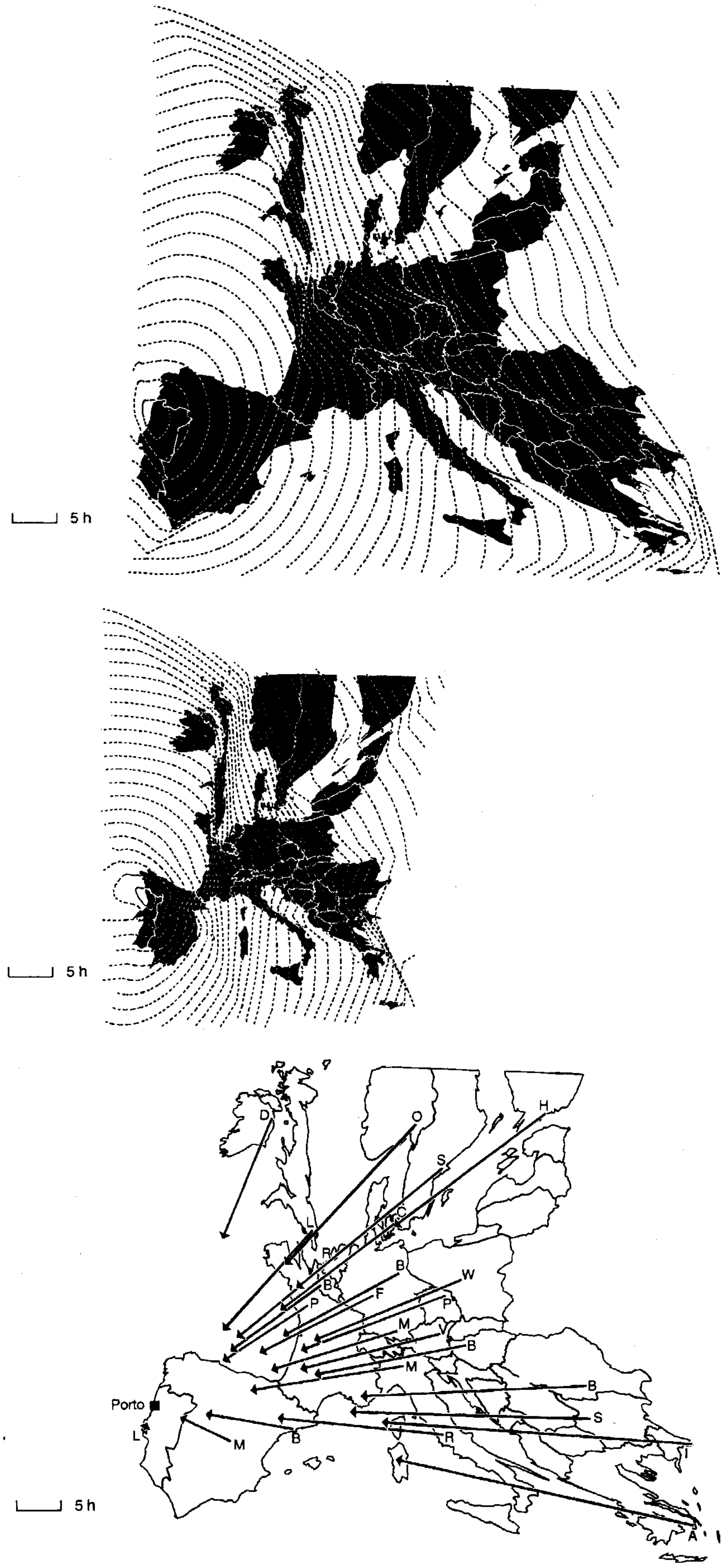
It is shown how, by using two different methods of analysis, different answers to the above question may result.

3.1 Spatial Integration

One technique of visualising the effects of decreasing travel times are time-space maps. Time-space maps represent the time space. The elements of a time-space map are organised in such a way that the distances between them are not proportional to their physical distance as in topographical maps, but proportional to the travel times between them. Short travel times between two points result in their presentation close together on the map; points separated by long travel times appear distant on the map. The scale of the map is no longer in spatial but in temporal units. The change of metric results in distortions of the map compared to physical maps if the travel speed is different in different parts of the network (Spiekermann and Wegener 1993; 1994). Time-space maps may include all elements of normal maps such as coast lines or borders, transport networks or built-up areas. In practice only elements relevant for understanding the map are displayed. The emphasis is on the distortions of time-space maps compared with physical maps or with other time-space maps.

The examples for time-space maps in Figure 2 show Europe (excluding Russia and the Ukraine) as seen from Porto in Portugal, i.e. from a peripheral perspective. Porto is the capital of the Norte region, which belongs to the most lagging and most remote regions in Europe (see Figure 1). The two upper maps plot lines around Porto which, in a physical map would be equidistant circles spaced 100 kilometres from each other. In the time-space maps, however, the circles are distorted because the average rail travel speeds are different in different parts of the maps. The larger map at the top shows travel times by rail in the year 1994, the smaller map in the centre rail travel times in the year 2010 under the assumption that the programme of trans-European

Figure 2: Time-space maps of the rail network in Europe: travel times from Porto, 1993 (top) und 2010 (centre) and change 1993-2010 (bottom)



networks will be implemented as envisaged by the International Union of Railways (Walrave 1993).

The maps show that the impacts of the new high-speed rail lines are substantial. In 1994 the first five to six lines around Norte are far apart from each other, i.e. they reflect the low rail travel times on the Iberian peninsula. In time-space Norte is separated from the rest of Europe. However, some effects of first high-speed links are visible. France is contracted by the first TGV lines and Germany by the first north-south ICE-link. Much more striking are the slow speeds of the rail network in eastern and in particular south-eastern Europe which lead to a large representation on the time-space map.

The full "space-eating" effect of high-speed rail becomes visible with the implementation of the trans-European rail network. In 2010 the continent will have dramatically shrunk in time space, yet its shape will have become much more similar to the familiar physical map. Norte will be much better integrated into Europe. This is highlighted by the map at the bottom showing how selected European cities are "pulled" towards Porto. Average travel times between Norte and most European destinations are reduced by more than half.

Time-space maps are well suited to visualise the reductions in travel times achieved by the trans-European networks. They might, therefore, support the claim of the Maastricht Treaty that trans-European rail network will benefit the peripheral regions in Europe. This, however, could be misleading as similar maps can be produced also for the main economic centres (Wegener et al. 1994). Moreover, time-space maps show travel time reductions only for the most accessible nodes of the networks. What they do not show, or even hide, are the much smaller travel time reductions in the areas between the nodes. In some cases travel times there may even increase, for instance when with the introduction of high-speed rail intermediate stops of former express trains are only served by local trains. This, however, is not revealed by time-space maps.

3.2 Spatial Disintegration

Accessibility can be defined as the potential for opportunities for interaction (Hansen 1959) or in more operational terms, the "attractiveness of a node in a network taking into account the mass of other nodes and the costs to reach those nodes via the network" (Bruinsma and Rietveld 1996). There are numerous ways to measure accessibility, ranging from simple weighted aggregates of travel time (e.g. Guitérrez and Urbano 1996) to sophisticated approaches based on spatial interaction models (e.g. Keeble et al. 1982, Bruinsma and Rietveld 1993).

Previous accessibility studies have concentrated on accessibility indicators calculated for cities or regions and have ignored the fact that accessibility is continuous in space. To represent a continuous surface in this study a raster-based data structure was applied. As no raster-based population data for Europe are available, synthetic raster data were generated using microsimulation in combination with a geographic information system (Wegener and Spiekermann 1996). For that purpose thé European territory was disaggregated into some 70 000 raster cells of 10 kilometres width. Two sets of input data were prepared, the distribution of population in Europe and current and future rail travel times in Europe:

- Raster-based population data were generated by the allocation of urban and national population to 10-kilometre raster cells. For each country first the population of large cities was allocated to cells at and close to their geographical location. The number of cells for each city was determined as a function of the total population of the city. After distributing the urban population, the remaining population of each country was evenly distributed across the rest of the country, i.e. a homogenous density of the rural population was assumed. The result was a data file with estimated population for each of the about 70 000 raster cells of Europe.
- For rail travel times a simplified network linking major European cities was used with travel times of 1993 and estimated travel times for 2010, i.e. travel times with the high-speed rail network of the rail master plan in operation. The access time from each cell to the nearest node of the network was calculated assuming an air-line travel speed of 30 km/h. The total travel time between two cells therefore consists of three parts: the access time from the origin cell to the nearest network node, the travel time on the network, and the terminal time to the destination cell from the node nearest to it. If the direct air-line travel time between two cells was shorter than travel over the network, the shorter direct travel time was used.

The accessibility indicator calculated here is a variation of the daily accessibility proposed by Törnqvist (1970) and Cederlund et al. (1991). Törnqvist developed the notion of contact networks as early as 1970 hypothesising that the number of interactions with other cities would be a good indicator of the position of a city in the urban hierarchy. The magnitude of the accessibility indicator corresponds to the number of people that can be reached from a city by a return trip during a work day with a minimum stay of a certain time.

Daily accessibility indicators were calculated for the years 1993 and 2010 for each of the 70 000 raster cells taking account of the population at and travel time to all other 70 000 cells. The population of all destination cells that can be reached from the origin cell within a certain number of hours is weighted equally regardless of travel time; for all other raster cells the weight is zero. Five hours is assumed to be the maximum one-way door-to-door travel time for a one-day return trip.

The accessibility surfaces so derived are presented in three-dimensional form in Figure 3. The elevation of the accessibility surfaces in the two diagrams is proportional to the population that can be reached within five hours. The top diagram displays daily accessibility by rail in 1993. Large differences in accessibility become visible. Urban regions have the highest and rural areas the lowest accessibility. Accessibility decreases from the city centres to the rural areas. Moreover, the areas in central Europe, both urban and rural, have a higher accessibility than regions at the European periphery. With a little imagination the "Blue Banana", the European megalopolis stretching from London along the Rhine corridor to Northern Italy, can be recognised. Although peripheral agglomerations such as Moscow, St. Petersburg or Istanbul are poorly connected to the network, they have high accessibility values because of their large population.

Figure 3: Daily accessibility by rail (number of persons reached in five hours), 1993 (top) and 2010 (bottom)

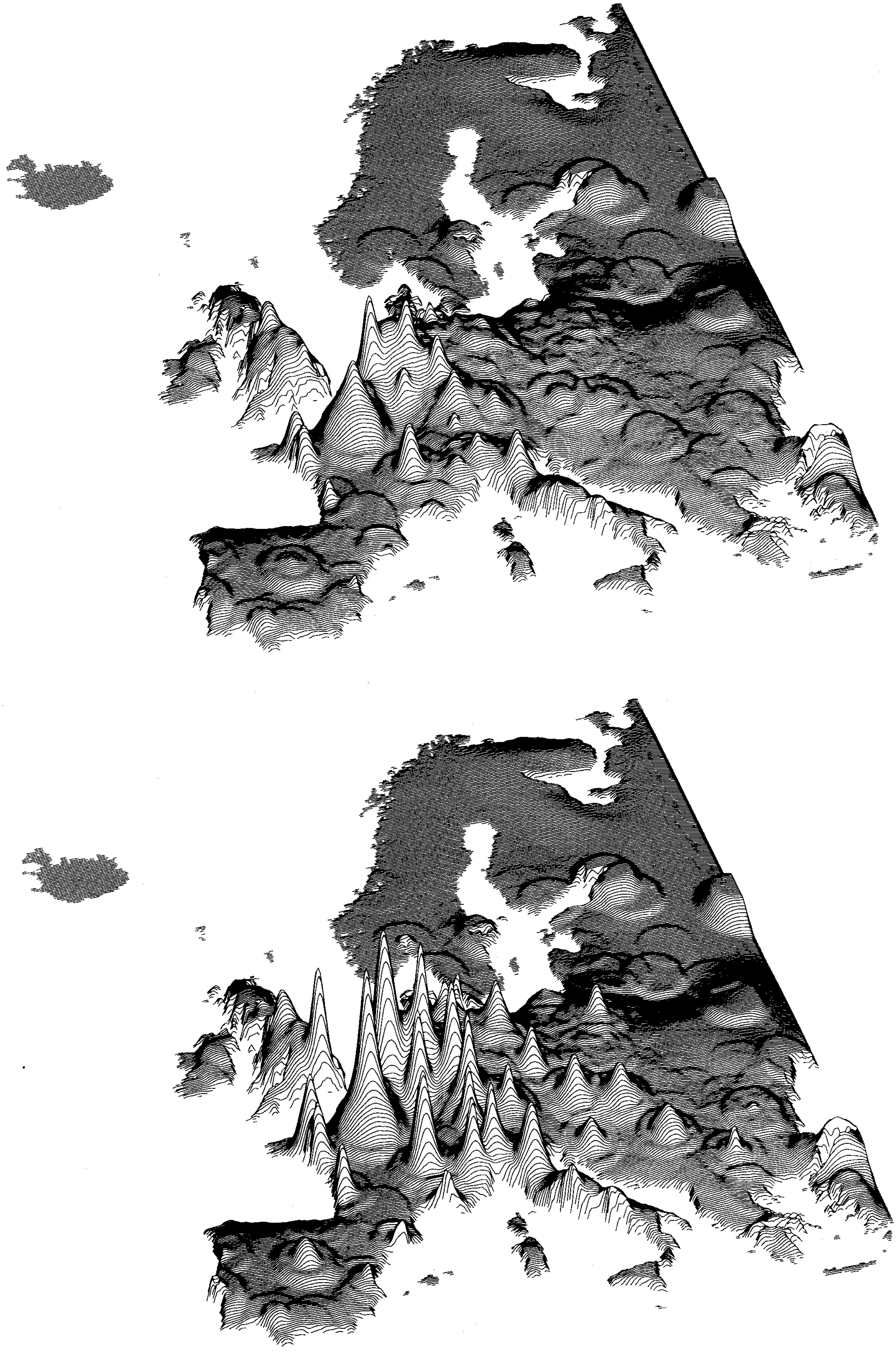
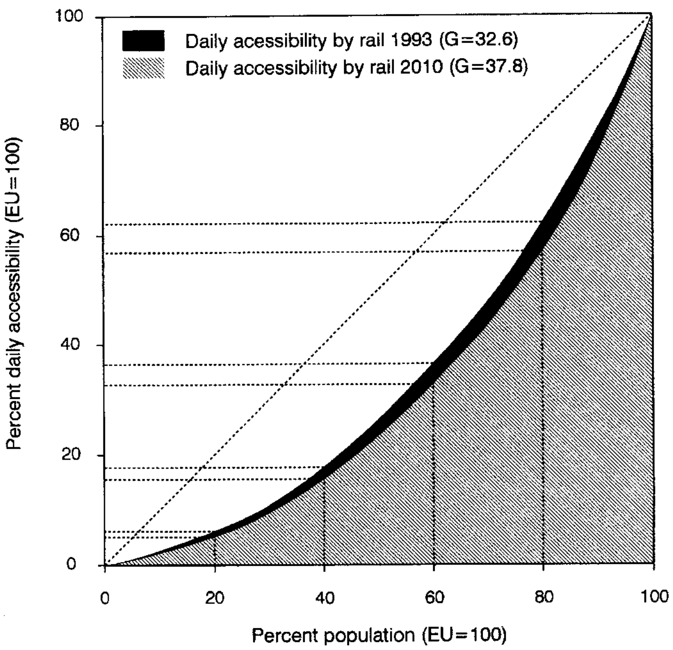


Figure 4: Lorenz distributions of daily accessibility by rail, 1993 and 2010



The bottom diagram shows the same indicator for 2010. The only change in input is the assumption that the trans-European high-speed rail network will be in operation. The overall accessibility pattern seems to be not much different, but the polarising effect of the new network becomes apparent. Only urban regions that are also nodes of the network have benefited, while the regions in between have not. Also the differences in accessibility between cities in the core and the periphery have become larger. The growth in accessibility of cities in the "Blue Banana" is several times larger than that of cities at the European periphery. The growth in accessibility for cities at the periphery such as Porto is hardly visible, whereas the peaks in the economic core areas of Europe have become much more pronounced.

The visual impression of increasing differences in accessibility between core and periphery is confirmed by Figure 4. The figure compares the rank-ordered distributions of the daily accessibility indicators displayed in Figure 3 averaged for NUTS 2 regions within the European Union for the years 1993 and 2010. Indeed the distribution for 2010 (the area shaded in grey) is more polarised than the one for 1993 (the area shaded in black). The same result is expressed by the Gini coefficients (G) given in brackets for both distributions.

Figure 5 reveals which regions are the winners of this polarisation. The figure correlates average daily accessibility by NUTS 2 region in 1993 with that of 2010 in a scatter diagram. As expected from Figure 3, it is a very similar set of regions in the core of Europe as the one that dominated the upper right quadrant of Figure 1. By definition (because the indicators shown in the diagram are expressed as percent of the EU average accessibility of the respective year), the majority of the remaining regions lose in relative terms because they do not gain, and this is particularly true for the peripheral regions at the bottom of the distribution, many of which are also among the poorest regions in Figure 1, such as Norte.

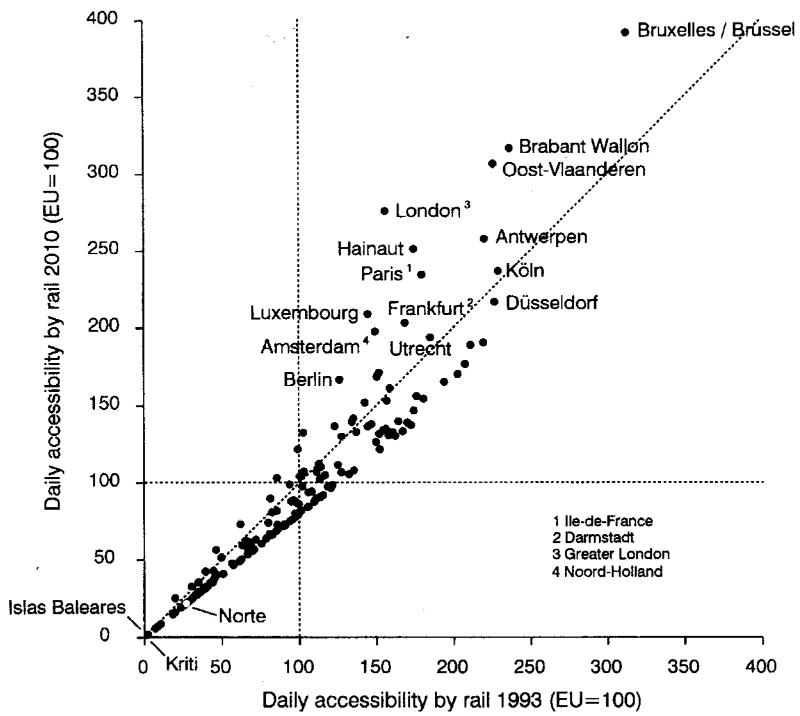
4. Conclusions

The analysis of the impacts of the development of the trans-European rail network confirms the view that the trans-European networks, in contrast to the claims of the Maastricht Treaty, may widen rather than narrow the differences in accessibility between central and peripheral regions in Europe.

This does not imply that the relative gains in rail accessibility of peripheral regions may not be beneficial to their economic development, however, it must be pointed out that these gains will always be overshadowed by the much larger gains in rail accessibility of the regions in the European core. It is therefore not possible to refer to the trans-European high-speed rail networks as instruments to promote the cohesion between the regions in Europe and the reduction of interregional economic and social disparities. A European transport policy truly committed to that goal would have to significantly shift the focus to transport links within and between the peripheral regions, not in addition to but at the expense of transport investments in the European core.

However, it has to be kept in mind that this analysis has looked at only one mode, high-speed rail, and that the most favourable area for the development of high-speed rail is in the densely populated central regions of Europe where major cities are at ideal distances apart. It remains to be investigated whether other trans-European transport net-

Figure 5: Average daily accessibility by rail of NUTS 2 regions, 1993 versus 2010



works, for instance the network of European motorways, have similar effects or indeed help to redress the disparities between central and peripheral regions. This will be done in future studies.

In terms of methodology, the spatially disaggregate accessibility indicators presented in this paper seem to be superior to previous more aggregate indicators, because the continuous representation of space gives a much more detailed picture of intraregional disparities. However there is room for a number of improvements which will be addressed in future work. The population data used will be made more homogenous by taking into account data for all cities with a population of more than 50 000 and for NUTS 3 regions and regions of similar size in eastern Europe. Also the networks will be represented with more detail such as all stops of the future high-speed rail network. However spatial disaggregation of accessibility may not be sufficient. Sectoral disaggregation of accessibility indicators might reveal very different accessibility landscapes depending on the specific connectivity needs of particular industries. Equally important may be a disaggregation by transport mode, not for choosing the least-cost mode on each relation, but for utilising the different kinds of locational information contained in each of them.

Beyond all refinements of accessibility indicators, however, the question of what they are to achieve reappears. After all, accessibility is not a desirable good by itself but a means to an end, in this case economic activity. Therefore the final benchmark for the quality of accessibility indicators are not theoretical beauty or plausibility but explanatory power in a predictive framework where economic indicators such as GDP or added value per capita or employment are the explanandum. Only if it is possible to demonstrate that the accessibility indicators so generated contribute more to our understanding why some regions grow and some decline will they be worth the extra effort and complexity.

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