Socio-economic Assessment of Spatial Impacts of TEN Investments

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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. A prominent role for the achievement of these goals is played by the envisaged trans-European networks in the fields of transport, communications and energy (TEN). Article 129b of the 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 masterplans for rail, road, waterways, ports and airports together require public and private investment 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, 1994). At the 1994 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 masterplan are in peripheral countries, whereas sixty percent are in countries with an already highly developed road infrastructure. 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.

In the face of these uncertainties and goal conflicts, the consistent prediction and the rational and transparent evaluation of the likely socio-economic impacts of major transport infrastructure investments and transport system improvements become of primary social relevance and political importance both for the European Union and the Member States.

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This paper presents an overview on the methodology and first results of an ongoing research project conducted for DG VII (Transport) of the European Commission as part of the 4th Framework for Research and Technological Development. The project is one of three parallel and coordinated projects directed at the development and adoption of a comprehensive and transferable methodology for the assessment of socio-economic impacts of major transport infrastructure investments and transport system improvements. It aims at

- designing an interactive, transparent modelling system for forecasting the impacts of impacts of transport infrastructure investments and transport system improvements (road, rail and air) on socio-economic activities and development, including spatial and temporal distribution and uncertainty/probability of impacts;
- developing flexible input and output interfaces for linking the modelling system both to its own data base and to data bases and evaluation methods developed in other projects;
- demonstrating the usability of the modelling system by applying it to a number of relevant case studies in the framework of various scenarios of political, social and economic developments.

The paper starts with a statement of the problem and a review of previous studies on the spatial impact of transport infrastructure. It then explains the approach selected for the project and presents the first results of exploratory analytical exercises with readily available data. It closes with an outlook on future work in the project.

2. Problem Statement

The 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 the locations of input materials and markets will, ceteris paribus, be more productive, more competitive and hence more successful than regions with inferior accessibility.

However, 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 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 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 has been much less successful. The reason for this failure 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).

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 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 et al. 1995; Vickerman, 1996).

While these two effects may partly cancel each other out, one factor unambiguously increases existing differences in accessibility. New transport infrastructure tends to be built not between core and periphery but within and between core regions because this is where transport demand is highest (Vickerman, 1991a). It is therefore likely that the trans-European transport networks will not reduce but widen the differences in accessibility and economic opportunity between central and peripheral regions.

In the face of these countervailing tendencies, to consistently forecast the likely consequences of major transport investments or transport system improvements is not an easy task and remains associated with uncertainty (Aberle, 1983). There exist a variety of methodological approaches. The simplest approach is to estimate regional production functions in which transport infrastructure figures in the form of regional indicators such as total length of highway in a region (e.g. Biehl, 1986, 1991; Blum, 1982; Johansson, 1993; Cutanda and Joaquina, 1994; Holtz-Eakin and Schwartz, 1995). At the other extreme are sophisticated dynamic or equilibrium models based on multiregional input-output and spatial interaction models (e.g. Amano and Fujita, 1970; Echenique, 1994; Fayman et al., 1995; Butler and Madsen, 1996). However, where the former type of model fails to take account of the connective and synergetic properties of networks, the latter type imposes demanding requirements on data collection, model calibration and computing effort to make it applicable in a wide range of cases. There is a more recent approach midway between the two which has the requisite variety to respond to the kind of policy questions asked but is parsimonious with in its data and computing requirements. This approach, too, uses regional production functions but represents transport infrastructure in the form of complex accessibility indicators taking account of the connectivity of the networks. Pioneering theoretical work in this field has been done by Rietveld (1989a, 1989b; Rietveld and Nijkamp, 1993) and, with respect to definitions of accessibility, by Bruinsma and Rietveld (1993, 1996).

Even if the forecasting has been satisfactorily performed, there remains the problem of evaluating the predicted impacts in the light of economic, social and environmental goals. This evaluation has become increasingly difficult because of the widespread lack of consensus about the goals transport planning and policy making should serve. Broadly speaking, there are three sets of goals everybody agrees should be considered (Masser et al., 1992): (1) *Growth.* Transport infrastructure should support economic development in cities and regions, in particular with respect to their international and global competitiveness. (2) *Equity.* Transport infrastructure should help to improve cohesion and cooperation between cities and regions in order to redress existing inequalities between locationally advanced and disadvantaged regions. (3) *Sustainability.* Transport infrastructure should not worsen but, if possible, improve environmental conditions in cities and regions by reducing congestion and attracting traffic to more energy-efficient and less polluting modes.

However, these three goals are frequently in conflict. While the inherent incompatibility of growth (efficiency) with equity and sustainability is commonplace, it is less well known that there may also be disagreement between equity and sustainability objectives. Moreover, these goal conflicts become even more pronounced if the interests of different groups of the population are considered. In addition, all three sets of goals have a strong spatial component.

Indicators for the evaluation of transport investments therefore have to take account of these goal conflicts. Efficiency-oriented indicators such as time and cost savings, economic rate of return and economic opportunities have to be traded off against changes in the distribution of social indicators such as accessibility to jobs, education, health care, retail facilities and recreation as well as environmental indicators such as energy use, land consumption, air pollution, traffic noise and intrusion into ecologically sensitive natural habitats; and all these indicators need to considered both in spatial terms, i.e. with respect to their spatial distribution between different regions, between cities and countryside and between core and periphery as well as in social terms, i.e. with respect to their impacts on specific groups of the population, to industry, transport operators and local and regional governments. Needless to say that the indicators need to be policy-sensitive, i.e. have to be designed in a way that they directly or indirectly show the impacts of policy decisions in the field of transport.

3. Theoretical Framework

Regional structures with their locationally fixed activities and transport systems with their inter-location flows can be seen as two facets of the same settlement pattern as they are contingent upon each other within the system of spatial economic systems. Within-location activities generate transport, whereas capacity bottlenecks in the transport system constrain the intensity of land use; a high degree of specialisation of flows in the transport system gives rise to a high degree of complexity and variety in locational production and consumption functions. Changes in the transport system induce positive (or sometimes negative) changes of locational attractiveness and so changes in within-location activities.

Locational attractiveness and spatial behaviour

Locations and transport facilities are evaluated by their users according to their utility: locations according to the degree of freedom, self-fulfilment, profit or promotion they provide, transport facilities according to the savings in time and costs they make possible, which in turn contribute to enhancing the freedom of action in temporal, spatial and monetary terms (see Bökemann, 1983). Governments at the European, Member State and regional level change the attractiveness of the locations in their territory through transport investments which are capitalised in terms of individual utility by their users. The utility for society at large is then the aggregate of individual utility gains.

In economic terms, the usability of a location depends on a combination of transportable factors and saleable products. Factors and revenues derived at a location are mediated by its endowments: The value of a location is determined by its suitability and capacity for activities and its accessibility with respect to relevant other activities, sources or markets. Owners have an interest that the value of their locations is not negatively affected. If, for instance through a major transport investment, the value of the location changes, they adjust their use of the location to its new value or move to another location and so negatively affect the tax base of the region in question. They may also change their voter behaviour if they disapprove of the change that has taken place. The observed behaviour of land owners in a region can therefore be interpreted as the aggregate evaluation of changes in locational attractiveness. Land prices signal not only supply and demand on the land market but also the willingness of households and firms to move into a region. Similarly, the net migration rate of a region indicates its relative attractiveness, as do changes in its tax revenue.

These interdependencies can be used to model the regional impacts of transport investments in terms of regional economic output, employment, household income, net migration and population based on regional production functions. However, in contrast to traditional production functions, here transport infrastructure is considered in the form of multi-modal activity-specific accessibility or potential indicators.

4. Methodology

The methodology developed in the project consists of a simulation model for forecasting the socio-economic impacts of major transport infrastructure investments and transport system improvements in Europe. The model predicts the development of regional added value, employment, net migration, households and population over time in response to exogenous forecasts of socio-economic trends and major transport infrastructure investments and transport system improvements. The spatial dimension of the model is established by subdividing the territory of the Union (or the whole of Europe) into geographical regions at the NUTS-II level. The temporal dimension is established by dividing time into time periods of one or two years.

The model moves through time from a base year, say 1995, to a target year which may be 2005, 2015 or, for an investigation of long-term impacts, 2025. For each simulation period, the model predicts for each region the changes in added value, employment, net migration, households and population that are likely to result from exogenous changes of multi-modal accessibility caused by transport investments and transport system improvements. These changes are the difference between the results of a base scenario (in which no changes of the transport system are assumed) and a policy scenario (in which the transport investments and transport system improvements under study are implemented). Base scenario and policy scenario are identical except for the policies under study.

Input data of the model are largely compiled from generally available Eurostat and national sources. There are three categories of data:

- spatially aggregate data on long-term economic, social and political trends such as time-series data on final demand and productivity by industry, fertility and mortality, migration and household formation, plus exogenous assumptions about their development during the forecasting period;
- regional data on added value, employment, net migration, households and population for the base year and one recent year of the past;
- detailed network data of the relevant transport modes (air, rail, road and inland waterways) in link-coded form with and without the transport policies under study, including data on link capacity, costs and level of service and across-the board data such as petrol prices and transport-related taxes, user charges or regulations.

Based on these data the model predicts for each region and each period the expected development of added value and employment by industry as a function of exogenous trends, regional endowment and transport accessibility using a generalised regional production function. A generic form of that function is

$$Q_{ir} = f_{ir}\ (K_{ir}\ ,\ L_{ir}\ ,\ A_{kr}\ ) \qquad (1)$$

where Q_{ir} is the quantity of industry i in region r to be predicted, K_{ir} and L_{ir} are production functions such as capital and labour respectively, and A_{kr} is the accessibility of region r with respect to activity k expressed as a function of the quantities W_{ks} of activity k in regions s weighted by multimodal generalised transport or travel costs between regions r and s:

$$A_{kr} = \sum_{s} W_{ks} \exp(-\beta c_{rs}) \qquad (2)$$

Migration, household and population data are derived from the predicted economic indicators using concepts from export base and migration theory. The age composition of population is updated using a cohort survival model linked to national population forecasts.

Outputs of the model are economic and social indicators such as added value, employment, net migration, households and population for each region and each time period between the base year and the forecasting horizon.

The simulation model is calibrated using time-series data for the exogenous socio-economic parameters and comparative-statics data of regional development in one or more time periods in the past.

The indicators are either outputs of the simulation model of regional development described above or are directly calculated from the regional and network data used in that model. This implies that the evaluation of socio-economic and spatial impacts can be performed without depending on transport flow and modal split data generated in complex transport and travel models.

Major categories of indicators of socio-economic and spatial development are:

- economic indicators such as added value, household incomes, time and cost savings, rate of return of transport investments;

- social indicators such as job opportunities, accessibility to jobs, education, health care, retail facilities and recreation;

- environmental indicators such as land consumption and intrusion into ecologically sensitive natural habitats.

Another useful classification of indicators is between within-place and accessibility indicators. Within-place indicators measure activities and attributes within a region such as economic or residential activities. Accessibility indicators measure the utility derived from remote activities existing and accessible in other regions via the transport networks. Equation (2) showed a generic example of an accessibility indicator. Accessibility indicators can also be interpreted as measures of the level of interaction or spatial cohesion between regions.

All indicators are evaluated both in spatial terms, i.e. with respect to their spatial distribution between different regions, between cities and countryside and between core and periphery as well as in social terms, i.e. with respect to their impacts on specific groups of the population, to industry, transport operators and local and regional governments.

Macro indicators describe the distributional effects of the policies under study in terms of concentration measures or a rank order of regions with respect to a particular indicator. Concentration measures (such as the GINI coefficient) describe inter-regional disparities and serve as target indicators of an equity-oriented regional policy. Regional rank orders describe the relative position of a region compared to every other region. The Spearman correlation coefficient can be used to measure the redistributional effects of a policy. Aggregates of regional accessibility indicators can be interpreted as measures of total spatial interaction or spatial cohesion between the regions.

5. First Results

In a first round of exploratory analyses it was 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, 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. In a second round the accessibility indicators were correlated with indicators of regional economic activity such as gross domestic product (GDP) per capita.

Accessibility

One way of visualising the impact of transport infrastructure on spatial structure are disaggregate accessibility indicators. Figure 1 (top) displays the accessibility surface of the rail network of Europe in 1993 using a potential indicator of the form shown in Equation (2). The elevation of the surface at each point indicates the magnitude of the population potential at that point. Strong disparities 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 population potential 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. Figure 1 (bottom) displays the *change* in accessibility between 1993 and 2020. Now it is clear that, while the general pattern of accessibility has remained the same, the difference between centre and periphery has become more pronounced. The highest absolute changes are in the nodes of the future high-speed rail network, and this growth is much more pronounced in central Europe than in the European periphery. Gutiérrez and Urbano (1996) conducted a similar analysis for the trans-European road network and concluded that peripheral regions gained most. However, that result may be due to the fact that they used an accessibility indicator without distance decay function.

Economic Impacts

Accessibility is not a desirable good by itself but a means to an end, here 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 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.

Figures 2 to 3 show first results of investigations aimed at clarifying the role of accessibility for economic development of regions in Europe. For this experiment, the accessibility measures presented in Figure 1 were aggregated for NUTS-2 regions and graphically correlated with two different indicators of economic development.

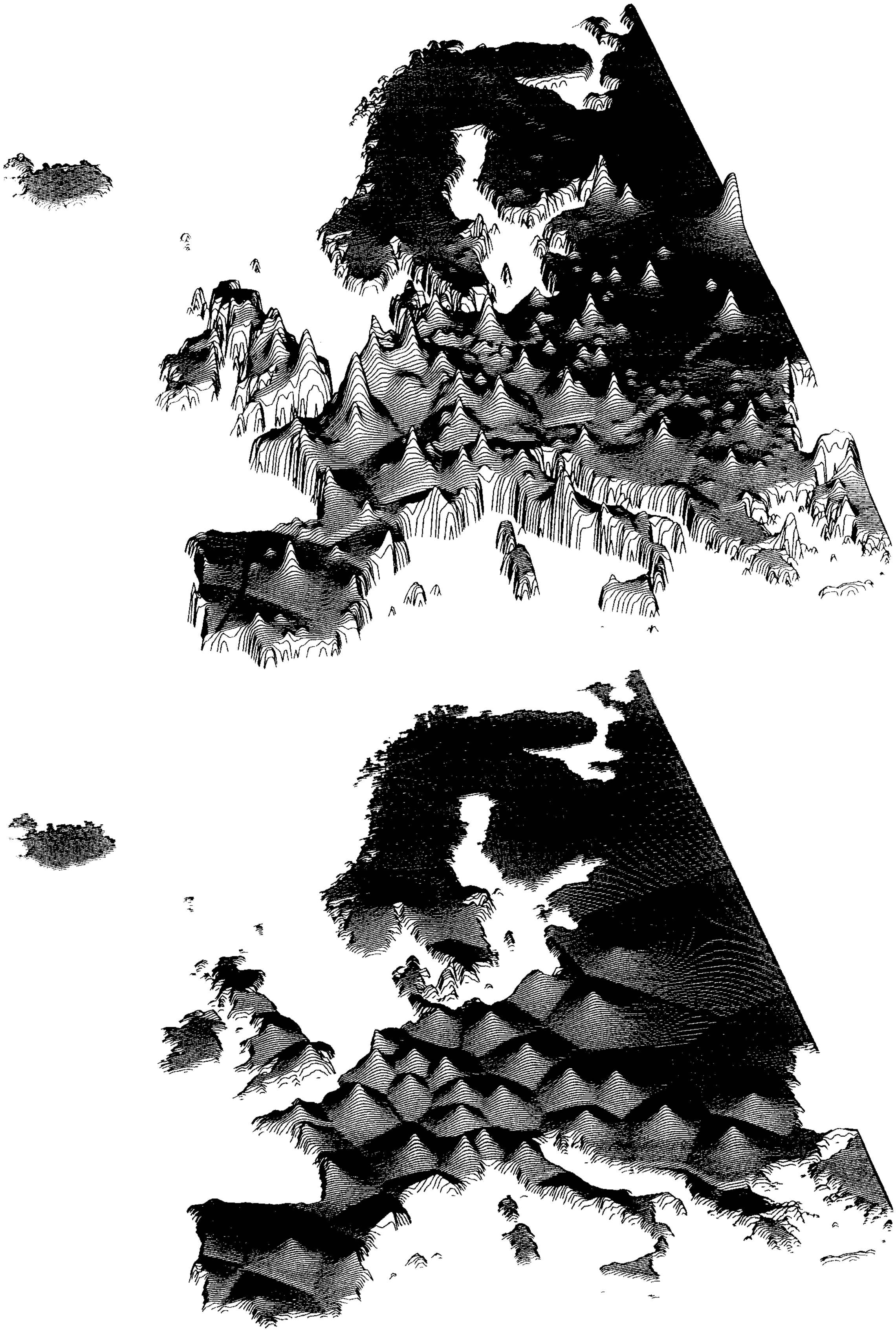
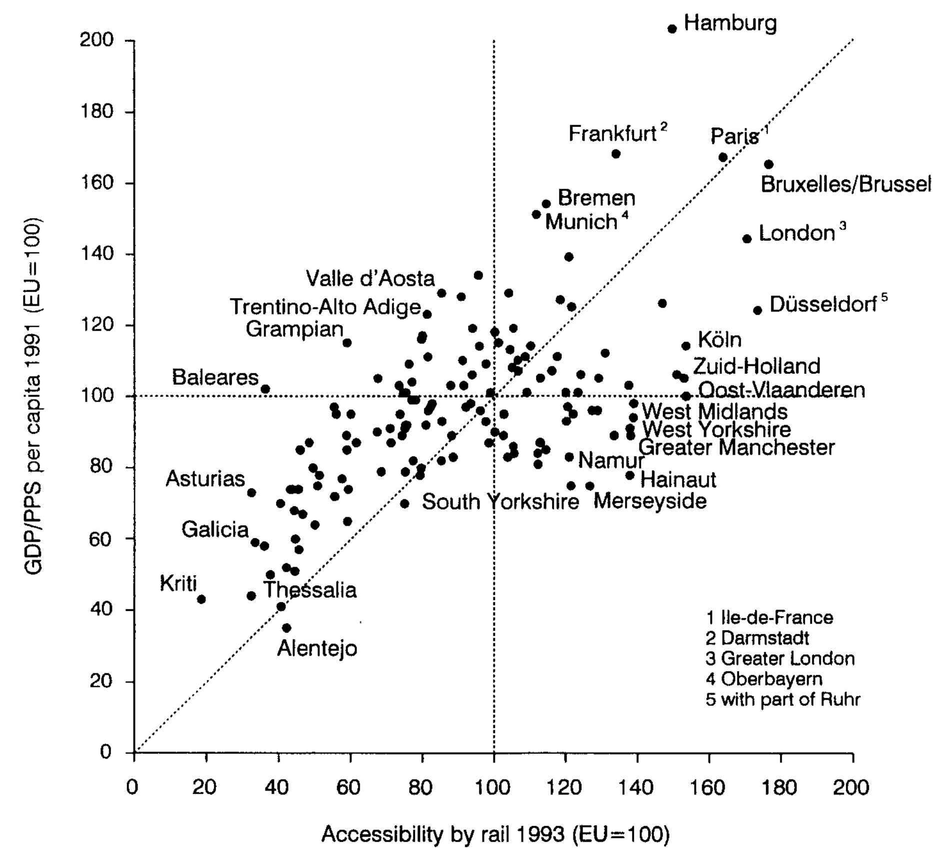


Figure 1. Accessibility by rail in Europe in 1993 (top) and difference between 1993 and 2010 (bottom).



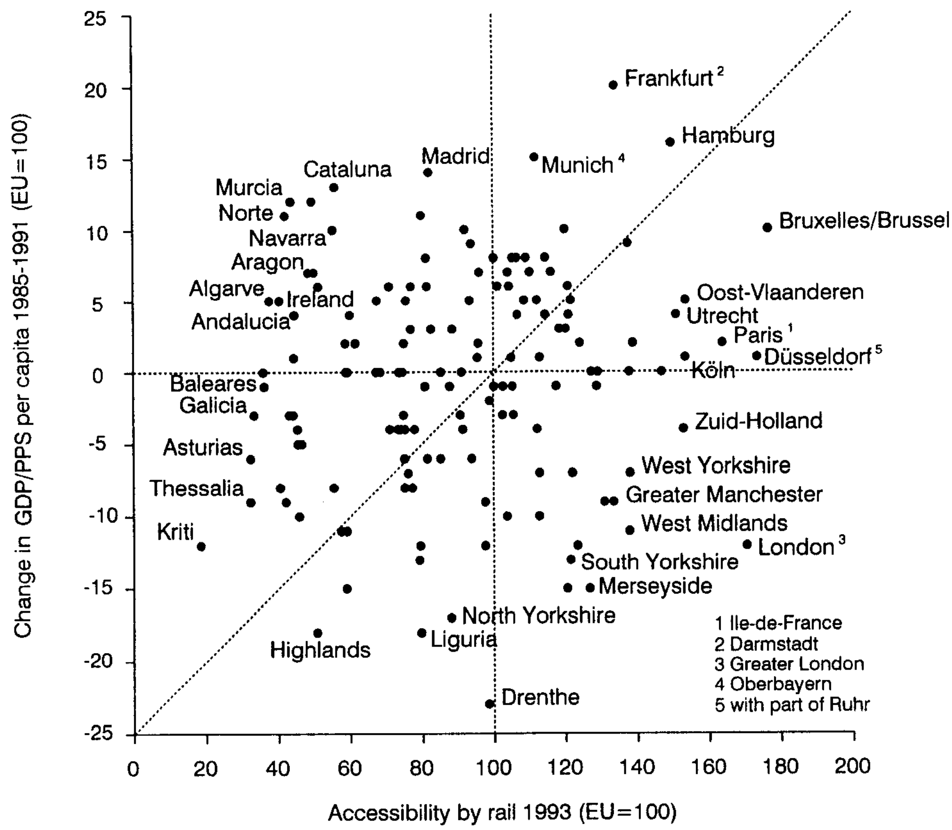


Figure 2. Accessibility by rail v. gross domestic product (GDP) per capita adjusted for purchasing power standards (PPS): level (top) and change (bottom).

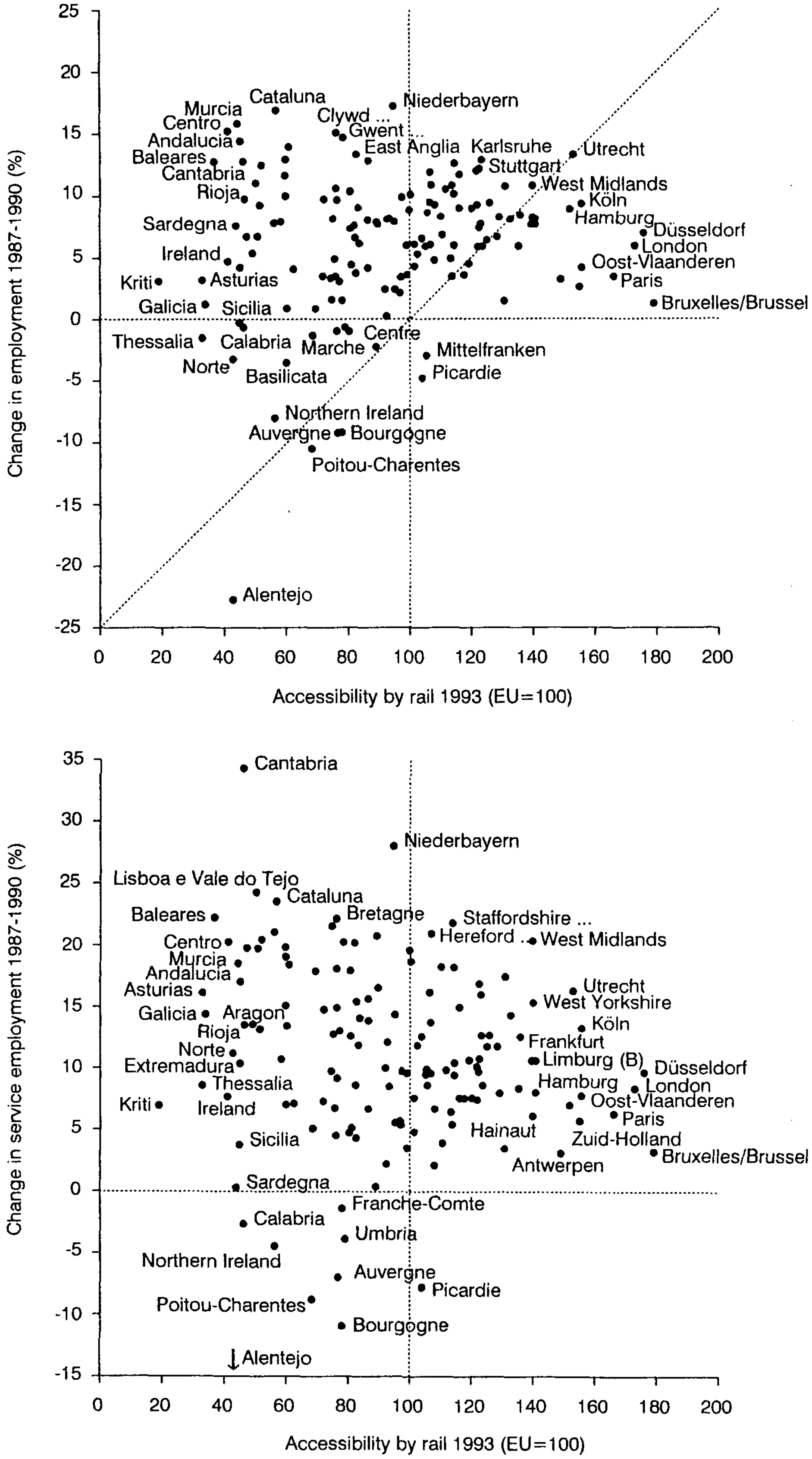


Figure 3. Accessibility by rail v. change in total employment (top) and service employment (bottom).

Figure 2 shows the correlation between accessibility and gross domestic product (GDP) per capita adjusted by purchasing power standards (PPS) (Eurostat, 1990-96). There is a clear relationship between accessibility and the level of GDP per capita (top): the regions with the highest GDP are also most accessible by rail because of their favourable location in the trans-European railway network. Conversely, the poorest regions are also the least accessible ones. In addition, there is a group of regions in the European core with excellent accessibility but only middle-range GDP per capita; these tend to be old industrial regions. However, the relationship between accessibility and economic *development* or change in GDP per capita (bottom) is much less clear. While there are still regions with high accessibility and high growth, there are also regions (again the old industrial regions) which despite their good accessibility have continued to decline; and there are, on the other hand, regions that have experienced significant economic growth although their accessibility is very poor; these tend to be regions at the southern periphery of Europe.

If accessibility is correlated with change in employment rather than GDP, the relationship becomes even more diffuse. Figure 3 plots accessibility by rail against change in total employment (top) and service employment (bottom). Although the period examined was a period of rapid growth in employment in almost all parts of Europe, no significant correlation between accessibility and the rate of employment growth can be detected. In particular again the regions at the southern periphery of Europe experienced high growth of employment irrespective of their poor accessibility. The same is true for service employment, even though modern service industries are often said to be critically dependent on excellent European rail accessibility.

Figure 4, finally, looks into the future and asks whether the planned trans-European networks are likely to significantly redress the economic disparities revealed above. The top diagram confronts present accessibilities by rail with those to be expected in 2010 if the current plans for the trans-European networks will be implemented. However, to make the comparison more relevant, all accessibility indices are expressed relative to the EU average accessibility of 1993 and 2010, respectively, which is to say that the general growth in accessibility due to higer speeds is ignored. It becomes apparent that the high-speed rail network of the future does not significantly modify the rank order of accessible and remote regions but rather reinforces the vast differences in accessibility. In the bottom diagram the change in relative accessibility is correlated with present GDP per capita to find out whether the substantial investments in transport infrastructure are, as the Maastricht Treaty suggests, directed towards the economically lagging regions. The diagram says that no significant relationship can be found as both prosperous and economically disadvantaged regions are among those that benefit most from the trans-European rail investments, whereas many lagging regions gain only little or even loose.

7. Conclusions

The analysis of accessibility shown in this paper indicates that through the trans-European networks the difference in accessibility between centre and periphery in Europe may become more pronounced. This does not imply that the gains in accessibility of peripheral regions may not be good for their economic development, however they will always be overshadowed by the much larger gains in accessibility of the regions in the European core. It is therefore not possible to refer to the trans-European 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

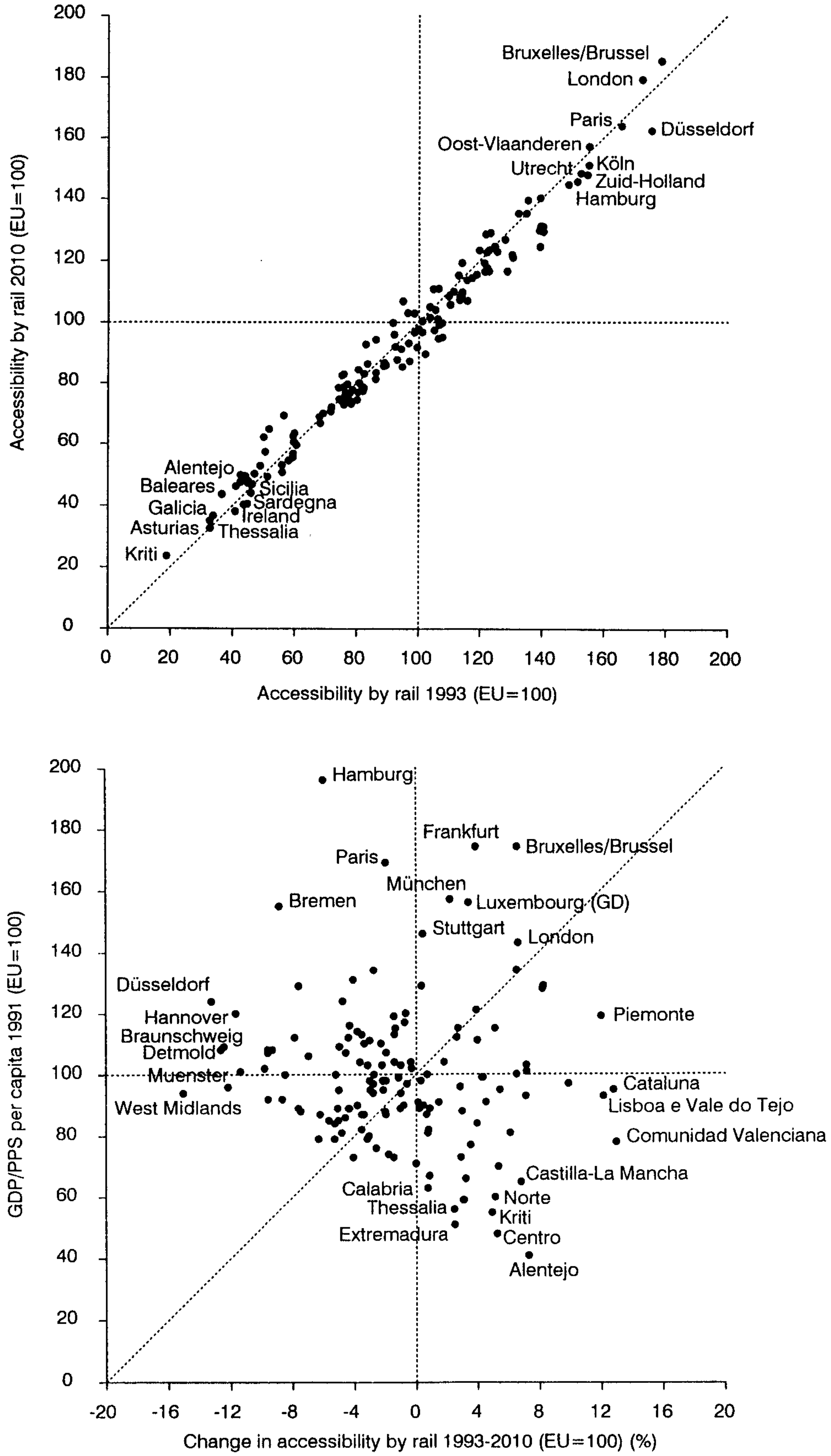


Figure 4. Accessibility by rail 1993 v. 2010 (top) and change 1993-2010 v. GDP per capita adjusted for purchasing power standards 1993 (PPS) (bottom).

significantly shift the focus of the trans-European networks investment programme to transport links within and between the peripheral regions, not in addition to but at the expense of transport investment in the European core.

The results on the economic impacts of trans-European networks presented in this note are much too preliminary to draw final conclusions. However, they confirm the warnings against too simplistic expectations that a particular transport infrastructure project will result in quick economic growth of a region. Certainly other factors such as the regional labour market, the availability of services, a good business climate and an attractive environment are equally essential for the economic success of a region. Transport infrastructure has a role to play only where it significantly improves the accessibility of a region compared with its competitors. In addition it may be necessary to develop accessibility indicators especially addressing the needs of particular industries with respect to specific modes, commodity types or types of customers or suppliers. To experiment with different kinds of accessibility in combination with other location factors will be the objective of future research.

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