# European regional accessibility and the spatial impacts of transport energy price increases

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## 1. Introduction

The relationship between transport infrastructure and economic development has become more complex than ever. There are successful regions in Europe 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 on the periphery, but there are also prosperous peripheral regions such as the Nordic countries. To make things even more difficult, some of the fastest growing regions economically are among the most peripheral.

In this situation, the European Union expects to contribute to reducing the socio-economic disparities between its regions through the development of the trans-European transport networks (TEN-T). However, although the TEN and TINA networks are one of the most ambitious initiatives of the European Community, the TEN programme is not undisputed. Critics argue that many of the new connections do not link peripheral countries to the core but strengthen the ties between central countries and thus reinforce their accessibility advantage. In addition, the reduced energy supply with rising transport costs which can be expected in the future complicates the situation even more

The consistent prediction and the rational and transparent evaluation of the likely socio-economic impacts of major transport infrastructure investments and rising energy prices has therefore become of great political importance. The paper summarises the main findings of recent European research projects that addressed these questions in quantitative terms. The paper commences with an analysis of the current spatial distribution of accessibility indicators across Europe and the relationship between accessibility and economic performance. Then the SASI model based on this relationship is introduced. Finally, the spatial impacts of a set of transport infrastructure policy and energy price scenarios forecast by the SASI model are presented.

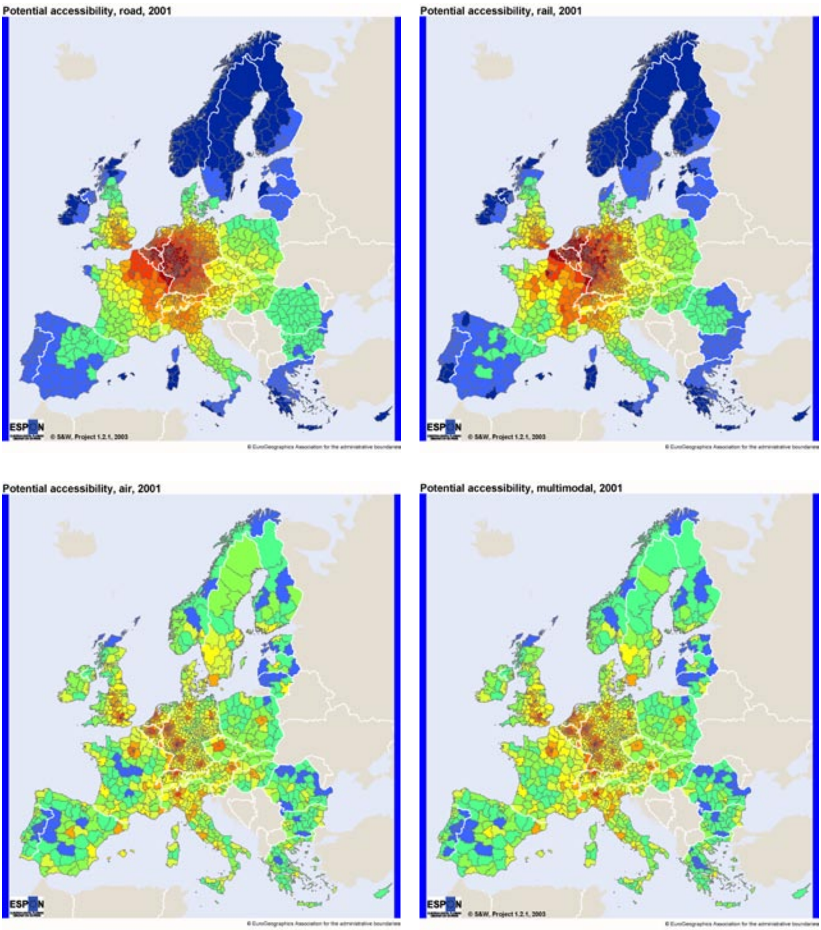
## 2. Accessibility and regional development

In the context of spatial development, the quality of the transport infrastructure in terms of capacity, connectivity, travel speeds etc. determines the competitive advantage of locations relative to other locations, i.e. their accessibility. Investment in transport infrastructure leads to changes in accessibility and may result in changes in spatial development patterns. There are numerous definitions and concepts of accessibility.

A general definition is that "accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where 'area' may be a region, a city or a corridor" (Wegener *et al.*, 2001).

In Espon 1.2.1 (Transport Services and Networks : Territorial Trends and Basic Supply of Infrastructure for Territorial Cohesion), potential accessibility indicators were calculated (Espon 1.2.1, 2005). Potential accessibility is based on the assumption that the attraction of a destination increases with size and declines with distance, travel time or cost. Accessibility indicators were calculated for road, rail and air as well as multimodal accessibility (Figure 1) :

– Potential accessibility by road is characterised by a clear distinction of centre and periphery. Accessibility by road is the only modal accessibility indicator that reproduces the "Blue Banana", the central area now called the "European Pentagon" ;
– Potential accessibility by rail also shows a core-periphery pattern in Europe. However, the highest accessibility is much more concentrated in the cities of the central areas serving as main nodes in the high-speed rail networks. Investments in high-speed rail links enlarge the corridors of high potential accessibility by rail, as is visible in France where the TGV lines towards the Mediterranean and the Atlantic lead to corridors with accessibilities clearly above the European average ;
– The areas of highest potential accessibility by air are strongly concentrated around major airports all over Europe. Nevertheless, airport regions in the central EU areas have higher accessibility values than airport regions in other parts. The accessibility of the environs of airports is limited, which is demonstrated by a steep decline in accessibility with growing distance from the airport. Potential accessibility by air yields a completely different picture than accessibility based on surface transport. The map of Europe is converted into a patchwork of regions with high accessibility surrounded by regions with low accessibility. Low accessibility is therefore no longer a concern of regions in the traditional European periphery, but now also of regions in the European core.
– If the three modes are combined to multimodal potential accessibility, regions with above-average accessibility are mainly located in an arc stretching from Liverpool to northern Italy. However some agglomerations in more remote areas are also classified as central or at least intermediate because their international airports improve their accessibility. The European periphery begins already in regions usually considered as central. Several regions in Germany, Austria and France have below-average accessibility values. Many regions in Portugal, Spain, Ireland, Scotland, Wales, Norway, Sweden, Finland, southern Italy and Greece have very low accessibility values as well as nearly all regions of the new member states of the European Union. The only exceptions are the capital cities and partly their surrounding regions because of international airports and important rail connections. For all other regions, the combined effect of low quality surface transport and lack of air accessibility lead to low overall accessibility.



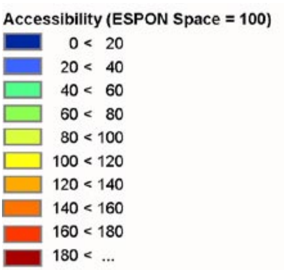




*Figure 1. Potential accessibility, by road (top left), by rail (top right), by air (bottom left) and multimodal (bottom right) (Espon 1.2.1, 2005)*

A more sophisticated way of classifying regions by accessibility is to take also their economic performance into account. Economic theory suggests that regions that have better access to raw materials, suppliers and markets are, ceteris paribus, economically more successful than regions in remote, peripheral locations. As transport infrastructure is an important policy instrument to promote regional economic development, it is highly policy-relevant to know which regions have been able to take advantage of their location and which regions have not.

In order to explore this classification, NUTS-3 regions in EU-27 plus Norway and Switzerland are plotted in the small diagram at the bottom of Figure 2 showing GDP per capita v. multimodal potential accessibility. The diagram confirms that in general the more accessible regions are economically more successful, however there are several exceptions. The dispersion suggests a typology of regions with respect to whether the level of GDP can be explained by the level of accessibility. The typology is constructed by subtracting for each region the accessibility index from the GDP index, i.e. the residuals between accessibility and GDP. The map in Figure 2 shows these residuals.

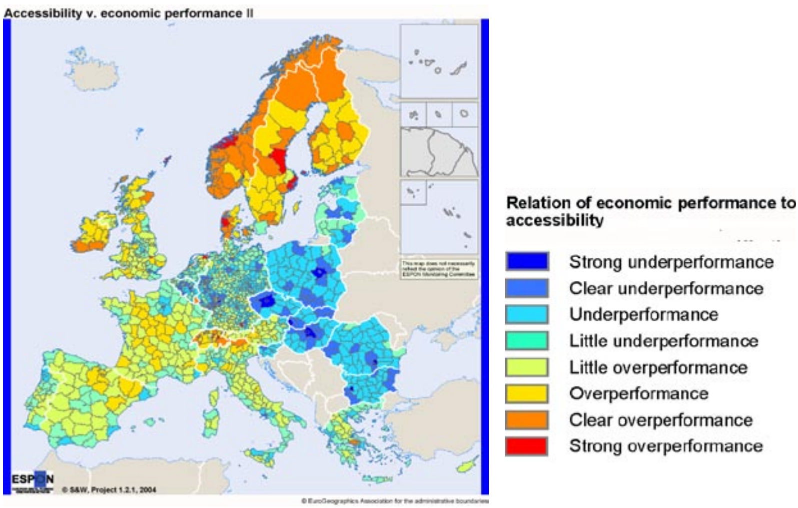



*Figure 2. Accessibility v. economic performance, 2001 (Espon 1.2.1, 2005).*

Regions with clear over-performance compared to their accessibility are primarily located in the four Nordic countries. Apparently, the regional economies in the North are based on other assets than location, such as skilled labour and technology orientation. Many regions in the Alps and also in Ireland and Scotland are also in a much better economic position than their location would suggest. A number of urban

NUTS-3 regions in Germany belong also to this high-performing type ; however, this might be an artefact of the small NUTS-3 regions in that country. More rural regions in France and Spain have an economic performance somewhat better than their location. Other regions are not able to utilise the economic potential of their location in Europe. Nearly all regions of the new EU member states belong to this type, however, also some old-industrialised regions in Germany and Belgium. Some regions in southern Europe are underperforming as well.

## 3. The SASI Model

It becomes apparent from Figure 2 that the relationship between the transport system and regional economic performance is complex, i.e. that several other factors than accessibility play a role. These more complex relationships and feedbacks have been taken into account in the SASI model (Wegener and Bökemann, 1998, Espon 2.1.1, 2005). The SASI model is a recursive simulation model of socio-economic development of regions in Europe subject to exogenous assumptions about the economic and demographic development of Europe as a whole and transport infrastructure investments and transport system improvements, in particular of the trans-European transport networks (TEN-T).

For each region the model forecasts the development of accessibility and GDP per capita. In addition cohesion indicators expressing the impact of transport infrastructure investments and transport system improvements on the convergence (or divergence) of socio-economic development in the regions and polycentricity indicators expressing the impact of transport infrastructure investments on the polycentricity of national urban systems are calculated.

The main concept of the SASI model is to explain locational structures and locational change in Europe in time-series/cross-section regressions, with accessibility indicators being a subset of a range of explanatory variables. Accessibility is measured by spatially disaggregate accessibility indicators. The impacts of transport infrastructure investments and transport system improvements on regional production and other transport policies is modelled by regional production functions in which, besides non-transport regional endowment factors, sophisticated spatially disaggregate accessibility indicators are included. The model does not only represent spatial redistribution effects of transport policies within the European Union but also generative effects on the European economy as a whole. Although the model does not contain a full transport submodel, it takes account of network congestion in urbanised areas.

The SASI model differs from other approaches to model the impacts of transport on regional development by modelling not only production (the demand side of regional labour markets) but also population (the supply side of regional labour markets) and so is able to model unemployment. A second distinct feature is its dynamic road, rail and air network database including major historical network changes as far back as 1981 and expected network changes according to TEN-T planning documents.

The SASI model has six forecasting submodels : European developments, Regional accessibility, Regional GDP, Regional employment, Regional population and Regional labour force. A seventh submodel calculates Socio-economic indicators with respect to efficiency and equity. The spatial dimension of the model is established by the subdivision of the European Union plus Norway and Switzerland in 1,330 regions and by connecting these regions by road, rail and air networks. The *temporal* dimension of the model is established by dividing time into periods of one year duration. In each simulation year the seven submodels of the SASI model are processed in a recursive way, i.e. sequentially one after another. This implies that within one simulation period no equilibrium between model variables is established ; in other words, all endogenous effects in the model are lagged by one or more years.

## 4. Spatial impacts of transport infrastructure policy scenarios

In Espon 2.1.1 (Territorial Impacts of EU Transport and TEN Policies) a set of transport policy scenarios was defined and tested with different models among them the SASI model (Espon 2.1.1, 2005).

The main general result from the scenario simulations is that the overall effects of transport infrastructure investments and other transport policies are small compared with those of socio-economic and technical macro trends, such as globalisation, increasing competition between cities and regions, aging populations and increasing labour force participation and labour productivity. The second main result is that even large increases in regional accessibility translate into only very small increases in regional economic activity. However, this statement needs to be qualified, as the magnitude of the effect seems to depend strongly on the already existing level of accessibility :

– for regions in the European core with all the benefits of a central geographical location *plus* an already highly developed transport and telecommunications infrastructure, additional gains in accessibility bring only little additional incentives for economic growth ;
– for regions at the European periphery, however, which suffer from the remote geographical location *plus* an underdeveloped transport infrastructure, a gain in accessibility brings significant economic progress. But also the opposite may happen if the new connection opens a formerly isolated region to external competition. Significant positive economic effects for the new EU member states can only be expected if the TINA projects linking the new member states to the major centers of economic activity in western Europe are implemented.

Similar scenarios were calculated in Espon 1.1.3 (Enlargement of the European Union and the Wider European Perspective as Regards its Polycentric Spatial Structure) for the new EU member states. Here the scenarios examined the effects of enlargement as such and the associated reductions in border waiting times and different strategies of transport infrastructure investments in the new member states (Espon 1.1.3 2006).

The results were in general agreement with those achieved in Espon 2.1.1 indicating that transport infrastructure investments in the new member states could make a significant contribution to help these countries' economies to catch up with the old member states. Figure 3 demonstrates this by showing the impact on GDP per capita in a scenario in which in addition to the TEN and TINA implementation plans massive infrastructure improvements in the new member states are assumed.

However, a comparison between the two maps shows that, though in relative terms economic growth in the new member states is faster than in the old member states, the latter gain much more in absolute terms.

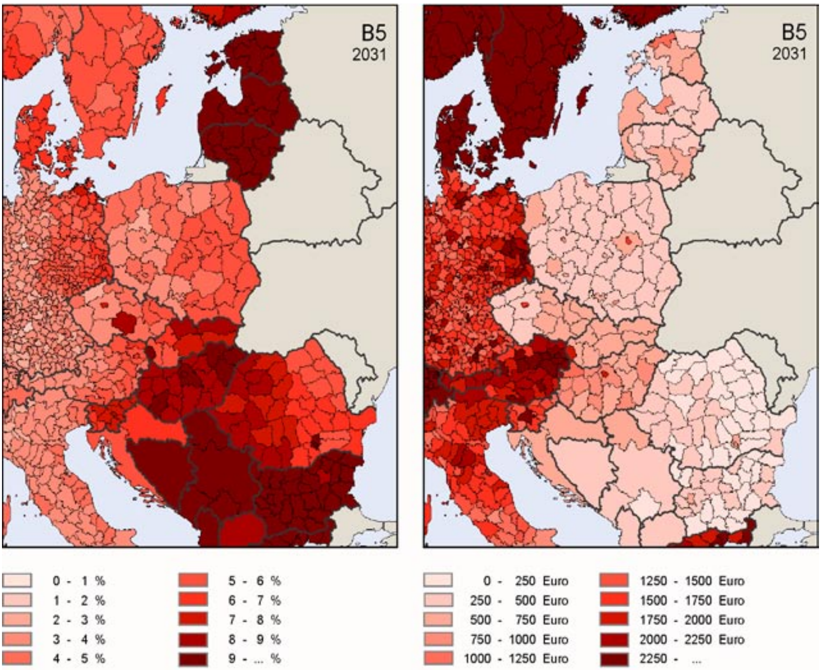



*Figure 3. Relative (left) and absolute (right) GDP effects, Scenario B5, 2031 (ESPON 1.1.3 2006 two map)*

## 5. Spatial impacts of transport energy price scenarios

In the STEPs project (Transport Strategies under the Scarcity of Energy Supply) looking at the transport and spatial impacts of rising energy prices the SASI model was used to simulate fifteen scenarios (Fiorello et al., 2006). Each of the scenarios is a combination of one assumption about fuel supply and corresponding fuel price rise and one set of policy response (see Table 1).

**Table 1. STEPs scenario framework**

| | Do-nothing | Business as usual | Infrastructure & technology | Demand regulation | All policies |
|---|---|---|---|---|---|
| Fuel price +1% p.a. | A-1 | A0 | A1 | A2 | A3 |
| Fuel price +4% p.a. | B-1 | B0 | B1 | B2 | B3 |
| Fuel price +7% p.a. | C-1 | C0 | C1 | C2 | C3 |

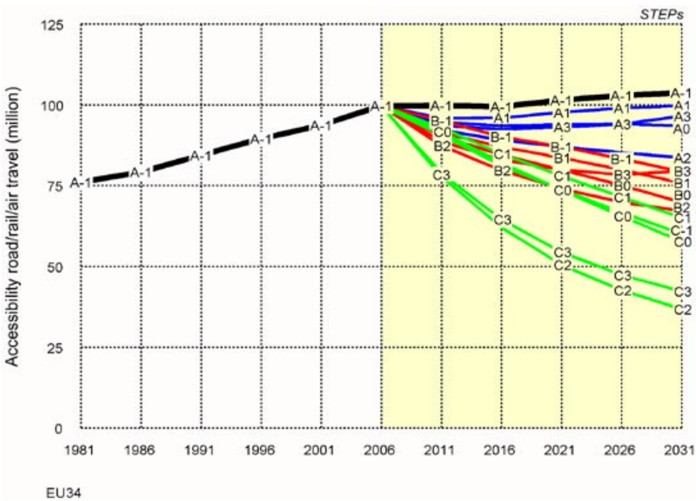



*Figure 4. SASI model results for STEPs scenarios: accessibility road/rail/air travel 1981-2031(million)(Fiorello et al.2006)*

All scenarios have significant impacts on the accessibility indicators of the SASI model. Both, the magnitude of average European accessibility and the spatial distribution of accessibility among the European regions are affected. The effects vary with the scenario assumption on fuel price increases and the different forms of policy intervention (Figure 4). In the past multimodal accessibility has grown continuously because of the infrastructure development and because of the removal of political, social or cultural barriers also incorporated in the SASI accessibility indicators. Although the Reference Scenario A-1 has no network development or acceleration of modes in the future, accessibility will slightly grow, because of the underlying assumptions on further European integration. In all scenarios, multimodal accessibility is below that of the Reference Scenario. This is to be expected for Scenarios B-1 and C-1 as their fuel cost increases are higher than in Scenario A-1. But there is also no policy scenario that leads to higher accessibility than Scenario A-1. This is so because in all policy scenarios transport, in particular road transport, is made even more expensive than the increase in fuel cost.

This is also true for policy scenarios in which rail is favoured either by assumptions on network development and an increase in speed (as in the infrastructure and technology scenarios A1, B1 and C1) or through a reduction of rail fares per km (as in the demand regulation scenarios A2, B2 and C2).

Even the combination of both (in Scenarios A3, B3 and C3) does not lead to gains in multimodal accessibility because of the massive policies against car and lorry use in these scenarios.

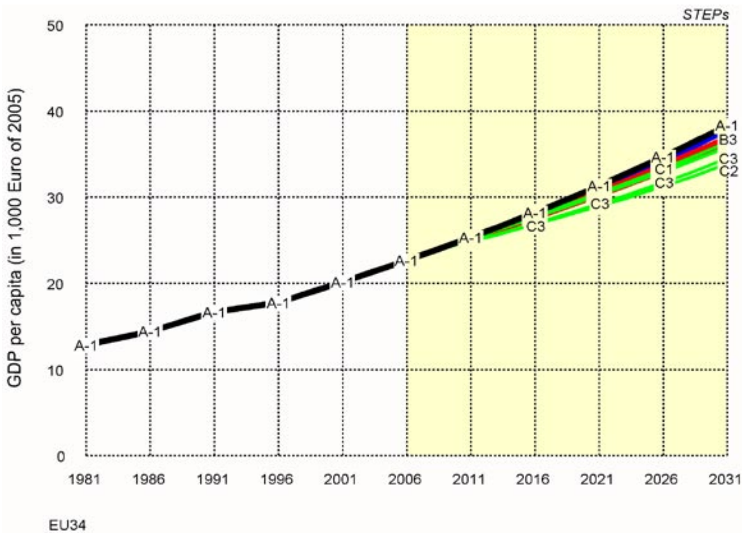



*Figure 5. SASI model results for STEPs scenarios: GDP per capita 1981-2031 (1,000 Euro of 2005) (Fiorello et al., 2006).*

The development of GDP for the different scenarios is shown in Figure 5 expressed as GDP per capita in Euro of 2005. In the Reference Scenario the economic growth of the past will continue in the future. However, there is no scenario which leads to additional growth ; quite the opposite : the fuel cost increases and all policy interventions slow down economic growth. Whereas in the Reference Scenario A-1 the average GDP per capita in 2031 will be about 38,000 Euro, the combination of high fuel price increases and strong policy response as in Scenarios C2 and C3 leads to an average GDP per capita of only about 34,000 Euro, i.e. more than ten percent less than in the Reference Scenario.

## 6. Conclusions

The paper has demonstrated that there are large disparities in accessibility in Europe. Transport infrastructure policies will lead to further growth in accessibility and economic growth, but might have a polarising effect on the European regions. Growing fuel costs and related policy responses will lead to a strong reduction in accessibility and economic growth. But at the same time the lower growth rates might lead to an increase in cohesion among the European regions, i.e. a more balanced spatial structure.

## 7. References

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