SPATIAL IMPACTS OF THE TRANS-EUROPEAN NETWORKS

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Abstract

The important role of transport infrastructure for regional development is one of the fundamental principles of regional economics. The paper presents results of a multi-regional recursive-dynamic model of regional socio-economic development applied to different scenarios of the further development of the TEN and TINA networks making forecasts in one-year increments until the forecasting horizon of 2021 for some 1,300 NUTS 3 regions of the enlarged European Union plus Norway and Switzerland. The model answers the question whether or not infrastructure improvements contribute to the reduction of economic disparities among regions and so the cohesion objective of the European Union. The impact of transport infrastructure investments on regional production is modelled by regional production functions in which, besides non-transport regional endowment factors, accessibility indicators are included. The model differs from other approaches to model 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). Changes in accessibility, GDP per capita and a set of different cohesion indicators are the main output of the model.

Keywords: Simulation; Transport; Accessibility; Regional development
Topic area: Transport and Spatial Development

1. Introduction

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.

In this situation, the European Union expects to contribute to reducing the socio-economic disparities between its regions by the development of the trans-European transport networks (TEN) in the old member states and the so-called Transport Infrastructure Needs Assessment (TINA) networks in the new member states. 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 counties and so reinforce their accessibility advantage. 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 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. These issues have received new attention through the enlargement of the European Union by ten countries in eastern and southern Europe in 2004.

The consistent prediction and the rational and transparent evaluation of likely socioeconomic impacts of major transport infrastructure investments has therefore become of great political importance. In several EU-funded research projects models for forecasting the economic and spatial impacts of large transport investments in Europe were developed. One of them was the project "Socio-Economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements" (SASI) conducted in the 4th Framework Programme for Research and Technological Development (Fürst et al., 2000; Schürmann et al., 2001). The SASI model was further developed in the project "Integrated Assessment of Spatial Economic and Network Effects of Transport Investments and Policies" (IASON) in the 5th Framework Programme (Bröcker et al., 2002a; 2002b; 2004).

The main goal of the application of SASI in IASON was to forecast the impacts of transport infrastructure investments and other transport policies on socio-economic activities and developments in Europe with special attention on the spatial and temporal distribution of impacts. The extended SASI model was applied to a number of different scenarios of implementation of the TEN and TINA networks and of additional transport policies.

2. Model overview

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 the European Union as a whole and transport infrastructure investments, in particular of the trans-European transport networks, and other transport policies.

The main concept of the SASI model is to explain locational structures and locational change in Europe in combined time-series/cross-section regressions, with accessibility indicators being a subset of a range of explanatory variables. The focus of the regression approach is on the long-term spatial distributional effects of transport policies. Factors of production including labour, capital and knowledge are considered as mobile in the long run, and the model incorporates determinants of the redistribution of factor stocks and population. The model is therefore suitable to check whether long-run tendencies in spatial development coincide with the spatial development objectives of the European Union. The application of the SASI model is restricted, however, in other respects: The model generates mainly distributive and only to a limited extent generative effects of transport cost reductions, and it does not produce regional welfare assessments fitting into the framework of cost-benefit analysis.

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). A second distinct feature is its dynamic network database based on a 'strategic' subset of highly detailed pan-European road, rail and air networks including major historical network changes as far back as 1981 and forecasting expected network changes according to the most recent EU documents on the future evolution of the trans-European transport networks.

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. Figure 1 visualises the interactions between these submodels.

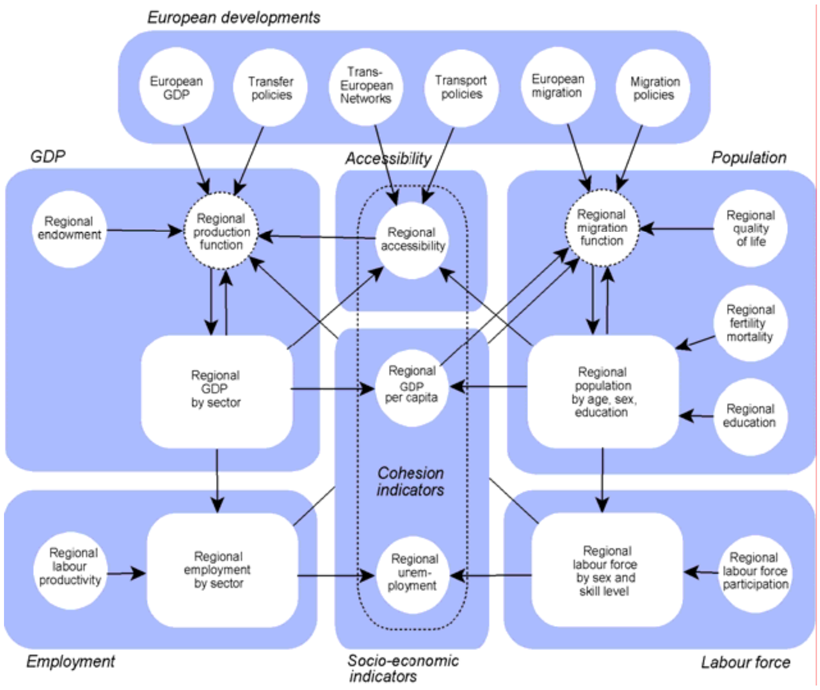

Figure 1. The SASI model

The *spatial* dimension of the model is established by the subdivision of the European Union and the ten accession countries plus Norway, Switzerland, Bulgaria and Romania in 1,321 regions and by connecting these by road, rail and air networks. 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 of the European Union are calculated.

The *temporal* dimension of the model is established by dividing time into periods of one year duration. By modelling relatively short time periods both short- and long-term lagged impacts can be taken into account. 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.

In the framework of the IASON project, several model improvements and model extensions with respect to model theory, model data and model technique were implemented:

- From a theoretical point of view, two major improvements are the replacement of travel time accessibility indicators by generalised travel cost and to forecast regional gross domestic product (GDP) per capita rather than total regional production. In addition, the model was made more responsive to other transport policies, such as transport pricing policies, and the set of cohesion indicators to assess the impacts of transport policies was extended.

- The model database was disaggregated both in spatial (from NUTS 2 to NUTS 3) and sectoral terms (from three to six economic sectors), and was extended to cover the new EU member states and Norway, Switzerland, Bulgaria and Romania.
- Finally, the model software was enhanced with graphical windows, dialogue boxes, time-series plots, maps and 3D representations of spatial distributions for monitoring simulations and comparison between scenarios.

A detailed description of the original SASI model and the model extensions implemented in IASON can be found in Schürmann et al. (2001) and Bröcker et al. (2002a). The common spatial database used in IASON is documented in Bröcker et al. (2002b). All simulation results achieved with the SASI model are described in Bröcker et al. (2004).

3. Scenarios

The scenarios simulated with the SASI model in IASON can be classified into six categories (see Table 1):

Table 1. Transport scenarios simulated in IASON

Scenario	Code
000 Reference scenario	
Reference scenario	000
A Network scenarios	
Implementation of all TEN priority projects (Essen list)	A1
Implementation of all high-speed rail priority projects (Essen list)	A21
Implementation of all conventional rail priority projects (Essen list)	A22
Implementation of all road priority projects (Essen list)	A23
Implementation of all rail priority projects (Essen list)	A24
Implementation of all TEN and TINA projects	A3
Implementation of all TEN projects	A4
Implementation of new priority projects	A51
Implementation of new priority rail projects	A52
Implementation of new priority road projects	A53
Scenario A3 plus implementation of additional projects in accession countries	A61
Scenario A3 plus implementation of maximum projects in accession countries	A62
B Pricing scenarios	
SMC pricing applied to road freight	B1
SMC pricing applied to all modes (travel and freight)	B2
C Combination scenario	
Scenario A1 plus Scenario B2	C1
D Rail freight scenario	
Dedicated rail freight network	D1
E TIPMAC scenarios	
TIPMAC business-as-usual scenario	E1
TIPMAC fast implementation scenario	E2

- *Reference Scenario*. Scenario 000 is the base or reference scenario serving as a benchmark for comparisons, where no network improvements after 2001 were assumed.
- *Network scenarios*. Scenarios A1 to A62 implement different assumptions on the further development of the European transport networks.

- *Pricing scenarios*. Scenarios B1 and B2 examine different schemes of social marginal cost (SMC) pricing. They differ in the kind of pricing. These scenarios do not assume any network development, i.e. the pricing scenarios are applied to the networks of the reference scenario.
- *Combination scenario*. Scenario C1 is a combination of network scenario A1 and pricing scenario B2.
- *Rail freight scenario*. Scenario D1 assumes the development of a dedicated rail freight network in Europe.
- *TIPMAC scenarios*. Scenarios E1 and E2 represent combinations of network and pricing scenarios corresponding to the assumptions made in the TIPMAC project.

All scenarios rely on the trans-European transport network GIS database developed by the Institute of Spatial Planning of the University of Dortmund (IRPUD). The *strategic* road and rail networks used in IASON are subsets of this database, comprising the trans-European networks specified in Decision 1692/96/EC of the European Parliament and of the Council, further specified in the *TEN Implementation Report* and latest revisions of the TEN guidelines provided by the European Commission (2002) and the latest documents on the priority projects (European Commission, 2003), the TINA networks as identified and further promoted by the TINA Secretariat (2002), the Helsinki Corridors as well as selected additional links in eastern Europe and other links to guarantee connectivity of NUTS-3 level regions.

4. Results

The following paragraphs present the model results for a subset of all scenarios, namely for scenarios A1 and A3, A51 and A62, B1 and B2, and scenario C1, in terms of changes in accessibility and GDP per capita and their effects on cohesion.

4.1. Accessibility

Accessibility is a core concept of the SASI model. The maps in Figures 2 and 3 show the four types of accessibility indicator calculated and used as explanatory variables in the regional production functions: accessibility rail/road (travel), accessibility rail/road/air (travel), accessibility road (freight) and accessibility rail/road (freight).

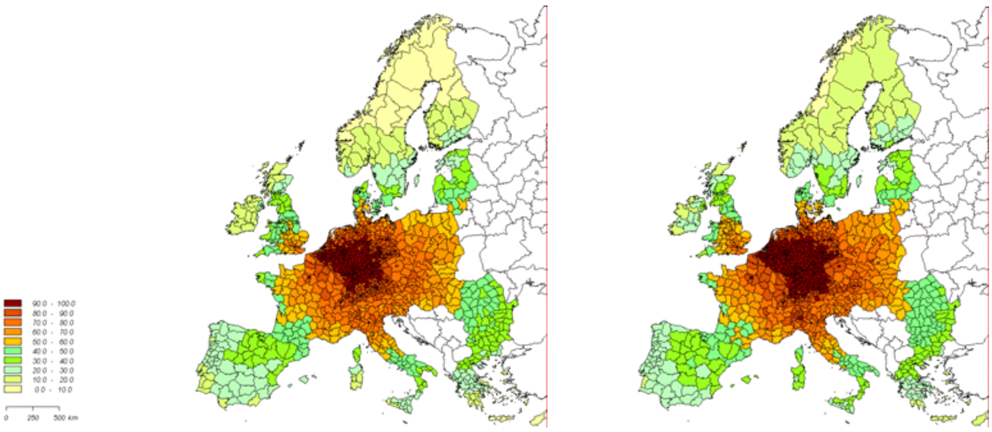

Figure 2. Reference scenario 000: Accessibility rail/road (travel, million) in 2020 (left), accessibility rail/road/air (travel, million) in 2020 (right)

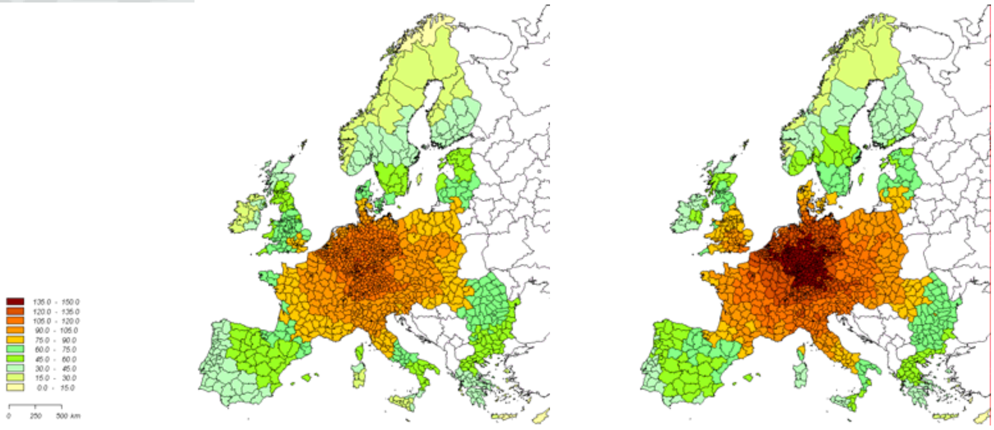

Figure 3. Reference scenario 000: Accessibility road (freight, million) in 2020 (left), accessibility rail/road (freight, million) in 2020 (right)

The familiar pattern of the highly accessible European core with its peak in the Benelux countries, west and south-west Germany, Switzerland and northern Italy emerges, leaving the Nordic countries, northern England, Scotland and Ireland, Portugal and Spain, southern Italy and Greece as clearly peripheral in the present European Union. Of the accession countries, the Czech Republic, Slovakia, Hungary and parts of Poland belong to the European core, whereas the Baltic states and Romania and Bulgaria (and the two island states Cyprus and Malta) remain peripheral.

Figures 4 to 7 show the changes in accessibility caused by the policies in the selected scenarios (i.e., the difference between the accessibility in the policy scenario and in the reference scenario in 2020). The classes of the legend and the colour code are identical in all maps to allow easy comparison. Red colour shades indicate positive differences (i.e. the accessibility in the policy scenario is higher), whereas blue indicates negative differences.

As to be expected, the network scenarios A1 and A3 improve accessibility everywhere but to a different degree and not equally in all parts of Europe.

The 'classical' TEN priority projects of the Essen list (Scenario A1) aimed primarily at improving the accessibility of the peripheral regions in the Mediterranean and the Nordic countries (see Figure 4 left). Today, with the enlargement of the European Union, the task of better linking the accession countries in central and Eastern Europe to the European core has become more important. If all network links designated as TEN and TINA are assumed to be implemented as in Scenario A3, the gains in accessibility are much larger and more evenly distributed over the European territory (see Figure 4 right).

Conversely, all pricing policy scenarios reduce accessibility because per-km costs are included in the generalised-cost function. It is important to note that in all pricing scenarios marginal social cost pricing is applied only to transport links in the present European Union. If only freight transport on roads is priced, as in Scenario B1, the regions most affected are therefore peripheral regions in the present EU member states which depend on long-distance connections to markets – road accessibility by lorry goes down by more than twenty percent in parts of Portugal, Spain, southern Italy and Greece, and in the North in Scotland and Sweden, with Norway also affected (see Figure 5 left). In the more comprehensive pricing scenario B2, in which all modes and both travel and freight are subject to pricing, the effects are concentrated in the central regions which depend on business and leisure travel, whereas the accession countries in eastern Europe are only little affected (see Figure 5 right).

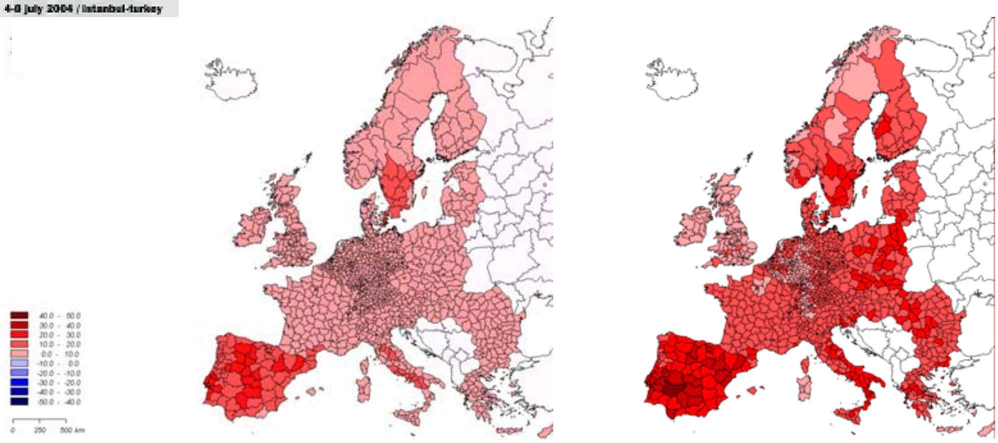

Figure 4. Percent change in accessibility rail/road/air (travel). Scenario A1: TEN priority projects (left), Scenario A3: all TEN/TINA projects (right)

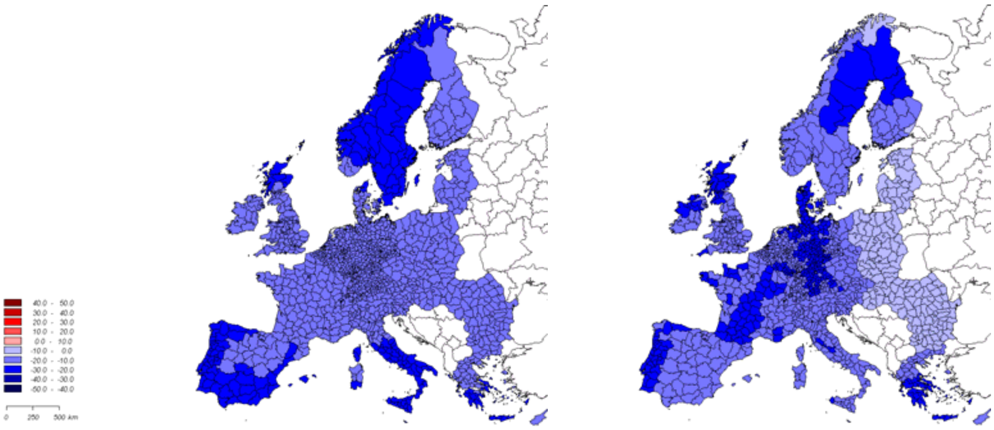

Figure 5. Percent change in accessibility road (freight). Scenario B1: freight road pricing (left). Percent change in accessibility rail/road/air (travel). Scenario B2: pricing of all modes (right)

Figure 6 shows the combined effects of network scenario A1 and pricing scenario B2 (Scenario C1) on multimodal travel accessibility. Now the increased costs due to transport pricing are partly offset by the positive effects of the network improvements, for some Spanish regions the balance is positive. However, because more network improvements in Scenario A1 are located in peripheral regions, the core of Europe with the highest accessibility (see Figures 2 and 3) is now losing more in accessibility than many peripheral regions.

Figure 7 presents the effects of the additional network scenarios on accessibility. If one compares the accessibility effects of the new list of priority projects of Scenario A51 (see Figure 7 left) with those of the Essen list of Scenario A1 (see Figure 4 left), the differences seem not very great. However, the new projects in Poland and the Baltic states, which also improve accessibility in Finland, can be clearly identified. Figure 7 right showing the effects of the most optimistic interpretation of the TINA outline plan in Scenario A62 should be compared with Figure 4 (right), in which only the minimum implementation scheme of TINA projects in Scenario A3 is assumed. The results are quite spectacular with accessibility increases in Poland, Slovakia, Romania and Bulgaria and the Baltic states between 40 and 50 percent. Again, Finland participates in these gains, but also central Europe gains because of the improved access to eastern markets.

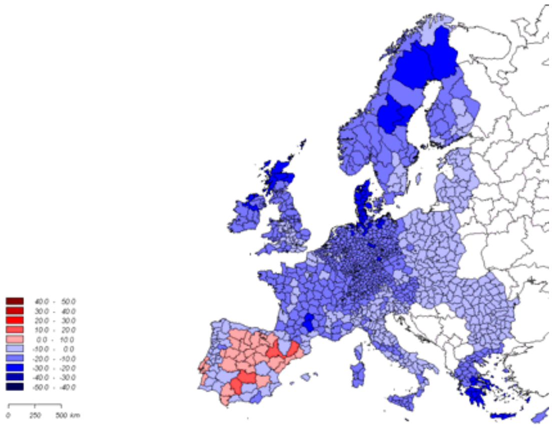

Figure 6. Percent change in accessibility rail/road/air (travel). Scenario C1: combination of scenarios A1 and B2

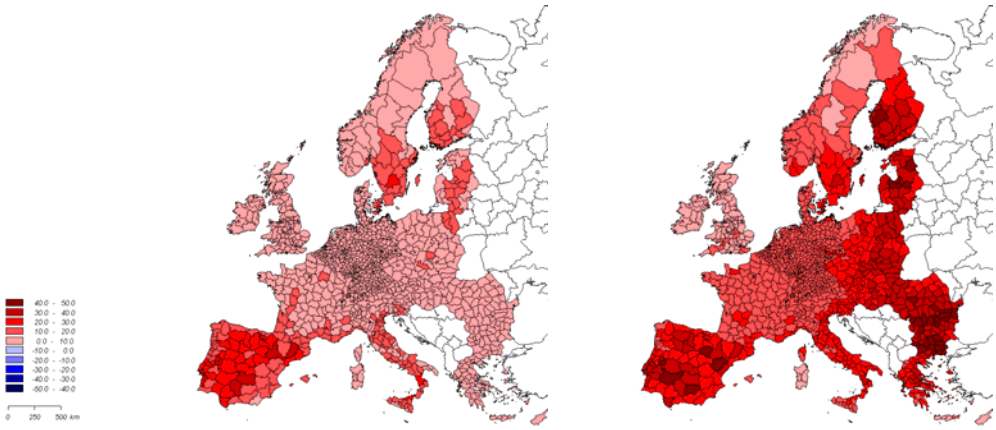

Figure 7. Percent change in accessibility rail/road/air (travel). Scenario A51: new priority projects (left), Scenario A62: Scenario A3 plus maximum projects in accession countries in eastern Europe (right)

Table 2 summarises the accessibility effects of all simulated policy scenarios. It shows for each policy scenario the percentage difference in accessibility between the policy scenario and the reference scenario in 2020 for four groups of regions: the present European Union (EU15), Switzerland and Norway (CH+NO), the ten accession countries plus Bulgaria and Romania (CC12) and the total study region (EU27+2). As accessibility indicator here the sum of two of the four accessibility indicators used in SASI was applied: accessibility rail/road/air (travel) and accessibility rail/road (freight).

As it was already observed, all network scenarios have a positive effect on accessibility. The degree of improvement, obviously, is a function of the number of projects and the volume of investment. The high-speed rail priority projects are much more effective than the conventional rail projects, and the rail projects are much more effective than the road improvement projects, but this may be caused by the greater number of high-speed rail and rail projects in the two priority lists. Not surprisingly, if all TEN and TINA projects are implemented, the effects are more substantial, and if even more projects are implemented as in Scenarios 61 and 62, the effects are even larger. Remarkably, the largest accessibility effect is achieved by the dedicated rail freight network of Scenario D1, presumably because of the general technical improvement of the rail network assumed in Scenario D1.

Table 2. SASI model results: accessibility

Scenario		Accessibility difference between policy scenario and reference scenario in 2020 (%)			
		EU15	CH+NO	CC12	EU27+2
A1	TEN priority projects	+6.42	+4.72	+2.48	+5.68
A21	High-speed rail priority projects	+5.50	+3.28	+2.20	+4.86
A22	Conventional rail priority projects	+0.82	+0.90	+0.18	+0.71
A23	Road priority projects	+0.32	+0.81	+0.15	+0.30
A24	Rail priority projects	+6.16	+4.05	+2.35	+5.43
A3	All TEN/TINA projects	+12.74	+11.09	+14.40	+12.99
A4	All TEN projects	+11.06	+9.61	+5.07	+9.96
A51	New priority projects	+8.20	+7.06	+5.78	+7.74
A52	New priority rail projects	+7.84	+6.37	+4.96	+7.29
A53	New priority road projects	+0.48	+0.92	+1.01	+0.59
A61	A3 + additional projects in CC12	+13.74	+11.80	+17.18	+14.30
A62	A3 + maximum projects in CC12	+14.93	+12.73	+22.96	+16.30
B1	SMC pricing road freight	–4.44	–4.90	–5.65	–4.67
B2	SMC pricing all modes travel / freight	–13.37	–13.01	–9.46	–12.67
C1	A1+B2	–6.55	–8.24	–6.68	–6.61
D1	Dedicated rail freight network	+18.78	+17.95	+12.42	+17.63
E1	TIPMAC business-as-usual scenario	+12.55	+10.56	+14.32	+12.82
E2	TIPMAC fast TEN + SMC	+4.75	+1.59	+11.58	+5.89

Transport pricing policies, on the other hand, reduce accessibility. Again not surprisingly, the more profound effect occurs if all modes and both travel and goods transport are subjected to pricing as in Scenario B2. If both network and pricing scenarios are combined as in Scenario C1, the outcome depends on the pricing level – in Scenario C1 the negative impacts of the pricing outweigh the positive impacts of the network improvements.

Figure 8 presents the same information in graphical form. The left hand side shows the development of accessibility between 1981 and 2021 in the present European Union (EU15) and on the right the same for the ten accession countries plus Bulgaria and Romania (CC12). Each line in the diagram represents the development of accessibility in one scenario, the heavy black line the reference scenario. All scenarios are identical until the year 2001. The lines are colour-coded to indicate the scenario groups.

In the reference scenario accessibility increases after 2001, although in it no network improvements are assumed after 2001. These increases are due to the reduction of waiting times at borders and political, cultural and language barriers through the enlargement of the European Union and further integration assumed for all scenarios. It is obvious that these effects are much stronger for the accession countries than for the member states of the present European Union.

The accessibility of the accession countries as a whole is not much less than in the present European Union as a whole. However, there remain large differences in accessibility both in the European Union and among the accession countries. It can be seen that the network scenarios tend to be implemented incrementally and so slowly build up their impact over time, whereas the pricing scenarios work like a shock and then follow the general trend of the reference scenario.

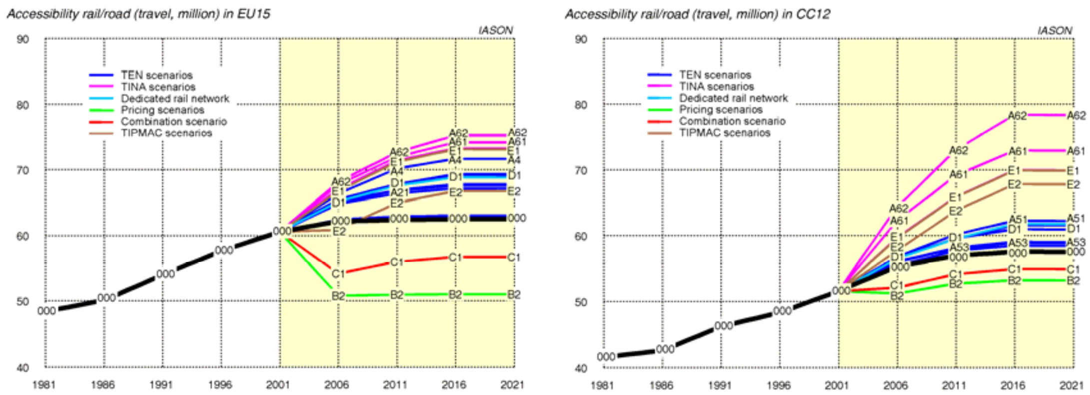

Figure 8. Accessibility rail/road (travel, million): in the European Union (left) and in accession countries (right)

The comparison of the two diagrams seems to indicate that the effects of the network scenarios are stronger in the accession countries, whereas the pricing scenarios more strongly affect the member states of the present European Union. This effect will be discussed again in the section on cohesion effects.

4.2. GDP per capita

The major policy-relevant output of the SASI model is regional GDP per capita, i.e. GDP totalled over all six sectors divided by population.

Figures 9 to 12 show the changes in GDP per capita caused by the same policies as for accessibility (i.e., the difference between GDP per capita in the policy scenario and GDP per capita in the reference scenario in 2020). Again, the classes of the legend and the colour code are identical in all maps to allow easy comparison. Red colour shades indicate positive differences (i.e. the GDP per capita in the policy scenario is higher), whereas blue indicates negative differences. However, in contrast to the accessibility maps, now the regional GDP per capita are standardised as percent of the EU27+2 average, so that the generative effects of the forecast GDP forecasts are neutralised and only the distributional effects are shown. This serves to demonstrate that even if the model predicts that all regions gain in GDP per capita, there are relative winners and losers.

Figure 9 demonstrates that regions that gain in accessibility also gain in GDP per capita. A comparison of Figure 9 with Figure 4 shows that if the 'classical' TEN priority projects of the Essen list are implemented as in Scenario A1, the network improvements in the cohesion countries Portugal, Spain and Italy are successful in promoting economic development in these countries as intended. Figure 9 (right) shows that, as in Figure 4 (left), the implementation of all TEN and TINA projects would spread the impacts over a wider area including the accession countries in eastern Europe.

Similar observations, but with the opposite sign, can be made with respect to the impacts of transport pricing policies. Figure 10 shows the effects of road pricing for lorries (Scenario B1) and pricing of all modes for both travel and goods transport (Scenario B2), respectively. Figure 10 left (Scenario B1) conforms to expectation: the peripheral regions, which lose most in accessibility (see Figure 5 left), also lose most in GDP per capita. The reverse occurs in the case of the more comprehensive pricing scheme of Scenario B2 (Figure 10 right). Now the peripheral regions seem to be the (relative) winners, because the central regions suffer more under the high charges on travel.

If network scenario A1 and pricing scenario B2 are combined as in Scenario C1, the result isa superposition of the effects of both (see Figure 11). A comparison with the accessibility map of Scenario C1 (Figure 6) shows that regions with high losses in accessibility also lose GDP per capita and that regions with gains or only slight losses in accessibility perform well economically.

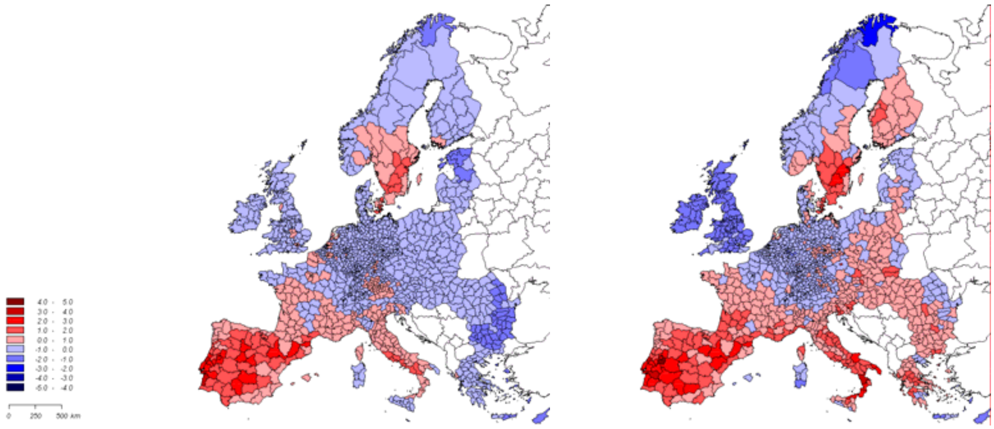

Figure 9. Percent change in GDP per capita (EU27+2=100). Scenario A1: TEN priority projects (left),Scenario A3: all TEN/TINA projects (right)

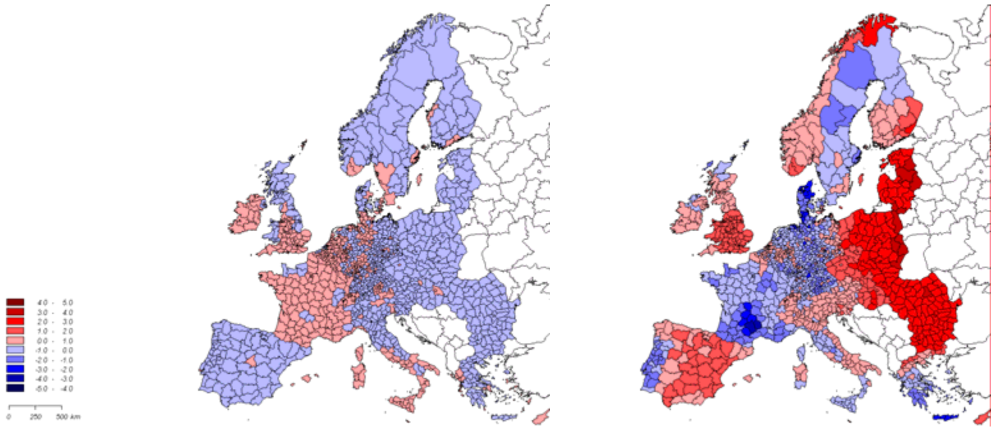

Figure10. Percent change in GDP per capita (EU27+2=100). Scenario B1: freight road pricing (left),Scenario B2: pricing of all modes (right)

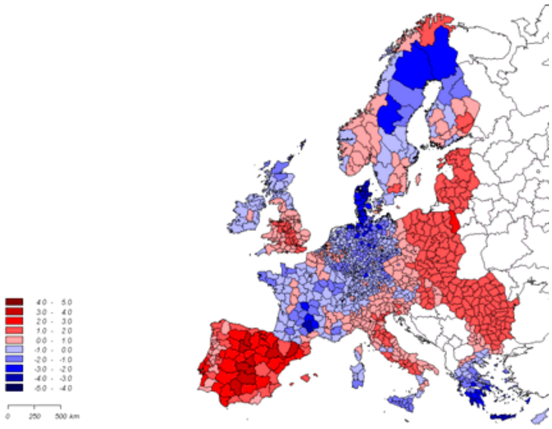

Figure11. Percent change in GDP per capita (EU27+2=100). Scenario C1: combination of scenarios A1 and B2

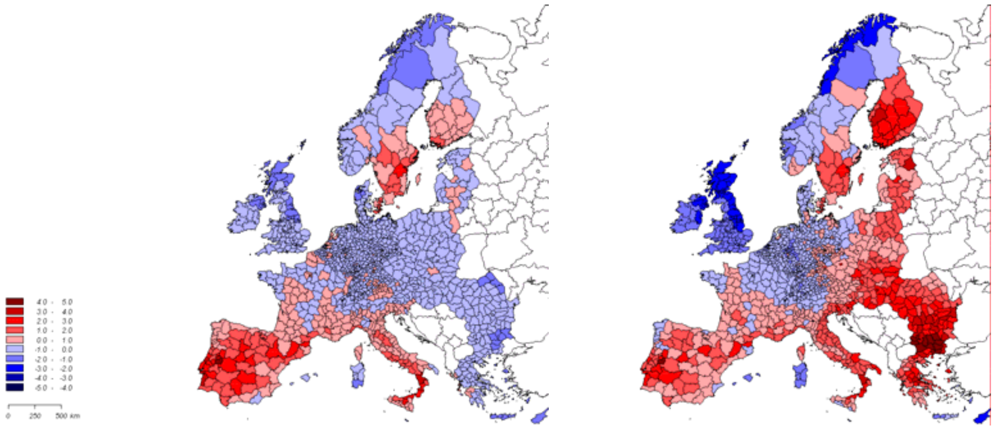

Figure12. Percent change in GDP per capita (EU27+2=100). Scenario 51: new priority projects (left), Scenario A62: Scenario A3 plus maximum projects in accession countries in eastern Europe (right)

The same relationship between accessibility and GDP per capita holds true for the two remaining scenario examples. The changes in GDP per capita resulting from the new priority projects in Scenario 51 (Figure 12 left) correspond with the changes in accessibility in that scenario in Figure 7 (left). A comparison with the GDP per capita in Scenario A1, in which the 'old' priority projects are implemented (see Figure 9 left), shows that the economic effects of the two priority lists are very similar, except that the new priority projects redress some of the disadvantages of the peripheral regions in eastern Europe. Not surprisingly, the massive network policies in eastern Europe in Scenario A62 lead to significant additional economic growth in the accession countries (Figure 12 right).

Table 3 summarises the GDP per capita effects of all policy scenarios. It shows, similar to Table 2, for each policy scenario the percentage difference in GDP per capita between the policy scenario and the reference scenario in 2020 for the four groups of regions. GDP per capita shown is the total of GDP of the six sectors divided by population, unstandardised.

In this unstandardised form, all network scenarios have a positive effect on GDP per capita. As with accessibility, the largest effects are associated with the more comprehensive investment programmes: all TEN projects (Scenario A1), all TEN and TINA projects (Scenario A3) and the larger version of the additional projects in CC12 (Scenario A62). Also in economic terms, high-speed rail is more effective than conventional rail, and rail is more effective than road – but again with the caveat that this result may be due to the larger proportion of rail, and in particular high-speed rail, projects among the projects of the two priority lists. In economic terms, the dedicated rail network is not as successful as its accessibility effect might suggest.

Transport pricing policies reduce not only accessibility but also GDP per capita. Remarkably, pricing of only freight transport on roads (Scenario B1), has only little economic effect despite its significant negative effect on accessibility (see Table 2). However, if all modes and both travel and goods transport are subjected to pricing as in Scenario B2, the negative effect is very strong and is in fact the strongest effect of all scenarios whether positive or negative. If both network and pricing scenarios are combined as in Scenario C1, the negative effect of pricing by far outweighs the positive impact of the network improvements.

Table 3. SASI model results: GDP per capita

Scenario		GDP per capita difference between policy scenario and reference scenario in 2020 (%)			
		EU15	CH+NO	CC12	EU27+2
A1	TEN priority projects	+1.25	+0.88	+0.32	+1.19
A21	High-speed rail priority projects	+1.07	+0.55	+0.28	+1.01
A22	Other rail priority projects	+0.14	+0.20	+0.01	+0.13
A23	Road priority projects	+0.09	+0.18	+0.03	+0.09
A24	Rail priority projects	+1.17	+0.74	+0.30	+1.11
A3	All TEN/TINA projects	+2.59	+2.14	+2.90	+2.58
A4	All TEN projects	+2.19	+1.84	+0.78	+2.11
A51	New priority projects	+1.62	+1.31	+1.02	+1.58
A52	New priority rail projects	+1.54	+1.17	+0.86	+1.49
A53	New priority road projects	+0.12	+0.20	+0.21	+0.13
A61	A3 + additional projects in CC12	+2.84	+2.30	+3.70	+2.85
A62	A3 + maximum projects in CC12	+3.10	+2.48	+5.16	+3.16
B1	SMC pricing road freight	–0.10	–0.16	–0.19	–0.11
B2	SMC pricing all modes travel/freight	–3.84	–3.38	–1.62	–3.72
C1	A1+B2	–2.38	–2.47	–1.23	–2.33
D1	Dedicated rail freight network	+1.71	+1.61	+1.06	+1.68
E1	TIPMAC business-as-usual scenario	+2.54	+2.03	+2.89	+2.52
E2	TIPMAC fast TEN + SMC	+0.33	–0.84	+2.20	+0.35

Figure 13 presents the same information in graphical form. The left-hand side shows the development of GDP per capita between 1981 and 2021 in the present European Union (EU15), the right-hand side the same for the accession countries (CC12).

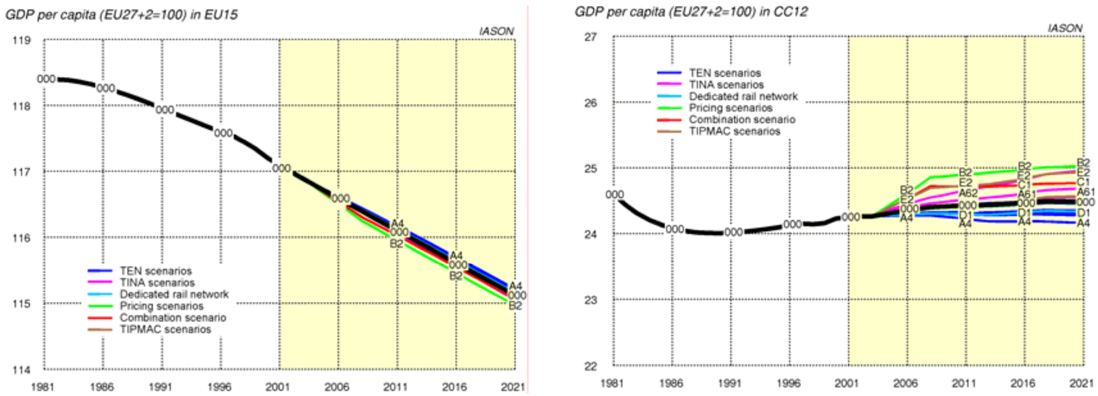

Figure 13. GDP per capita (EU27+2=100) in the European Union (left) and in the accession countries (right)

A comparison of Figure 13 with the same diagrams for accessibility (Figure 8) demonstrates that relatively large changes in accessibility translate into only very small changes in economic performance (note the difference in scale of the two pairs of diagrams). In fact the changes in GDP per capita caused by transport policy are tiny in relation to the changes caused by other driving forces, such as innovation, productivity gains or globalisation. For instance it is assumed for all scenarios that total GDP in the study area grows by 70 percent until 2021, or by 2.66 percent annually. Even the effect of the implementation of all TEN and TINA projects would amount to less than one year's growth or increase the annual growth rate by a mere 0.08 percent.

A further look at Figure 13 shows that the average GDP per capita in the accession countries is less than one fifth of that in the member states of the present European Union, and that this vast gap in is narrowing, though very slowly. Transport policy seems to contribute only very little to this convergence, and if it does it does so by improving accessibility in the accession countries rather than reducing accessibility in the European core. The comprehensive pricing scenario B2 and the massive transport infrastructure programme of Scenario 62 accomplish most in closing the gap, whereas the dedicated rail freight network (Scenario D1) and the implementation of all TEN projects (Scenario A4) tend to increase it. This leads to the issue of cohesion.

4.3. Cohesion

Strengthening cohesion between the regions in the European Union and reducing the economic and social disparities between them is one of the main goals of the European Union. Transport policy is one of the major policy instruments of the European Union to serve this goal in conjunction with the goal to increase the economic competitiveness of regions. With the enlargement of the European Union and the accession of ten of the twelve candidate countries, cohesion issues become of growing importance.

There are many possible ways to measure the cohesion effects of transport policy measures. Five indicators of territorial cohesion were applied to the results of the scenario simulations. The five indicators are:

- *Coefficient of variation (CoV)*. This indicator is the standard deviation of region indicator values expressed in percent of their European average. The coefficient of variation ranges between zero (no variation) and one (extreme polarisation).

- *Gini coefficient (Gini)*. The Gini coefficient measures the area between the accumulated distribution of sorted indicator values and the straight line representing an equal distribution. Like the coefficient of variation, the Gini coefficient ranges between zero (equal distribution) and one (extreme polarisation).

- *Geometric/arithmetic mean (G/A)*. This indicator compares two methods of averaging among observations: geometric (multiplicative) and arithmetic (additive) averaging. If all observations are equal, the geometric and arithmetic mean are identical, i.e. their ratio is one. If the observations are very heterogeneous, the geometric mean and hence the ratio between the geometric and the arithmetic mean go towards zero.

- *Correlation between relative change and level (RC)*. This indicator examines the relationship between the percentage change of an indicator and its magnitude by calculating the correlation between them. If the correlation between the changes in GDP per capita of the region and the levels of GDP per capita in the regions is positive, the more affluent regions gain more than the poorer regions and disparities in income are increased.

- *Correlation between absolute change and level (AC)*. This indicator is constructed as the previous one except that absolute changes are considered.

As an example, the latter two cohesion indicators were calculated for all scenarios for each year of the simulation. The results are shown in Figures 14 and 15. The diagrams are interpreted as follows: lines above the heavy black line represent positive correlation coefficients, i.e. belong to scenarios which are anti-cohesion. Lines below the black line represent negative correlation, i.e. belong to pro-cohesion scenarios. The distance from the black line indicates the intensity of the relationship between change and level.

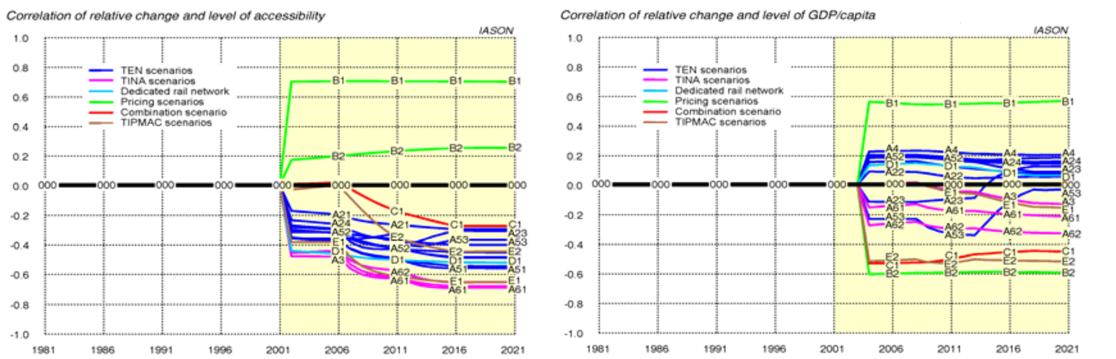

Figure 14. Correlation of relative change and level of accessibility (left) and of GDP per capita (right)

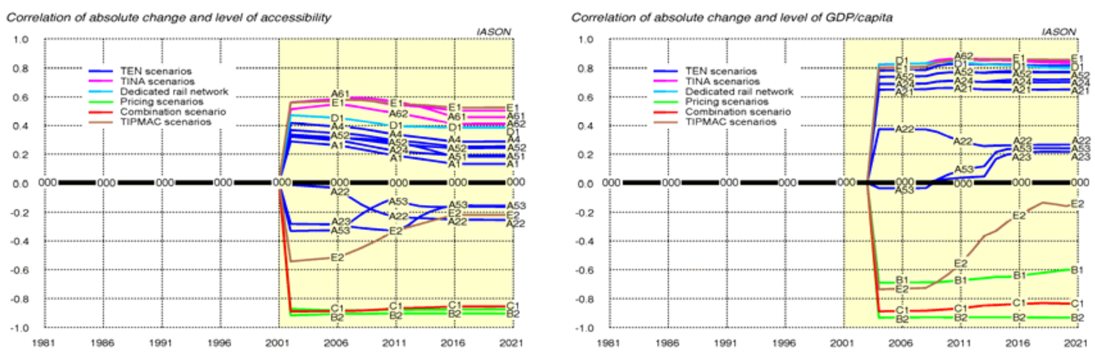

Figure 15. Correlation of absolute change and level of accessibility (left) and of GDP per capita (right)

Tables 4 and 5 summarise the information gained from the five cohesion indicators for accessibility and GDP per capita. The two tables show that with respect to accessibility, almost all policies examined contribute to cohesion, except the two pricing scenarios B1 and B2 – if one applies one of the first four indicators, coefficient of variation, GINI coefficient, geometric/arithmetic mean or relative correlation. However, if one consults also the fifth indicator, absolute correlation, the picture is more complex as more often than not the sign of the indicator is reversed. In terms of GDP per capita, the choice of the indicator is even more critical as now even the relative correlation indicator signals polarisation where the coefficient of variation and the Gini coefficient signal cohesion.

It is therefore not easy to assess whether a transport policy supports economic cohesion. Of the policy scenarios examined here, most network scenarios are pro-cohesion except the two road-only scenarios. The scenario assuming road pricing for lorries (Scenario B1) is clearly anti-cohesion, whereas the comprehensive transport pricing scenario B2 is strongly pro-cohesion. However, it is not clear whether these effects are caused by the fact that the two pricing schemes were only applied to the present European Union.

Table 4. SASI model: accessibility cohesion effects

Scenario		Accessibility cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	TEN priority projects	+	+	++	+	–
A21	High-speed rail priority projects	+	+	+	+	–
A22	Conventional rail priority projects	+	+	+	+	+
A23	Road priority projects	+	+	+	+	+
A24	Rail priority projects	+	+	+	+	–
A3	All TEN/TINA projects	++	++	++	++	–
A4	All TEN projects	+	+	++	++	–
A51	New priority projects	+	+	++	++	–
A52	New priority rail projects	+	+	++	+	–
A53	New priority road projects	+	+	+	+	+
A61	A3 + additional projects in CC12	++	++	++	++	–
A62	A3 + additional projects in CC12	++	++	++	++	–
B1	SMC pricing road freight	–	–	–	—	++
B2	SMC pricing all modes travel/freight	–	–	–	–	++
C1	A1+B2	+	+	+	+	++
D1	Dedicated rail freight network	++	++	++	++	–
E1	TIPMAC business-as-usual scenario	++	++	++	++	—
E2	TIPMAC fast TEN + SMC	+	++	++	+	+

Table 5. SASI model: GDP per capita cohesion effects

		GDP per capita cohesion effects (+/–)				
	Scenario	CoV	Gini	G/A	RC	AC
A1	TEN priority projects	+	+	·	–	—
A21	High-speed rail priority projects	+	+	·	–	—
A22	Conventional rail priority projects	+	+	·	–	–
A23	Road priority projects	–	–	·	–	–
A24	Rail priority projects	+	+	·	–	—
A3	All TEN/TINA projects	+	+	·	+	—
A4	All TEN projects	+	+	–	–	—
A51	New priority projects	+	+	·	–	—
A52	New priority rail projects	+	+	·	–	—
A53	New TEN priority road projects	–	–	·	+	–
A61	A3 + additional projects in CC12	+	+	+	+	—
A62	A3 + additional projects in CC12	+	+	+	+	—
B1	SMC pricing road freight	–	–	·	—	++
B2	SMC pricing all modes travel/freight	+	+	+	++	++
C1	A1+B2	+	+	+	+	++
D1	Dedicated rail freight network	+	+	·	–	—
E1	TIPMAC business-as-usual scenario	+	+	·	+	—
E2	TIPMAC fast TEN + SMC	+	+	+	++	+

+/++ Weak/strong cohesion effect: disparities reduced
–/— Weak/strong anti-cohesion effect: disparities increased
· Little or no cohesion effect

5. Conclusions

The conclusions that can be drawn from the scenario simulations with the extended SASI model can be summarised as follows.

Methodological

The SASI model differs from other approaches to modelling the impacts of transport on regional development by modelling not only regional production (the demand side of regional labour markets) but also regional population (the supply side of regional labour markets). A second major advantage of the model is its comprehensive geographical coverage. Its study area are all regions of the fifteen member states of the European Union and the ten accession countries plus Norway, Switzerland, Bulgaria and Romania at the NUTS3 or equivalent level. A third feature is its dynamic network database. Based on a 'strategic' subset of highly detailed pan-European road, rail and air networks, the model uses one of the most sophisticated transport network representations available in Europe today, allowing both backcasting of network development as far back as 1981 and forecasting network development until the year 2020.

The SASI model uses regional production functions in which transport infrastructure is represented by accessibility. The model is particularly flexible in incorporating 'soft' non-transport factors of regional economic development beyond the economic factors traditionally included in regional production functions. These may be indicators describing the spatial organisation of the region, i.e. its settlement structure and internal transport system, or institutions of higher education, cultural facilities, good housing and a pleasant climate and environment. In addition to these tangible endowment indicators, regional residuals taking account of intangible factors not considered are included in the production functions.

An important feature of the model is its dynamic character. Regional socio-economic development is determined by interacting processes with a vast range of different dynamics. Whereas changes of accessibility due to transport infrastructure investments and transport system improvements become effective immediately, their impacts on regional production are felt only two or three years later as newly located industries start operation. Regional productivity and labour force participation are affected even more slowly. The sectoral composition of the economy and the age structure of the population change only in the course of decades. A model that is to capture these dynamics cannot be an equilibrium model but has to proceed in time increments shorter than the time lags of interest.

The work in IASON has proved that the SASI model is operational, that its data requirements – beyond the network database – can be largely met by existing statistical data sources and that it is capable of providing policy-relevant results.

Results

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, ageing of the population, shifting labour force participation and increases in labour productivity. These trends have a much stronger impact on regional socio-economic development than transport policies. If one considers that under normal economic circumstances the long-term growth of regional economies is in the range between two and three percent per year, additional regional economic growth of less than one or two percent over twenty years is almost negligible.

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 through even larger airports or even more motorways or high-speed rail lines may will bring only little additional incentives for economic growth. For regions at the European periphery or in the accession countries, however, which suffer from the remote geographical location *plus* an underdeveloped transport infrastructure, a gain in accessibility through a new motorway or rail line may bring significant progress in economic development. But, to make things even more complex, also the opposite may happen if the new connection opens a formerly isolated region to the competition of more efficient or cheaper suppliers in other regions.

If the different types of policies are compared, high-speed rail projects seem to be more effective in terms of promoting regional economic activity than conventional rail projects, and rail projects seem to be more effective than road projects. All transport pricing scenarios have negative economic effects but these can be mitigated by their combination with network scenarios with positive economic effects, although the net effect depends on the magnitude of the two components. Not surprisingly, large comprehensive programmes have more substantial effects than isolated projects.

As regards the cohesion goal, the situation is very complex. There are several methods and indicators to measure the contribution of a policy or policy combination to the cohesion objective. However, these methods and indicators give partly contradictory results. In particular the most frequently applied indicators of cohesion, the coefficient of variation and the Gini coefficient, tends to signal convergence where in many cases in fact divergence occurs. The coefficient of variation, the Gini coefficient, the ratio between geometric and arithmetic mean and the correlation between relative change and level measure *relative* differences between regions and classify a policy as pro-cohesion if economically lagging regions grow faster (in relative terms) than economically more advanced, i.e. more affluent regions. However, one percent growth in a poor region in absolute terms is much less than one percent growth in a rich region. Even if poorer regions grow faster than rich regions (in relative terms), in most cases the income gap between rich and poor regions (in absolute terms) is widening. Which concept of cohesion (or convergence or divergence) is applied, is a matter of definition – and political preference. It is therefore of great importance to clearly state which type of cohesion indicator is used in an analysis.

Beyond these methodological difficulties, it has become clear that many infrastructure investment programmes of the past have been anti-cohesion, i.e. have contributed to widening the spatial disparities between central and peripheral regions in Europe. This is even true for the 'old' list of TEN priority projects. The 'new' list of priority projects is a clear advance in this respect. However, there is room for improvement, as some of the scenarios have shown. The simulations have demonstrated that rapid upgrading and extending of the rail and road infrastructure in eastern Europe would contribute to the economic and social integration of the accession countries after the enlargement of the European Union.

References

Bröcker, J., Kancs, A., Schürmann, C., Wegener, M., 2002a. Methodology for the Assessment of Spatial Economic Impacts of Transport Projects and Policies. IASON Deliverable 2. Kiel/Dortmund: Christian-Albrechts-Universität Kiel/Institut für Raumplanung, Universität Dortmund.

Bröcker, J., Kretschmer, U., Schürmann, C., Spiekermann, K., Stelder, D., Wegener, M., 2002b. The IASON Common Spatial Database. IASON Deliverable 3. Kiel/Dortmund: Christian-Albrechts-Universität Kiel/Institut für Raumplanung, Universität Dortmund.

Bröcker, J., Meyer, R., Schneekloth, N., Schürmann, C., Spiekermann, K., Wegener, M., 2004. Modelling the Socio-Economic and Spatial Impacts of EU Transport Policy. IASON Deliverable 6. Kiel/Dortmund: Christian-Albrechts-Universität Kiel/Institut für Raumplanung, Universität Dortmund.

European Commission, 2002. Trans-European Transport Network. TEN-T Priority Projects. Luxembourg: Office for Official Publications of the European Communities.

European Commission, 2003. Vorschlag für eine Entscheidung des Europäischen Parlaments und des Rates zur Änderung des geänderten Vorschlages für eine Entscheidung des Europäischen Parlaments und des Rates zur Änderung der Entscheidung Nr. 1692/96/EG über gemeinschaftlich Leitlinien für den Aufbau eines transeuropäischen Verkehrsnetzes. Brüssel: Kommission der Europäischen Gemeinschaften.

Fürst, F., Schürmann, C., Spiekermann, K., Wegener, M., 2000. The SASI Model. Demonstration Examples. SASI Deliverable D15. Dortmund: IRPUD.

Schürmann, C., Spiekermann, K., Wegener, M., 2001. Regional Economic Impacts of trans-European Transport Networks. In: WCTR Society (Ed.): 2001 WCTR Proceedings. Seoul: WCTR Society.

TINA Secretariat. 2002. Status of the Pan-European Transport Corridors and Transport Areas. Developments and Activities in 2000 and 2001. Vienna: TINA Secretariat.