ASSESSING REGIONAL ECONOMIC IMPACTS OF THE TEN AND TINA NETWORKS

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1. POLICY BACKGROUND AND INTRODUCTION

The important role of transport infrastructure for regional development is one of the fundamental principles of regional economics. In its most simplified form it implies that regions with better access to locations of input materials and markets will, ceteris paribus, be more productive, more competitive and hence more successful than remote and isolated regions. Therefore, the European Commission is stating that good accessibility of European regions improve their competitive position but also the competitiveness of Europe as a whole. The trans-European transport networks (TEN) for the EU 15 member states and the TINA networks in the new EU member states are dedicated to improve regional accessibility, strengthen their competitive position and eventually lead to cohesion among European regions.

However, the question whether the trans-European transport networks contribute to cohesion is not undisputed. Critics argue that many projects do not link peripheral but central regions with each other. Moreover, although new infrastructure linking peripheral regions to central regions is enabling producers in peripheral regions to market their products in the agglomerations, it also opens up the closed local markets in peripheral regions to new competitors from central areas which might destroy old traditional monopolies in peripheral areas and so counter-act to promoting regional development in the periphery.

The paper is based upon the project *Integrated Appraisal of Spatial Economic and Network Effects of Transport Investments and Policies* (IASON) of the 5th RTD Framework of the European Union. The main goal of this project was to improve understanding of the impacts of transport policies on short- and long-term spatial development in the EU and to develop a unified framework for the assessment of transport policies integrating network, regional economic and macro-economic impacts.

The paper will focus on the design and application of a regional economic model developed in IASON. It describes the results of the model in terms of GDP and accessibility forecasts, applied to a set of 19 different TEN / TINA transport infrastructure scenarios. The regional economic model developed is based on NUTS 3 level, simulating spatial development for a period of 20 years into the future on a yearly basis for some 1,300 regions of the enlarged European Union and Norway and Switzerland. With these features, the model incorporates strong temporal and explicit spatial components, in order to reveal distinct spatial patterns of economic development through time and space. The model is based on a quasi-production-function approach where accessibility is incorporated as an additional production factor, transforming changes in accessibility into changes in the economic performance of regions. The model results allow to test different transport policies against the main objectives of the European Union, i.e. strengthen the competitiveness of regions and contributing to cohesion, and thus is able to give recommendations which transport policy is likely to contribute most to the policy goals. Eventually, the model tries to give answers to the question whether or not transport infrastructure policies are the right measures to decrease disparities in economic performance of regions in the enlarged European Union.

The first part of the paper describes the regional economic model developed, its model structure and model principles and its main output. The second part is devoted to present 19 network scenarios analysed. The last part of the paper will give an overview on the model results in terms of accessibility and GDP, and will end with policy recommendation which of the transport scenarios is best suited to contribute to the competitiveness and cohesion aims of the European Union.

2. THE SASI MODEL

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 and transport system improvements, in particular of the trans-European transport networks (TEN-T).

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 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. Its application is restricted, however, in other respects: The model generates many 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), which makes it possible to model regional unemployment. 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.

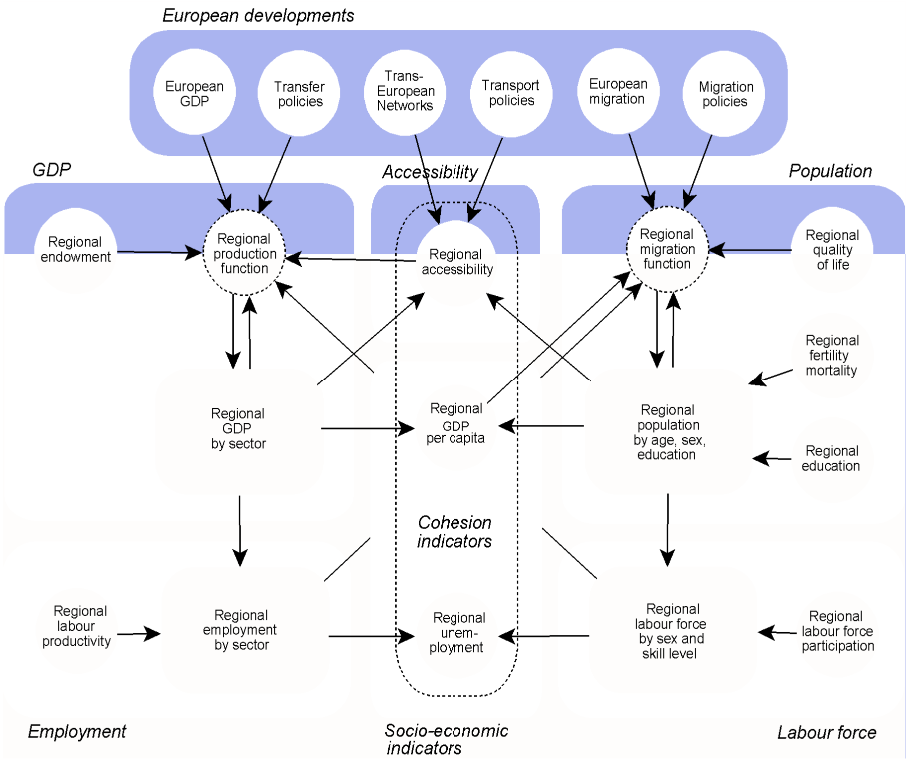

Figure 1. The SASI Model.

The *spatial* dimension of the model is established by the subdivision of the European Union and the 12 candidate countries in eastern Europe 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 a couple of model improvements and model extensions have been implemented, with respect to model theory, model data and model techniques:

From a theoretical point of view, the two major improvements are the replacement of travel time accessibility indicators by travel cost indicators, and to forecast rates of change of regional development rather than levels of regional production. Moreover, the model was made more responsive to non-transport policies, such as regional economic policies or immigration policies, and to a broader range of transport policies, such as 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 level) and sectoral terms (from three economic sectors to six), and was extended to cover the new EU member states and Norway and Switzerland as well.

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. (2002; 2004)

3. THE TEN / TINA NETWORKS AND SCENARIOS TESTED

The TEN and TINA outline plans represent one of the most ambitious initiatives of the European Union since its foundation including lots of individual and combined projects. The assessment of these projects were done by applying different scenarios of the further development of the networks. The scenarios simulated with the SASI model can be classified into six categories (Table 1):

- *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, i.e. they vary in the number, selection and timing of implementation of network links.
- *Pricing scenarios*. Scenarios B1 and B2 examine different schemes of social marginal cost (SMC) pricing. They differ in the kind of pricing regime. These scenarios do not implement 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.

Table 1. Transport scenarios simulated in IASON.

Scenario	Code
000 Reference scenario	
Reference scenario	000
A Network scenarios	
TEN priority projects (Essen list)	A1
High-speed rail priority projects (Essen list)	A21
Conventional rail priority projects (Essen list)	A22
Road priority projects (Essen list)	A23
Rail priority projects (Essen list)	A24
All TEN and TINA projects	A3
All TEN projects	A4
New priority projects	A51
New priority rail projects	A52
New priority road projects	A53
A3 + additional projects in candidate countries	A61
A3 + maximum projects in candidate 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

All scenarios rely on the trans-European transport network GIS database developed by the Institute of Spatial Planning of the University of Dortmund and now maintained by RRG. The *strategic* road, rail and inland waterways 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), latest publications on the priority projects (European Commission, 2003), on 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. SIMULATION 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)*.

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 EU15. Of the new EU member states and candidate countries, the Czech Republic, Slovakia, Hungary and parts of Poland belong to the European core, whereas the Baltic states and Romania and Bulgaria (and of course the two island states Cyprus and Malta) remain peripheral.

Figures 4 to 6 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 the accessibility 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.

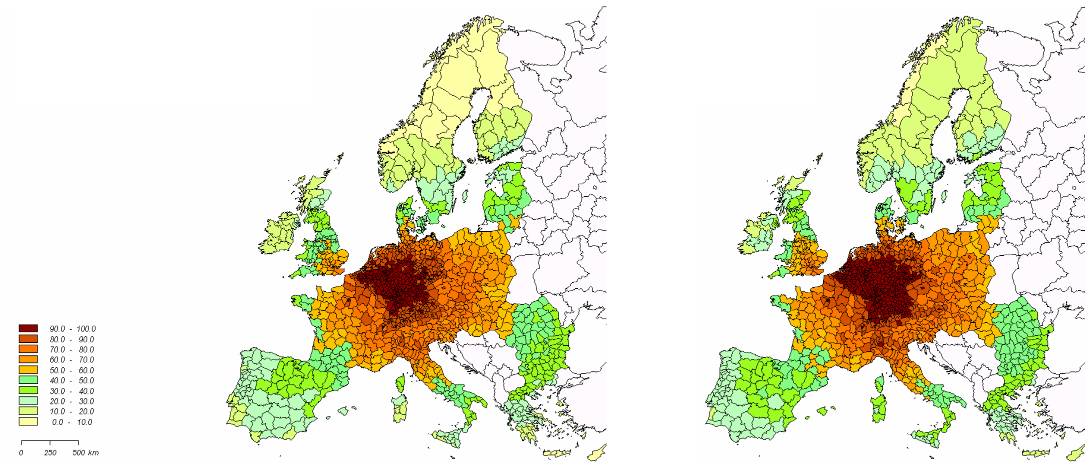

Figure 2. Reference scenario 000: Accessibility rail/road (travel, million) in 2020 (left), accessibility rail/road/air (travel, million) in 2020 (right)

As to be expected, the network scenarios A1, A3, A51 and A62 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 new member states 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).

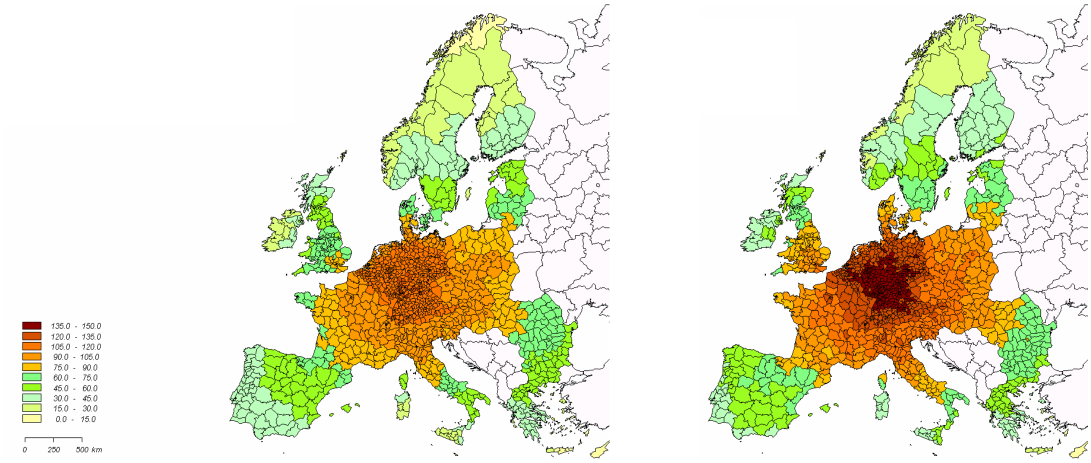

Figure 3. Reference scenario 000: Accessibility road (freight, million) in 2020 (left), accessibility rail/road (freight, million) in 2020 (right).

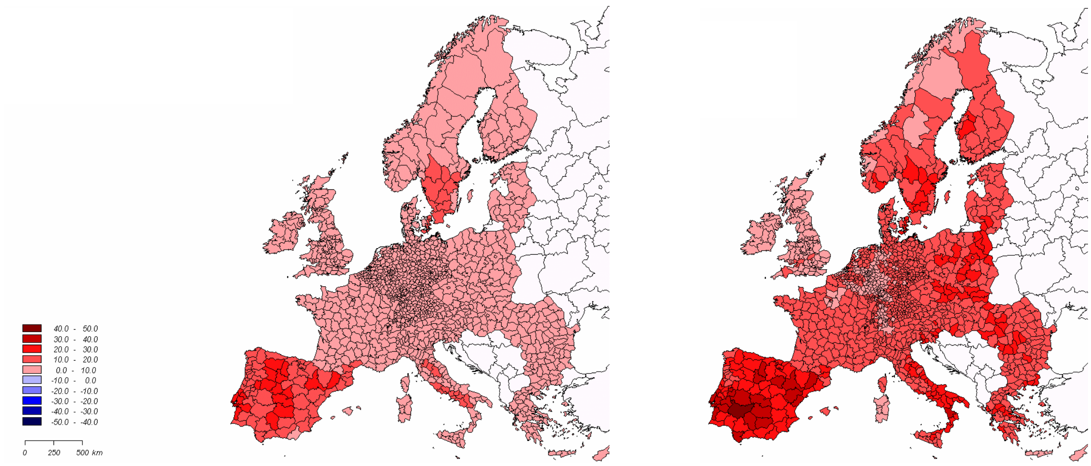

Figure 4. Percent change in accessibility rail/road/air (travel): TEN priority projects (Scenario A1) (left), all TEN/TINA projects (Scenario A3) (right).

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 EU15. If only freight transport on roads is priced, as in Scenario B1, the regions most affected are therefore peripheral regions in EU15 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 new member states in eastern Europe are only little affected (see Figure 5 right).

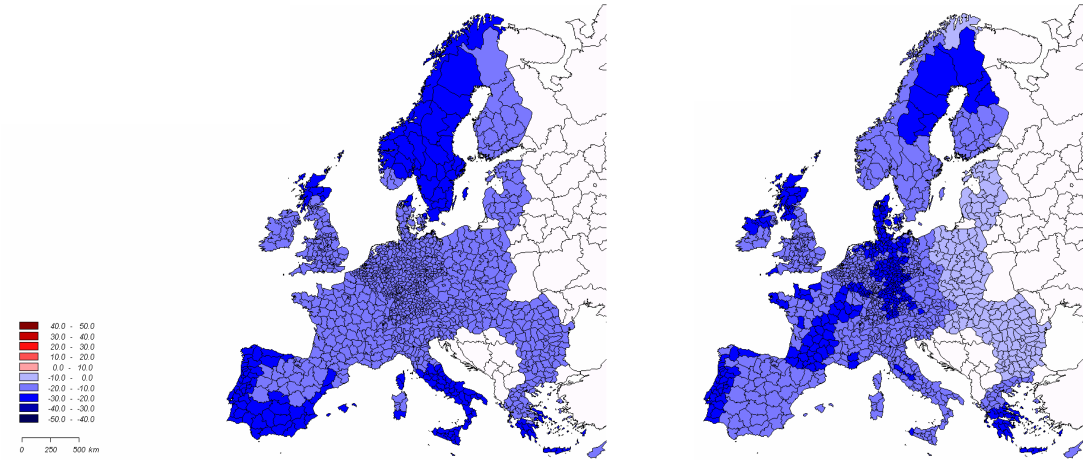

Figure 5. Percent change in accessibility road (freight) by freight road pricing (Scenario B1) (left), percent change in accessibility rail/road/air (travel) by pricing of all modes (Scenario B2) (right).

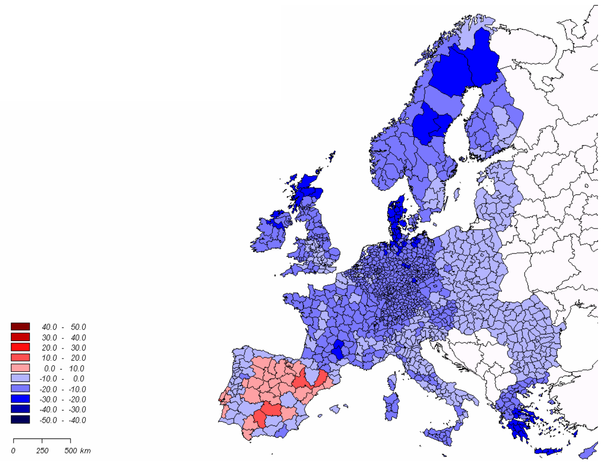

Figure 6. Percent change in accessibility rail/road/air (travel by combination of scenarios A1+B2 (Scenario C1).

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.

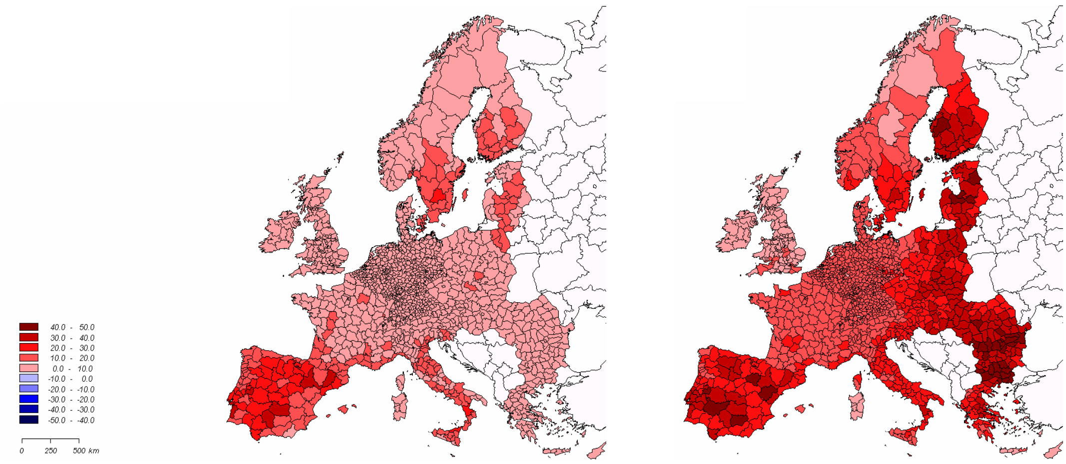

Figure 7. Percent change in accessibility rail/road/air (travel): Nnew priority projects (Scenario A51) (left), A3 + maximum projects in eastern Europe (Scenario A62) (right).

Table 2 and Figure 8 summarise the accessibility effects of all simulated policy scenarios.

Table 2 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 old European Union (EU15), Switzerland and Norway (CH+NO), the new EU member states and 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.

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.

Table 2. SASI model results: accessibility

Scenarios		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

Figure 8 presents the same information in graphical form. The left hand side shows the development of accessibility between 1981 and 2021 in the EU and on the right the same for the new member states and Romania and Bulgaria (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 EU15. The accessibility of the new member states and Romania and Bulgaria as a whole is not much less than in the EU15. However, there remain large differences in accessibility between both. 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.

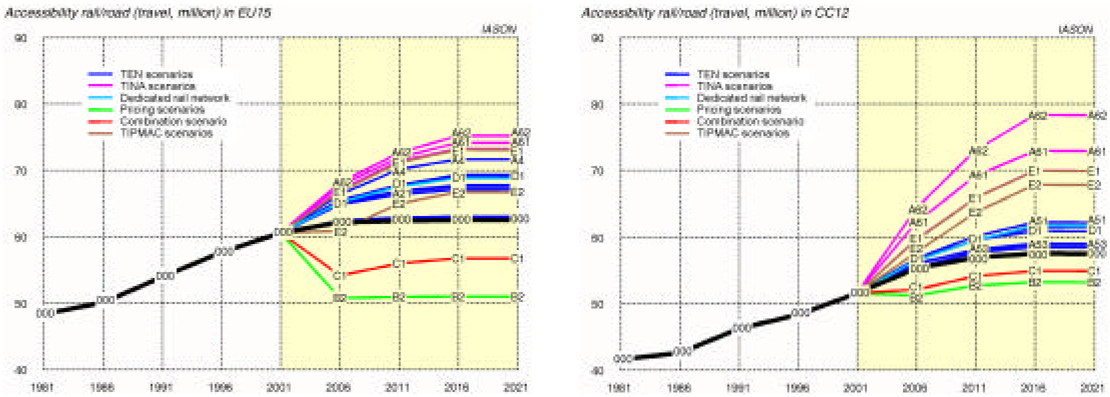

Figure 8. Accessibility rail/road (travel, million): in the European Union (left) and in the candidate countries (right).

The comparison of the two diagrams seems to indicate that the effects of the network scenarios are stronger in the new EU member states, whereas the pricing scenarios more strongly affect the member states of EU15. 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 policies in the same set of 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 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 the new EU member states 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 is, as to be expected, a superposition of the effects of both policies (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.

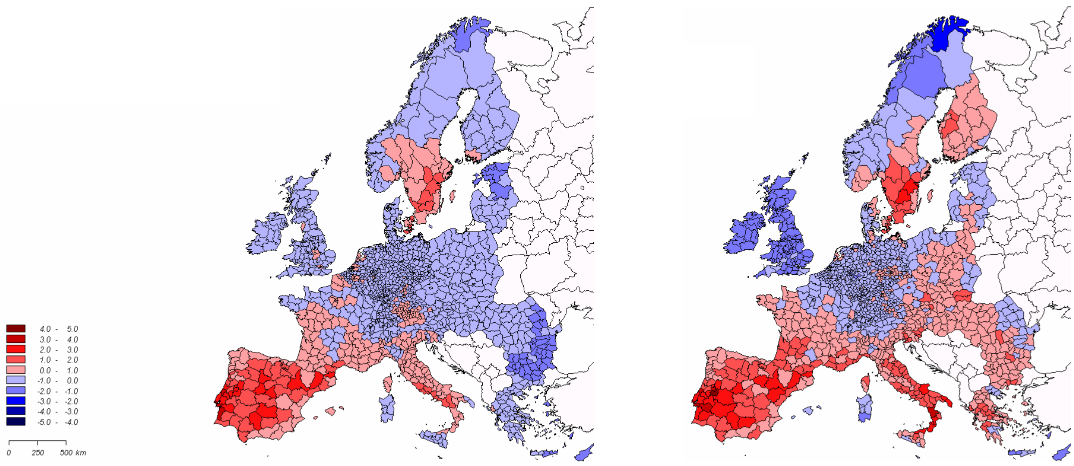

Figure 9. Percent change in GDP per capita (E27+2=100): TEN priority projects (Scenario A1) (left), all TEN/TINA projects (Scenario A3) (right).

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 A51 (Figure 12 left) correspond well 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 new EU member states, Romania and Bulgaria (see Figure 12 right).

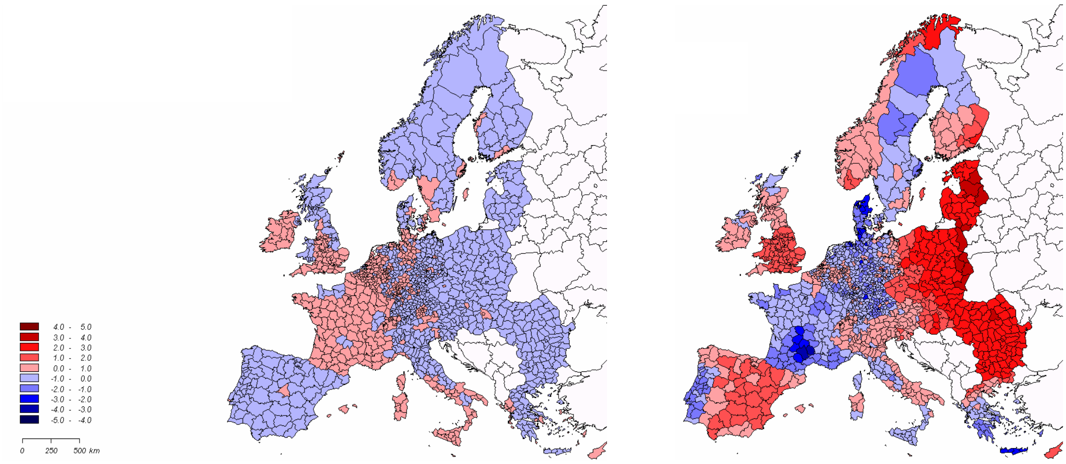

Figure 10. Percent change in GDP per capita (E27+2=100): freight road pricing (Scenario B1) (left), pricing of all modes (Scenario B2) (right).

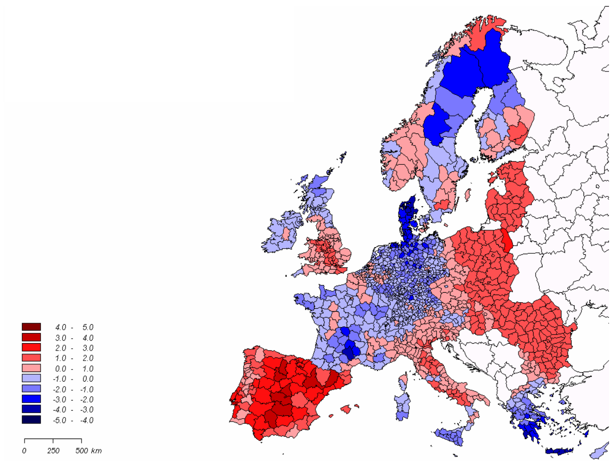

Figure 11. Percent change in GDP per capita (E27+2=100) by combination of scenarios A1+B2 (Scenario C1).

Table 3 and Figure 13 summarise the GDP per capita effects of all simulated policy scenarios.

Similar to Table 2, Table 3 shows 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.

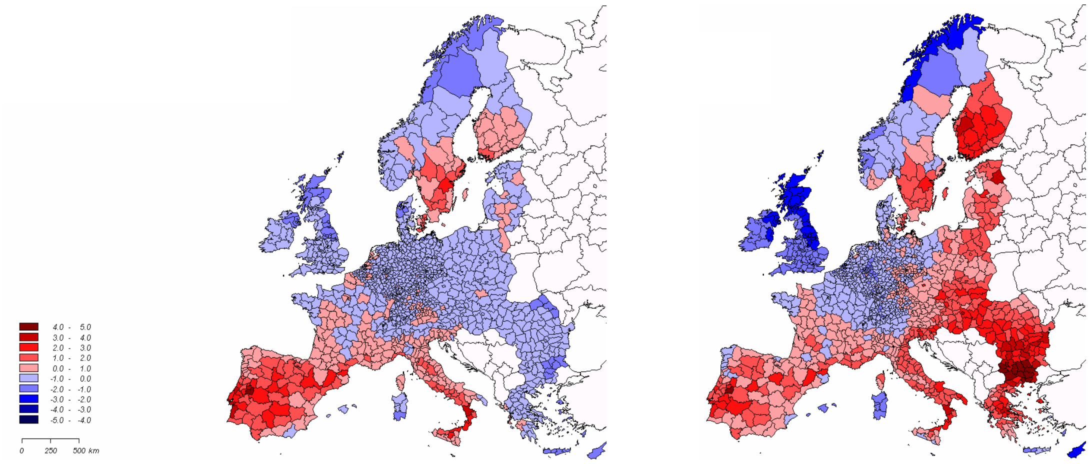

Figure 12. Percent change in GDP per capita (E27+2=100): new priority projects (Scenario A51) (left), A3 + maximum projects in eastern Europe (Scenario A62) (right).

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.

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) and on the right the same for the twelve candidate countries (CC12).

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 economic 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 new EU member states and Romania and Bulgaria is less than one fifth of that in the EU15, and that this vast gap 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 new member states 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.

Table 3. SASI model results: GDP per capita

Scenarios		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

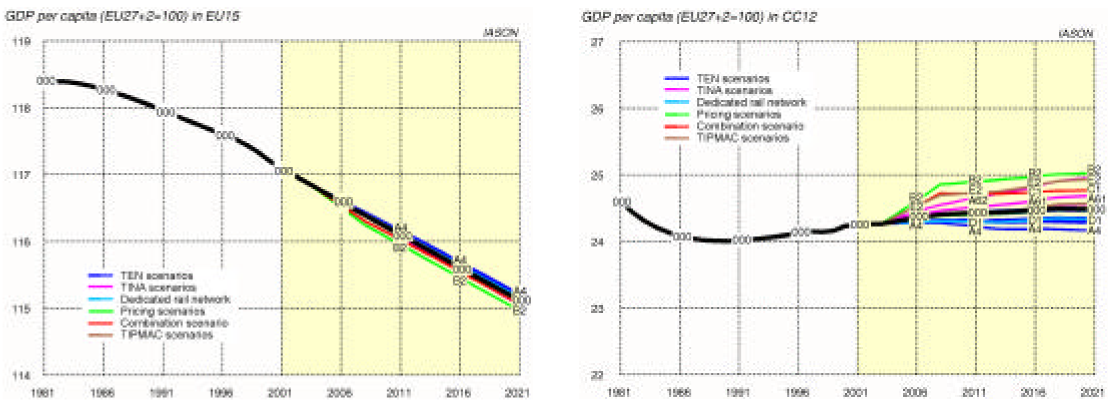

Figure 13. GDP per capita (EU27+2=100): in the European Union (left) and in the candidate countries (right).

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 coefficient between them. If for instance 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 that disparities in income are increased. If the correlation is negative, the poorer regions gain more than the rich regions and disparities decrease.
- *Correlation between absolute change and level (AC)*. This indicator is constructed as the previous one except that absolute changes are considered.

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 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.

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

	Scenario	GDP per capita 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	+	+	+	++	+

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

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.

5. CONCLUSIONS

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

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 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 indicator of cohesion, the coefficient of variation, tends to signal convergence where in many cases in fact divergence occurs. The coefficient of variation, the Gini coefficient and the ratio between geometric and arithmetic mean 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 of the two concepts of cohesion (or convergence or divergence) is used, is a matter of definition. It is therefore of great importance to clearly state which type of cohesion indicator is used.

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. (2002) *Methodology for the Assessment of Spatial Economic Impacts of Transport Projects and Policies.* Berichte aus dem Institut für Raumplanung 54, Institut für Raumplanung, Dortmund, Kiel.

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, Christian-Albrechts-Universität Kiel/Institut für Raumplanung, Universität Dortmund, Kiel/Dortmund.

European Commission (2002) *Trans-European Transport Network. TEN-T priority projects,* Office for Official Publications of the European Communities Luxembourg.

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 Verkehrsnetze,* Kommission der Europäischen Gemeinschaften, Brüssel.

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

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

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