ESPON 2.1.1
Territorial Impact of EU Transport and TEN Policies

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This report represents the final results of a research project conducted within the framework of the ESPON 2000-2006 programme, partly financed through the INTERREG programme.

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Foreword

This report is the final report presenting the results of the research conducted by the project group of ESPON 2.1.1 from August 2002 to August 2004.

The project was led by Prof. Dr. Johannes Bröcker, professor for international and regional economics at the Institute of Regional Research at the University of Kiel and consisted of the following institutions:

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Department of Infrastructure, Kungl Techniska Högskolan, Stockholm, Sweden,

Centre for European, Regional and Transport Economics, Kent, UK,

Bundesamt für Bauwesen und Raumordnung, Bonn, Germany.

Furthermore the Institute of Transport Economics, Oslo, Norway and the Federal Office for Spatial Development, Bern, Switzerland, have contributed to the research.

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The aim of the research group was to assess the territorial impact of EU transport and ICT policies. This has been achieved by defining policy scenarios, defined upon European policy documents and evaluating the impacts of the policies with three economic models. The model results are evaluated with respect to the European policy goals cohesion, polycentricity and sustainability by applying indicators that operationalize the spatial policy goals. Research has been performed, how national transport policies interact with European policy and how transport policy interacts with other policy areas. Finally, recommendations are given in this report based on the derived results of this research.

The report is structured into 7 chapters. The first part of the report consists of the executive summary and the explanation of the core methodologies and concepts. The second part of the report is the core part. It itself is structured in 6 chapters. Chapter 2 sets the scene and describes the present situation in transport and ICT infrastructure in the EU. It presents hypotheses and describes the policy scenarios that are analysed. Chapter 3 describes the applied methodologies, starting with the description of the models, and then describing our concepts of measuring the achievement of policy goals and concluding with a causality analysis of transport and economic development. In chapter 4 the results of the research are presented, subdivided in the impacts of policies on economic development, on cohesion, on polycentricity and on transportation flows. The chapter concludes with a discussion of trade-offs between the policy goals cohesion and efficiency that arises in these scenarios. Chapter 5 discusses the institutional interactions in transport policy. The emphasis is put on the vertical and horizontal interactions that occur in political decisions and lead to formulation of policy goals. Chapter 6 concludes the research and formulates policy recommendations based on the research. Chapter 7 finally gives an outlook of possible future research, which might be useful in the field of transport and ICT from the point of view of the project group.

This report and previous interim reports can be downloaded at the ESPON website: www.espon.lu.

This report is not validated by the ESPON Monitoring Committee and does not necessarily reflect the opinion of members of the ESPON Monitoring Committee.

Table of contents

Responsibilities for the chapters of this report

The Institute for Regional Research as the lead partner of the project has been responsible for the compilation and final editing of this report. The responsibility for single chapters and sub-chapters of this report have been in the hands of the respective project partners.

The Institute of Regional Research had the responsibility for writing chapter 3.2, 4.1.2, 6 and had the responsibility for the executive summary.

Spiekermann & Wegener have written chapters 2.2, 3.1, 3.6, 4.1.1, 4.2.1 and chapter 7.

The Free University of Amsterdam was responsible for chapters 3.5, 3.8 and 4.2.

Politecnico di Milano has written the parts of chapter 2.2 and 2.3. Furthermore, they have written chapter 4.1.3.

The Department of Infrastructure, Kungl Techniska Högskolan, Stockholm, has written chapter 3.4 and 4.1.4.

The Centre for European, Regional and Transport Economics, Kent, has written chapter 2.1, chapter 5 and contributed to chapter 7.

Bundesamt für Bauwesen und Raumordnung, Bonn , has written chapter 2.4, 3.7, 4.2.2 and 4.3.

Executive Summary

1.1 Executive Summary

1.1.1 Introduction

The objective of ESPON 2.1.1 is to assess the territorial impacts of EU Transport and TEN policies. The major question is how far the TEN provide the right answers for a territorial development as described in the European Spatial Development Perspective (ESDP) (European Commission, 1999).

The measures proposed in the White Paper "European Transport Policy for 2010: Time to Decide" (European Commission, 2001) should provide the framework for the investigation. Reference has to be made to the policy options developed in the cross-sectoral approach of the ESDP. The ESDP stresses the need for an integrated approach for improved transport links, refers to the polycentric development model, highlights the efficient and sustainable use of infrastructure and emphasises the importance of the diffusion of innovation and knowledge. This integrated approach should be followed in analysing transport and telecommunication networks. The analysis should take into account the principle of territorial balance and the particular problems of peripheral regions.

In more detail, the tasks of ESPON 2.1.1 are:

- to develop methods for the assessment of territorial impacts of EU transport and TEN policies;
- to develop territorial indicators, typologies and concepts, establish database and mapping facilities and conduct empirical statistical data analyses;
- to analyse territorial trends, potentials and problems deriving from EU transport and TEN policies at different scales and in different parts of an enlarged European territory;
- to show the influence of transport, telecommunications and energy policies on spatial development at relevant scales;
- to show the interplay between EU and sub-EU spatial policies and best examples for implementation;
- to recommend further policy developments in support of territorial cohesion and a polycentric and better balanced EU territory;
- to find appropriate instruments to improve the spatial co-ordination of EU and national sector policies and the ESDP.

In ESPON 2.1.1 the evaluation of the territorial impacts of EU transport and telecommunication policies is mainly conducted via scenario analysis. For this, three different forecasting models and a set of analytical techniques to post-process the model results were used.

1.1.2 Analysis of Transport Sector and TEN Policies in an Enlarged Europe

The distinguishing structural features of the transport sector are that it involves both infrastructure and service. In this project we are more concerned with the specific effects of infrastructure, and in particular the high-level infrastructures of the Trans-European Networks. However, infrastructure cannot be analysed independently of the level and quality of service provided on the infrastructure. In particular, we need to ensure that new additions to the stock of infrastructure do not distort the competitive position of different transport modes from that set out in transport policies. The quality of infrastructure at the level of the region, especially at the NUTS-3 level, depends as much on access to the network as on the quality of the network itself. Access to the network is, for the road mode, both about the density of interchanges on major routes and the quality of the local network linking to that higher level..

The identification of different levels of infrastructure and the interaction between modes identifies the need for clarity in the way policy is enacted and communicated between different policy actors. Although transport has a distinctive position in the European Union Treaties with the commitment to the development of a Common Transport Policy, large elements of transport policy are the responsibility of national, regional and local governments under the subsidiarity principle. Whilst it is essential that local transport policy is developed at as local level, where it can be developed more efficiently and be responsive to the needs and wishes of local communities, it is also critical that such local policies are informed by and consistent with EU transport policy. EU transport policy has to set a clear framework within which other policies can be developed. This needs to involve clear and acceptable rules on competition between modes as well as on the technical, social and fiscal matters affecting transport. Developing consistent evidence on the true costs of each mode, including values of time, statistical life and environmental damage, which is acceptable to all member states, has been vital in achieving the consistent evaluation of investments and of policies to manage growth. Such evidence is critical in the modelling work which lies behind our estimates of the impact of developments in the TEN networks.

However, both the general thrust of policy and the specific values which inform that policy is refracted through national (and more local) policy making. Where local transport policy uses different values this introduces distortions in the relative performance of different modes. This is not just a question of reflecting different local priorities, important though that is, but of having spillover effects on other jurisdictions which affects both the efficiency of a mode and the distribution of costs and benefits. We identify in Chapter 5 some of the evidence of the way that national transport policies conflict with EU policy and introduce potential distortions which affect the performance of TENs.

A second main strand in policy is that of regulation and pricing. Although these are implemented in different ways and may have different behavioural responses they both have a direct effect on the absolute and relative costs of different modes. The White Paper on *European Transport Policy for 2010: The Time to Decide* places the need to make users aware of the true costs of transport at the heart of improving information in order to get more efficient decisions. At the core of this policy is the need to make users aware of the marginal social costs of transport including the cost of environmental damage, accidents and time lost through congestion. The imposition of a different charging regime remains a matter for national governments, however, since it impinges on national tax policies. In the meantime different national governments impose rather different types of policy which affect the level of service provided by infrastructure and the competitive positions of different modes.

1.1.3 Transport Policy Scenarios

The transport infrastructure scenarios were implemented using the GIS-based pan-European road, rail, waterway and air network database developed by the Institute of Spatial Planning of the University of Dortmund (IRPUD, 2003) and now maintained and further developed by the Büro für Raumforschung, Raumplanung and Geoinformation – RRG (Schürmann, 2004). The *strategic* networks used for the modelling are subsets of this database comprising the TEN and TINA networks plus a substantial number of additional links to guarantee connectivity of NUTS-3 regions in the European Union and of the regions in non-EU member countries.

All transport policy scenarios are introduced into the two regional economic models as changes of transport costs between regions over time and between scenarios (see Chapter 3). For that the historical and possible future developments of the networks are required as input. The evolution of networks over time is established in the database in five-year intervals; the network database (for rail and road) contains information for the years 1981 to 2021. Parameters for transforming network information into cost estimates are taken from the SCENES project (ME&P et al., 2000).

Table 1.1 Transport policy scenarios

Time horizon	Policy type	Scenario characteristics	
Retrospective 1991-2001	Reference	A0	Do-nothing
	Infrastructure	A1	Only rail projects
		A2	Only road projects
		A3	Rail and road projects
Prospective 2001-2021	Reference	00	Do-nothing
	Infrastructure	B1	Priority projects (new list)
		B2	TEN/TINA projects
		B3	TEN/TINA projects except cross-border corridors
		B4	TEN/TINA cross-border corridor projects only
		B5	TEN/TINA projects only in Objective 1 regions
	Pricing	C1	Reduction of the price of rail transport
		C2	Increase of the price of road transport
		C3	Social marginal cost pricing of all modes
	Combination	D1	Priority projects plus SMCP (B1+C3)
		D2	TEN/TINA projects plus SMCP (B2+C3)

Retrospective scenarios

- *A1 Only rail projects.* In this scenario, European rail infrastructure developed according to reality up to the year 2001 whereas road infrastructure is that of the year 1991. The scenario results give the isolated impacts of rail infrastructure development on the regional economies.
- *A2 Only road projects.* In this scenario, the road infrastructure developed according to reality during the 1990s, whereas rail infrastructure is kept as it was in the year 1991. The scenario results give the isolated effects of road infrastructure development on regional economies.

- *A3 Rail and road projects.* In this scenario, both rail and road infrastructure developed according to the real development. The scenario results allow an assessment of the effects of infrastructure developments during the last decade on regional economic development.

Prospective scenarios

- *B1 Priority projects (new list).* In this scenario, only the new list of priority projects of the TEN network will be realised, no other infrastructure development will happen. This scenario gives insight into the impacts of the current political priorities concerning transport infrastructure development.
- *B2 TEN/TINA projects.* In this scenario, all projects of the TEN/TINA programme for road and rail plus some national infrastructure development will be realised. The scenario includes also the Motorways of the Sea which are treated as part of the road network for freight transport. This scenario predicts the regional economic impacts of a full realisation of the trans-European network programme plus corresponding infrastructure in Norway and Switzerland.
- *B3 TEN/TINA projects except cross-border corridors.* This scenario contains only a subset of the projects of Scenario B2. Now infrastructure development is restricted to those links that have primarily a national function, i.e. all cross-border links remain in the scenario with the status they have in the year 2001. This scenario addresses the regional impacts of a purely nationally oriented transport infrastructure policy.
- *B4 TEN/TINA cross-border corridor projects only.* This scenario is the counterpart to Scenario B3. Now only those links of the full TEN/TINA and the national infrastructure programmes of Scenario B2 are included which are located in cross-border corridors. This scenario might bring out the added value in terms of regional economic development when concentrating purely on international projects.
- *B5 TEN/TINA projects only in Objective 1 regions.* Eventually, this scenario concentrates on infrastructure investments in Objective 1 regions of the Structural Funds for the period 2000-2006, i.e. only the projects of Scenario B2 in eligible areas will be developed, all other links will remain as they are in the year 2001. The scenario might contribute to the question of what would happen if European transport infrastructure policy would focus solely on the least favoured areas in Europe.

Pricing scenarios

As laid out in chapter 1.1.2 pricing policies are a different option to influence mobility behaviour of persons and firms which. The White Paper on *European Transport Policy for 2010: The Time to Decide* places the need to make users aware of the true costs of transport at the heart of improving information in order to get more efficient decisions by the users. At the core of this policy is the need to make users aware of the social costs of transport including the cost of environmental damage, accidents, noise and time lost through congestion. The imposition of a different charging regime remains a matter for national governments, however, since it impinges on national tax policies. In the meantime different national governments impose rather different types of policy which affect the level of service provided by infrastructure and the competitive positions of different modes. The political aim of European transport policy is a harmonised European wide scheme in transport pricing.

The true social costs of transport modes of course differ between modes, it is expected that the price for road transport is considerably higher than rail transport and inland waterway transport. Several EU funded research projects have put effort in determining the true costs of transport as the UNITE and the RECORDIT project. In order to provide a tractable set of alternatives, three pricing scenarios were defined aimed at capturing different current ideas on transport pricing at a broad European level. All pricing scenarios are based on the Reference Scenario 00, i.e. in order to isolate the impact of pricing no infrastructure development is assumed to take place:

- *C1 Reduction of the price of rail transport*. The scenario assumes a ten percent reduction of rail charges to achieve a better modal balance by subsidising environmental-friendly alternatives to road transport.

- *C2 Increase of the price of road transport*. In this scenario, the price of road transport is increased by ten percent. This scenario reflects policies member states are using for political reasons instead of applying the optimum level of road charging of social marginal costs.

- *C3 Social marginal cost pricing of all modes.* The assumption is that all modes are charged an additional ten percent of the costs. This pricing scenario assumes that all modes can be charged close to their marginal social costs.

It is recognised that the way the pricing scenarios would be implemented in reality would influence behaviour and therefore eventual outcomes – an across-the-board increase in licence fees or fuel tax would have different impacts from congestion-related road pricing. This recognises that overall the current contribution of road users to the total costs of the road network including environmental effects, accident costs, noise and congestion is fairly close to break-even, but that this disguises considerable differences between very low cost coverage in urban areas (and some inter-urban situations) in peak hours and very high coverage made by users of non-congested rural roads. We assume that a ten-percent increase is a reasonable representation of what might be feasible and gives insight into the effects of social marginal cost pricing on regional economic development.

1.1.4 Results of the SASI model

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 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.

The retrospective scenarios show that the impacts of European transport policy on regional economic development have been small and their distributional effects minimal. The prospective scenarios suggest that the socio-economic impacts of transport policy may be larger if the ambitious plans of the TEN and TINA programmes will be actually implemented – however, the experience of the recent past has shown that large delays in implementation are not unlikely.

If the different types of policies are compared, the results can be summarised as follows:

- Infrastructure policies have larger effects than pricing policies, and the magnitude of the effect is related to the number and size of projects.
- Significant positive economic effects for the new EU member states can only be expected if the TINA projects linking the new member states to the major centres of economic activity in western Europe are implemented.
- The effect of pricing scenarios depends on their direction: scenarios which make transport less expensive have a positive, scenarios which make transport more expensive, a negative economic effect. However this result might need to be qualified if the subsidies or revenues associated with the policies were taken into account.
- Negative effects of pricing policies 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.

Further important results of the simulations with the SASI model refer to the impacts of transport policies on cohesion and polycentricity. These results are presented in Sections 4.1.1 and 4.2.

SASI cohesion results

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 tend 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 poor 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.

The impacts of the thirteen transport scenarios on cohesion can be summarised as follows:

- If the whole ESPON Space is considered, all scenarios contribute to convergence in relative terms in both accessibility and GDP per capita, except pricing scenarios which make transport more expensive. However, in absolute terms the opposite holds: All scenarios increase the gap between in accessibility and GDP per capita between the rich regions in the European core and the poorer regions at the European periphery.
- If only the accession countries are considered, only infrastructure scenarios which strengthen the corridors between eastern and western Europe improve accessibility in all accession countries; all other projects widen the gap between capital cities and rural regions. For GDP per capita, the general pattern is absolute divergence as in the whole ESPON Space except for the pricing scenarios which make transport more expensive
- Scenarios which reduce the disparities between the old and new member states may do so at the expense of larger disparities within the accession countries.

The analysis of cohesion effects confirms that different cohesion indicators give different results and that in particular the distinction between relative and absolute convergence or divergence is important. The analysis also shows that the spatial level at which cohesion is measured matters. It is therefore of great importance to clearly state which type of cohesion indicator at which spatial level is used.

SASI polycentricity results

The approach measures polycentricity by identifying three dimensions of polycentricity: the *size* or importance of cities (population, economic activity), their *distribution in space* or *location* and the *spatial interactions* or *connections* between them:

Size Index

The first and most straightforward prerequisite of polycentricity is that there is a distribution of large and small cities. It can be shown empirically and postulated normatively that the ideal rank-size distribution in a territory is loglinear. Moreover, a flat rank-size distribution is more polycentric than a steep one. Finally, a polycentric urban system should not be dominated by one large city. To operationalise this, two sub-indicators were defined: (a) the slope of the regression line of the rank-size distribution of population and (b) the degree by which the size of the largest city deviates from that regression line. When calculating the regression line, all but the largest city are considered. The primacy rate is interpreted as population dominance: a primacy rate above one indicates that the primate city is "too large" for the urban system of the country.

Location Index

The second prerequisite of a polycentric urban system is that its centres are equally spaced from one another – this prerequisite is derived from the optimal size of the market area of centrally provided goods and services. Therefore a uniform distribution of cities across a territory is more appropriate for a polycentric urban system than a highly polarised one where all major cities are clustered in one part of the territory.

A second step in the analysis of polycentricity is therefore to analyse the distribution of cities over space. One possible approach is to subdivide the territory of each country into service areas such that each point in the territory is allocated to the nearest centre – such areas are called Thiessen polygons. Thiessen polygons can be constructed by dividing the territory into raster cells of equal size and to associate each cell with the nearest urban centre. In this way the areas served by each centre can be measured and compared.

Connectivity Index

A third property of polycentric urban systems is that there is functional division of labour between cities, both between higher-level centres and the lower-level centres in their territory and between cities at equal levels in the urban hierarchy. This implies that the channels of interaction between cities of equal size and rank, but in particular between lower-level and higher-level cities, must be short and efficient. It is obvious that this requirement may be in conflict with the postulate that cities of equal size and rank should be equally spaced over the territory.

There are principally two ways to measure connectivity. One is to measure actual interactions. Ideally, the analysis would reveal functional relationships between cities of equal size or rank and between cities of different size or rank in the urban hierarchy. Appropriate indicators of such interactions would be flows of goods or services, travel flows or immaterial kinds of interactions, such as telephone calls or e-mails. The second possibility is to measure the *potential* for interactions. Measures of interaction potential could be infrastructure supply, i.e. the level of road connections (motorways, roads) or the level of service of rail (number of trains) or air (number of flights) connections. An urban system with good connections between lower-level centres is more polycentric than one with mainly radial connections to the dominant capital. In polycentric urban systems also lower-level centres have good accessibility.

For measuring interaction potential, here the multimodal accessibility of FUAs calculated for ESPON 1.1.1 was used. Two sub-indicators were defined: (f) the slope of the regression line between population and accessibility of FUAs and (g) the Gini coefficient of accessibility of FUAs. The two sub-indicators have similar meaning: the flatter the regression line, the more accessible are lower-level centres compared to the primate city, and the lower the Gini coefficient, the less polarised is the distribution of accessibility.

With the three component polycentricity indices, the Size Index, the Location Index and the Connectivity Index, a comprehensive Index of Polycentricity can be constructed.

For each sub-indicator a z-shaped value function was defined by specifying at which indicator value polycentricity is zero and at which it is one hundred.

SASI polycentricity results

The results of the forecasts of polycentricity of the European and national urban systems with the SASI model can be summarised as follows:

- The polycentricity of the *European* urban system has increased in the past and is likely to continue to increase in the future as large cities in the accession countries catch up with cities in western Europe.
- However, polycentricity of the European urban system will mainly grow in the accession countries, whereas it will decline in western Europe because of the continued growth of the largest cities.
- Polycentricity of *national* urban systems in Europe has declined in the past and is like to continue to decline in the future.
- All transport infrastructure policies examined accelerate the decline in polycentricity of national urban systems because they tend to be directed at primarily connecting large urban centres.
- Transport pricing scenarios which make transport less expensive have the same effect as infrastructure improvements.
- Transport pricing scenarios which make transport more expensive in general strengthen the polycentricity of national urban systems.

The comparison of polycentricity of MEGAs at the European level and polycentricity of FUAs in individual countries shows that, as with cohesion indicators, the spatial scale at which the analysis is conducted, matters.

Transport policies which reinforce polycentricity at the European level, may increase the dominance of capital cities within their national urban systems and so contradict the goal of the ESDP to achieve a balanced polycentric urban system. It will be the task of further research to point towards rational trade-offs in this goal conflict.

1.1.5 Results of CGEurope

Two models have been used to analyse the 13 transport policy scenarios, the second model is the CGEurope model. The CGEurope model is a spatial computable general equilibrium model of goods transport and business passenger flows with monopolistic competition. Changes in transport prices transform into changes in goods prices and enhancements of business opportunities through less expensive business travel. The market form, in which goods are supplied in each region, is monopolistic competition. Goods are transported by road, rail, air transport and ship. The labour stock is fixed. So, the results can be regarded as short termed effects of the analysed policy bundles, but it has also to be emphasized, that the approach of modelling the impacts is different from the SASI model. The indicator which is the output of the model is the change in terms of equivalent variation. The equivalent variation has the feature one can measure the impact on the households' welfare in a region as a monetary amount.

Table 1.2 and Table 1.3 show the impacts of the scenarios aggregated on the ESPON space, the EU15 and the 12 accession countries. All numbers are to be regarded as relative changes compared to the “without-case” in percentage points.

Table 1.2 Aggregated changes of equivalent variation by policy scenario

	A1	A2	A3	B1	B2	B3	B4
EU27+2	0.049	0.115	0.158	0.144	0.262	0.237	0.042
EU15	0.049	0.116	0.159	0.144	0.251	0.231	0.038
AC12	0.048	0.096	0.138	0.165	0.504	0.365	0.136

Table 1.3 Aggregated changes of equivalent variation by policy scenario (continued)

	B5	C1	C2	C3	D1	D2
EU27+2	0.058	0.048	-0.285	-0.362	-0.212	-0.092
EU15	0.046	0.049	-0.285	-0.363	-0.214	-0.103
AC12	0.325	0.038	-0.281	-0.336	-0.168	0.174

In the retrospective A-scenarios measuring the impact of the past development from 1991 to 2001 the overall impact of rail infrastructure changes is relatively smaller than the impact of road investments. The overall impact of the rail package is 0.05% compared to 0.115% caused by investments in road infrastructure. The spatial pattern of effects in A3 representing the combined rail and road effect is therefore to a great extent explained by the impact of roads. The overall impact of both policies amounts to 0.158%

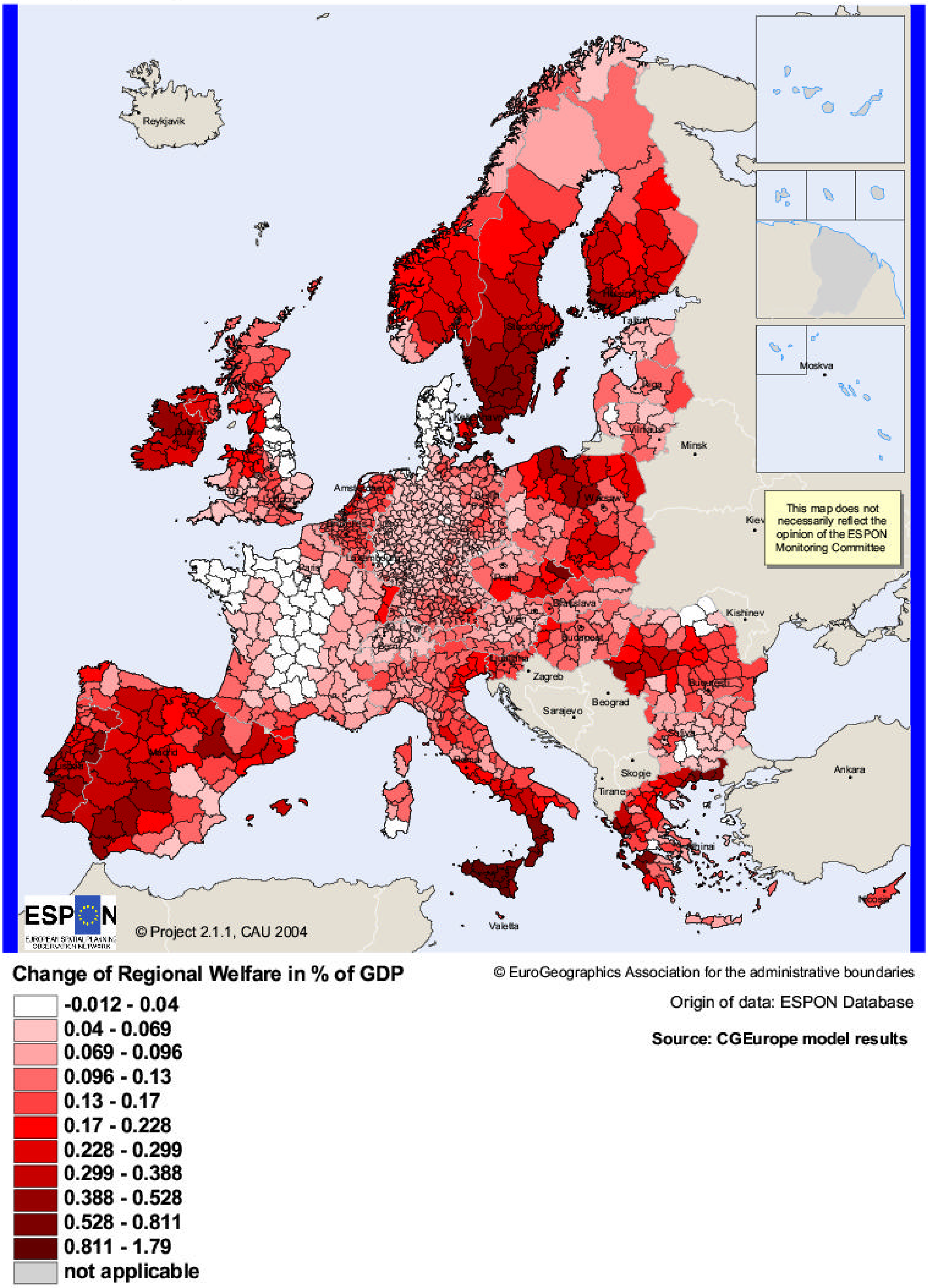
In relative terms, A3 shows a pro-cohesion tendency, that is the effects tend to be higher in less developed, poorer and more peripheral regions. They are also higher in objective-1 regions (0.179 %) and in lagging regions (0.187 %) than in the whole space (0.158 %). The pro-cohesion tendency is mainly caused by infrastructure development within the EU15 that has favoured poorer regions more than richer ones. This is confirmed by the inequality measures. As expected, equality is highest within EU15. The distribution of GDP per capita is considerably more unequal within AC12 and even slightly more unequal in the whole ESPON space due to the large income differentials between the present EU and the candidate countries.

Regarding polycentricity, scenario A3 can be said to favour polycentricity. On the macro scale, the fact that the Pentagon is favoured less than the average points towards a gain in polycentricity. A tendency in favour of polycentricity on the meso scale can be inferred from the observation that the impact is smallest in very densely populated regions (0.096 %), medium in urbanised areas (0.186 % and 0.135) and largest in rural regions (0.295% and 0.225 %).

The spatial pattern of the scenario that analyses the impact of the retrospective rail infrastructure development is different. There is virtually no correlation between relative effects and GDP per capita, except from AC12, where the correlation is slightly positive. That means that within AC12 gains are a bit higher in richer regions, so that the distribution is made more unequal.

The prospective B-scenarios measure the impact of the most likely development of road and rail infrastructure until 2021. The B1 scenario is an impact analysis of the new list of TEN priority projects including the motorways of the sea. It can be seen from the model results displayed on map 1.1, that the impact of the projects on the Iberian Peninsula, Southern Italy, Greece, Denmark and South Sweden show high positive impacts in the regions, in which they are implemented. The overall effect of the policy package is relatively small, a benefit of 0.144% of GDP of the EU27+2 area. The cohesion indicators show that the effect of the scenario is pro-cohesive for EU-15 and EU-27. However, it shows an anti-cohesive tendency within the accession countries. The policy package furthermore benefits most the objective-1 regions and lagging regions. The periphery of Europe gains above average, as well as the Pentagon of Europe gains below average (0.093 %).

Change of Regional Welfare in Scenario B1

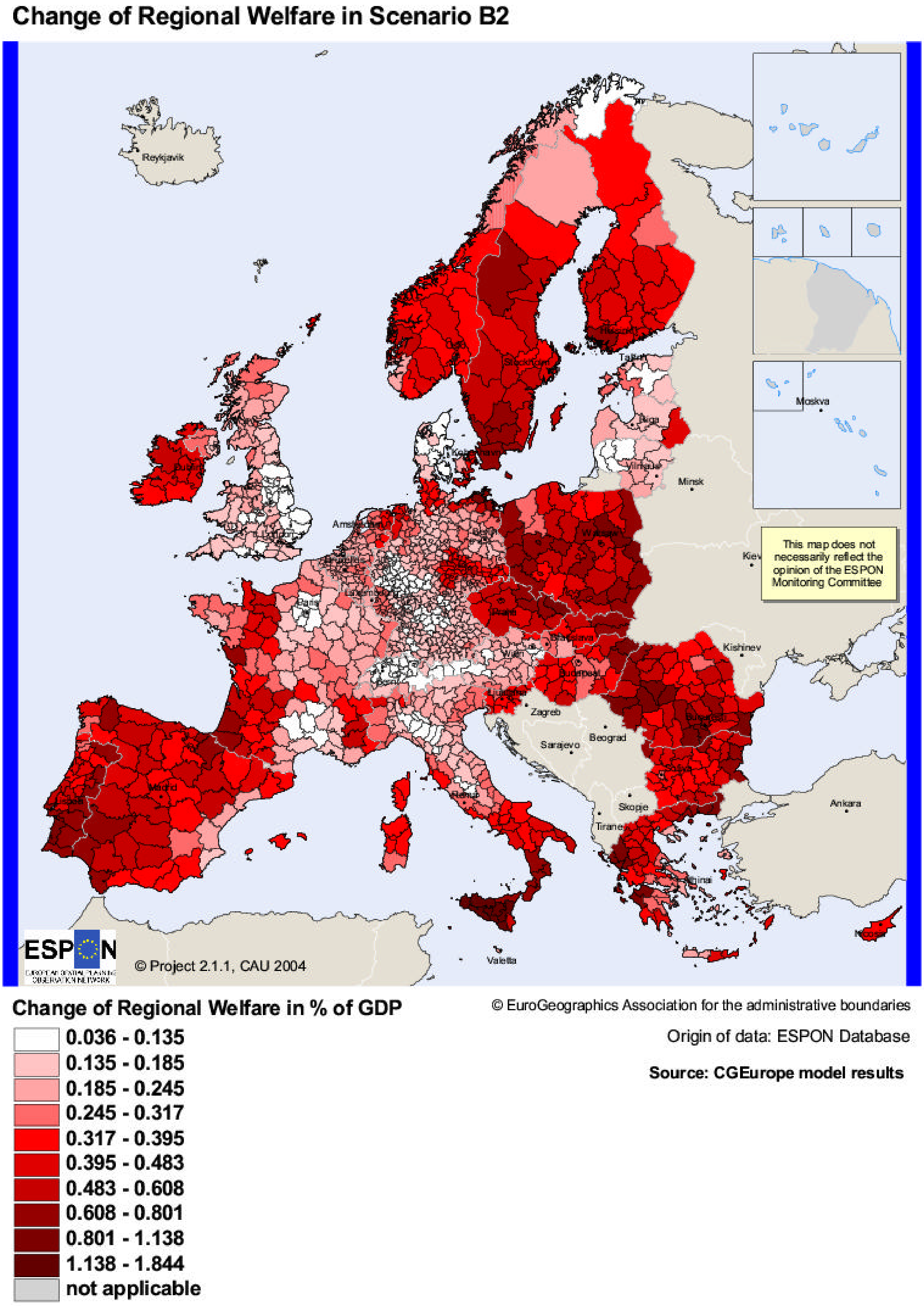


Map 1.1 Changes of regional welfare in scenario B1

The scenario B2 shows the effect of the completion of the complete list of the TEN and TINA projects including some further projects financed within the country of origin. The distribution of the impacts is shown on map 1.2. Like the A3-scenario, the B2-scenario is pro-cohesive, as confirmed by the cohesion indicators. It is more in favour of cohesion for the whole area than for the two subspaces, because the cohesion effect is partly caused by the impacts in Eastern Europe, which are more than twice as large in the poorer accession countries than in the richer EU15. The pro-cohesion tendency of the prospective infrastructure development can also be seen from the fact that effects are on average considerably higher in lagging and potentially lagging regions (0.493 % and 0.304 %) than in non lagging regions (0.21 %). They are also considerably higher in objective-1 regions (0.402 %) then in the whole EU27+2 space (0.262 %).

The B3 and B4 scenario are two subsets of the B2 scenario, in which the TEN/TINA networks are split into investments in cross-border (scenario B4) projects and investments in infrastructure projects not crossing borders (scenario B3) to isolate the effect of both kinds of projects. The effect of the scenario of the transport projects within countries has a higher impact than the cross-border projects, because the majority of the European networks do not cross borders. As regards cohesion and polycentricity, most of what has already been said for the B2 scenario also applies for the B3 scenario. The B4 scenario has a lower overall impact of 0.042% with an impact of 0.038% for EU15 and 0.136% in AC12, which alone suggests a pro-cohesive tendency of these investments alone. The magnitude of the effects on regional scale suggests that the impact on the Eastern European regions is considerably higher than in the EU15. The border projects between Bulgaria, Greece and Romania have very high positive impacts for the border regions in these countries. Furthermore, the biggest number of cross-border projects is located in the area of Poland, Czech Republic, Slovakia and Hungary, which account for most of the benefits in this scenario. What can finally be said, is that the B4 scenario is also favourable for cohesion, which is confirmed by all measures of cohesion in relative terms.

Scenario B5 describes the impact of the infrastructure development in objective-1 regions. The effect of this scenarios is, of course, pro-cohesive within the ESPON space and the EU15, the effect in the accession countries also tends to be positive, but not absolutely clearly, because two of the five cohesion indicators show a slight anti-cohesion tendency. The effect in the regions classified as lagging is even higher than in the objective-1 regions, which is due to the fact that not all objective-1 regions are necessarily lagging regions. This tendency shows that these investments benefit the least well-off of the objective-1 regions above average.



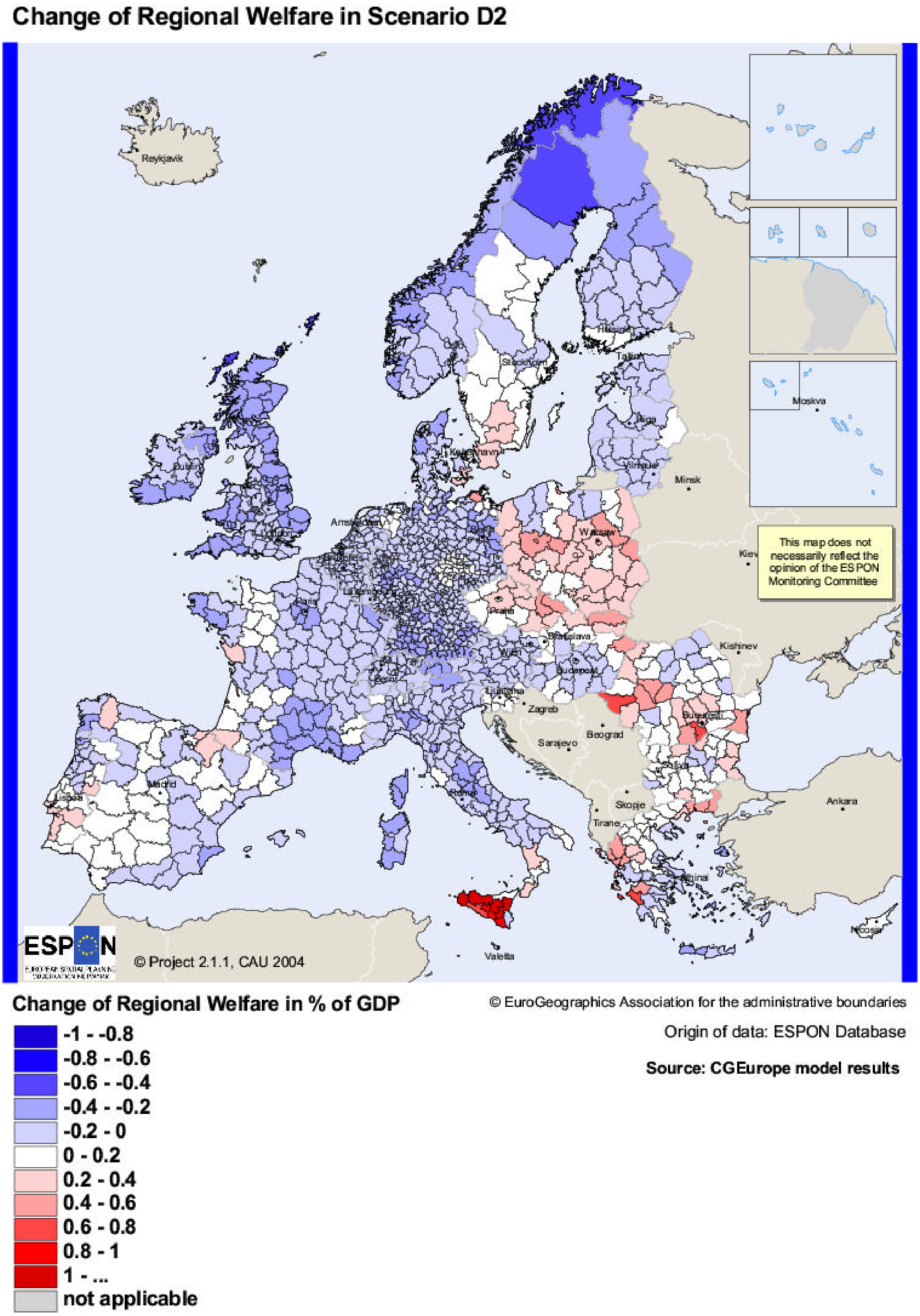
Map 1.2 Changes of regional welfare in scenario B2

The spatial implications of pricing policies increasing private transportation cost, irrespective of whether this concerns road transport only or all four transport modes under consideration, are exactly the opposite of those in the A-scenarios and B1 and B2-scenarios. This is revealed by the results of scenarios C2 and C3, which show a similar spatial pattern irrespective, if only road transport or all modes of transport are made more expensive. Both are inequality increasing. Inequality indices increase for both scenarios, the whole space and the two subspaces. The fact that losses in lagging and potentially lagging regions as well as in objective-1 regions significantly exceed the average also fits with this general picture.

The centre-periphery pattern is also very clear. Losses are below average in the Pentagon, smallest in agglomerated regions, medium in urban regions and highest in rural regions. Furthermore, it can be said, that the better the accessibility in the reference situation, the smaller the losses. It is furthermore well visible, that there are two overlaying centre-periphery patterns, a national and a European one. The national pattern is due to the fact that spatial interaction is much more intense within countries than between them. Hence, not only regions in the European periphery, but also regions in the periphery of their respective national markets suffer from increasing transportation costs, because their interaction with the markets is more dependent on transportation than that of more central regions. This also explains why losses in border regions and coastal regions are also above average.

Summarising these observations, pricing policies increasing private transportation costs can very clearly be said to work against the general objectives of cohesion and polycentricity.

Finally, the D-scenarios, which are mixtures of B1, respectively B2, and C3, show an overlay of the contradicting tendencies of the infrastructure and pricing policies. Regarding spatial income distribution, the pro-cohesion impact of the B-scenarios slightly dominates, but there are no clear patterns with regard to polycentricity.



Map 1.3 Change of regional welfare in scenario D2

As a summary of cohesion results Table 1.4 shows qualitatively the impact of scenarios on spatial income distribution. Note that a plus sign means more equal distribution, that is a pro-cohesion impact of the respective scenario. The table clearly reveals the same tendencies of the results from both models with respect to the income distribution in relative terms: rail policy has little effect, road investments are pro-cohesion, higher prices for road transport are anti-cohesion. Different outcomes are only shown for absolute effects from the pricing scenarios. Though both models predict larger relative losses in poorer regions, the variance of these relative losses is smaller according to the CGEurope model than according to the SASI model. Therefore the fact that high income regions are in a relatively better position does not compensate for the fact that similar relative losses lead to absolutely larger losses in these regions, according to CGEurope results.

Table 1.4 CGEurope: cohesion effects in EU27+2

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	.	.	+	+	-
A2	Only road projects 1991-2001	+	+	+	+	-
A3	Rail and road projects 1991-2001	+	+	+	+	-
B1	Priority projects	+	+	+	+	-
B2	TEN/TINA projects	+	+	+	+	-
B3	TEN/TINA except cross-border corridors	+	+	+	+	-
B4	TEN/TINA only cross-border corridors	+	+	+	+	-
B5	TEN/TINA only in objective-1 regions	.	+	+	+	+
C1	Reduction of price of rail transport	-	.	+	+	-
C2	Increase of price of road transport	-	-	-	-	++
C3	SMCP of all modes	-	-	-	-	++
D1	B1+C3	+	+	+	+	+
D2	B2+C3	+	+	+	+	+

+/++	Weak/strong cohesion effect: disparities reduced	CoV	Coefficient of variation (%)
–/––	Weak/strong anti-cohesion effect: disparities increased	Gini	Gini coefficient (%)
·	Little or no cohesion effect	G/A	Geometric/arithmetic mean
		RC	Correlation relative change v. level
		AC	Correlation absolute change v. level

1.1.6 ICT Policy Scenarios

The three main ICT policies that the EU intends to implement are, according to the *eEurope 2002 Action Plan* of the European Union:

- a cheaper, faster and secure Internet, i.e. a focus on ICT investments on ICT infrastructure;
- investments in people and skills, i.e. an adoption support policy;
- a stimulus for the use of the Internet (e-government, e-commerce, intelligent transport systems), i.e. a policy oriented towards service promotion.

These three policies are expected to have different impacts:

- The first policy is expected to generate positive effects captured by an increase of the ICT endowment. However, it does not act on real use (what we label "accessibility"). This policy can be applied to lagging areas to reduce the infrastructural gap and to non-lagging areas in order to overcome the bottlenecks that characterise these areas. In our model, this policy corresponds to an increase in Internet connections.
- The second policy is a medium-term policy, since it supports the adoption process (it acts on the degree of ICT accessibility of an area). This policy can be applied both to advanced countries and regions as well as (in a strategic way) to lagging areas which can reduce their peripherality through a high level of telecommunications accessibility. In our model, this policy corresponds to an increase in accessibility.
- The third policy is a long-term policy since it aims at developing advanced ICT services (and their employment) in the economy, influencing long term efficiency of the whole productive system. In our model, this policy influences the share of high-tech employment.

Given a certain level of financial resources devoted to ICT, three scenarios can be envisaged on the basis of the policies chosen (Table 2.3). We forecast the impact of the policy scenarios on regional GDP per capita until the year 2020. These impacts are measured by the percentage difference between the scenario and a do-nothing scenario.

1.1.7 Results of the STIMA model

The final report presented here describes the methodology, the estimation and forecasting results of the territorial impact of ICTs policies. The report differs from TIR in the following aspects:

- it contains updated data on ICTs (2002 data replacing 1999 data), available from INRA 2003 report[1];

[1] The INRA report 2003 has been provided to the group by ESPON project 1.2.2., and in particular by the Centre for Urban and Regional Development Studies of the University of

- it presents updated estimates on marginal efficiency of investments for internet connections, based on 2002 data;
- it presents new quantitative scenario results for GDP, accessibility and internet connections, based on the updated estimates of marginal efficiency of investments for internet connections;
- it contains new maps for GDP, accessibility and internet connections growth rates representing the new scenarios;
- it shows a new typology of regions by ICTs policy impact, based on the new scenario results;
- it contains new results on cohesion (GINI and Lorenz curve).

The new forecasts provided in this report differ from the ones presented in TIR from the quantitative point of view, while from the qualitative point of view, and especially from the main messages which stem from the analysis, no deep changes emerge with respect to the results contained in TIR. This does not surprise, given the structural features of the forecasted economic events; the role of ICTs is important for the definition of GDP level, its growth and its distribution. Therefore, the EU policies in this sector are relevant, both for efficiency aims (GDP growth) and for cohesion purposes (GDP distribution); the different regional levels of ICTs endowment (*digital divide*), in fact, imply a relevant policy impact on cohesion.

The 2002 ICTs data have not been used to estimate ICTs and GDP relationships (i.e. the base model), given the non-availability of 2002 regional GDP level and given the structural characteristics of the relationships examined. On the contrary, new data on internet connections have turned out to be very useful to update the marginal efficiency of investments. Differentiated policy scenarios are presented based on different hypotheses on future ICTs policies (indiscriminate, efficiency, cohesion policies) and for each of them the corresponding per capita GDP at year 2020 is forecasted.

From the methodological point of view, the STIMA model (Spatial Telecommunications IMpact Assessment)[2], as introduced in SIR and TIR, is based on the estimate of a *production function*, and it allows to measure the impact that ICTs have on regional performance.

Using data from Eurostat Regio, ITU, EOS Gallup and INRA 2003 surveys, per capita GDP is estimated through a model, based on accessibility, internet connections, fixed telephony penetration, cable and satellite TV, total and

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Newcastle. Several corresponding e-mails and phone calls have constantly been undertaken with ESPON 1.2.2 also in this last year of work.

[2] In Italian, “stima” means estimate, assessment and esteem.

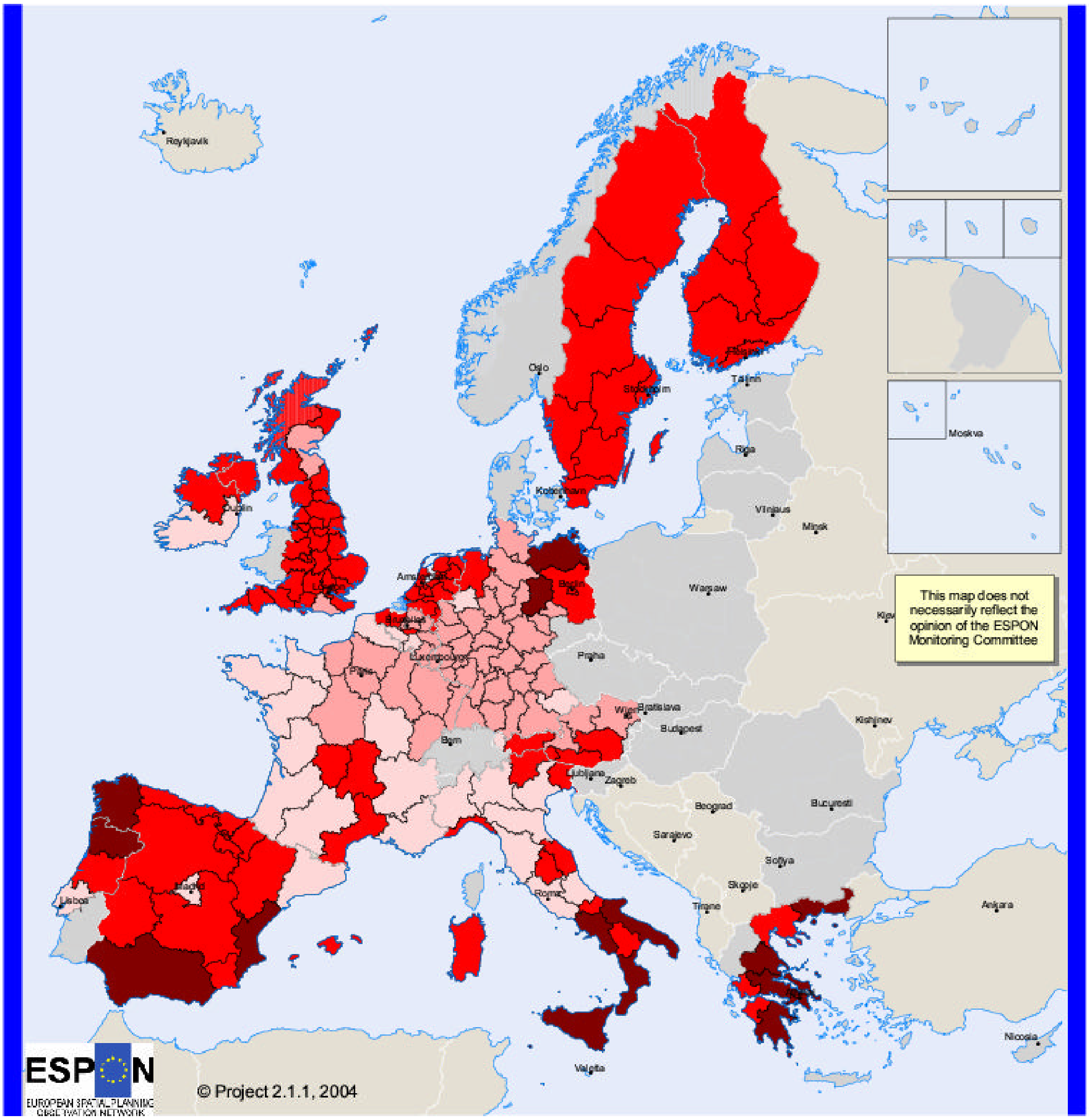
high tech employment. Estimates are corrected for the spatial dependence problem and the model is calibrated. On the basis of the estimates obtained by the model and on hypotheses of ICTs investments distribution among regions and actions, we are able to forecast the impacts on GDP growth of three scenarios: an indiscriminate, an efficiency and a cohesion scenario.

The main results can be summarised as follows:

1. ICTs investments have different marginal efficiencies, depending on the infrastructure or services in which they are spent. The choice of infrastructures and services to be developed has a critical role on the territorial impact of ICTs policies;
2. ICTs policies suggested by the eEurope Action plan can lead to very different scenarios, depending on the distribution of regional investments;
3. our hypotheses envisage three scenarios: the indiscriminate scenario (A), in which financial resources are allocated indiscriminately among ICTs factors and among regions, despite their economic situation; the efficiency scenario (B), in which the marginal efficiency of investments explains the allocation of financial resources to more advanced regions and infrastructures; the cohesion scenario (C), in which less developed regions take advantage from the allocation of all resources;
4. the three scenarios give rise to different impacts on GDP: scenario A shows a growth rate of GDP in 20 years equal to 0.033%, while scenario B shows a higher rate (0.037%) and, as expected, scenario C shows the lowest rate (0.023%). When growth rates are calculated in the three scenarios for lagging and non-lagging regions, they turn up to be very different. They are significantly higher for non lagging regions in scenario B, while they are significantly higher for lagging regions in scenario C, as expected;
5. these three scenarios provide a different impact on income distribution, too. While scenario A does not change the present distribution of per capita GDP, since it applies to all regions indiscriminately, scenarios B and C have relevant effects: scenario C concentrates investments in lagging regions, reducing regional disparities and increasing cohesion, while scenario B increases disparities, by favouring more efficient regions;
6. the study is also able to demonstrate that within the two typologies of regions (objective 1 regions vs. advanced regions), different reactions to a specific ICTs policy exist. Within non-lagging regions, some areas are able to take advantage from both indiscriminate and efficiency

policies, while others react exclusively to efficiency policies; similarly, there are lagging regions that react dynamically to cohesion policies, while others seem unable to react. This typology of regions is displayed on map 1.4.

Typology of regions by ICT policy impacts



Typology of regions by ICT policy impacts © EuroGeographics Association for the administrative boundaries

- Regions reacting to efficiency and indicriminate ICT policies
- Regions reacting to efficiency ICT policies
- Regions with low reaction on ICT policies
- Regions reacting to cohesion ICT policies
- no data

Map 1.4 Typology of regions by ICTs policy impacts

1.1.8 Polycentric Links

Transport and TEN policies have an impact on the spatial development policy, even though one has to be aware of the fact that fundamental factors such as technological change or economic integration are likely to have a stronger impact. The polycentric link analysis tries to verify fundamental aims of spatial planning given in the ESDP for transport and TEN policy scenarios.

A set of links that connect central places across the ESPON space is designed as a testing raster for an impact analysis of transport and TEN policies. It is analysed for accessibility deficits, the relation to regional economic backwardness and for expected transport policy scenarios impacts on priority links. Two future infrastructure-related scenarios (2001-2021) are compared to the reference scenario (2001): priority projects (new list) as B1 scenario and TEN/TINA projects as B2 scenario.

The polycentric links are chosen regarding their potential to strengthen urban networks and to improve access to supply functions of centres. These links are classified by priority in relation to the coincidence of accessibility deficits with regional economic backwardness. As expected, it turns out that the accession countries and some parts of the southern member states show accessibility deficits and economic backwardness mostly related to the two evaluation criteria.

The comparison of straight-line speeds shows much more significant cases of link improvement in the rail network than in the road network. The differences in link improvements between the B1 and B2 scenarios are caused by the large extent of the B2 scenario. This applies especially to the implementation of all TEN/TINA projects 2001-2021 strengthening economic and social cohesion.

The polycentric link analysis leaves monetary terms behind and focuses on a balanced polycentric development to complement cost benefit aspects of transport planning. The accessibility conditions in the area of the ESPON space are measured from the European down to the regional level in an understandable way. The results are presented in the form of general maps in order to indicate deficits in accessibility for disadvantaged cities and regions. It is reasonable to define a prior axial system of relevant links and to develop a set of approved normative accessibility standards for different functional levels of links connecting centres.

1.1.9 Overloaded Corridors

This analysis deals with *overloaded transport corridors*, the drawback of an improved transport infrastructure. Results of a DG TREN study "TEN-STAC" are used for the classification and illustrative mapping of overloaded corridors and for a brief empirical analysis of transportation flows at the regional level as an input to the ESPON database. The study provides information about the road assignment for the year 2000 and a scenario forecast for the year 2020. One policy scenario is examined with regard to the transport flows development in the ESPON space and its impact unburdening regions and corridors.

According to the "EUROPEAN+" TEN-STAC scenario, road transport flows for the year 2020 in comparison to the base year 2000 have grown by almost 43 percent. The transport flow volumes are increasing almost all over the study area. The rail transport flows are increasing disproportionally but will not be able to compensate the increase of road transportation flows within the ESPON space.

The European core area holds a share of 39 percent of kilometres travelled in the ESPON space, until 2020 this share will decline to around 35 percent. Urban regions are more burdened by the load of traffic, but rural areas more and more take over the load. Accession countries have the highest relative gain in road transportation. Near to railway corridors that take over a large amount of the transportation volume, regions show disproportionally lower, relative transportation flow increases than other regions.

Thus, in areas and corridors with a high traffic density, the conditions for a modal shift to environmentally friendly modes of transport such as railways and waterways furthermore should be improved.

1.1.10 Institutional Issues and Policy Interactions

The problem of a common European transport policy is strongly related to the institutional structure of the EU. While the concept of TENs has been articulated at an EU level, the implementation of much of transport policy has been at the level of the national governments, or even at a lower regional or local government level. This multi-level decision making, involving different institutions with different objectives, gives rise to two fundamental dangers. One concerns the policy interactions at the EU level, and will be referred to as horizontal conflicts. The so-called vertical conflicts, on the other hand, result from interactions between the different levels of policy making, typically between the EU level and the national governments.

First, we deal with the nature of horizontal conflicts. Transport policy addresses two fundamental concerns of the EU: the improvement of the European competitiveness and the cohesion between the member states. Problems arise, however, when transportation policy is supposed to secure objectives that are more efficiently pursued by other policy areas. Since the way in which transport itself interacts with other policy sectors is poorly understood, the danger is that those kinds of horizontal interactions may result in single sectoral policies running counter one another.

Within the main policy areas related to the internal market one conflict appears between transport policy and the Stability and Growth Pact. While it is a long-term objective of transport policy to support the removal of barriers, in the short run it is a major consumer of public funds. Under pressure on public budgets, given by the Stability and Growth Pact, transport policy is frequently the target of expenditure cut-backs.

A main policy interaction appears within transport policy itself. On the one hand, infrastructure investments aim at reducing transport cost, while on the other hand pricing mechanisms for transport networks should make users aware of the real resource costs of transport, when they differ from private costs. The conflict results from a failure to implement policy in its totality. Realizing single and distinct measures runs the risk of making the situation worse.

A similar conflict arises between transport and environmental policy. Reducing transport costs increases mobility, which is a pre-requisite for a single market in goods and services. But on the other hand the increase in transport negates the objective of environmental sustainability. In order to secure the latter, the user must face the true social cost of transport, including environmental externalities.

The interactions with structural and cohesion policies, and with the ESDP in particular, are clearly central to the discussion. Transport policies have an ambiguous impact on spatial development, as the results of chapter 4 reveal. Promoting mobility by improved infrastructure has a decentralizing impact, favouring peripheral regions. However, this only holds for road network improvements, not for rail investments. For externality pricing policies even the opposite effect is observed. In addition, it has to be mentioned that some structural details as the impact on firms in different sectors are still unconsidered in the modelling exercise in order to fully understand the impacts of policy measures.

Closely related to the question of cohesion is the interaction between transport and agriculture policy. The agricultural sector is not only affected due to the support of the internal market by transport policy. Transport also plays an important role in attracting alternative sources of employment in rural areas, which are in general less affluent than more central regions.

As a second source of political conflict there is a vertical interaction, taking place between EU and national transport policy. Although the Council, Commission and Parliament may develop clear policy directions, the actual impact of policy depends critically on the way in which the member states enact legislation to effect the policy objectives. A danger to policy consistency already emerges, when member states have to develop a specific interpretation of the EU policy measures. However, since large parts of the transport policy are fully reserved to the member states, there is a balance between national and EU objectives, with weights differing between the countries. Vertical as well as horizontal conflicts may appear whenever either of the different interests dominates the others.

In this study, policy interaction was analysed by examining the content of relevant national policy documents. Unfortunately, very few countries have a clear single statement of transport policy. This problem also depends on the question of relative involvement of national and regional governments in transport policy. Furthermore, available documents do not necessarily represent the actual policy measures implemented. The emphasis placed for example on each policy element or the policy objectives may change within the period of validity of a policy.

One impression is that essentially EU15 members pay little attention to EU policy in setting their own priorities. In other words, EU policy is not used as a support for their policy, so that unlike in other policy areas, EU policy does not serve as the rational for unpopular actions on a national scale. In general, TENs seem to be more important in determining regional policy or at least regional pressure on national policy. Regions have shown a strong interest to be "on the network".

In most countries there is less interest in pricing mechanisms for efficiency reasons. Charging is seen more as a means towards raising revenues necessary for future infrastructure investments, or in the context of prevention of environmental damage. Furthermore, since national governments have often used the transport sector as a major source of tax revenue, many member states have strong incentives to resist further harmonisation in the fields of transport.

Countries differ significantly in their environmental priorities, depending also on their location. More peripheral countries which are less affected by congestion seem to place more emphasis on global environmental issues, as do some of the smaller member states - issues which they can typically only affect marginally, but where they have some need to influence the decisions of their bigger neighbours.

Concerning the question of cohesion, national policy clearly addresses national rather than EU cohesion objectives. The problem is therefore that benefits of transport infrastructure are not counted by the member states, when they accrue in another country. The task for the policy is to establish a mechanism to recognise those benefits and to overcome this problem.

1.1.11 Conclusions

According to the ESDP, the main objective of EU policy measures is to ensure a sustainable development for the entire European Union. Competitiveness as well as efficiency and growth should be enhanced, while paying attention to a balanced spatial development and environmental sustainability. However, these goals are partly in conflict with one another. For this reason it is quite clear that transportation policy initiatives cannot be designed such that all goals are favoured at the same time. One possibility is to revise those policy measures in the direction of a more balanced spatial development, if one is willing to give up a certain degree of economic efficiency. Instead of doing so, one can leave the transportation policy unchanged in favour of a higher degree of efficiency. Spatial imbalances should then be equalized by transfer payments to those regions suffering from losses.

The scenario results and the analysis of policy interactions in chapter 5 reveal three fundamental political goals between which trade-offs may appear:

(1) economic efficiency

(2) spatial equity, and

(3) environmental sustainability.

We deal with two out of three possible conflicts, (a) the trade-off between economic efficiency and spatial equity, and (b) the trade-off between spatial equity and environmental sustainability.

a) Efficiency versus equity

This conflict arises, because traditional cost benefit analysis assigns high profitability to projects generating intensive use. This, however, is predominantly the case for the central and agglomerated regions which often have a higher income than the peripheral regions. Therefore a risk of anti-cohesion appears, whenever spatial equity considerations are neglected in project evaluation. Fortunately, this risk turned out to be less virulent during the last decade than suggested, as our results from the A-scenarios show. These ex-post scenarios represent the infrastructure development in Europe within the decade 1991 to 2001. Our simulation reveals a spatial pattern of economic benefits which is more or less neutral with regard to the spatial equity objective. SASI estimates of accessibility as well as the CGEurope results point, with the exception of the rail scenarios, to a slight decrease of the spatial inequality. Therefore a complete re-orientation of infrastructure policy is, from that point of view, not necessary.

There are two caveats, however. The first one concerns the measures of spatial equity. The above mentioned result is based on a relative measure, that is benefits are given in percentage terms. For a poorer region, however, a higher gain in percentage terms, in relation to a rich region, may still be a lower gain in absolute terms, since it refers to a lower base. The optimistic picture concerning the decrease in spatial inequality only applies, if we accept the, commonly used, relative equity measure.

The second caveat is that it may be pure incidence that the ex-post analysis of the projects does not indicate anti-cohesion, because networks in peripheral areas were completed at that time. However, infrastructure policy that neglects the spatial dimension runs the risk of re-concentrating on the highly congested central regions that are threatened by a collapse of traffic. The advice is therefore to monitor systematically the spatial distribution of benefits generated by newly installed infrastructure capacity.

The results for the TEN and TINA projects show that these infrastructure measures are mostly in favour of a balanced spatial development in Europe. However, some indicators point to an increase in inequality in the accession countries. Although the projects contribute to accessibility and growth in those regions, they improve even more the accessibility in the central regions which already have a relatively high income. In order to compete with the higher developed European centres, the accession countries will have to exploit the economies of agglomeration, such that a movement towards polycentricity on the European scale encounters a loss of polycentricity on the national and local scale.

In our opinion, this conflict between efficiency and equity should not be solved by revising the TEN and TINA plans such that the centres are favoured less. Instead, the poorer countries should receive compensating transfers such that they can develop their secondary networks and let their peripheries gain from the spread effects of more rapid growth in the centres. The decision on those secondary networks, however, should be assigned to the national and local level, where the respective benefits appear.

The efficiency-equity trade-off turns out to be more pronounced in ICT policy than in transportation policy. For a cohesion scenario. the STIMA model reveals rather large costs in terms of loss of efficiency. The growth rate of per capita GDP is supposed to decrease from 0.0037 to 0.023, while an efficiency scenario leads to a worsening of regional disparities. Also in this case, the inference is not to choose an indiscriminate policy option, since this would not only reduce the costs but also the advantages in terms of both efficiency and cohesion. Instead one should pay attention to the most appropriate ICTs policy actions, according to specific regional needs. Our main concern is to find policies that avoid the discrimination between “imitative regions” and “advanced technological regions”, but support the development of “adaptive regions”, in which ICTs adoption reflects industrial vocations of the local area.

b) Spatial equity versus environmental sustainability

There is a wide consensus, that pricing instruments are the most attractive way to deal with the problem of environmental externalities. Those instruments are analysed in our so-called C-scenarios. Since all transport modes damage the environment, the aim should not be only to shift the transport in favour of the less damaging modes, but to reduce the overall amount of transport. This actually means an increase in transportation costs. The conflict with the goal of balanced spatial development appears, because this cost increase is most unfavourable for lagging regions, rural regions and peripheral regions, those who are in general less affluent than the centres. Consequently, all indicators in the SASI results (expect those reporting absolute changes) and the welfare effects of the CGEurope model show that SMCP for all modes aggravates spatial disparities.

Again, caveats have to be kept in mind. First, some GDP estimators of the SASI model do not point in the same direction, but show results in favour of cohesion for a SMCP applied to all modes. Second, the conclusion again reverses, if one uses an absolute instead of a relative measure of equity. Third, the variation of effects by type of regions is by no means dramatic. Forth, our analysis does not take congestion fees into account, so that the results are biased towards an overestimation of an anti-cohesion tendency.

The main political conclusion is that pricing scenarios should not be abandoned in favour of spatial equality objectives. Instead, a policy worsening regional income disparities should be accompanied by transfers in favour of those regions suffering from losses. Such an instrument mix of pricing and compensation is the right way both to protect the environment in an efficient way, and to avoid undesired spatial imbalances.

An attractive feature of an ICT policy scenario such as our cohesion scenario is that it runs little or no risk of generating undesired environmental side effects. Hence, support of ICT resources and use in lagging regions is strongly recommended as an instrument to foster balanced growth in Europe.

1.1.12 Further Research Issues and Data Gaps to Overcome

The work of ESPON 2.1.1 has shown that meaningful forecasts of the impacts of European transport and ICT policies can be made.

The models and analytical techniques used have produced plausible and policy-relevant results. From a methodological point of view, the models and techniques have proved to be sufficiently sensitive to policy input at different spatial scales and degrees of temporal resolution but at the same time sufficiently robust in the face of serious but unavoidable deficiencies of and gaps in the available data. The results presented have been sufficiently comparable to allow for cross-validation between models and analytical techniques.

Nevertheless there remain questions that could not be answered during this project and which require further research

At first a number of substantive research questions to which no final answers could be given in the project but which need to be addressed in future work are listed:

- *Socio-economic impacts*. Can we identify a stable impact of transport and ICT policies on GDP and economic welfare? Are there network effects, i.e. is the impact of large policy programmes greater than the sum of the impacts of the development of individual links? Is GDP per capita sufficient as a measure of regional well-being, or should more meaningful indicators of quality of life be included in the analysis?
- *Cohesion*. How do we measure the contribution of transport and ICT policies to cohesion? How can the theoretical questions of relative and absolute convergence, appropriate indicators and conflicts between efficiency and cohesion goals encountered in the project be resolved?
- *Polycentricity*. How do we measure the contribution of transport and ICT policies to polycentricity? What is the trade-off between scale economies of concentration and lower transport costs encouraging dispersion? Do lower transport costs always encourage dispersion, is there an optimum level of transport or transport intensity in the economy? At what spatial level should polycentricity be assessed, and how can the conflicts between polycentricity at different levels be resolved?
- *Governance*. What is the appropriate institutional structure to ensure the efficient delivery of transport and ICT policy consistent with the needs of EU spatial policy? How much government at which level? How can policy be communicated between different levels of decision making?

The need to answer these four substantive research questions leads to three broad areas of research: improving modelling, introducing policy into models and designing optimal institutional arrangements for policy.

Introducing policy into models

The three forecasting models used in ESPON 2.1.1 have in common that they translate all policy input into transport cost changes, for instance by using exogenously established values of time. This implies that all types of policy can be interpreted as cost changes.

However, it is not clear what cost changes are to expect from social marginal cost pricing and liberalisation of transport markets and how these can be entered into the models. Moreover, similar policy changes could have different effects in different national contexts depending on their starting point and the size of the change. The assumption that all users treat changes in cost/price, e.g. changes in fuel tax and directly charged road tolls equally and symmetrically needs to be empirically examined. It is well known that elasticities are not symmetric: users respond differently to price increases and price reductions, and this may lead to different responses of spatial activity patterns, locations etc.

Designing optimal institutional arrangements for policy

The work of ESPON 2.1.1 has frequently pointed to potential conflicts between different EU policy areas. Lack of consistency in policy objectives and instruments between different sectors and levels of policy making leads to conflicts in the implementation of EU transport and ICT policies.

If it is assumed that there will be no changes in the institutional arrangements concerning the delivery of transport and ICT policy, i.e. that the Common Transport Policy and common ICT policy will be formulated at the EU level but its delivery will remain mainly through national and regional governments under the principle of subsidiarity, it becomes necessary not only to forecast but also evaluate the likely impacts of transport and ICT policies.

For this the development of unambiguous indicators becomes paramount. Such indicators need to be capable of assessing the extent to which national and regional policies conform to agreed EU policy goals and through which national and regional policies can be designed to ensure a greater degree of horizontal consistency between policy fields and between countries and regions across the EU territory.

1.2 Concepts, Methodologies, Typologies and Indicators Explained

1.2.1 Methodology: SASI

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. For each region the model forecasts the development of accessibility, GDP per capita and unemployment. 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 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. Accessibility is measured by spatially disaggregate accessibility indicators which take into account that accessibility within a region is not homogenous but rapidly decreases with increasing distance from the nodes of the networks. 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 development objectives discussed above. Its application is restricted, however, in other respects: The model generates distributive, not 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.

1.2.2 Methodology: CGEurope

CGEurope is a multiregional spatial computable general equilibrium model, in which transport costs explicitly appear as firms' expenditures for transport and business travel. It works with the assumption of the market forms of monopolistic competition in each region for the markets of tradable goods and perfect competition for local goods and for factor markets. The production functions are linear homogeneous nested CD-CES functions. As a response on transport policies, prices as well as quantities react on changes in transport cost and times resulting in changes in income and welfare in each region.

The main indicator for the regional consequences is the welfare change of regional households as measured by the household's utility function, which is transformed to the so-called Hick's measures of variation, which measures the welfare change as the monetary equivalent. The focus of the CGEurope model is on evaluating welfare effects in a comparative static equilibrium analysis, that means by comparing cases “with” and “without”, leaving everything else unchanged. It studies welfare gains and losses given the spatial distribution of factors of production.

The evaluation of the situation with and without is done by the definition of scenarios, in which travel times and costs before and after the implementation of certain transport policies are computed by deriving these cost for each region pair by shortest route algorithm. Based on these transport cost and times and actual national trade flows, interregional trade flows are calibrated. As the CGEurope model is a model with a consistent microeconomic foundation of preference-based consumer behaviour, the impact on equivalent variation of household welfare can be derived. This impact on this measure is calculated for 1321 NUTS-3 regions of the ESPON space for each of the 13 transport policy scenarios.

1.2.3 Methodology: STIMA

The STIMA model (Spatial Telecommunications IMpact Assessment) assesses the impact of ICTs on both efficiency and equity, quantitatively measured by GDP growth and GDP distribution.

From the methodological point of view, the STIMA model, as introduced in the SIR, is based on the estimate of a *quasi production function*, and it allows measuring the role that ICTs play on regional performance.

STIMA estimates the following quasi production function:

$$Y_{rt} = f(L_{TOTrt}, K_{OVErt}, K_{ICTrt}, A_{ICRrt}, I_{rt}, E_{rt}, Y_{r(t-1)}, R_{rt}) \quad (1.1)$$

which summarises the following conceptual framework: regional income level (Y_{rt}) depends on the level of production factors available locally and on the presence of the enabling factors. In our methodology, the production factors are threefold: two traditional production factors - labour (L_{TOTrt}) and social overhead capital (K_{OVErt}) - and a particular production factor, strictly linked with ICTs endowment and use, i.e. *accessibility*. The latter is measured in terms of telecommunications infrastructure endowment (K_{ICTrt}) and telecommunications intensity of use (A_{ICTrt}). A wide conceptual difference exists between the two accessibility measurement indicators: the former measures the ICTs endowment, since it represents the supply of ICTs infrastructures and not necessarily the real use, while the latter is what we label "accessibility", since it measures the real use of these technologies.

Equation (1.1) also contains the enabling factors which have been highlighted as the necessary condition to understand the relationship between ICTs and regional development: I_{rt}, E_{rt}, $Y_{r(t-1)}$, R_{rt} represent respectively the innovative capacity, the economic structure, the regional growth and the ICTs regulatory régime; all influence the impact that ICTs have on economic development.

1.2.4 Inequality Indicators

The welfare implications of transport policies will be analysed on the basis of a social welfare function. This welfare function assumes that the welfare of groups can be determined as the average value of the logarithms of the incomes of individuals in the groups. This measure differs from the more commonly used per capita (untransformed) income for a good reason: average income does not take into account the effects of inequality. In general, inequality is regarded as undesirable, and countries or groups of countries should therefore be regarded as having a lower level of social welfare if there is more inequality (at a given level of per capita income). The measure that is used here takes this effect into account.

However, the social welfare function used here can be easily related to average per capita income since it allows a convenient decomposition: it can be written as the difference between the logarithm of average per capita income (the more common welfare indicator) and an inequality measure. This inequality measure is a member of the family of such measures proposed by Atkinson (1970) in a path breaking analysis of the welfare economics of income inequality. At the same time, the inequality indicator can itself be easily decomposed as the sum of inequality between subgroups (for instance: countries are subgroups of regions) and inequality between such subgroups. This means that we can write inequality in the European

Union as the (population weighted) sum of inequality within the member countries and inequality between countries. The easiest way to interpret the value of the inequality indicator is as the percentage difference between average per capita income and welfare. That is: the inequality indicator gives the welfare cost of inequality as a percentage of per capita income.

However, this indicator is not the only indicator used to measure the impact of policies on cohesion. Furthermore, it is made use of further often used inequality measures as the Gini-coefficient, the coefficient of variation, the coefficient of correlation of the relative impacts with GDP/capita and the coefficient of correlation of the absolute impacts with GDP/capita.

1.2.5 Impact of Scenarios on Development Potential

Polycentric development has emerged as a key concept during the European Spatial Development Perspective (ESPD) process. A preliminary method for analysing polycentricity effects of EU Transport and TEN Policies has been developed. It combines indicators for the dimensions *mass*, *competitiveness*, *connectivity* and *development trend* into a composite indicator of *development potential*.

The following four indicators have been selected on the basis of relevance and availability of endogenous model results:

<u>Mass</u>: population density in the year 2021

<u>Competitiveness</u>: gross domestic product (GDP) per capita in the year 2021

<u>Connectivity</u>: multimodal accessibility in the year 2021

<u>Development trend</u>: difference in GDP/capita between the years 2021 and 2001

Each indicator is measured at the NUTS 3 spatial level and computed from the results of the SASI model. For each scenario a composite indicator of development potential is computed:

<u>Development potential</u>: geometric average of the values of the four indicators (mass, competitiveness, connectivity and development trend).

This composite indicator is used to compare the impacts of transport policy scenarios on development potential at the NUTS 3 territorial level. By analysing the spatial pattern of these impacts, the effects on the potential for polycentric development may be indicated.

The composite indicator of development potential can be used to produce endogenous typologies of NUTS 3 regions in terms of development potential in a similar way as the typology of MEGAs (Metropolitan European Growth

Areas) suggested by ESPON 1.1.1. The composite indicator of development potential may also, of course, be aggregated to any exogenous typology.

1.3 Networking undertaken towards other ESPON TPGs and Co-operation within the Project Group

The work on the ESPON project progressed with strong co-operation with other ESPON projects. Through the co-operation of BBR in the project, tight contact has been maintained with ESPON 3.1. Through the mutual participation of S&W in projects 1.1.1 and 1.2.1, contact with those projects has been very intensive. The accessibility measures and the measurement of disparities in transport infrastructure are harmonised with the approach used in project 1.2.1. Co-ordination on polycentricity concepts, indicators and typologies has been sought with ESPON 1.1.1, ESPON 3.1 and ESPON 1.1.2. In addition to the TIRs such co-ordination was based on the sequence of Guidance Papers.

For the gathering of ICT data Roberta Capello held close contact with ESPON 1.2.2 for the exchange of data in the field of telecommunication and impact analysis of ICT policies. Therefore, efforts of CURDS as lead partner of ESPON 1.2.2 to gather regional data on telecommunication infrastructure endowment has therefore also benefited this project's research.

The approach on measuring the impacts of transport scenarios on polycentric development is harmonised with the approach presented in the final report of ESPON 1.1.1.

The research was conducted co-operatively. It was the aim to give a complete picture of impacts of European transport and telecommunication policy. It was the intention to let each partner base their own research and conclusions on the results of other partners within the TPG to make the impact analysis as coherent as possible. Therefore, the task distribution for the reports was that the results of the modellers were passed on to those partners that have dealt with the evaluation of the modelling results with respect to policy goals. Finally, these results have been used by those who have written the conclusions and policy recommendations.

2 Setting the Scene

The objective of ESPON 2.1.1 is to assess the territorial impacts of EU Transport and TEN policies. The major question is how far the TEN provide the right answers for a territorial development as described in the European Spatial Development Perspective (ESDP) (European Commission, 1999).

The measures proposed in the White Paper "European Transport Policy for 2010: Time to Decide" (European Commission, 2001) should provide the framework for the investigation. Reference has to be made to the policy options developed in the cross-sectoral approach of the ESDP. The ESDP stresses the need for an integrated approach for improved transport links, refers to the polycentric development model, highlights the efficient and sustainable use of infrastructure and emphasises the importance of the diffusion of innovation and knowledge. This integrated approach should be followed in analysing transport and telecommunication networks. The analysis should take into account the principle of territorial balance and the particular problems of peripheral regions.

In more detail, the tasks of ESPON 2.1.1 are:

- to develop methods for the assessment of territorial impacts of EU transport and TEN policies;
- to develop territorial indicators, typologies and concepts, establish database and mapping facilities and conduct empirical statistical data analyses;
- to analyse territorial trends, potentials and problems deriving from EU transport and TEN policies at different scales and in different parts of an enlarged European territory;
- to show the influence of transport, telecommunications and energy policies on spatial development at relevant scales;
- to show the interplay between EU and sub-EU spatial policies and best examples for implementation;
- to recommend further policy developments in support of territorial cohesion and a polycentric and better balanced EU territory;
- to find appropriate instruments to improve the spatial co-ordination of EU and national sector policies and the ESDP.

In ESPON 2.1.1. the evaluation of the territorial impacts of EU transport and telecommunication policies is mainly conducted via scenario analysis. For this, three different forecasting models and a set of analytical techniques topost-process the model results were used. Chapter 3 presents the methodologies, Chapter 4 the results, and Chapters 5 analysis relevant policy interactions. Finally, Chapter 6 gives conclusions and policy recommendations.

This introductory chapter commences with an analysis of the transport sector and the TEN in an enlarged Europe. Based on this, the scenarios for transport and ICT policies that will be analysed in the subsequent parts of the report are presented.

2.1 Analysis of the Transport Sector and the TEN in an Enlarged Europe

Transport and communications are at the centre of developments in the European economy and play a critical role in the enlargement of the European Union. Efficient and effective communications are essential for the competitiveness of European industry and commerce, the cohesion of the European economy and the welfare of Europe's citizens. Despite this pivotal role, policy towards transport and communications has often been developed without sufficient regard for its impact on these wider aspects. Similarly other policy areas, relating to both macroeconomic growth and stability and other sectoral and spatial policies, have often been developed without consideration of their implications for transport and communications. This leads to conflict and confusion. Here we set out the issues for the ESPON project highlighting the key points which affect all our work; a more detailed analysis of policies and their institutional setting is contained in Chapter 5.

The transport and communications sector is large and diverse. It includes all forms of transport, by land, sea and air as well as the various components of the ICT sector. The need to include both transport and communications is because they serve the same basic purpose of linking together economic activities which are separated by space; this is not to argue that they are substitutes for one another – indeed they are more likely to be complementary activities in which growth in one leads to growth in the other. Transport and communications have similar structures and similar impacts and thus need to be considered side by side.

The distinguishing structural features of the sector are that it involves both infrastructure and service. In this project we are more concerned with the specific effects of infrastructure, and in particular the high-level infrastructures of the Trans-European Networks. However, infrastructure cannot be analysed independently of the level and quality of service provided on the infrastructure. In particular, we need to ensure that new additions to the stock of infrastructure do not distort the competitive position of different transport modes from that set out in transport policies. The quality of infrastructure at the level of the region, especially at the NUTS-3 level, depends as much on access to the network as on the quality of the network itself. Access to the road network depends both on the density of interchanges on major routes and the quality of the local network linking to them. For other modes it usually requires a multi-modal dimension; access to high-speed rail stations, combined transport terminals, airports or seaports typically also involves the local road network. The quality of the interchanges then becomes the critical factor in the service which that major mode can provide.

The identification of different levels of infrastructure and the interaction between modes identifies the need for clarity in the way policy is enacted and communicated between different policy actors. Although transport has a distinctive position in the European Union Treaties with the commitment to the development of a Common Transport Policy, large elements of transport policy are the responsibility of national, regional and local governments under the subsidiarity principle. Whilst it is essential that local transport policy is developed at local level, where it can be developed more efficiently and be responsive to the needs and wishes of local communities, it is also critical that local policies are informed by and consistent with EU transport policy. EU transport policy has to set a clear framework within which other policies can be developed. This needs to involve clear and acceptable rules on competition between modes as well as on the technical, social and fiscal matters affecting transport. Developing consistent evidence on the true costs of each mode, including value of time, statistical life and environmental damage, which is acceptable to all member states, has been vital in achieving the consistent evaluation of investments and of policies to manage growth. Such evidence is critical in the modelling work which lies behind our estimates of the impact of developments in the TEN networks.

However, both the general thrust of policy and the specific values which inform that policy is refracted through national (and more local) policy making. Where local transport policy uses different values this introduces distortions in the relative performance of different modes. This is not just a question of reflecting different local priorities, important though that is, but of having spillover effects on other jurisdictions which affect both the efficiency of a mode and the distribution of costs and benefits. We identify in Chapter 5 some of the evidence of the way that national transport policies conflict with EU policy and introduce potential distortions which affect the performance of the TEN. Nevertheless, this is a two way process and transport policy has to be acceptable at the level of the individual users and hence EU policy has to be informed by a bottom-up approach which can identify where there are conflicts of interest and define a means of resolving those conflicts, including the recognition that implementing a specific policy in some areas may imply the need for compensation in that area or in others.

The policy framework can be represented as in Table 2.1 which shows the way in which specific policy areas impact on each other and which demonstrates the complexity of defining policy scenarios for impact analysis.

Table 2.1. Transport and ICT policy interactions

EU transport policies	***EU non-transport policies***	***National transport policies***	***Regional transport policies***	***Local transport policies***
Infrastructure polices - TEN - Bottlenecks	Structural and regional. Stability and growth.	National infrastructure priorities. National budgets.	Regional infrastructure priorities. Regional budgets	Local infrastructure priorities. Local budgets
Transport policies - Pricing - Modal competition - Mobility - Safety - Urban transport	Competition Environment Agriculture	Fuel tax policies. Road pricing policies. National subsidies.	Regional subsidies	Local subsidies Local road pricing/congestion charging/parking
ICT policies - Galileo - Broadband - Other e-Europe	Structural and regional. Competition. Education and culture.	National ICT policies		

Representing a complex range of EU, national, regional and local policies in terms of simple scenarios requires the making of a number of simplifying assumptions. As it is clear from previous work on TEN policies in the TENASSESS project (ICCR et al., 1999), there is no easy classification of policy stances, and the way in which EU policies are refracted through national and lower level policies differs considerably from member state to member state (see Chapter 5 for further discussion of this point).

The "White Paper" on European transport policy (European Commission, 2001) recognises that the main policy instruments are infrastructure, regulation and pricing. We use these to establish a set of broad policy scenarios from which the modelling work can derive more specific parameters.

At the simplest level we can define infrastructure policy in terms of the development of networks. This is likely to be comprehensive at the EU level, and reasonably comprehensive at the national level. At the regional or local level it is much more difficult to include all possible infrastructure developments, but this omission is not likely to have any great significance for most of the accessibility indicators which form the basis for much of our work. Most infrastructure is reasonably clearly defined, and the nature of decisions is that changes to networks are very visible, the main concern is whether such infrastructure will be completed within planned timescales. Given budget uncertainties this must be a particular concern over new infrastructure in the new member states of central and Eastern Europe, but the constraints of the Stability and Growth Pact are likely to result in the slippage of a number of schemes. The recent review of the TEN of the Van Miert Group (HLG, 2003) illustrates that only two of the initial fourteen Essen list projects were in operation by 2003, and only a further three are expected to be in full operation by 2007. This group illustrates the potential for conflicts between national priorities by noting how much more difficult it has been to complete international projects.

A second main strand in policy is that of regulation and pricing. Although these are implemented in different ways and may have different behavioural responses, they both have a direct effect on the absolute and relative costs of different modes. The White Paper places the need to make users aware of the true costs of transport at the heart of improving information in order to get more efficient decisions. At the core of this policy is the need to make users aware of the marginal social costs of transport including the cost of environmental damage, accidents and time lost through congestion. The imposition of a different charging regime remains a matter for national governments, however, since it impinges on national tax policies. Different national governments impose rather different types of policy which affect the level of service provided by infrastructure and the competitive positions of different modes; some use high levels of fuel tax and annual licence charges (particularly on heavy goods vehicles), but also expect competing modes such as rail to meet their full costs; others use lower levels of tax on vehicles and fuel but expect users to meet the costs of high-level infrastructure more directly through tolls whilst providing higher levels of subsidy to rail modes as an incentive for users to switch modes (see evidence from the UNITE project: Link et al., 2001; Nelthorp et al., 2001). This confusion of policies poses problems for those trying to use high-level infrastructure internationally; it also poses problems for attempts to model policies effectively. Hence, the pricing scenarios used in this report should be regarded as typical policy examples, which are however not likely to be realised in pure form in isolation. Reality will be a mixture of policies that can not be predicted precisely.

ICT policy is not developed so coherently as transport policy as to be able to identify specific infrastructures or pricing impacts. EU policies focus on three main areas: on investments in ICT infrastructure to secure a cheaper, faster Internet; on investments in people and skills to support adoption; on promotion of use through Internet service development (e-government, e-commerce, intelligent transport systems). The scenarios modelled consider alternative spatial distributions of these developments which are termed indiscriminate, efficiency and cohesion scenarios. The first simply assumes that investment is distributed according to population and equally distributed across the three main policy areas. The second concentrates investment more in more developed regions (where it has greatest direct impact on EU competitiveness) with an emphasis on infrastructure development in these regions but more emphasis on accessibility to ICT resources in lagging regions. The third scenario sees all investment focused on lagging regions but an equal distribution between the three policy areas.

Finally we need to consider the issue of the enlargement of the European Union. This is implicit in much of what has been discussed above since the new member states can be characterised by reference to the same set of indicators, we have included infrastructure developments in these countries and we have reviewed transport policy developments in the accession countries for the analysis in Chapter 5. However, certain policy areas become more critical in these countries. Budget balances are substantially more precarious, infrastructure needs at the local level are more severe and there are more serious environmental conflicts arising from an old vehicle stock. It is assumed that the level of investment, the diffusion of technology and best practice over the forecast period will lead to a gradual approximation so that the underlying production and behavioural functions for these countries will converge on those of the old member states over the period. There may, however, be potentially more policy conflict over the period and we examine that in more detail in Chapter 5.

2.2 Scenarios

There is reason to believe that the existing disparities in regional endowment with transport and telecommunications infrastructure are serious impediments for the rapid socio-economic development of lagging and peripheral regions. It is therefore one of the strategic policy objectives of the

European Union to contribute to the reduction of economic disparities between central and peripheral regions by upgrading and extending transport and telecommunications infrastructure as defined within the TEN and TINA programmes.

The main output of ESPON 2.1.1 are therefore model-based scenarios of the regional socio-economic impacts of European transport and telecommunications policies, including impacts on cohesion and polycentricity.

Scenarios studied are both retrospective (transport infrastructure scenarios for the decade 1991 to 2001) and prospective (transport infrastructure and pricing scenarios for the period 2001 to 2021 and ICT policy scenarios to guide future European transport and telecommunications policy making).

Transport policies are analysed at the NUTS-3 level for the ESPON Space, i.e. for the 25 present EU member states and the 2 candidate countries Bulgaria and Romania plus Norway and Switzerland, while ICT policies are analysed only at NUTS-2 level for the former European Union of 15 member states due to lack of data. The results are presented in the form of maps, tables and diagrams and analysed with respect to spatial objectives, such as the cohesion and polycentric developments objectives stated in the ESDP (see Chapter 4).

In this section the policy scenarios of ESPON 2.1.1 are specified. The transport scenarios examined can be classified into infrastructure scenarios and pricing scenarios and are defined in Section 2.2.1. The telecommunications scenarios will be presented separately in Section 2.2.2.

2.2.1 Transport Policy Scenarios

The transport scenarios examined can be classified into retrospective scenarios looking at the impact of past infrastructure development (Section 2.2.1.1) and prospective scenarios examining the potential impact of possible future infrastructure and other transport policies (Section 2.2.1.2). Table 2.2 gives an overview on the scenarios.

The transport infrastructure scenarios were implemented using the GIS-based pan-European road, rail, waterway and air network database developed by the Institute of Spatial Planning of the University of Dortmund (IRPUD, 2003) and now maintained and further developed by the Büro für Raumforschung, Raumplanung and Geoinformation – RRG (Schürmann, 2004). The *strategic* networks used for the modelling are subsets of this database comprising the TEN and TINA networks plus a substantial number of additional links to guarantee connectivity of NUTS-3 regions in the European Union and of the regions in non-EU member countries.

All transport policy scenarios are introduced into the two regional economic models as changes of transport costs between regions over time and between scenarios (see Chapter 3). For that the historical and possible future developments of the networks are required as input. The evolution of networks over time is established in the database in five-year intervals; the network database (for rail and road) contains information for the years 1981 to 2021. Parameters for transforming network information into cost estimates are taken from the SCENES project (ME&P et al., 2000).

Table 2.2 Transport policy scenarios

Time horizon	Policy type	Scenario characteristics	
Retrospective 1991-2001	Reference	A0	Do-nothing
	Infrastructure	A1	Only rail projects
		A2	Only road projects
		A3	Rail and road projects
Prospective 2001-2021	Reference	00	Do-nothing
	Infrastructure	B1	Priority projects (new list)
		B2	TEN/TINA projects
		B3	TEN/TINA projects except cross-border corridors
		B4	TEN/TINA cross-border corridor projects only
		B5	TEN/TINA projects only in Objective 1 regions
	Pricing	C1	Reduction of the price of rail transport
		C2	Increase of the price of road transport
		C3	Social marginal cost pricing of all modes
	Combination	D1	Priority projects plus SMCP (B1+C3)
		D2	TEN/TINA projects plus SMCP (B2+C3)

2.2.1.1 Retrospective scenarios

The first group of scenarios looks backwards. The question is to what degree transport infrastructure development during the last decade has contributed to economic development and its regional distribution in Europe. First, the Reference Scenario A0 was defined which assumes that no transport infrastructure development has happened between 1991 and 2001, i.e. the transport infrastructure of 2001 is that of 1991. In this scenario (like in the policy scenarios) only the reduction of border waiting times, and in the case of the SASI model, the reduction of other barriers to spatial interaction like political and social barriers has taken place during that decade. Three policy scenarios were developed and compared with the reference case for the year 2001:

- *A1 Only rail projects.* In this scenario, European rail infrastructure developed according to reality up to the year 2001 whereas road infrastructure is that of the year 1991. The scenario results give the isolated impacts of rail infrastructure development on the regional economies.
- *A2 Only road projects.* In this scenario, the road infrastructure developed according to reality during the 1990s, whereas rail infrastructure is kept as it was in the year 1991. The scenario results give the isolated effects of road infrastructure development on regional economies.
- *A3 Rail and road projects.* In this scenario, both rail and road infrastructure developed according to the real development. The scenario results allow an assessment of the effects of infrastructure developments during the last decade on regional economic development.

2.2.1.2 Prospective scenarios

The prospective scenarios are considering possible transport policies and their impacts in the period 2001 to 2021. They comprise three groups of policies: infrastructure policies, pricing policies and combinations of both.

All scenarios are compared with the Reference Scenario 00 in which the transport infrastructure of the year 2001 is frozen for future years. In this scenario (like in all policy scenarios) only the reduction of border waiting times, and in the case of the SASI model, the reduction of other barriers to spatial interaction like political and social barriers take place.

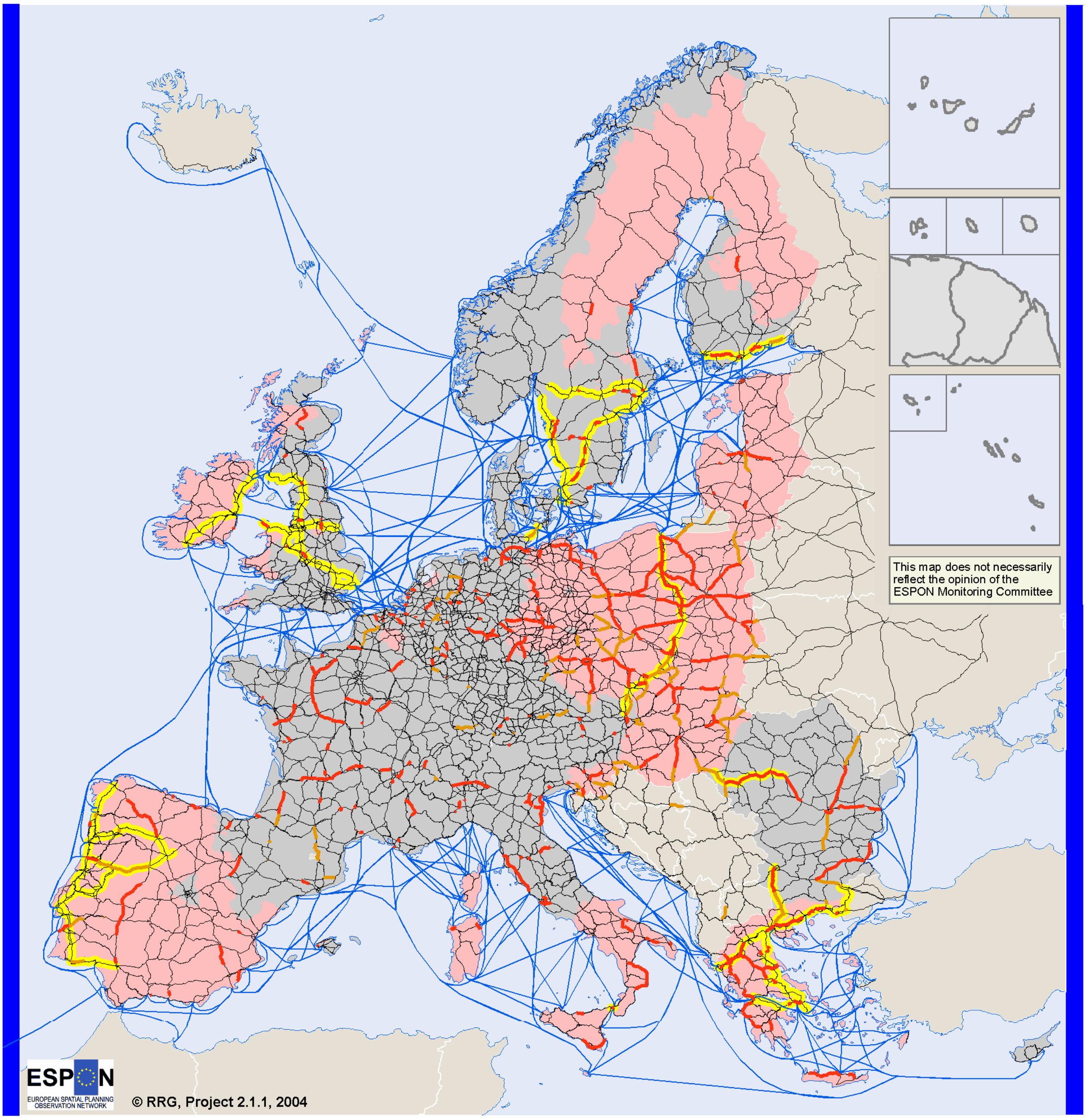
Infrastructure scenarios

The first group of prospective scenarios is dealing with different hypothetical options concerning future transport infrastructure development. The infrastructure scenarios are mainly concerned with the trans-European network policy of the European Union, but contain also some national infrastructure projects, in particular in Switzerland and Norway.

The status and type of the infrastructure projects and their expected year of completion were taken from policy documents (European Commission, 2003a; 2003b; European Union 2004) and available review report such as the *TEN Implementation Report* (European Commission, 1998), the *TEN-Invest* study (Planco Consulting et al., 2003), the *Van Miert High Level Group* (HLG, 2003), the *TINA Status Report* (TINA Secretariat, 2002), and from national sources.

This information was used to compile five different infrastructure scenarios. Maps 2.1 and 2.2 display the road and rail model networks and the assumptions for the transport infrastructure network development separately for road and rail by indicating on which links something will happen in future. The maps do not show the year in which a certain infrastructure project will be ready, however, this is part of the network database and thus part of the scenario. The five scenarios differ in the amount and spatial focus of infrastructure development:

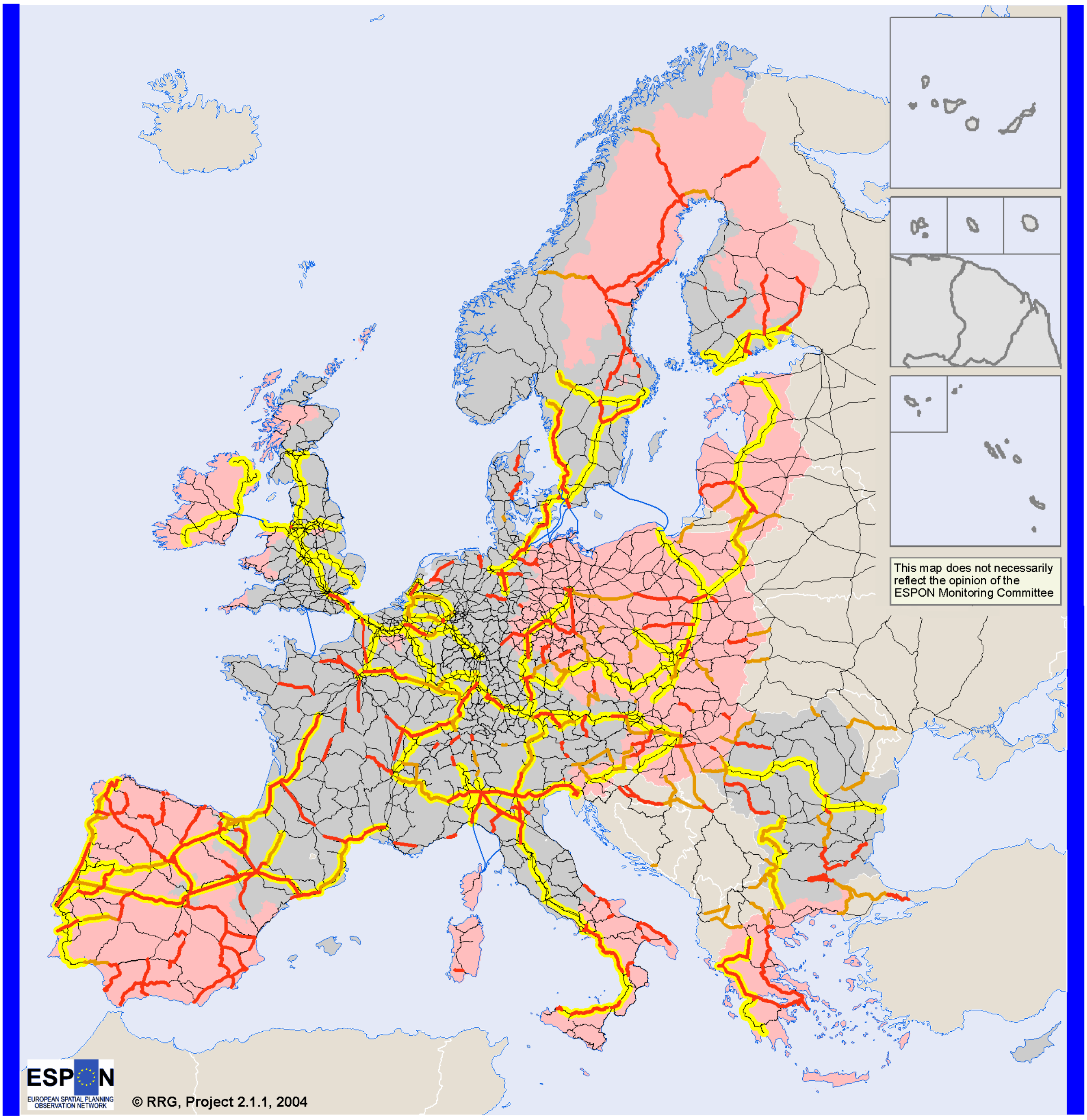
Road network



- Road links
- Road priority projects (Scenario B1)
- Road projects, non cross-border (Scenarios B2, B3, B5)
- Road projects, cross-border (Scenarios B2, B4, B5)
- Objective 1 areas (Scenario B5)
- Short sea shipping links

Map 2.1 Road network development of the infrastructure scenarios

Rail network



- Rail links
- Rail priority projects (Scenario B1)
- Rail projects, non cross-border (Scenarios B2, B3, B5)
- Rail projects, cross-border (Scenarios B2, B4, B5)
- Objective 1 areas (Scenario B5)
- Rail ferry links

Map 2.2 Rail network development of the infrastructure scenarios

- *B1 Priority projects (new list).* In this scenario, only the new list of priority projects of the TEN network will be realised, no other infrastructure development will happen. This scenario gives insight into the impacts of the current political priorities concerning transport infrastructure development.
- *B2 TEN/TINA projects.* In this scenario, all projects of the TEN/TINA programme for road and rail plus some national infrastructure development will be realised. The scenario includes also the Motorways of the Sea which are treated as part of the road network for freight transport. This scenario predicts the regional economic impacts of a full realisation of the trans-European network programme plus corresponding infrastructure in Norway and Switzerland.
- *B3 TEN/TINA projects except cross-border corridors.* This scenario contains only a subset of the projects of Scenario B2. Now infrastructure development is restricted to those links that have primarily a national function, i.e. all cross-border links remain in the scenario with the status they have in the year 2001. This scenario addresses the regional impacts of a purely nationally oriented transport infrastructure policy.
- *B4 TEN/TINA cross-border corridor projects only.* This scenario is the counterpart to Scenario B3. Now only those links of the full TEN/TINA and the national infrastructure programmes of Scenario B2 are included which are located in cross-border corridors. This scenario might bring out the added value in terms of regional economic development when concentrating purely on international projects.
- *B5 TEN/TINA projects only in Objective 1 regions.* Eventually, this scenario concentrates on infrastructure investments in Objective 1 regions of the Structural Funds for the period 2000-2006, i.e. only the projects of Scenario B2 in eligible areas will be developed, all other links will remain as they are in the year 2001. The scenario might contribute to the question of what would happen if European transport infrastructure policy would focus solely on the least favoured areas in Europe.

Pricing scenarios

Pricing policies are a different option to influence mobility behaviour of persons and firms which will eventually lead to changes in the location behaviour of firms and thus changes in regional economic development. In order to provide a tractable set of alternatives, three pricing scenarios were defined aimed at capturing different current ideas on transport pricing at a broad European level. All pricing scenarios are based on the Reference Scenario 00, i.e. in order to isolate the impact of pricing no infrastructure development is assumed to take place:

- *C1 Reduction of the price of rail transport*. The scenario assumes a ten percent reduction of rail charges to achieve a better modal balance by subsidising environmental-friendly alternatives to road transport.

- *C2 Increase of the price of road transport*. In this scenario, the price of road transport is increased by ten percent. This scenario reflects policies member states are using for political reasons instead of applying the optimum level of road charging of social marginal costs.

- *C3 Social marginal cost pricing of all modes.* The assumption is that all modes are charged an additional ten percent of the costs. This pricing scenario assumes that all modes can be charged close to their marginal social costs.

It is recognised that the way the pricing scenarios would be implemented in reality would influence behaviour and therefore eventual outcomes – an across-the-board increase in licence fees or fuel tax would have different impacts from congestion-related road pricing. This recognises that overall the current contribution of road users to the total costs of the road network including environmental effects, accident costs and congestion is fairly close to break-even, but that this disguises considerable differences between very low cost coverage in urban areas (and some inter-urban situations) in peak hours and very high coverage made by users of non-congested rural roads. We assume that a ten-percent increase is a reasonable representation of what might be feasible and gives insight into the effects of social marginal cost pricing on regional economic development.

Combination scenarios

Finally, two scenarios integrate the previous types of policy into policy packages consisting of infrastructure developments and social marginal cost pricing of all modes:

- *D1 Priority projects plus SMCP (B1 + C3).* The scenario combines transport infrastructure development in form of the priority projects (Scenario B1) with the social marginal cost pricing as defined in Scenario C3.

- *D2 TEN/TINA projects plus SMCP (B1 + C3).* The scenario combines the complete development of the TEN/TINA networks plus national infrastructure projects, in particular in Norway and Switzerland, with the social marginal cost pricing of all modes of Scenario C3.

There may be some inconsistencies in such scenarios since it is clear that the imposition of social marginal cost pricing may obviate the need for some infrastructure (and create the need for some other), but it is impossible to determine the nature of this trade-off.

2.2.2 ICT policy scenarios

The three main ICT policies that the EU intends to implement are, according to the *eEurope 2002 Action Plan* of the European Union:

- a cheaper, faster and secure Internet, i.e. a focus on ICT investments on ICT infrastructure;
- investments in people and skills, i.e. an adoption support policy;
- a stimulus for the use of the Internet (e-government, e-commerce, intelligent transport systems), i.e. a policy oriented towards service promotion.

These three policies are expected to have different impacts:

- The first policy is expected to generate positive effects captured by an increase of the ICT endowment. However, it does not act on real use (what we label "accessibility"). This policy can be applied to lagging areas to reduce the infrastructural gap and to non-lagging areas in order to overcome the bottlenecks that characterise these areas. In our model, this policy corresponds to an increase in Internet connections.
- The second policy is a medium-term policy, since it supports the adoption process (it acts on the degree of ICT accessibility of an area). This policy can be applied both to advanced countries and regions as well as (in a strategic way) to lagging areas which can reduce their peripherality through a high level of telecommunications accessibility. In our model, this policy corresponds to an increase in accessibility.
- The third policy is a long-term policy since it aims at developing advanced ICT services (and their employment) in the economy, influencing long term efficiency of the whole productive system. In our model, this policy influences the share of high-tech employment.

Given a certain level of financial resources devoted to ICT, three scenarios can be envisaged on the basis of the policies chosen (Table 2.3). We forecast the impact of the policy scenarios on regional GDP per capita until the year 2020. These impacts are measured by the percentage difference between the scenario and a do-nothing scenario.

Scenario A: Indiscriminate

This scenario envisages a widespread diffusion of ICT infrastructures and services throughout Europe with the implementation of all three European ICT policies in all countries and regions of the European Union irrespective their economic level and ICT endowment. The funds are subdivided among regions according to their population share and then devoted in equal parts to the three policies.

Table 2.3 ICT policy scenarios

ICT scenarios	Regions	ICT policies
A Indiscriminate	*All regions* Investments distributed according to regional population	*All regions* 33% accessibility 33% Internet 33% high-tech employment
B Efficiency	*Lagging regions* 20% of investments distributed according to the share of population *Non-lagging regions* 80% of total investments distributed according to the share of population	*Lagging regions* 70% accessibility 30% Internet *Non-lagging regions* 30% accessibility 70% Internet
C Cohesion	*Lagging regions* 100% of investments distributed according to the share of population	*Lagging regions* 33% accessibility 33% Internet 33% high-tech employment

Scenario B: Efficiency

The second scenario envisages the implementation of ICT policies according to the higher marginal efficiency of the concerned ICT factors. 80 percent of financial resources in ICT are devoted to non-lagging regions that are more efficient, while the remaining 20 percent of investments goes to the lagging regions. In each subgroup investments are weighted by population, while policies differ substantially between subgroups:

- In Objective 1 areas, ICT accessibility policies are developed, with 70 percent of regional resources, while limited resources are devoted to ICT infrastructure development (30 percent).
- In non-lagging areas, ICT infrastructure development policies are implemented with 70 percent of regional resources, while the remaining 30 percent are devoted to ICT accessibility.

The rationale behind this scenario lays in the different marginal efficiency of Internet connection and accessibility: since the first indicator has a higher marginal efficiency (0.96 compared to 0.25 of accessibility), it can be better exploited in advanced areas thanks to the reduction of congestion effects. The peripherality of non-lagging areas, however, could be reduced through an increase in accessibility, while the existing ICT infrastructure is sufficient for the present regional needs.

Scenario C: Cohesion

This third scenario envisages the implementation of ICT policies only for lagging regions as has been the case in the past with the STAR and Telematique projects. In this case all resources are devoted to Objective 1 regions, one-third for each policy.

The three scenarios are expected to produce very different territorial impacts:

- Scenario A should have a weak impact on efficiency and little effect on regional disparities. The relatively low impact on efficiency is mainly due to the existence of indivisibilities in investments that risk preventing for any positive income growth effects. No effects on regional disparities are expected, since if any positive effect on efficiency is developed, it is equally distributed over regions.
- Scenario B is expected to provide a positive impact on efficiency in all regions. The effect on regional disparities should be negative, because the already advanced regions are favoured.
- Scenario C is expected to provide a positive impact on regional disparities, since it is devoted to favouring low-income regions.

2.3 The Existing Regional Disparities in ICT Infrastructure

Current regional disparities in ICTs endowment, known as *digital divide*, appear very clearly when one looks at maps based on data extracted from the INRA Survey[3]. It is worth mentioning that data for other countries as e.g. Norway might also be available. To ensure consistency of the model results in chapter 4.1.3, this consistent dataset for several countries gathered by a common methodology had to be used and countries not covered by this dataset could not be included. In particular, we present here the maps concerning fixed telephony penetration (Fig. 2.1) and Internet connections (Fig 2.2), which are two indicators used in our methodology. It is worth to mention that data for other countries as e.g. Norway might also be available. To ensure consistency of the results of the model in chapter

[3] EOS Gallup (1999).

4.1.3, this consistent dataset for several countries gathered by one particular methodology is used.

The first map shows that the percentage of households with a fixed telephone is quite high everywhere (most regions are above 75% penetration level), as expected due to the pervasive presence of the telephone in everyday life (Map 2.3). The highest penetration rates are in Southern England, part of Germany and Southern Scandinavian Countries, but also Germany, the Netherlands, Greece and Northern Italy show very high penetration levels. In more peripheral regions like in Portugal and in Southern Italy, the penetration is relatively less high.

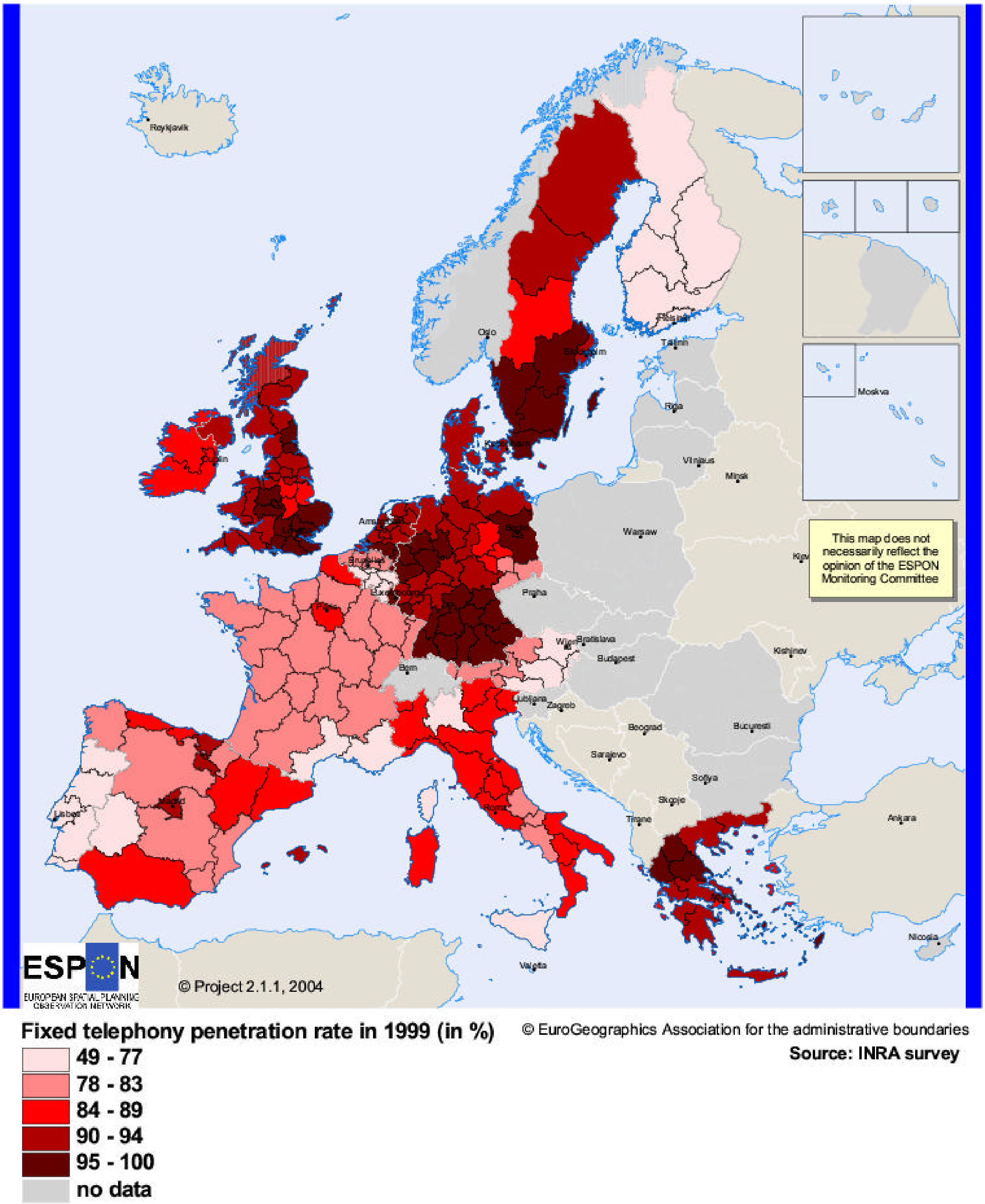
Home Internet access shows higher regional differences, resulting in a higher digital divide (Map 2.4). In this case, the regional difference is shown between regions of Spain, Portugal and Greece in comparison to regions in Northern Countries, like Scandinavian Countries[4], Great Britain, The Netherlands and Germany. These latter show a much lower penetration rate of Internet access at home than the former group of regions.

In order to estimate the per capita GDP, we built an accessibility indicator which is important for the definition of current regional disparities, in terms of ICTs use[5]. Our ICTs accessibility indicator, based on population and Internet as e-commerce vehicle (percentage of connected using Internet for e-commerce purposes), highlights, as expected, the strong position of geographically central and highly populated regions, with some exceptions: Southern Spain and Italy show high virtual accessibility due to their higher than average Internet use (Map 2.5). This map is drawn on 1999 data, since the variable “Internet as e-commerce vehicle” is not available in the INRA report.

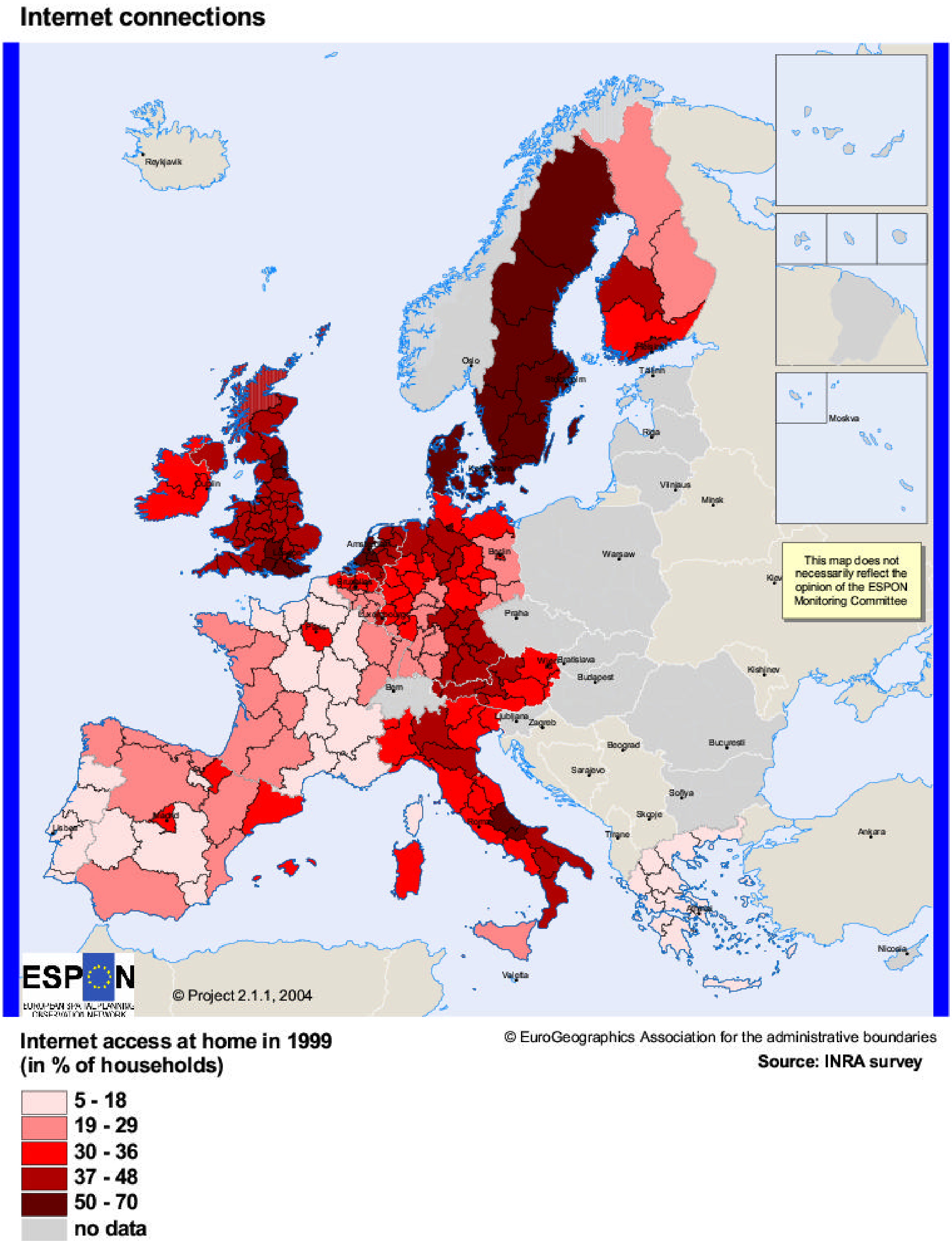
[4] It should also be remembered that many important mobile phone producers are located in Scandinavian regions. For the maps of mobile telephony penetration rates, see INRA report (2003).

[5] For the methodology used to build the accessibility indicator, see section 3.3.3.

Fixed telephony penetration

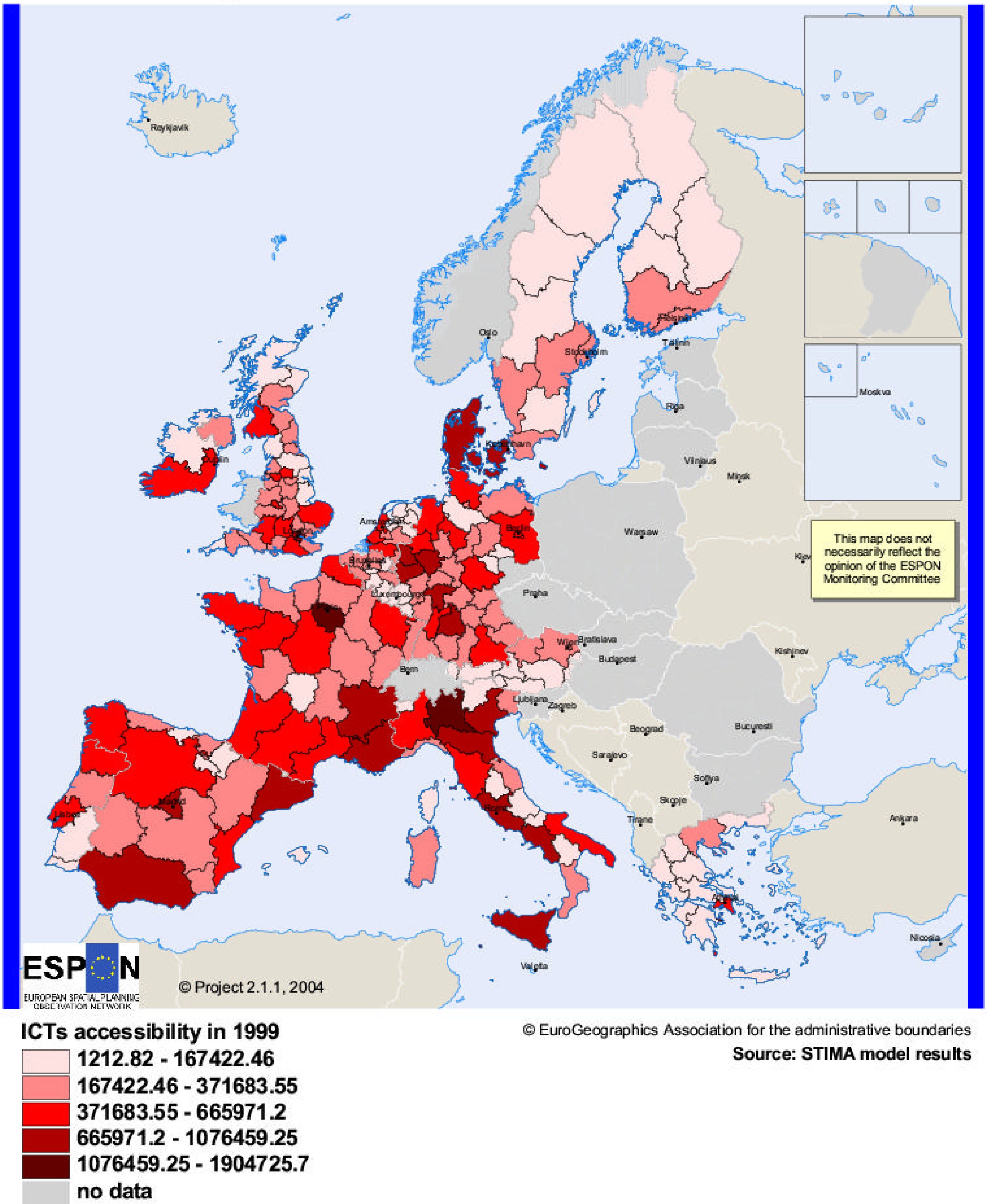


Map 2.3 Fixed telephony penetration



Map 2.4 Internet connections

ICTs Accessibility



Map 2.5 ICTs Accessibility

2.4 Typologies

For the evaluation of the results produced by modelling the impact of transport and ICT policies the forecasted output values of the models have been evaluated all together according to typologies and additionally by country. Tables showing the mean values for subsets selected from all regions are made to support the interpretation of results and also to help on plausibility checking. The contents of these tables are shown in annex C.

Typologies provided by the ESPON database and several other available regional classifications were collected and used for the tabulation. The aggregate date is calculated by the arithmetic mean weighted by the regional GDP in EURO generally.

Objective 1 and Objective 2 regions (for analytical purpose only)

Based on COM "Second progress report on economic and social cohesion" (30 January 2003) NUTS3 level regions situated within objective 1 regions are listed as Objective 1 regions. The type Objective 2 region includes regions containing at least one Objective 2 region (partly).

Relative Rurality

This is a typology of urban-rural settlement patterns, which based on population size and was analysed in the framework of NUTS3 regions by TPG 1.1.2. The original typology of 6 classes was simplified into 3 classes, denoting low, medium and high rurality.

Pentagon

The "Pentagon" is shaped by London, Paris, Munich, Milan and Hamburg. About 41 percent of the population of EU 15 are living in this core area, which is only 18 percent of the EU 15 territory, and producing 49 percent of the EU 15 GDP.

Settlement Structure

The settlement structure typology of the BBR consists of three basic types defined by population density and situation regarding centres: agglomerated regions, urbanised areas and rural regions. Furthermore these three classes are broken down into 9 subclasses:

Type I Agglomerated regions

Type 1 City Core regions in NUTS2-type 1 or 2

Type 2 Very densely populated regions in NUTS2-type 1 or 2

Type 3 Densely populated regions in NUTS2-type 1 or 2

Type 4 Rural regions in NUTS2-type 1 or 2

Type II Urbanised areas

Type 5 City Core regions in NUTS2-type 3 or 4

Type 6 Densely populated regions in NUTS2-type 3 or 4

Type 7 Rural regions in NUTS2-type 3 or 4

Type III Rural regions

Type 8 More densely populated regions in NUTS2-typ 5 or 6

Type 9 Less densely populated regions in NUTS2-typ 5 or 6

Lagging Regions

The typology of lagging regions is based on the combination of regional values of GDP per inhabitant (in EURO) and the unemployment rate. Both indicators are standardised and after reversing the scale for unemployment aggregated by their geometric mean. All regions are ranked by the resulting index and finally classified as follows: Regions with lowest index values up to the coverage of 30 percent of the ESPON space total population are classified as "lagging regions", up to 50 percent as "potentially lagging regions". All other regions fall into the category "non lagging regions". (This typology has been done for the BBR analysis of polycentric links presented in section 3.7.1)

Multimodal Accessibility Potential

This typology is based on a time based, multimodal accessibility-indicator, which is already calculated by S&W within the framework of project 1.2.1. This indicator is standardised on the ESPON-average (100). The classification gives a five class typology ranging from very central over central, intermediate, peripheral to very peripheral (The overseas are classified as very peripheral without calculation.).

3 Methodologies

This chapter presents the methodologies applied in ESPON 2.1.1. First the three forecasting models, the SASI model, the CGEurope model and the STIMA model, are presented. Then five analytical techniques used to further process and analyse the model results are discussed: a method to calculate a complex index called Development Potential, a comparison of different cohesion indicators, a method to measure and forecast polycentricity, a method to identify overloaded transport corridors and a method to analyse causality between model variables.

The applications of these models and analytical techniques are presented in Chapter 4.

3.1 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 ESPON Space as a whole and transport infrastructure investments and transport system improvements, in particular of the trans-European transport networks (TEN-T) and TINA 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 and polycentricity indicators expressing the impact of transport infrastructure investments on the polycentricity of national urban systems are calculated.

The main concept of the SASI model is to explain locational structures and locational change in Europe in time-series/cross-section regressions, with accessibility indicators being a subset of a range of explanatory variables. Accessibility is measured by spatially disaggregate accessibility indicators. The 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 spatial development objectives of the European Union.

The SASI model differs from other approaches to model the impacts of transport on regional development by modelling not only production (the demand side of regional labour markets) but also population (the supply side of regional labour markets) and so is able to model unemployment. A second distinct feature is its dynamic 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 TEN-T and TINA planning documents (see Chapter 2).

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 3.1 visualises the interactions between these submodels.

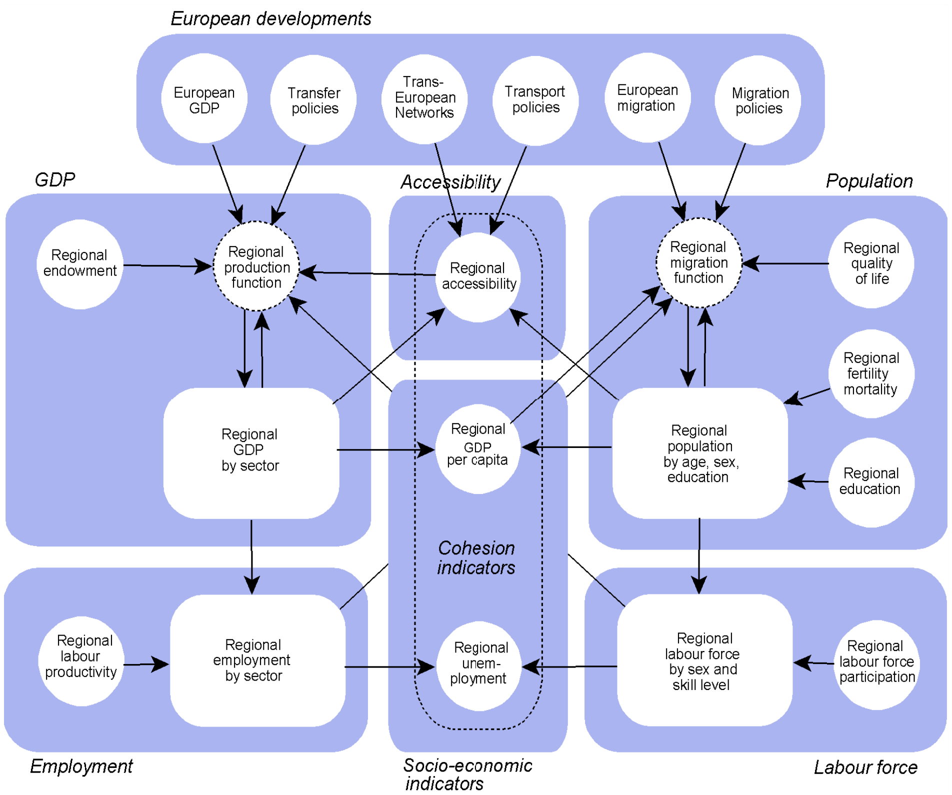


Figure 3.1 The SASI model

The *spatial* dimension of the model is established by the subdivision of the European Union and the twelve accession countries in eastern Europe plus Norway and Switzerland in 1,321 regions and by connecting these regions by road, rail and air networks. For each region the model forecasts the development of accessibility, GDP per capita, employment, population and migration. The *temporal* dimension of the model is established by dividing time into periods of one year duration. In each simulation year the seven submodels of the SASI model are processed in a recursive way, i.e.

sequentially one after another. This implies that within one simulation period no equilibrium between model variables is established; in other words, all endogenous effects in the model are lagged by one or more years.

The mathematical specification of the original SASI model was presented in EUNET/SASI Deliverable 8 (Wegener and Bökemann, 1998). The extended version of the SASI model used in the IASON project was described in IASON Deliverable D2 (Bröcker et al., 2002a). The IASON Common Spatial Database used for the model in IASON was presented in IASON Deliverable D3 (Bröcker et al., 2002b). The results of the policy simulations for IASON was presented in IASON Deliverable D6 (Bröcker et al., 2004).

3.1.1 Model Implementation

In this section the specification of model variables and parameters of the seven submodels of the SASI model is summarised.

European Developments submodel

The *European Developments* submodel is not a 'submodel' in the narrow sense because it simply processes exogenous assumptions about the wider economic and policy framework of the simulations and makes sure that external developments and trends are considered.

For each simulation period the simulation model requires the following assumptions about European developments:

(1) *Assumptions about the performance of the European economy as a whole*. The performance of the European economy is represented by values of sectoral GDP for the total study area consisting of the European Union, the twelve accession countries and Norway and Switzerland between 1981 and 2021.

(2) *Assumptions about immigration and outmigration across Europe's borders*. European migration trends are represented by annual immigration and outmigration of the 29 countries of the ESPON Space between 1981 and 2021.

These two groups of assumptions serve as constraints to ensure that the regional forecasts of economic development and population remain consistent with external developments not modelled. To keep the total economic development exogenous means that the model is prevented from making forecasts about the general increase in production through transport infrastructure investments (generative effects). However, its parameters are estimated in a way that makes it capable of doing that. Therefore the constraints are only applied to the Reference Scenario (see Section 2.2.1);

by applying the adjustment factors of the Reference Scenario also to the policy scenarios, only the *changes* in generative effects induced by the policies are forecast.

(3) Assumptions about transfer payments by the European Union via the Structural Funds and the Common Agricultural Policy or by national governments to support specific regions. European and national transfer payments are taken into account by annual transfers (in Euro of 1998) received by the regions in the European Union during the period 1981 to 1996 and forecasts for the period 1996 to 2016.

(4) *Assumptions about European integration*. The accessibility measures used in the SASI model take account of existing barriers between countries, such as border waiting times and political, cultural and language barriers. These barriers are estimated for the period 1981 to 1996 and forecast for the period 1996 to 2016 taking into account the expected effects of the enlargement of the European Union and further integration.

The data for these four types of assumptions do not need to be provided for each year nor for time intervals of equal length as the model performs the required interpolations for the years in between.

(5) *Assumptions about the development of trans-European transport networks.* The European road, rail and air networks are backcast for the period between 1981 and 2001 and, based on assumptions on the development of trans-European networks, forecast until the year 2016 in five-year increments (see Section 2.2.1).

(6) *Assumptions about policy decisions on the trans-European networks*. A *policy scenario* is a time-sequenced investment programme for addition, upgrading or closure of links of the trans-European road, rail and air networks (see Section 2.2.1).

Regional Accessibility submodel

For the selection of accessibility indicators to be used in the model three, possibly conflicting, objectives were considered to be relevant: First, the accessibility indicators should contribute as much as possible to explaining regional economic development. Second, the accessibility indicators should be meaningful by itself as indicators of regional quality of life. Third, the accessibility indicators should be consistent with theories and empirical knowledge about human spatial perception and behaviour.

In the light of these objectives, potential accessibility, i.e. the total of destination activities, here population, $W_s(t)$, in 1,321 internal and 51 external destination regions s in year t weighted by a negative exponential function of generalised transport cost $c_{rsm}(t)$ between origin region r and destination region s by mode m in year t was adopted (see Schürmann et al., 1997):

$$A_{rm}(t) = \sum_s W_s(t) \exp[-b\, c_{rsm}(t)] \tag{3.1}$$

where $A_{rm}(t)$ is the accessibility of region r by mode m in year t, $W_s(t)$ is the destination to be reached in region s represented by population in s, and $c_{rsm}(t)$ is the generalised travel cost between regions r and s.

The generalised travel costs $c_{rsm}(t)$ consist of a time component, a cost component and a barrier component:

For the time component, rail and air timetable travel times and road travel times calculated from road-type specific travel speeds were used and converted to cost by assumptions about the value of time of travellers and drivers. Only one common value of time was assumed for the whole study area, i.e. no distinction was made between the different wage levels and purchasing powers of countries.

The border waiting times mentioned above were converted to monetary cost equivalents. In addition, following Bröcker (1984; 1996), political, cultural and language barriers were taken into account of as cost penalties added to the transport costs:

$$c_{rsm} = c'_{rsm}(t) + e_{r's'}(t) + s_{r's'} + \ell_{r's'} \quad \text{with } r \in \mathbf{R}_{r'} \quad (3.2)$$

in which $c'_{rsm}(t)$ is the travel cost between region r and region s in year t and $e_{r's'}(t)$, $s_{r's'}$ and $\ell_{r's'}$ are exogenous time penalties for political, cultural and language diversity in year t between the countries $\mathbf{R}_{r'}$ to which regions r and s belong:

- $e_{r's'}(t)$ is a *European integration factor* reflecting in which supranational structures the two countries are, i.e. which political and economic relationship existed between them in year t,
- $s_{r's'}$ is a *cultural similarity factor* reflecting how similar are cultural and historical experience of the two countries.
- $\ell_{r's'}$ is a *language factor* describing the grade of similarity of the mother language(s) spoken in the two countries

While the latter two factors were kept constant over the whole simulation, $e_{r's'}(t)$ was reduced from year to year to account for the effect of European integration and, for the ten accession countries, the effect of their becoming members states of the European Union. The accessibility indicators used in the model were not standardised to the European average to show increases in accessibility over time.

Modal accessibility indicators were aggregated to one indicator expressing the combined effect of alternative modes by replacing the impedance term $c_{rsm}(t)$ by the composite or *logsum* impedance (Williams, 1977):

$$c_{rs}(t) = -\frac{1}{l} \ln \sum_{m \in \mathbf{M}_{rs}} \exp[-l \; c_{rsm}(t)] \qquad (3.3)$$

where $\mathbf{M}_{rs}$ is the set of modes available between regions r and s. Four composite accessibility indicators are used: accessibility by rail and road for travel, accessibility by rail, road and air for travel, accessibility by road for freight and accessibility by rail and road for freight.

Regional GDP submodel

The GDP submodel is based on a quasi-production function incorporating accessibility as additional production factor. The economic output of a region is forecast separately for the six economic sectors used in SASI: agriculture, manufacturing, construction, trade/transport/tourism, financial services and other services (see IASON Deliverable D3, Bröcker et al., 2002b) in order to take different requirements for production by each sector into account. The regional production function predicts annual regional GDP per capita:

$$q_{ir}(t) = \mathrm{f}\,[\mathbf{C}_{ir}(t), \mathbf{L}_{ir}(t), \mathbf{A}_{ir}(t), \mathbf{X}_{ir}(t), \mathbf{S}_r(t), R_{ir}(t)] \qquad (3.4)$$

where q_{ir}(t) is annual GDP per capita of industrial sector i in region r in year t, $\mathbf{C}_{ir}(t)$ *is* a vector of capital factors relevant for industrial sector i in region r in year t, $\mathbf{L}_{ir}(t)$ is a vector of indicators of labour availability relevant for industrial sector i in region r in year t, $\mathbf{A}_{ir}$ is a vector of accessibility indicators relevant for industrial sector i in region r in year t, $\mathbf{X}_{ir}(t)$ is a vector of endowment factors relevant for industrial sector i in region r in year t, $\mathbf{S}_r(t)$ are annual transfers received by the region r in year t and R_{ir}(t) is a region-specific residual taking account of factors not modelled (see below). Note that, even though annual GDP is in fact a flow variable relating to a particular year, it is modelled like a stock variable.

Assuming that the different production factors can be substituted by each other only to a certain degree, a multiplicative function which reflects a limitational relation between the factors was chosen. Since this kind of function introduces the coefficients as exponents of the explaining variables it is possible to interpret the coefficients as elasticities of production reflecting the importance of the different production factors for economic growth in a sector. The operational specification of the regional production functions used in the SASI model is:

$$q_{ir}(t) = C_{ir}(t-5)^{a} L_{ir}(t-1)^{b} A_{ir}(t-1)^{g} \ldots X_{ir}(t-1)^{d} \ldots S_{r}(t-1)^{e} \exp(r) R_{ir}(t) \qquad (3.5)$$

where $C_{ir}(t–5)$ is the economic structure (share of regional GDP of sector i) in region r in year $t–5$, $L_{ir}(t–1)$ is a labour market potential indicating the availability of qualified labour in region r and adjacent regions (see *Regional Labour Force* below), $A_{ir}(t–1)$ is accessibility of region r relevant for sector i in year $t–1$, $X_{ir}(t–1)$ is an endowment factor relevant for sector i in region r in year $t–1$, $S_r(t–1)$ are transfer payments received by region r in year $t–1$, $R_{ir}(t)$ is the regression residual of the estimated GDP values of sector i in region r in year t and a, b, c, d, e and r are regression coefficients. The ... indicate that depending on the regression results multiple accessibility indicators and endowment indicators can be included in the equation.

The economic structure variable is used as an explanatory variable because the conditions for production in a certain sector depend on the given sectoral structure, which reflects historic developments and path dependencies not covered by other indicators in the equation. The economic structure variables is delayed by five years as structural change is a slow process.

Endowment factors are indicators measuring the suitability of the region for economic activity. They include traditional location factors such as capital stock (i.e. production facilities) and intraregional transport infrastructure as well as 'soft' quality-of-life factors such as 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 (for the specification of the composite quality-of-life indicator, see Schürmann, 1999).

In addition, monetary transfers to regions by the European Union such as assistance by the Structural Funds or the Common Agricultural Policy or by national governments are considered, as these may account for a sizeable portion of the economic development of peripheral regions. Regional transfers per capita $S_r(t)$ are provided by the *European Developments* submodel (see above).

To take account of 'soft' factors not captured by the endowment and accessibility indicators of the model, all GDP per capita forecasts are multiplied by a region- and sector-specific residual constant R_{ir}. In the period 1981 to 1996, R_{ir} is the ratio between observed and predicted GDP per capita of sector i in region r in each year; hence in this period observed sectoral regional GDP is exactly reproduced by the model. In the period 1997 to 2021, the last residuals calculated for the year 1996 are applied.

In addition, the results of the regional GDP per capita forecasts are adjusted such that the total of all regional GDP meets the exogenous forecast of economic development (GDP) of the study area as a whole by the *European Developments* submodel (see above). However, these constraints are applied only to the Reference Scenario; in the policy scenarios the adjustment factors calculated for the Reference Scenario in each forecasting year are applied. In this way, the *changes* in generative effects induced by the policies are forecast.

Regional GDP by industrial sector is then

$$Q_{ir}(t) = q_{ir}(t)\, P_r(t) \qquad (3.6)$$

where $P_r(t)$ is regional population (see below).

Regional Employment submodel

Regional employment by industrial sector is derived from regional GDP by industrial sector and regional labour productivity.

Regional labour productivity is forecast based on exogenous forecasts of labour productivity in each country:

$$p_{ir}(t) = p_{ir}(t-1)\,\frac{p_{ir'}(t)}{p_{ir'}(t-1)} \quad \text{with } r \in \mathbf{R}_{r'} \qquad (3.7)$$

where $p_{ir}(t)$ is labour productivity, i.e. annual GDP per worker, of industrial sector i in region r in year t, $p_{ir'}(t)$ is average labour productivity in sector i in year t in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs. The rationale behind this specification is the assumption that labour productivity by economic sector in a region is predominantly determined by historical conditions in the region, i.e. by its composition of industries and products, technologies and education and skill of labour and that it grows by an average sector-specific growth rate.

Regional employment by industrial sector is then

$$E_{ir}(t) = Q_{ir}(t) \,/\, p_{ir}(t) \qquad (3.8)$$

where E_{ir}(t) is employment in industrial sector i in region r in year t, $Q_{ir}(t)$ is the GDP of industrial sector i in region r in year t and $p_{ir}(t)$ is the annual GDP per worker of industrial sector i in region r in year t.

Regional Population submodel

The *Regional Population* submodel forecasts regional population by five-year age groups and sex through natural change (fertility, mortality) and migration. Population forecasts are needed to represent the demand side of regional labour markets.

Changes of population due to births and deaths are modelled by a cohort-survival model subject to exogenous forecasts of regional fertility and mortality rates. To reduce data requirements, a simplified version of the cohort-survival population projection model with five-year age groups is applied. The method starts by calculating survivors for each age group and sex:

$$P'_{asr}(t) = P_{asr}(t-1)\ \ [1 - d_{asr'}(t-1,t)] \qquad \text{with } r \in \mathbf{R}_{r'} \tag{3.9}$$

where $P'_{asr}(t)$ are surviving persons of age group a and sex s in region r in year t, $P_{asr}(t\text{-}1)$ is population of age group a and sex s in year t-1 and $d_{asr'}(t-1,t)$ is the average annual death rate of age group a and sex s between years t-1 and t in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs.

Next it is calculated how many persons change from one age group to the next through ageing employing a smoothing algorithm:

$$g_{asr}(t-1,t) = 0.12\ P'_{asr}(t) + 0.08\ P'_{a+1sr}(t) \qquad \text{for } a = 1,19 \tag{3.10}$$

where $g_{asr}(t\text{-}1,t)$ is the number of persons of sex s changing from age group a to age group a+1 in region r. Surviving persons in year t are then

$$P_{asr}(t) = P'_{asr}(t) + g_{a-1sr}(t-1,t) - g_{asr}(t-1,t) \qquad \text{for } a = 2,19 \tag{3.11}$$

with special cases

$$P_{20sr}(t) = P'_{20sr}(t) + g_{19sr}(t-1,t) \tag{3.12}$$

$$P_{1sr}(t) = P'_{1sr}(t) + B_{sr}(t-1,t) - g_{1sr}(t-1,t) \tag{3.13}$$

where $B_{sr}(t\text{-}1,t)$ are births of sex s in region r between years t-1 and t:

$$B_{sr}(t-1,t) = \sum_{a=4}^{10} 0.5\ [P'_{a2r}(t) + P_{a2r}(t)]\ \ b_{asr'}(t-1,t)\ \ [1 - d_{0sr'}(t-1,t)] \qquad \text{with } r \in \mathbf{R}_{r'} \tag{3.14}$$

where $b_{asr'}(t-1,t)$ are average number of births of sex s by women of child-bearing five-year age groups a, $a = 4,10$ (15 to 49 years of age) in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs between years t-1 and t, and $d_{0sr'}(t-1,t)$ is the death rate during the first year of life of infants of sex s in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs. The exogenous forecasts of death and birth rates in the above equations are national rates.

Migration within the European Union and immigration from non-EU countries is modelled in a simplified migration model as annual regional net migration as a function of regional indicators expressing the attractiveness of a region as a place of employment and a place to live to take into account both job-oriented migration and retirement migration:

$$m_r(t) = a \left(\frac{q_r(t-3)}{\overline{q}(t-3)} - 1.5 \right) + b \left(\frac{v_r(t-3)}{\overline{v}(t-3)} - 1.5 \right) \quad (3.15)$$

The attractiveness of a region as a place of employment is expressed as the ratio of regional GDP per capita $q_r(t–3)$ and average European GDP per capita $\overline{q}_r(t-3)$. The attractiveness of a region as a place to live is expressed as the ratio of the regional quality of life $v_r(t–3)$ and average European quality of life $\overline{v}(t-3)$. For the specification of the composite quality-of-life indicator, see Schürmann (1999). Both indicators are lagged by three years to take account of delays in perception.

The forecasts of regional net migration are adjusted in size so that they comply with total European net migration forecasts by the *European Developments* submodel.

Regional educational attainment, i.e. the proportion of residents with higher education in region r, is forecast exogenously assuming that it grows as in the country or group of regions to which region r belongs:

$$h_r(t) = h_r(t-1)\ h_{r'}(t)\ /\ h_{r'}(t-1) \qquad \text{with } r \in \mathbf{R}_{r'} \quad (3.16)$$

where $h_r(t)$ is the proportion of residents with higher education in region r in year t, and $h_{r'}(t)$ is the average proportion of residents with higher education in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs.

Regional Labour Force submodel

Regional labour force is derived from regional population and regional labour force participation.

Regional labour force participation by sex is partly forecast exogenously and partly affected endogenously by changes in job availability or unemployment. It is assumed that labour force participation in a region is predominantly determined by historical conditions in the region, i.e. by cultural and religious traditions and education and that it grows by an average country-specific growth rate. However, it is also assumed that it is positively affected by availability of jobs (or negatively by unemployment):

$$\ell_{sr}(t) = \ell_{sr}(t-1)\ \ell_{sr'}(t)\ /\ \ell_{sr'}(t-1) - j_s\ u_r(t-1) \qquad \text{with } r \in \mathbf{R}_{r'} \quad (3.17)$$

where $\ell_{sr}(t)$ is labour force participation, i.e. the proportion of economically active persons of sex s of regional population of sex s 15 years of age and older, in region r in year t, $\ell_{sr'}(t)$ is average labour participation of sex s in year t in country or group of regions $\mathbf{R}_{r'}$ to which region r belongs, $u_r(t$-1) is unemployment in region r in the previous year t-1 (see below), and j_s is a linear elasticity indicating how much the growth in labour productivity is accelerated or slowed down by regional unemployment. Because at the time of execution of the *Regional Labour Force* submodel regional unemployment in year t is not yet known, unemployment in the previous year t-1 is used. Regional labour force by sex s in region r, $L_{sr}(t)$, is then

$$L_{sr}(t) = P_{sr}(t)\ \ell_{sr}(t) \qquad (3.18)$$

where $P_{sr}(t)$ is population of sex s 15 years of age and older in region r at time t and $\ell_{sr}(t)$ is the labour force participation rate of sex s in region r in year t.

Regional labour force is disaggregated by skill in proportion to educational attainment in the region calculated in the *Regional Population* submodel (see above):

$$L_{sr1}(t) = h_r(t)\ L_{sr}(t) \qquad (3.19)$$

with $L_{sr1}(t)$ being skilled labour and the remainder unskilled labour:

$$L_{sr2}(t) = L_{sr}(t) - L_{sr1}(t) \qquad (3.20)$$

The *labour market potential* of a region is a destination-oriented accessibility indicator of the potential type. The measure is proportional to the potential number of workers living in the region and in-commuting from adjacent regions taking into account the competition between regions for workers:

$$A_s(t) = \sum_r L_r(t)\ E_s(t)\ \ \exp[-b\ c_{rs}(t)] \qquad (3.21)$$

where $A_s(t)$ is the labour market potential of region s at time t, $L_r(t)$ is labour living in region r at time t, $E_s(t)$ is employment (jobs) in region s at time t and $c_{rs}(t)$ is the impedance between regions r and s. Equation (1) could be standardised in a way that $A_s(t)$ equals the potential number of workers living in or commuting to region s as in Equation (2):

$$A_s(t) = \sum_r \frac{E_s(t)\ \ \exp[-b\ c_{rs}(t)]}{\sum_s E_s(t)\ \ \exp[-b\ c_{rs}(t)]} L_r(t) \qquad (3.22)$$

but this is not presently done. Interregional impedance $c_{rs}(t)$ is calculated from airline distance (in km) between the centroids of regions r and s converted to travel time (minutes). The parameter *ß* is scaled such that only potential in-commuters from adjacent regions are considered.

Socio-Economic Indicators submodel

Total GDP and employment represent only the supply side of regional socio-economic development. To derive policy-relevant indicators, they have to be related to the demand side, i.e. to population and labour force. This is done be calculating total regional GDP per capita and regional unemployment. Since accessibility, besides being a factor determining regional production, is also an indicator of regional locational advantage and quality of life, accessibility indicators are considered a policy-relevant output of the model.

In addition, the SASI model calculates macro indicators measuring the spatial distribution of economic activity and settlements within Europe or within individual countries or regions:

- Cohesion indicators measure the degree of equality or inequality in accessibility or GDP per capita.
- Polycentricity indicators measure the degree of polycentricity of urban systems.

The methods used to calculate cohesion and polycentricity indicators are presented in Sections 3.5 and 3.6, respectively.

3.1.2 The Model Database

The SASI model requires three types of data: data required for the calibration, of the model, data required for the validation of the model and data required for each simulation run.

Calibration data

Calibration data are data needed for calibrating the regional production functions in the *Regional GDP* submodel, labour productivity in the *Regional Employment* submodel and the migration function in the *Regional Population* submodel. The four calibration years 1981, 1986, 1991 and 1996 are used to gain insights into changes in parameter values over time. The following data groups were collected or estimated where unavailable.

Regional data (1,321 regions)

Regional GDP per capita by industrial sector 1981, 1986, 1991, 1996
Regional labour productivity by industrial sector 1981, 1986, 1991, 1996
Regional endowment factors 1981, 1986, 1991, 1996
Regional labour force 1981, 1986, 1991, 1996
Regional transfers 1981, 1986, 1991, 1996

Network data

Node and link data of strategic road network in 1981, 1986, 1991, 1996
Node and link data of strategic rail network in 1981, 1986, 1991, 1996
Node and link data of air network in 1981, 1986, 1991, 1996

Validation data

Validation data are reference data with which the model results between the base year and the present are compared to assess the validity of the model. Validation is preferable over calibration where processes simulated in the model are unobservable because of lack of data. Validation can be used to experimentally adjust model parameters that cannot be calibrated until the model results match available aggregate data. The following data were collected or estimated where unavailable:

Regional data (1,321 regions)

Regional population (by age and sex) 1981, 1986, 1991, 1996, 2001
Regional GDP (by industrial sector) 1981, 1986, 1991, 1996, 2001
Regional labour force (by sex) 1981, 1986, 1991, 1996, 200
Regional employment (by industrial sector) 1981, 1986, 1991, 1996, 2001
Regional unemployment rate in 1981, 1986, 1991, 1996, 2001

Simulation data

Simulation data are the data required to perform a typical simulation run. They can be grouped into *base-year* data and *time-series* data:

Base-year data describe the state of the regions and the strategic transport networks in the base year. Base-year data are either regional or network data and are identical with the data for 1981 used for calibration. Time-series data describe exogenous developments or policies defined to control or constrain the simulation. They are either collected or estimated from actual events for the time between the base year and the present or are assumptions or policies for the future.

Time-series data must be defined for each simulation period, but in practice may be entered only for specific (not necessarily equidistant) years, with the simulation model interpolating between them.

European data (29 countries)

Total European GDP by industrial sector, 1981-2021
Total European immigration and outmigration, 1981-2021

National data (29 countries)

National GDP per worker by industrial sector, 1981-2021
National fertility rates by five-year age group and sex, 1981-2021
National mortality rates by five-year age group and sex, 1981-2021

National immigration limits, 1981-2021
National educational attainment, 1981-2021
National labour force participation by sex, 1981-2021

Regional data (1,321 regions)

Regional endowment factors, 1981-2021
Regional transfers, 1981-2021

Network data

Changes of node and link data of strategic road network, 1981-2016
Changes of node and link data of strategic rail network, 1981-2016
Changes of node and link data of air network, 1981-2016

3.1.3 Model Calibration

The regional production functions were estimated by linear regression of the logarithmically transformed Equation 3.5 for the 1,321 internal regions and the six industrial sectors used in IASON for the years 1981, 1986, 1991 and 1996. The dependent variable is regional GDP per capita in 1,000 Euro of 1998.

Because of numerous gaps and inconsistencies in the data, extensive research was necessary to substitute missing or inconsistent data by estimation or by analogy with similar regions. In particular for the accession countries in eastern Europe, which underwent the transition from planned economies to market economies, information on regional GDP was inconsistent or completely missing. It was therefore necessary to substitute regional GDP data for the years 1981 to 1991 for all regions by backcasts from 1996 regional GDP by sector based on overall sectoral GDP growth between 1981 and 1996, thus creating a fictitious past with only 1996 regional GDP as real data.

The independent variables of the regressions were a large set of regional indicators of potential explanatory value from which the following were selected:

*sgdp**n***	Share of GDP of sector ***n*** (%)
*gdpw**n***	GDP per worker in sector ***n*** (1,000 Euro of 1998)
acct	Accessibility rail/road/air travel
acctf	Accessibility rail/road/air travel and rail/road freight
rlmp	Regional labour market potential (accessibility to labour)
soilq	Soil quality (yield of cereals in t/ha)
pdens	Population density (pop/ha)
rdinv	R&D investment (% of GDP)

eduhi Share of population with higher education (%)
quali Quality of life indicator (0-100)

Data on European or national subsidies originally included in the set of explanatory variables (see Equation 3.5) were eventually excluded because of the multiplicative nature of the regional production functions – they had the effect that estimated GDP per capita in regions without subsidies went to zero. To take account of the slow process of economic structural change, independent variables *sgdp**n*** and *gdpw**n*** are lagged by five years; all other independent variables are lagged by one year, i.e. the most recent available value is taken. Because no data are available for years before 1981, no lags are applied for 1981.

Table 3.1 shows the regression coefficients for the selected variables for 1996, and Figure 3.2 compares observed and predicted GDP per capita in services for the 1,321 regions in 1996. Given the large number of regions and the exclusion of region size by the choice of GDP per capita as dependent variable, the results are very satisfactory. GDP per capita in services is underpredicted in industrial cities with universities in Germany, Darmstadt (DE711) and Erlangen (DE252), and the core cities of two large metropolitan areas, Berlin (DE301) and München (DE21H). The regression parameters for 1996 were used for the simulation.

Table 3.1 SASI model: calibration results

Variables	Regression coefficients					
	Agriculture	Manufac-turing	Construc-tion	Trade, tourism, transport	Financial services	Other services
sgdpn	0.593078	0.945329	0.854567	0.988154	1.352444	0.856616
gdpwn	0.534609	0.767691	0.813972	0.817103	0.277778	0.873002
acct	0.059524			0.079135	0.351658	0.186729
acctf		0.089031	0.200961			
rlmp		0.009814				
soilq	0.029439					
pdens	-0.096862			0.017962		
rdinv		0.118710				
eduhi		0.042143				0.097539
quali				0.389184		
Constant	-0.162314	-0.495868	-1.673584	-0.107157	0.006541	-1.129410
r^2	0.610	0.616	0.561	0.643	0.613	0.741

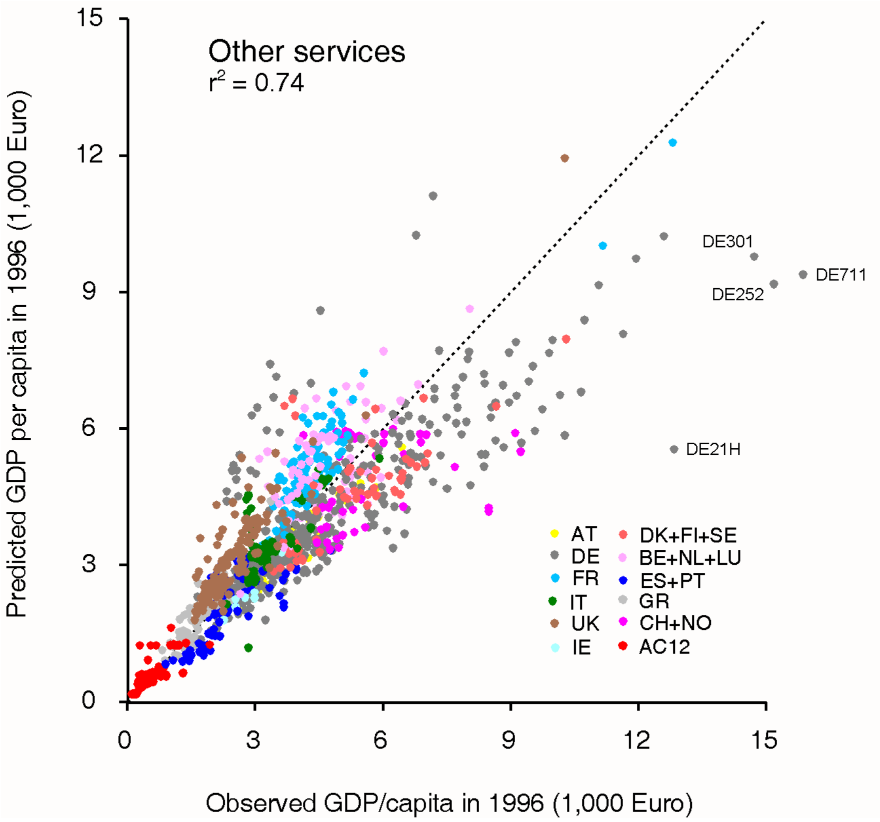


Figure 3.2 SASI model calibration results: GDP/capita in services in 1996

3.2 CGEurope Model

3.2.1 Model Design

CGEurope is a spatial general equilibrium model covering the whole world, subdivided into 1373 regions. Those include 1321 of 1329 Nuts-3 regions of the ESPON space. The remaining eight regions, of which 2 are in Portugal, 2 in Spain, and 4 in France have not been analysed, because they are remote regions, only loosely connected to the European transport networks. The model is comparative-static, which means that for each scenario analysis two equilibria are compared. One can be referred to as a "with-world", where the respective scenario projects are in place. The "without-world" on the other hand shall denote the status-quo situation, with transport networks and pricing to remain unchanged.

In each region there is assumed to be a set of households, owning a bundle of immobile production factors which is used by regional firms for goods production. We distinguish between two types of goods, locals and tradables. Local goods can only be sold within the region of production, while tradables are sold everywhere in the world, including the own region.

Producers of local goods use factor services, local goods itself and tradables as inputs. The output of locals is assumed to be completely homogeneous, and is produced under constant returns to scale. Firms take prices for inputs as well as their output as given, while they do not make any profits. Instead of directly selling their products to households or other firms, they can use it as the only input needed to produce tradables. The respective technology is increasing returns to scale. Tradable goods are modelled as being close but imperfect substitutes, following the "Dixit-Stiglitz" approach. For producers of tradables, only input prices are given, while the output price can be set under the framework of imperfect competition. Due to free market entry, however, profits are driven to zero, as they are in the market for locals.

Households are assumed to act as utility maximizers, taking all prices as given. Utility emerges from consumption of local goods and a composite of tradables, consisting of all, regionally produced and imported variants. Utility is modelled such that households appreciate a higher number of variants of tradables. The same income spent on more available variants means a higher utility for the households. In other words, they share a "love of variety". Households are assumed to spend all their disposable income in the respective period, not saving anything for future consumption. This means on the other hand, that we do not take capital accumulation into account. Investments are regarded as pure consumption, and are therefore subsumed under households' expenditures. The same holds true for public expenditures. Since we do not model a separate public sector, those expenditures are also assigned to the households. Thus, regional final demand is equal to regional households' consumption. The respective disposable income stems mainly from returns on regional production factors, which, as mentioned above are completely immobile and exclusively owned by regional households. As a consequence of perfect price flexibility, the regional factor supply is always fully employed. Apart from factor income, disposable income contains a positive or negative net transfer payment from the rest of the world, depending on whether the regional current account with respect to all other regions has a surplus or a deficit. This transfer is held constant in our simulations.

Trade of goods between regions is costly. To transport a good from A to B, requires resources of two kinds, namely (1) information and service costs, and (2) transportation costs, including costs for logistics. The former are assumed to come in form of costs for passenger travel. The cost amount of both kinds per unit of traded good is a function of the state of infrastructure, and an extra cost is added for international flows, representing tariffs as well as non-tariff barriers like language barriers, industry norms, and cost for cross border communication.

3.2.2 The Database for CGEurope

The model is calibrated for the base year 1997. For each region the respective nominal GDP, population and area is needed. These data have been collected from the Eurostat REGIO CD and the ESPON database. Furthermore matrix data is needed in the form of trade flows in nominal values in Euro from each country to each other. These data have been obtained from Feenstra (2000), who published a large consolidated dataset of imports and exports between all countries worldwide based on the World Trade Analyser (WTA) assembled by Statistics Canada over the period 1980-1997. Furthermore, information on bilateral trade flows have been obtained from OECD data and partly national sources for the CEEC.

Distance data is used for the calibration of the model. These data are calculations of transport cost based on the network database of S&W, which contains data for all major links in Europe, including their specific characteristics of speed limits and likelihood of congestion. To calculate transport cost, we introduce two cost components for trade costs: costs related to geographic distance and costs for overcoming impediments to international trade. If a pair of regions belongs to different countries, then the tranfer costs between these regions are increased by a specific mark-up factor for this country pair.

The costs related to geographic distance are both functions of time as well as distance. Both represent the most important cost components in travel. In road transport, for example, the distance related cost components represent fuel, lubricant, and maintenance of the transport vehicle. The time component includes mainly the wage for the driver and salary and/or opportunity cost of the business traveller. The time dependent component is unified for all regions. The parameter values for both components that we use are those that have been determined in the SCENES project[6] of the 4th RTD Framework Programme. For the time dependent component of the cost the weighted average over all countries has been used instead of a differentiated wage level for all countries.

[6] See SCENES (2000), pp.38-42

Transport cost are differentiated for all three transport modes road, rail and air transport, as well as two travel purposes, freight transport and business travel. Compared to the stage of the project presented in the Third Interim Report, a slight but important change has been made with respect to the definition of road transport. This mode now also includes waterway links, and is therefore supposed to give a more realistic picture of actual transport cost in road traffic. Based on the cost information, the shortest paths from each region to each region are calculated by a shortest route algorithm for the base year of each scenario. These shortest routes mean those routes, which are the least costly to get from the centroid of source region to the centroid of the destination region.

Transfer costs for goods flows are assumed to incur two types of costs, namely freight costs and costs of personal contacts for exchanging business information. These costs are measured as costs of passenger business travel. Both types of costs, freight costs as well as passenger travel costs are multimodal costs, composed of costs for road, rail and air. It is assumed that users choose between modes according to a logit choice model, which is the standard and well established approach in mode choice modelling. Parameters of that logit approach are chosen such that observed mode shares can be reproduced. This gives rise to a matrix of multimodal (logsum) cost for each pair of regions.

A mark-up factor for international trade is introduced, representing additional impediments in international trade. These additional cost include tariffs, and more important, all costs stemming from non-tariff barriers, like costs due to language differences, costs for bureaucratic impediments and time costs spent on at border controls. Trade impediments are determined during the calibration of the model. They are calculated such that the observed international trade flows equal the corresponding aggregates of trade flows between the regions of the two respective countries. These trade impediments are determined specific for each country pair.

3.2.3 Model Calibration

Calibrating the model means to assign concrete numbers to each parameter and exogenous variable such that the equilibrium solution reproduces the observed data.

However, this cannot provide all required parameters. Some parameters are taken from the literature, from statistical sources or from reports of similar research projects like SCENES. Regarding travel demand the position parameters are chosen such that travel information in the SCENES database are reproduced. The cost shares of the overall transport costs of freight and passenger travel are chosen such that the average cost shares for transport and logistics of firms in the EU are reproduced

3.2.4 Model Output Indicator

The evaluation of policy scenarios within CGEurope is based on a comparative-static analysis. This means that one compares two hypothetical worlds, a "with-world" assuming that the respective policy (infrastructure or pricing) is in place, and a "without-world" assuming it is not. Those two worlds correspond to two equilibria that differ only with respect to the transport cost scenario, while everything else is held constant.

The basic idea of how the simulation works is quite simple. After the calibration of CGEurope, we have the necessary parameters to explain the optimal behaviour of households and firms, depending on the prices. Starting from the initial equilibrium, a scenario will lead to a change of transport costs, caused by the respective change in the transport networks or pricing. The establishment of new transport links, for example, will directly reduce the prices paid by firms and households in a region, depending on how much it is economically connected to those regions which have now become more integrated. In the long run, the price changes will lead to regional market entry and exit, so that the regional income as well as the number of available variants will change. Those adjustments continue, until a new equilibrium is reached. The indicator of comparison is the utility change of households, brought about by a change in income in prices and in the access to product diversity. This utility change is translated into a monetary equivalent, which either can be expressed as an absolute per capita amount (€ per capita), or as a percentage of GDP in the reference situation. Loosely speaking, one may regard the relative impact as a percentage real income change.

These effects that are modelled are therefore generative effects of the change in transport infrastructure, whereas there are different models, as SASI which model distributive effects of policies, assuming that the overall effect of the implementation of infrastructure projects does not produce additional income in the European area, but changes its distribution.

It is important to note, that the way of financing the specific road projects is not considered in the analysis. The calculated impact isolates the effect from using the infrastructure, neglecting those from financing it. Therefore, the impact of the taxation and further financing of the transport projects is out of the scope of the analysis, as it would need further information on how the projects are funded in each region. Especially in tax-financed projects, it is difficult, if not impossible, to obtain information on financial sources and their spatial distribution. A similar caveat has to be made for the pricing scenarios: we neglect effects from redistributed revenues.

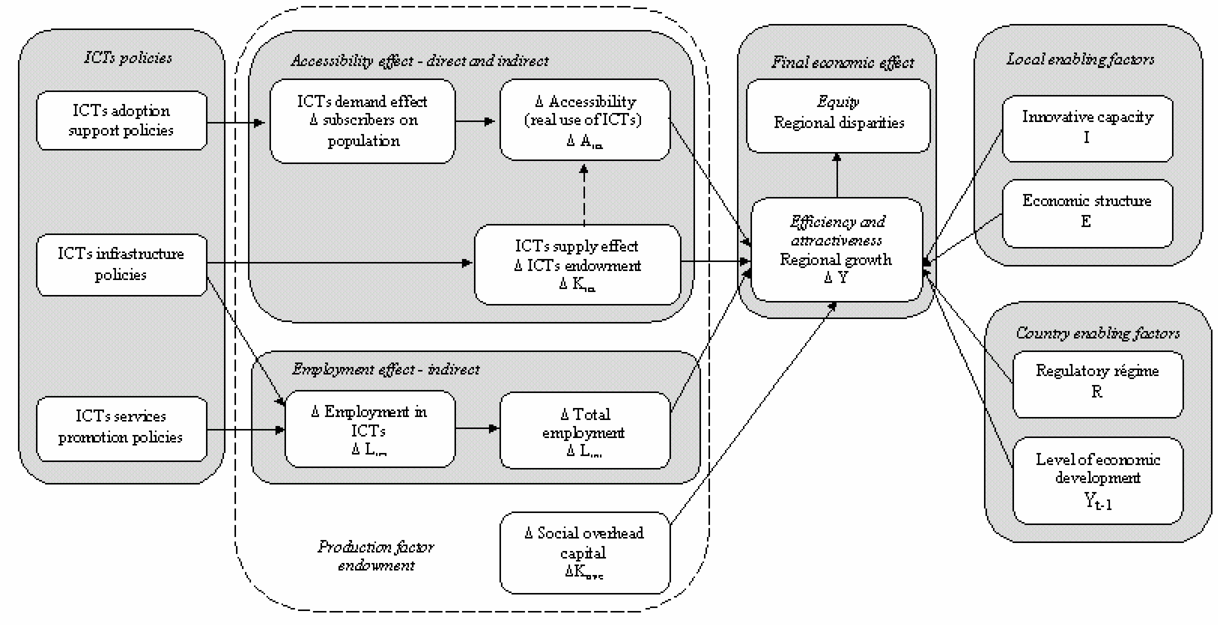
3.3 STIMA Model

3.3.1 The Conceptual Framework of the STIMA Model

The purpose of this section is to build an interpretative model to analyse the impact of ICT endowment and use on economic growth.

The conceptual framework of our STIMA (Spatial Telecommunications IMpact Assessment) model for ICTs spatial economic impact assessment is presented in Figure 3.3.

Figure 3.3 The STIMA model



From a conceptual point of view, the framework of the STIMA model is based on the idea that ICTs infrastructures and services are production factors which, together with the traditional labour and capital factors, account for the GDP level. Therefore, a change in ICT investments produces a change in ICT endowment which enters the production function and estimates changes in the per capita or absolute GDP growth rate.

Moreover, the linkage between ICTs adoption, ICTs innovative use and GDP is guaranteed by the presence of some "enabling factors", at both national and local level. The enabling factors that we envisage concern the *general level of economic development* of the Country analysed, the *regulatory régime* that characterises the ICTs market in the Country, the *economic structure* and the *innovative capacity* of the local area.

From the methodological point of view, the STIMA model, as introduced in the SIR, is based on the estimate of a *production function* (Biehl, 1986) to measure the role that ICTs play in regional performance.

Our aim is to assess the impact of ICTs from the point of view of efficiency and cohesion, the two EU most important policy goals. As a measure of efficiency, we use the regional income level and growth (per capita); as a measure of equity, we will use GINI coefficients and the corresponding Lorenz curve. Differences in relative regional per capita GDP growth (i.e.

regional per capita GDP growth rate with respect to the European growth rate), generated by the impact of different policies, will also be calculated.

The STIMA model estimates the following production function:

$$Y_{rt} = f\,(L_{TOTrt},\ K_{OVErt},\ K_{ICTrt},\ A_{ICTrt},\ I_{rt},\ E_{rt},\ Y_{r(t-1)},\ R_{rt}) \qquad (3.23)$$

which summarises the conceptual framework presented in Figure 3.3: regional income level (Y_{rt}) depends on the level of production factors available locally and on the presence of the enabling factors. In our methodology, the production factors are threefold: two traditional production factors - labour (L_{TOTrt}) and social overhead capital (K_{OVErt}) - and a particular production factor, strictly linked with ICTs endowment and use, i.e. *accessibility*. The latter is measured in terms of telecommunications infrastructure endowment (K_{ICTrt}) and telecommunications intensity of use (A_{ICTrt}). A wide conceptual difference exists between the two accessibility measurement indicators: the former measures the ICTs endowment, since it represents the supply of ICTs infrastructures and not necessarily the real use, while the latter is what we label "accessibility", since it measures the real use of these technologies.

Equation (3.23) also contains the enabling factors which are necessary to understand the relationship between ICTs and regional development, as discussed in the previous section: I_{rt}, E_{rt}, $Y_{r(t-1)}$, R_{rt} represent respectively the innovative capacity, the economic structure, the regional growth and the ICTs regulatory régime; all influence the impact that ICTs have on economic development.

This section outlined the conceptual framework of the STIMA model, and identified the conceptual "boxes" that we have to fill with indicators. In order to choose the best indicator for each concept, we have first to describe the available data. The next section is devoted to this purpose.

3.3.2 The STIMA Model: the Database

Our database covers two main areas: the economic indicators and the ICTs. For the economic indicators, our main source is the Eurostat REGIO theme. These data cover many different areas: GDP, employment, patents, human resources in high tech sectors, population. Moreover, data are in most cases at least 5-year time series.

As stated also in the previous reports, the availability of data on ICTs disaggregated at territorial level has always been a problem. SIR and TIR have been based on data from a survey commissioned by the European

Commission to EOS Gallup[7]. The present report is instead based also on data from the updated survey commissioned by the European Union to INRA, which contains 2002 ICTs data[8]; like EOS Gallup, INRA 2003 survey is by far the largest and most updated survey at a European level that has been undertaken in the sector, and covers only the 15 EU member states, so we have no data on Eastern European countries. Like EOS Gallup, it contains data at NUTS2 level.

The estimate of STIMA is still run on the basis of EOS Gallup 1999. In fact, given the non availability of GDP at NUTS2 for 2002, it would have been misleading and un-precise to look for a relation between the stock of available ICTs infrastructure in 2002 and GDP obtained in previous years. We therefore preferred to keep the estimate model on 1999 data, given also the consideration that the model estimates structural relationships, which do not change over three years. The new available data become instead useful in estimating an updated marginal efficiency of investments and therefore enter the scenario building. The marginal efficiency of investment is in fact estimated using the stock of cumulated financial capital in ICTs in the period 1990-2000; it is therefore more precise to calculate the marginal efficiency of investments on 2002 infrastructure data, when available.

Regions are divided into lagging and non-lagging regions, following the criteria expressed by the European Commission for the definition of Objective 1 NUTS-2 regions for the period 2000-2006[9]. The Objective 1 regions should meet one of the following requirements:

- GDP < 75% of EU average;
- most remote regions (DOM-TOM, Azores, Madeira, Canaries);
- very low population density (old Objective 6 areas - in particular the Scandinavian regions).

The database we built is able to cover all aspects involved in STIMA, thanks to the availability of variables at NUTS2 level (about 200 regions).

7 EOS Gallup (1999).

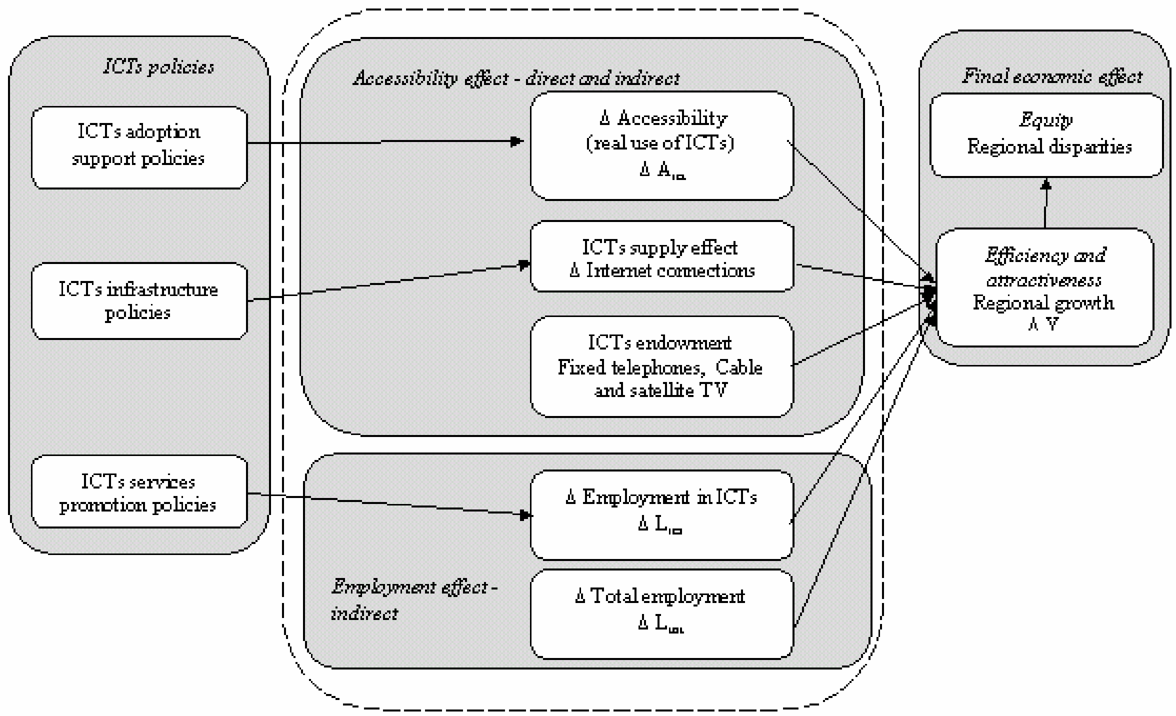
8 INRA (2003).

9 European Commission, 1999.

3.3.3 The STIMA Model: Indicators

Given the data availability, the indicators used in STIMA are presented in Figure 3.4.

Figure 3.4 The estimated STIMA model



With respect to the conceptual framework, some variables have been ignored, given the low quality or inexistence of data; it is the case, for example, of social overhead capital. However, their absence does not change the interpretative power of ICTs variables and therefore does not interfere with our final results.

As a measure of ICTs, several indicators are available at NUTS-2 level[10]: the number of Internet connections, the number of cable and satellite TVs, fixed telephony penetration, expressed by the percentage of households equipped with these technologies. Each indicator reflects a different level of technological endowment, from traditional telephone networks to advanced networks, such as Internet connections and cable and satellite TV. We avoided to build a single indicator, and left different ICTs indicators separate, in order to have a more detailed view on their role in GDP creation.

[10] EOS Gallup (1999) and INRA (2003).

Most indicators are represented by a specific variable, with the exception of accessibility, for which a more complicated indicator, than a simple variable, has been built.

Accessibility

Accessibility, or better "virtual accessibility", is an indicator we built on the basis of a gravitational model, adapted from Newton's universal gravitational law. In our model the population is used as mass, and "the share of households using Internet as an e-commerce vehicle" is used as an exponential to distance, as a deterrence to spatial friction[11], i.e. the larger the use, the less important the physical distance, as follows:

$$A_{ICTrt} = (S_s \ P_{st} \ / \ d_{sr}^{grt}) \qquad (3.24)$$

where:

A_{ICTrt} = accessibility of region r in year t

r, s = regions

P_{st} = population of region s in year t

d_{sr} = distance in km between region s and region r $\forall$ s $\neq$ r
(if s=r, d_{sr} is assumed to be = 1, because division by zero is not allowed)

g_{rt} = spatial friction between r and s, measured by the inverse of the intensity of ICTs use

u_{rt} =1/g = percentage of households using the Internet as e-commerce vehicle (available only for 1999)

3.3.4 ICTs Scenarios: Forecasting Methodology

Based on some hypotheses on the distribution of EU financial resources among regions and among possible policy scenarios (see section 2.4.2), the model presented in the previous section is able to provide an estimate of future GDP growth at 2020 and of its spatial distribution.

Our forecasting methodology can be summarised in a chart showing the different steps of the methodology (Figure 3.5). The first step is to build an indicator of the level of European countries investments in ICTs; for this purpose, first of all the sum of the ITU data on national investments in ICTs from 1990 to 2000 in the 15 EU member states, at 2000 prices is calculated.

Assuming that the EU financial effort in this field in the next 20 years will be equal to 2% of total investments by 15 EU member states, the financial resources will be around 20 billions euro[12]. The hypothesis of 2% has been chosen on the basis of some considerations on previous EU financial efforts in ICTs and on considerations that the financial resources will have to be

[11] See EOS Gallup (1999) for detailed maps.

[12] See section 4.1.4. for details on calculation.

distributed also to accession countries[13]. The amount, multiplied by 20, provides a 20-year investment amount (2nd step).

The total EU investment is distributed to regions in different ways in the different scenarios according to the hypotheses presented in sec. 2.3 (3rd step).

The 4th step concerns the estimate of the marginal efficiency of ICTs factors in which ICTs policies act (Internet connections, accessibility, high tech employment). Regression models between the ICTs infrastructures and capital invested in ICTs have been run. Capital invested in ICTs has been calculated by cumulating the investments 1990-2000 at 2000 prices[14]. The results of the three regressions will be presented in section 4.1.3. For internet connections, the marginal efficiency has been calculated on the basis of the new INRA 2003 data.

Once the marginal efficiency of investment, calculated for the different actions, has been multiplied by the regional investments level allocated to each region and each action, the increase in levels of Internet connections, accessibility and high tech employment is obtained (5th step). Starting from these new data, we are able to forecast per capita GDP at 2020 in the different scenarios (6th step), and to evaluate it from the point of view of efficiency and equity (7th step)[15]. Finally, it is possible to create a typology of regions according to the different impact of ICTs policies (8th step)[16].

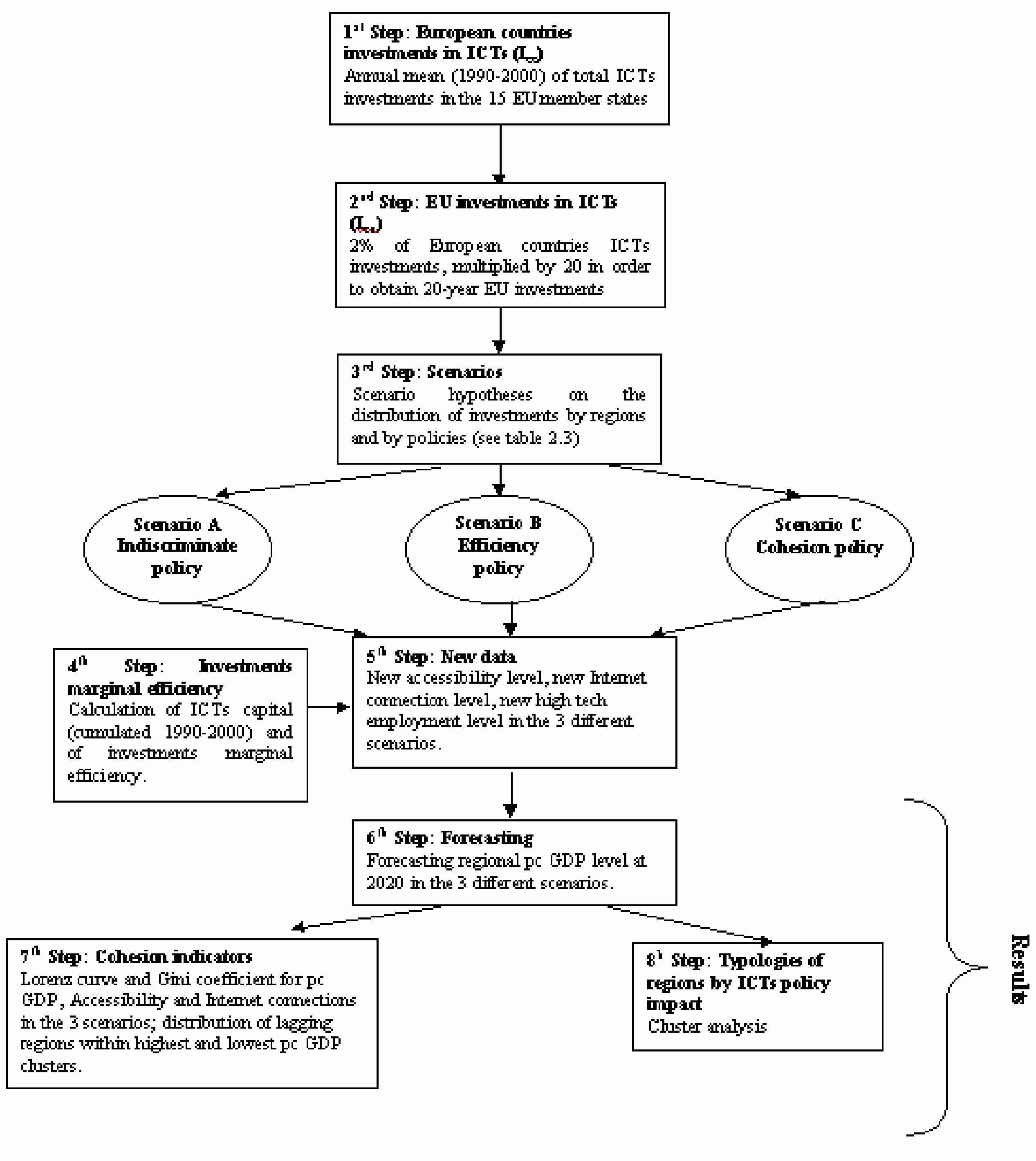
[13] The EU financial effort in the field of ICTs in the past is quantified around 4% of total European Countries financial investments. If the amount of resources devoted by the European countries to ICTs (due to small investments by the new accession countries) remains stable, the percentage of EU investments to the 15-member states will be reduced by half, given the entrance of the new accession Countries.

[14] We adopted here the technique used by the Italian Industrial Association (Confindustria) to calculate the financial capital invested.

[15] The results of the forecasting exercise will be presented in section 4.1.3, as well as the efficiency indicators. The cohesion indicators will be analysed in section 4.2.

[16] The typology of regions is obtained through a cluster analysis. See sec. 4.1.3.

Figure 3.5 Forecasting methodology step by step



3.4 Development Potential

3.4.1 Polycentric Development

Polycentric development has emerged as a key concept during the European Spatial Development Perspective (ESPD) process. In the ESPD (European Commission, 1999, p 20) this is motivated in the following way: "The concept of polycentric development has to be pursued, to ensure regionally balanced development, because the EU is becoming fully integrated in the global economy. Pursuit of this concept will help to avoid further excessive economic and demographic concentration in the core area of the EU."

3.4.2 Development Potential

The concept "development potential" has been used in analyses of the role of infrastructure in regional development and for characterising urban regions during recent decades. Biehl (1991) used indicators for infrastructure supply, location, agglomeration and sectoral structure to explain regional income of European regions. In the "Study on the construction of a polycentric and balanced development model for the European territory" (CPMR, 2002), key conditions for polycentric development were measured by a set of indicators representing mass, competitiveness, connectivity and development trend. Subsets of these indicators were used to produce typologies of urban systems in peripheral European regions. Similar types of indicators have been used by ESPON 1.1.1 for synthesising typologies of Functional Urban Areas (FUAs) and Metropolitan European Growth Areas (MEGAs).

3.4.3 Methodology

A methodology for analysing impacts on polycentric development of EU transport and TEN policies has been developed. Building on the tradition of analysing key conditions for development, it combines indicators for the dimensions *mass*, *competitiveness*, *connectivity* and *development trend* into a composite indicator of *development potential*. This composite indicator is used to compare the impacts of transport policy scenarios on development potential at the NUTS 3 territorial level. By analysing the spatial pattern of these impacts, the effects on the potential for polycentric development may be indicated. This methodology for illustrating polycentricity effects is strongly related to the CPMR and ESPON 1.1.1 approaches for producing urban typologies but is adapted to the output available from the models used in ESPON 2.1.1. It has been an explicit aim to develop a methodology, which is as consistent as possible with concepts and approaches of other ESPON projects, in particular ESPON 1.1.1.

3.4.4 Indicators

The following four indicators have been selected on the basis of relevance and availability of endogenous model results (for retrospective or prospective scenarios, respectively):

Mass: population density in the horizon year (2001 or 2021)

Competitiveness: gross domestic product (GDP) per capita in the horizon year (2001 or 2021)

Connectivity: multimodal accessibility in the horizon year (2001 or 2021)

Development trend: difference in GDP/capita between the horizon year and the base year (2001 and 1991 or 2021 and 2001)

Each indicator is measured at the NUTS 3 spatial level and computed from the results of the SASI model. The values of each indicator in each scenario are normalised by the their respective maximum values in the reference scenario (A0 for the retrospective analysis and 00 for the prospective analysis) and multiplied by 100. Hence, for the relevant reference scenario each indicator obtains positive values for each NUTS 3 area with a maximum value of 100. For the other scenarios the maximum values can deviate from 100.

For each scenario a composite indicator of development potential is computed:

Development potential: geometric average of the values of the four indicators (mass, competitiveness, connectivity and development trend).

The development potential is calculated for each of the 1321 NUTS 3 areas. Absolute and relative differences in development potentials between any policy scenario and the relevant reference scenario are used to illustrate the effects of specific policies.

The results are discussed in Section 4.1.4. Impacts of policies on the development potential are reported. The spatial patterns of these impacts are displayed in map form and the shares of impacts related to the European core region and to an urban/rural typology are calculated. Some comparisons with model results in terms of relative welfare or GDP/capita are outlined. The cohesion effects in absolute and relative terms are discussed in Section 4.5, where also the degree of conflict between cohesion and efficiency ambitions is analysed.

3.5 Cohesion Indicators

3.5.1 Introduction

There are various cohesion aspects associated with the policy measures studied in this report. One can look at the effects of the measures themselves and study the differences in these effects among regions or groups of regions. One can also look at the relation between these effects and the existing situation with respect to cohesion. In this report both aspects will be considered. In the present section we will introduce and discuss the set of indicators that can be used for this purpose, while in section 4.1 their application to the model results will be dealt with.

A basic question that can be asked about cohesion indicators is: why do we need them? The models that are used in this study make forecasts about the effects of various TEN scenarios on the level of European regions (NUTS2 or NUTS3). These forecasts contain detailed information about the expected effects of the policy measures. What else do we need? Some of this information is inevitably thrown away if it is summarised in cohesion indicators.

The answer to this fundamental question is, however, that cohesion indicators allow one to summarise the most useful aspects of the model output with respect to cohesion in a few numbers. It is impossible to deal with all the information in a direct way. For instance, the SASI and CGE models refer to 1321 NUTS3 regions and 13 policy scenarios and the human brain is unable to deal with the large number (13 times 1321) of figures involved. Summary measures are therefore necessary. This does not mean that the detailed information is, in some sense, worthless. In order to compute the cohesion indicators we need all this detailed information. The summary measures can be interpreted as concentrating one aspect of this information into a single number.

Before proceeding now to a discussion of the cohesion indicators to be used, we make to general remarks. The first concerns the level of regional detail. The basic material (model output) from the SASI and CGEurope models that we use refers to the regions of the fifteen original (before 2004) EU countries, the twelve former candidate countries that are now new members and the regions of Switzerland and Norway. These models use the NUTS3 level of regional detail (1321 regions for the whole area concerned). The STIMA refers to the 15 original members states and uses the NUTS2 level (282 regions).

The second remark concerns a methodological point of view. When computing the indicators we have throughout taken the point of view that the basic units to which we refer are persons. That means, for instance, that if we compute an average effect of a policy measure, it refers to the average person in the original member states, the new member states, et cetera. Since the basic material produced by the models refers to regions, we have to calculate the indicators as if all inhabitants of a region are alike.

What follows in this section is a general discussion of the cohesion indicators that will be used in chapter 4. The discussion will be informal, in the sense that no mathematical formulas will be presented.

3.5.2 Simple Cohesion Indicators

Cohesion indicators are macroanalytical indicators combining the indicators of individual regions into one measure of their spatial concentration. Changes in the cohesion indicators predicted by the model for future transport infrastructure investments reveal whether these policies are likely to reduce or increase existing disparities in those indicators between the regions. Two dimensions are relevant if cohesion indicators are to be compared:

- The first dimension is the area considered. Cohesion at the European level means a reduction of economic disparities between the rich regions in the European core and the poorer regions at the European periphery or, after the enlargement of the EU, between the old and new member states. Cohesion at the level of level of meso-regions or individual countries looks at the economic disparities within these areas. Both types of cohesion may be in conflict.

- The second dimension is the cohesion indicator used. It has been demonstrated in ESPON 2.1.1 that different cohesion indicators give different results (Bröcker et al., 2004). Some commonly used indicators even indicate convergence, while divergence has occurred according to another indicator. One important distinction is whether the indicator measures relative or absolute convergence or divergence – if, for instance, all regions gain in relative terms by the same percentage, the richer regions gain more in absolute terms.

The SASI and CGEurope models calculate the following five types of cohesion indicator to measure the convergence or divergence of economic conditions under different scenarios:

- *Coefficient of variation*. The coefficient of variation is the standard deviation of region indicator values expressed in percent of their European average. The coefficient of variation informs about the degree of homogeneity or polarisation of a spatial distribution. A coefficient of variation of zero indicates that all areas have the same indicator values. The different size of regions is accounted for by treating each area as a collection of individuals having the same indicator value. The coefficient of variation can be used to compare two scenarios with respect to cohesion or equity or two points in time of one scenario with respect to whether convergence or divergence occurs.

- *Gini coefficient*. The Lorenz curve compares a rank-ordered cumulative distribution of indicator values of areas with a distribution in which all areas have the same indicator value. This is done graphically by sorting areas by increasing indicator value and drawing their cumulative distribution against a cumulative equal distribution (an upward sloping straight line). The surface between the two cumulative distributions indicates the degree of polarisation of the distribution of indicator values. The Gini coefficient calculates the ratio between the area of that surface and the area of the triangle under the upward sloping line of the equal distribution. A Gini coefficient of zero indicates that the distribution is equal-valued, i.e. that all areas have the same indicator value. A Gini coefficient close to one indicates that the distribution of indicator values is highly polarised, i.e. few areas have very high indicator values and all other areas very low values. The different size of areas can be accounted for by treating each area as a collection of individuals having the same indicator value.

- *Geometric/arithmetic mean*. 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*. 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 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*. This indicator is constructed as the previous one except that absolute changes are considered. The distinction between relative and absolute change is relevant from an equity point of view. If, for instance, as a consequence of a transport project a rich and a poor region gained both ten percent in GDP per capita, cohesion indicators would indicate neither convergence nor divergence; however, in absolute terms the rich region would gain much more than the poor region. It is even possible that a region is a winner in relative terms but a loser in absolute terms.

3.5.3 Welfare and Inequality

The inequality measures that have been discussed in the previous subsection were formulated only on the basis of their mathematical properties. For this reason they are sometimes referred to as axiomatic inequality indexes. There is an alternative approach to the measurement of inequality that is closely linked to economic theory. In that approach, inequality measures are derived from a particular concept of social welfare. The pioneering article of this alternative approach was Atkinson (1970) who defined a whole class of inequality measures on the basis of a social welfare function. Such a function defines the well- being of a group of persons on the basis of their individual utilities. The latter are often interpreted as money metric utilities, and can for many practical purposes be identified with per capita income or GDP.

The two approaches should, however, not be regarded contradictory, but rather be seen as complementary. For instance, Atkinson stresses the importance of the principle of transfers. This is an axiom, that states that the value of an inequality measure should decrease if a person transfers some of his or her income to someone with a lower income.[17] This principle gives a desirable property of an indicator of inequality, which is closely related to economic analysis. The principle can also be applied to social welfare function and then it requires that social welfare must increase if such a transfer takes place.

Atkinson concentrated attention on the class of social welfare functions that define this welfare as the sum of a power function of individual income over all persons. We will not consider this general class here, but focus on the special case for which welfare is defined as the sum of the logarithms of the individual incomes. It can be shown that this welfare function can alternatively be written as the sum of the logarithm of average income and the logarithm of the ratio between the geometric and the arithmetic means of the individual incomes. The significance of this result is that it decomposes welfare in to average income, which ignores distributional issues, and the ratio of the two means, which is an indicator of equality (see above). Each of these two terms thus refers to one of the two most important aspects of the welfare concept: efficiency and equity.

Welfare, as defined above, is the sum of the logarithm of average income and that of the ratio of the two means. Since this ratio is always smaller

[17] The transfer should leave their relative positions unchanged.

than 1, its logarithm is negative. It can therefore be interpreted as indicating how much welfare is lost because of the existing inequality.

A welfare indicator that is even easier to interpret results when one exponentiates the logarithmic indicator just discussed. The result can again be interpreted as a welfare indicator, but now welfare is defined as the product of two terms: the first is equal to average income, and the second is the ratio of the geometric and arithmetic means. This second term has a value between 0 and 1 and represents the negative effect of inequality on social welfare. The ‘cost’ of inequality can be determined from this indicator as the fraction of average income that is lost because of the inequality. We calculate the impact of scenarios on both, the welfare and the average income, using the results from the CGEurope model, in Chapter ... Both effects are measured in terms of € per capita.

3.6 Measuring and Forecasting Polycentricity

Polycentricity is one of the core concepts of ESPON. Following the European Spatial Development Perspective (ESDP), the promotion of a 'balanced polycentric urban system' is one of the most frequently cited policy objectives of the programme. The interest in polycentric development is fuelled by the hypothesis put forward in the ESDP that polycentric urban systems are more efficient, more sustainable and more equitable than both monocentric urban systems and dispersed small settlements.

Polycentricity is the main topic of ESPON 1.1.1 "The Role, Specific Situation and Potentials of Urban Areas as Nodes of Polycentric Development". Polycentricity is important for ESPON 2.1.1 because of the potential impacts of transport and ICT policies for cities and hence the polycentricity of urban systems. This section summarises the methodology for measuring polycentricity developed in ESPON 1.1.1.

The approach measures polycentricity by identifying three dimensions of polycentricity: the *size* or importance of cities (population, economic activity), their *distribution in space* or *location* and the *spatial interactions* or *connections* between them:

Size Index

The first and most straightforward prerequisite of polycentricity is that there is a distribution of large and small cities. It can be shown empirically and postulated normatively that the ideal rank-size distribution in a territory is loglinear. Moreover, a flat rank-size distribution is more polycentric than a steep one. Finally, a polycentric urban system should not be dominated by one large city. To operationalise this, two sub-indicators were defined: (a) the slope of the regression line of the rank-size distribution of population and (b) the degree by which the size of the largest city deviates from that regression line. When calculating the regression line, all but the largest city are considered. The primacy rate is interpreted as population dominance: a primacy rate above one indicates that the primate city is "too large" for the urban system of the country.

An alternative is to perform the same analysis not for population but for GDP. As with the rank-size distribution of population, two sub-indicators were defined: (c) the slope of the regression line of the rank-size distribution of GDP and (d) the degree by which the GDP of the city with the largest GDP deviates from that regression line. When calculating the regression line, all but the city with the largest GDP are considered. Here the primacy rate is interpreted as economic dominance: a primacy rate above one indicates that the primate city is "too rich" for the urban system of the country.

Location Index

The second prerequisite of a polycentric urban system is that its centres are equally spaced from one another – this prerequisite is derived from the optimal size of the market area of centrally provided goods and services. Therefore a uniform distribution of cities across a territory is more appropriate for a polycentric urban system than a highly polarised one where all major cities are clustered in one part of the territory.

A second step in the analysis of polycentricity is therefore to analyse the distribution of cities over space. One possible approach is to subdivide the territory of each country into service areas such that each point in the territory is allocated to the nearest centre – such areas are called Thiessen polygons. Thiessen polygons can be constructed by dividing the territory into raster cells of equal size and to associate each cell with the nearest urban centre. In this way the areas served by each centre can be measured and compared.

In the present analysis airline distance was used to allocate raster cells to centres. As measure of inequality of the size of service areas (e) the Gini coefficient of inequality already discussed in the section on cohesion indicators above.

Connectivity Index

A third property of polycentric urban systems is that there is functional division of labour between cities, both between higher-level centres and the lower-level centres in their territory and between cities at equal levels in the urban hierarchy. This implies that the channels of interaction between cities of equal size and rank, but in particular between lower-level and higher-level cities, must be short and efficient. It is obvious that this requirement may be in conflict with the postulate that cities of equal size and rank should be equally spaced over the territory.

There are principally two ways to measure connectivity. One is to measure actual interactions. Ideally, the analysis would reveal functional relationships between cities of equal size or rank and between cities of different size or rank in the urban hierarchy. Appropriate indicators of such interactions would be flows of goods or services, travel flows or immaterial kinds of interactions, such as telephone calls or e-mails. The second possibility is to measure the *potential* for interactions. Measures of interaction potential could be infrastructure supply, i.e. the level of road connections (motorways, roads) or the level of service of rail (number of trains) or air (number of flights) connections. An urban system with good connections between lower-level centres is more polycentric than one with mainly radial connections to the dominant capital. In polycentric urban systems also lower-level centres have good accessibility.

For measuring interaction potential, here the multimodal accessibility of FUAs calculated for ESPON 1.1.1 was used. Two sub-indicators were defined: (f) the slope of the regression line between population and accessibility of FUAs and (g) the Gini coefficient of accessibility of FUAs. The two sub-indicators have similar meaning: the flatter the regression line, the more accessible are lower-level centres compared to the primate city, and the lower the Gini coefficient, the less polarised is the distribution of accessibility.

Polycentricity Index

With the three component polycentricity indices, the Size Index, the Location Index and the Connectivity Index, a comprehensive Index of Polycentricity can be constructed.

For each sub-indicator a z-shaped value function was defined by specifying at which indicator value polycentricity is zero and at which it is one hundred. Within this range linear interpolation was performed; outside the range polycentricity is zero or one hundred, respectively. Table 3.2 shows the threshold values defined for each of the seven sub-indicators:

Table 3.2 Value functions of polycentricity sub-indicators

	Rank-size distribution of population		Rank-size distribution of GDP		Size of service areas	Population and accessibility	
	Slope (a)	Primacy (b)	Slope (c)	Primacy (d)	Gini (e)	Slope (f)	Gini (g)
Indicator value at which polycentricity is 0	–1.75	7.5	–1.75	10	70	75	25
Indicator value at which polycentricity is 100	–0.5	0	–0.5	0	10	0	0

Table 3.3 shows the weights for the composition of the Polycentricity Index from the three component indices. Additive aggregation was used at the lower levels, whereas the three component indices were aggregated to the Polycentricity Index multiplicatively.

Table 3.3 Composition of the Polycentricity Index

Index	Indicator	Weights	Weights
Size	Slope of regression line of population Primacy rate of population Slope of regression line of GDP Primacy rate of GDP	10% 40% 10% 40%	33%
Location	Gini coefficient of service areas	100%	33%
Connectivity	Slope of regression line of accessibility Gini coefficient of accessibility	50% 50%	33%

Forecasting Polycentricity

In ESPON 2.1.1 the method of measuring polycentricity developed in ESPON 1.1.1 was integrated into the SASI model to evaluate the transport scenarios examined with respect to their impacts on the polycentric urban systems in individual member states.

A methodological difficulty in forecasting polycentricity is that polycentricity is studied with *cities* as geographical units, whereas the SASI model is based on NUTS-3 regions. Therefore the following assumptions were made to bridge the gap between NUTS-3 regions and cities:

- *Size Index*. The population and GDP of a city change as the population and GDP of the NUTS-3 region in which it is located.
- *Location Index*. The number of cities and hence the number and size of service areas remain constant.
- *Connectivity Index*. The accessibility of a city changes as the accessibility of the NUTS-3 region in which it is located.

The results of the evaluation of transport policy scenarios with respect to their impacts on polycentricity are presented in Section 4.3.

3.7 Polycentric Links and Overloaded Corridors

The ESDP focuses on polycentric development. Hence, it is desirable to evaluate the impacts of TEN measures on the quality of connections between a prescribed set of centres within different levels of the hierarchy of central places. The first part of this section deals with *polycentric and balanced development* and urban-rural partnership. It gives an outline of an approach to evaluation that makes use of a selection of abstract links that connect central places all over Europe. The second part deals with *overloaded transport corridors*, the drawback of an improved transport infrastructure.

3.7.1 Polycentric Links

The first part of this analysis operates with a systematic and structured selection of links that connect places within the polycentric hierarchical system of centres all over the ESPON space. This set of links is to be analysed for accessibility deficits, the relation to regional economic backwardness and in particular for effects caused by improved accessibility standards related to transport policy scenarios.

Basic data set for the construction of priority links and the network evaluation links is the list of FUAs provided by the project ESPON 1.1.1 TPG. With the overall typology, European centres are grouped by the three main classes "MEGA city", "transnational/national city" and "regional/local city". Further key sources are the accessibility cost matrices calculated for different scenarios within the ESPON 2.1.1 project.

Table 3.4 FUA Centres

Centre level	**Number of centres**	**Number of centres incl. higher levels**
MEGA (European)	76	
Transnational/national centre	258	334
Regional/local centre	1,254	1,588

Centres and Polycentric Links

Each FUA centre carries the functions of lower-level centres. This rule makes up a net of reference points as a basis for the construction of links. These abstract links are defined by the relation of two end points.

Based on this framework of a three-level-centre typology, two kinds of abstract spatial priority links are generated from the geographical position and given accessibility conditions of settlements by following a recursive hub and spoke principle:

- links connecting one-level centres in urban networks (non-directional interconnections)
- links connecting centres of different, adjacent levels forming trade areas (directional connections)

The construction of links is technically realised by geometric criteria (selection of closest centres, construction of Thiessen polygons to identify neighboured centres) in combination with an allocation analysis based on travel times in both the road and the rail transport mode (incl. ferry links). Finally, the links are filtered for redundancies and plausibility due to long distances or sea crossing. An important construction rule is that every centre except the MEGAs is connected to at least one higher-level centre. If the best reachable centre in road or rail mode differs from the closest centre, additional links are included.

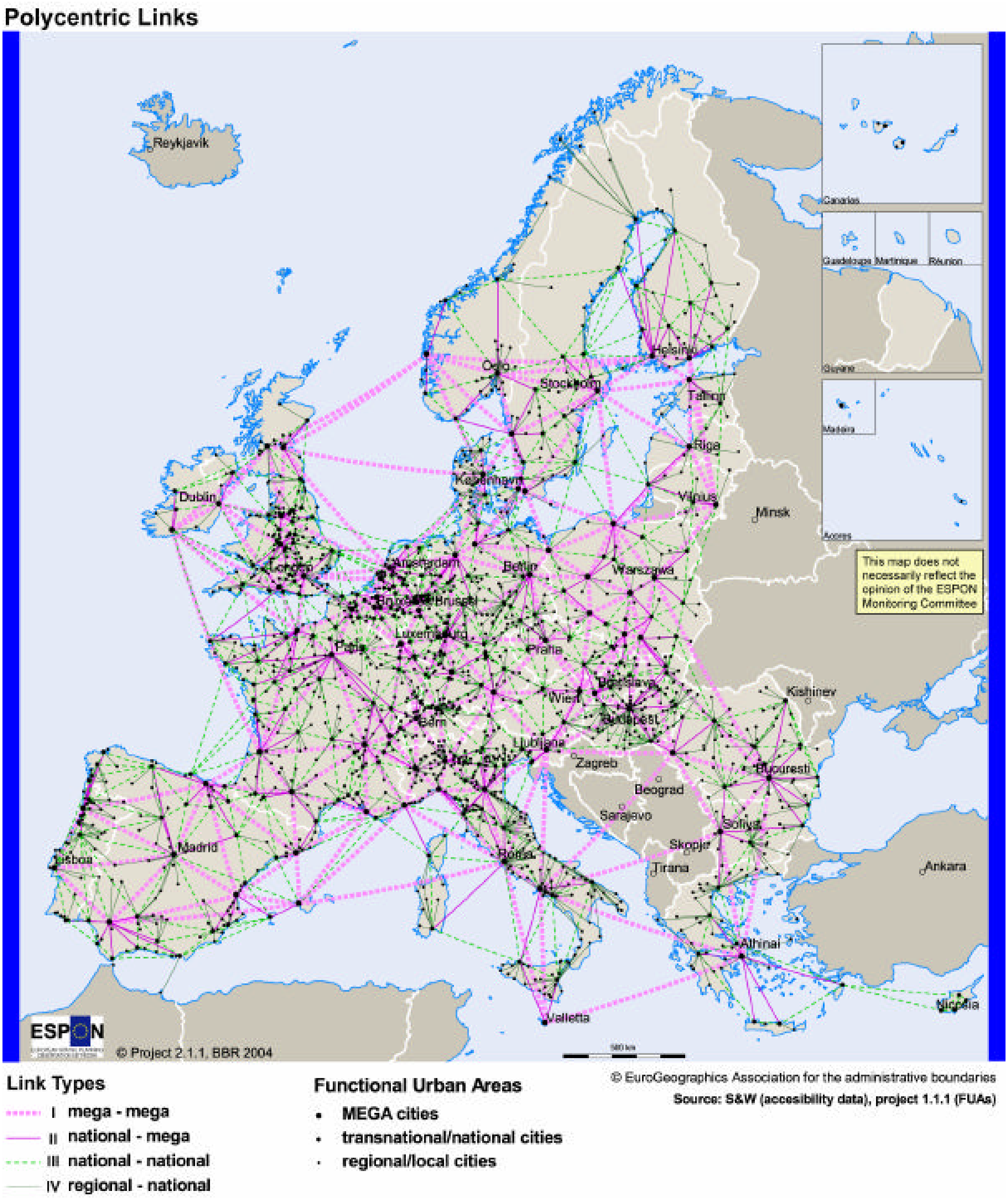
Table 3.5 Link Types

	Link type	Orientation	Cases
I	Connecting neighboured MEGA cities	Non-directional	209
II	Connecting transnational/national cities to MEGA cities	Directional	326
III	Connecting neighboured transnational/national cities	Non-directional	670
IV	Connecting regional/local cities to transnational/national cities	Directional	1,612

This procedure leads to a manageable subset of all possible relations between the numerous FUA centres. The 2,817 polycentric links make up an axial testing raster for transport and TEN policies concentrating on two aspects:

- Non-directional links are significant for spatial interaction networks between centres allowing trade, exchange or co-operation.
- Directional links connect centres to their best reachable centres that are one level above the starting point centre. These links carry important supply functions and allow access to infrastructure facilities.

Map 3.1 Polycentric Links



Not all of the polycentric links have the same priority with regard to the objectives of the ESDP. Especially links with accessibility deficiencies on the one hand and links between regions with a status of relative economic backwardness on the other hand can be addressed as priority links. The combination of both criteria defines a set of priority weighting factors for all polycentric links. The resulting class of priority links is supposed to strengthen the polycentric structure when improved by TEN or transport policies.

Accessibility Deficiencies

The whole set of links is not designed to meet specific transport modes. But it is classified by base level accessibility deficiencies regarding the appropriate standard levels of transport service by measuring straight-line speeds. This indicator represents the most important quality of transport service from the view of travellers – velocity. By considering the ratio of travel time and airline distance the negative effect of detour routes is measured implicitly.

Lagging Regions

To emphasize the balanced polycentric development, each link is also classified by the structural strength respectively backwardness of the two connected centres. For this purpose, an economic classification of centres/regions based on a simple regional NUTS-3 level ranking of a combined indicator (unemployment rate, GDP per capita) has been generated. On this data basis, a subset of priority links can be identified that connects centres situated in lagging regions. These centres are supposed to play a driving role in the process of regional economic development. This does not mean that they have got own structural problems necessarily.

Policy Scenario Impact Analysis

At last, transport and TEN policies are examined regarding their contribution to improve priority links. Whenever an improvement of accessibility is significant, the weight of each improved relevant priority link directly can be assigned to the causing policy scenario.

Two infrastructure-related scenarios are compared to the reference scenario (2001):

B1 Priority projects (new list) 2001-2021 and

B2 TEN/TINA projects 2001-2021.

Within the framework of this approach, no absolute indicator measuring polycentrism shall be calculated. However, a relative measure for a strengthened polycentric development is drawn by the comparison of the current status (the “without” scenario) to the status after the realisation of TEN policies (“with” scenarios). The significance of a comparison of two single indices expressing the overall accessibility deficiencies of two different network conditions appears to be limited compared to the regional distribution of priority link improvements.

The main hypothesis behind the polycentric links analysis is that besides the TEN/TINA measurements operating on transport efficiency and economic benefits they support a polycentric and balanced spatial development towards cohesion. The regional distribution of these effects is to be evaluated by testing the impacts on defined polycentric priority links corresponding to transport and TEN policy scenarios.

3.7.2 Overloaded Transport Corridors

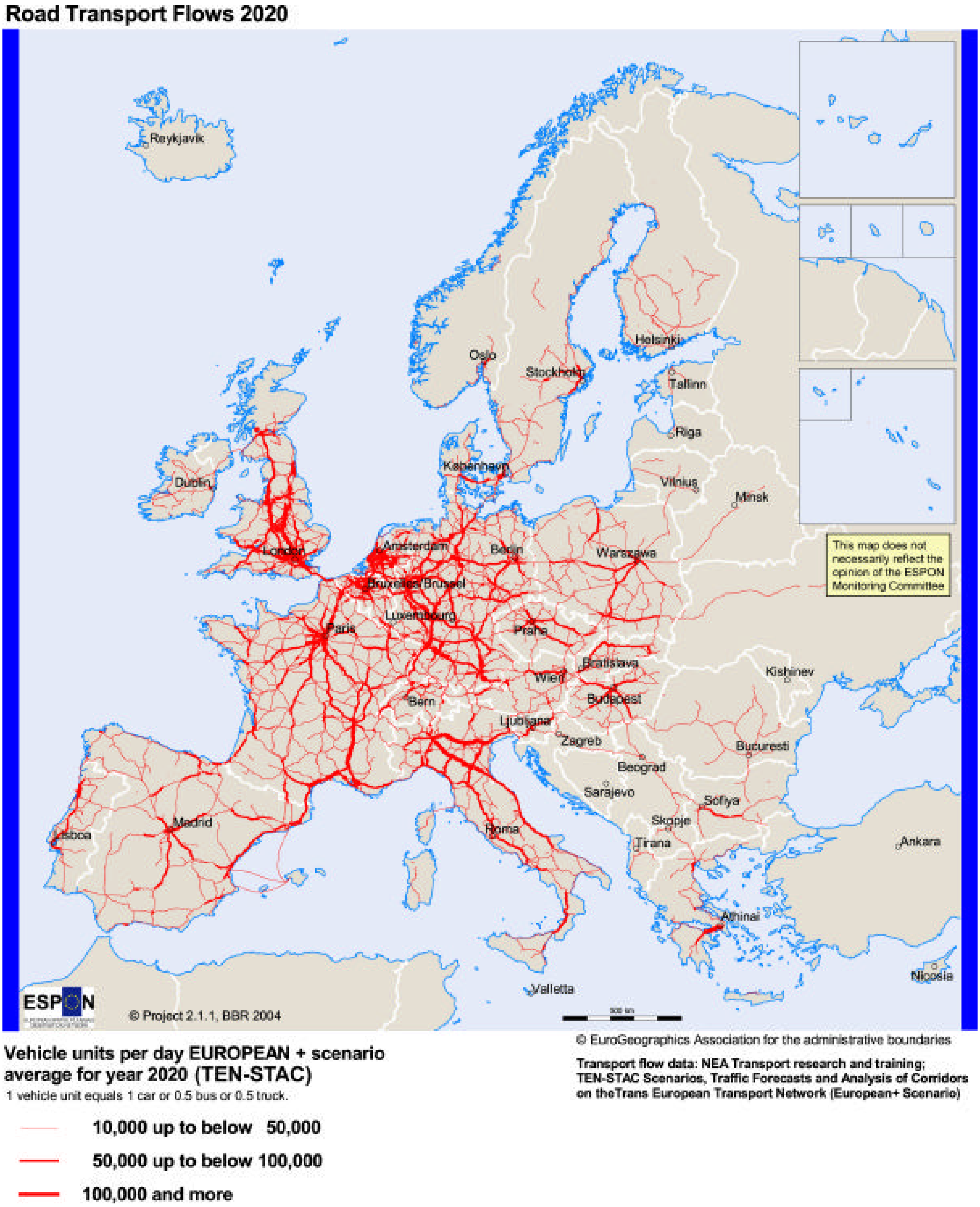
Regarding the sustainable use of infrastructure especially in urbanised regions a suitable analysis of overloaded transport corridors is desirable, too. For an adequate definition and selection of overloaded corridors besides highly congested urban areas, road transport as the determining factor has to be taken into account.

The analysis of overloaded transport corridors, however, has to be based on data of provided transport services and flows and on predictions, reassignments of flows resulting from TEN projects. This kind of data cannot be calculated from the models used within the ESPON 2.1.1 project consortium.

The results of the DG TREN study TEN-STAC “Scenarios, traffic forecasts and analysis of corridors on the Trans-European Transport Network” cover the data needs for almost the whole ESPON space. The study has produced traffic forecasts in 2020 including traffic assignment, estimation of the international traffic load on the network and socio-economic and environmental impacts according to different scenarios.

The TEN-STAC consortium has provided information about the road assignment for the year 2000 and the European+ scenario for the year 2020. The EUROPEAN+ scenario is the broadest of the TENS-STAC scenarios. It includes projects of national interest supposing additional investments plans of Member States besides the White Paper measures on the TENs and it also reflects baseline socio-economic trends as well as liberalisation and harmonisation as basic policy actions.

Map 3.2 Road Transport Flows 2020



Transportation Flow Analysis

The TEN-STAC study results are used for classification and mapping of corridors and for the empirical analysis of transportation flows at the regional level. Both techniques compare the distribution of "overloaded corridors" for the base year 2000 as a reference scenario in comparison to the situation according to the EUROPEAN+ scenario for the year 2020.

The indicator used for the regional breakdown of transport flow data at the NUTS-3 level focuses on road transport flows (regional density of kilometres travelled). Based on this indicator, regions that are burdened by the effects of high transportation flow volumes are identified.

Policy Scenario Impact Analysis

The transport and TEN policy scenario "European+" then is examined regarding to its expected contribution to unburden the concerned regions and corridors. The analysis combines and classifies the degree of overloading for selected regions and corridors with the expected extent of relief from traffic overload. In general, this can be achieved in two ways:

- a modal shift to rail and waterway transport networks (high priority) and
- a large-scale by-pass (low priority).

The main hypothesis here is that transport and TEN policies cause a relocation of transportation flows that in some regions may lead to the reduction of the transport burden especially by modal shifts from road to rail or waterways. This goal can be justified by a more sustainable use of infrastructure and lower external costs for these modes. The 2.1.1 project can not cover the entire broad topic of changing transportation flows but it tries to integrate TEN-STAC study results into the empirical framework of the ESPON programme.

Reference

The approach of a Spatial Impact Assessment (SPA) covering the two components of distribution and development objectives as well as transportation relief and modal shift objectives is based on concepts developed in Germany by the Federal Office for Building and Regional Planning together with the Federal Ministry of Transport, Building and Housing. It was designed and carried out to complement the cost-benefit analysis methods in the review of the Federal Transport Infrastructure and Investment Plan of 1992 (BVWP '92)[18].

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[18] A brochure entitled "Federal Transport Infrastructure Plan 2003: Basic features of the macroeconomic evaluation methodology", can be downloaded from: http://www.bmvbw.de/Bundesverkehrswegeplan-.806.13237/.htm

3.8 Causality Analysis

The accessibility to a certain region (or country) is generally thought to have a positive impact on its production. The higher regional accessibility, the greater the potential for economic growth. High accessibility goes hand in hand with low transportation costs, making regions more competitive due to lower production costs. Both the accessibility to input markets (for purchasing input materials) and selling markets (for selling products) should thus increase the production of a region. A theoretical exposition can e.g. be found in Fujita et al. (1999).

Indeed, the theoretical result that higher accessibility goes together with higher production has been confirmed in most of the empirical literature, although there remains quite some controversy about the exact elasticity of total output with respect to accessibility. In the following discussion of the empirical literature so far it should be noted that the definition of accessibility is not constant over different studies. In some studies it is measured as total track length or as the economic worth of public infrastructure, while others define a weighted sum of track lengths as an indicator for 'accessibility'. In this section the latter approach will be followed.

Aschauer (1989) specified *public capital* as a separate factor in the production function, and found that the marginal productivity of public infrastructure spending is two to four times higher than that of private investment spending. In particular, the decline in infrastructure investment in the United States was found to be an important factor in the productivity slowdown in the 1970s and 1980s. Aschauer’s findings have, however, been questioned by many authors. Economists argued that the marginal productivity of public infrastructure spending could never be that high, and, in more technical terms, the analysis was thought to suffer from *model misspecification*, *spurious correlation*, and the issue of *causality*.[19]

One of the shortcomings of Aschauer’s analysis is its failure to take *technological progress* into account. Consequently, its variation over time may be mistakenly picked up by other explanatory variables. The inclusion of a time trend is the mostly applied manner of taking into account technological growth. Tatom (1991) has demonstrated that the inclusion of a quadratic time trend considerably reduces the magnitude of Aschauer’s estimated marginal productivity of public infrastructure spending.

Another issue is known as the *capital obsolescence hypothesis*, which – in the particular case studied by Aschauer – means that the rising price of oil

[19] The following discussion is for an important part based on the introductory section of Duggal et al. (1999).

made some private capital obsolete. This is an intrinsic problem with the production function approach, because it does not take into account the (relative) prices of production factors. Other approaches, such as the cost function approach or the specification of a capital demand function would better be able to deal with this problem.[20] Simply including prices into the production function specification would not be theoretically consistent, because it mixes up the production and cost function specifications (Gramlich, 1994). An example of the cost function approach is Nadiri and Mamuneas (1994), who estimate translog cost functions for twelve different industries. Again, the estimated marginal productivity is smaller than Aschauer's estimate (but still statistically significant).

A third issue is the *interaction* between infrastructure and technological progress. Duggal et al. (1999) argue that infrastructure not only acts as a factor input in a direct sense, but also has a secondary effect through the possible implementation of technological innovations. Cost functions typically exhibit scale economies with respect to infrastructure, expanding markets as infrastructure networks improve, and potentially making the adaptation of new technologies cost effective. In fact, the hypothesis of Duggal et al. that infrastructure has a positive effect on technological innovation is supported by their econometric analysis for U.S. data over the period 1960-1989.

Infrastructure may also interact with other production factors. Kelijian and Robinson (2000) argue that infrastructure has an indirect effect through private inputs. Indeed, infrastructure affects factor and output prices of private firms. Thus, contrary to the previously mentioned issues, this aspect may lead to an *underestimation* of the marginal productivity of infrastructure spending.

Non-stationarity of the aggregate time series data is also a problem in the estimation of the marginal productivity of public infrastructure. Amongst others Tatom (1991) and Sturm and De Haan (1995) conclude that the correlation found between output growth and infrastructure is often spurious. Taking first differences is an option, but this often leads to disappointing results (Munnell, 1992; Sturm and De Haan, 1995). Another approach is to make use of possible trend stationarity of the time series data. In case the time series are stationary with respect to a certain time trend, the inclusion of this trend into the model specification will eliminate the problem of spurious correlation. This approach has, amongst others, been taken in Duggal et al. (1999).

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[20] Another approach is to estimate a purely mechanical simultaneous model, not being hindered by any theoretical constraints. For example, see McMillin and Smyth (1994) and Pereira and Flores de Frutos (1999), who estimate a VAR (Vector Auto Regressive) model.

The final problem, *causality*, concerns the simultaneous nature of infrastructure and output. Proper identification of the extent to which infrastructure determines production requires that the converse relation is also taken into account. Indeed, output will affect the infrastructure. First, higher output will lead to higher income, which in turn implies that more resources are available for spending on infrastructure. An elaboration on the issue of causality will follow in section 3.8.2.

In this section we have been able to make use of a panel of regional data, so that it is possible to purge the model from fixed and time effects and estimate the 'pure' effect of accessibility on regional production. In section 2 accessibility has been defined, while section 3.8.2 discusses the just mentioned problem with causality in more depth. In section 3.8.3 the regional production function will be described, while section 3.8.4 discusses the data that have been used to estimate it. The empirical results are presented in section 3.8.5. Section 3.8.6 concludes.

3.8.1 Accessibility

In the introduction given above, it became clear that much of the literature deals with 'infrastructure' as a production input, often being straightforwardly measured as 'total track length'. A major problem with this measure is that it disregards the infrastructure network quality. Another drawback of infrastructure as a production input is that it does not take into account its *potential use*. For example, airports in densely populated areas are likely to be more 'productive' than airports in less densely populated areas. To overcome these problems, one might weigh infrastructure with certain characteristics in a *potential function*. The *accessibility* of region i can be defined as given in the SASI model (section 3.1):

$$A_i = \sum_j (W_j)^a e^{-bc_{ij}}$$

where W_j denotes the *potential* of region j, and c_{ij} is a measure of 'cost' of travelling between the regions i and j. The potentials of the various regions are chosen equal to their populations, which corresponds with the idea that the accessibility to highly populated regions is more relevant than the accessibility to sparsely populated regions. The cost measure can e.g. be based on travel time and political and cultural barriers. The summation is over all possible regions, including the 'own region' i.

The advantage of making use of accessibility instead of infrastructure is that it takes into account network effects, and the potential use of the infrastructure in terms of population or production of regions nearby. A possible disadvantage is that the accessibility index de facto depends on the demand side, which would make it inappropriate for use in a production function specification. This can however be taken into account, as will be discussed in the next section.

As was discussed in section 3.1, the travel costs between two regions are composed of four parts:

the travel times between the regions;

the difference in the level of integration within Europe;

language differences;

cultural differences.

The travel times between regions are computed using timetable travel times (rail and air transport) and road-type specific travel speeds (road).[21] Aggregation over different modes (road, rail, air) takes places through the logsum impedance (see equation (3.3)).

$$c_{ij} = -\frac{1}{l}\ln\left[\sum_{m}\exp\left(-\,l c_{ijm}\right)\right]$$

where c_{ijm} equals the travel costs between the regions i and j given that mode m is used. Note that these travel costs consist precisely of the above mentioned components. The exact definitions of the various components, and the way in which these are computed, are given in Fürst et al. (1999). The potentials W_j are chosen equal to the population size of the various regions.

3.8.2 Causality

Regional production is generally influenced by a number of factors, such as capital, human capital, and accessibility. It is the latter that we are interested in here. It is often thought that accessibility will have a positive impact on regional production. However, the converse relation may hold true as well: highly productive regions may want to invest parts of their welfare

[21] See Bröcker et al. (2001).

in infrastructure, hence improving regional accessibility. Thus, there is the problem of *causality*: which factor influences the other to what extent? To what extent is regional production influenced by accessibility, and to what extent is accessibility influenced by regional production? The empirical answer to these questions will, in general, be difficult to obtain. Nevertheless, the availability of adequate data will allow for answering at least a part of these questions.

Let us first give a general specification of the theoretical model. Let production P be a function F of accessibility A and other factors X, and let accessibility be a function G of production P and other factors Y:

$$\begin{aligned} P &= F(A, X) \\ A &= G(P, Y) \end{aligned} \qquad (3.25)$$

It is well known that if either of these equations is estimated in isolation of the other, then biased parameter estimates will result. For example, consider the case where production is a linear function of accessibility, and accessibility is linear in production, i.e.:

$$\begin{aligned} P &= lA + F_1(X) \\ A &= mP + F_2(Y) \end{aligned} \qquad (3.26)$$

for some functions F_1 and F_2. This last equation can be rewritten as

$$P = \frac{1}{m} A + \frac{1}{m} F_2(Y) \qquad (3.27)$$

Thus, if production is specified as a linear function of accessibility it is unclear whether the specification in (3.26) or the one in (3.27) is estimated. Therefore, the estimated parameter will not be an estimator of λ, but rather an estimator of some (linear) combination of λ and $1/\mu$.[22]

[22] The classic example is the simultaneity of demand and supply in the market for a certain good, so that the identification of the good's price elasticity of demand can be difficult in practice (see Working, 1927).

Some well-known solutions exist to the problem just posed. For instance, one may estimate a *structural model*, which is directly based on (3.25). Such a specification would take the form

$$\begin{aligned} P &= F(A, X, e_1) \\ A &= G(P, Y, e_2) \end{aligned} \qquad (3.25a)$$

where the random variables e_1 and e_2 are most often assumed to follow a normal distribution. This specification would match the theoretical specification in (3.25), and, most importantly, identify all its parameters. However, a practical drawback of this approach is that the actual specification of F and G typically restricts the domain of the model parameters, so that in terms of model flexibility, other approaches are to be preferred.[23]

A second approach, known as estimation with *Instrumental Variables* (IV), exclusively focuses on the first equation in (1). It proceeds by (i) regressing A on a set of exogenous variables, and (ii) inserting the predicted values $\hat{A}$ from this regression into the production function specification:

$$P = F(\hat{A}, X, e_1) \qquad (3.28)$$

This last specification can then be estimated by Least Squares (if possible) or Maximum Likelihood techniques, both yielding consistent parameter estimates. It is important to note that this method is only theoretically consistent if the specification in (3.28) is of the form

$$F_0(P) = F_1(A) + F_2(X, e_1) \qquad (3.29)$$

and if the predicted values for $F_1(A)$ are inserted into this equation, and *not* $F_1(\hat{A})$. For example, if logarithmic transformations are preferred, then one could estimate the model

[23] See, e.g., MaCurdy et al. (1990), who discuss the estimation of structural models for labour demand.

STEP 1 : $a = Z'g + e_2$

STEP 2 : $\ln P = b_0 + b_1\hat{a} + X'b_2 + e_1$

where $a \equiv \ln A$. If the specification is not linear in F_1 and F_2 as in (3.29), then estimation with IV is still possible, but will require a generalised approach.

As a last remark, it should be realised that the success of this approach crucially depends on the availability of proper instruments. In practice, this is often a problem. However, if appropriate instruments are available, then this method has the advantage over the estimation of a structural model in the fact that it is more flexible.

A third way of dealing with the above-sketched problem is based on the *Granger causality test*.[24] This test first postulates a specification describing one part of the relation between production P and accessibility A, and then performs a statistical test on whether there *is* a causal relation. For instance, the linear specification

$$P_t = a_0 + \sum_{j=1}^{n} a_j P_{t-j} + \sum_{j=1}^{n} b_j A_{t-j} + g'X_t + e_t \qquad (3.30)$$

leads to a causality test of the form:

$$b_1 = \ldots = b_n = 0.$$

In trying to identify the causal relation between regional production and accessibility one could estimate (3.30), as well as its counterpart with A on the left hand side, and hence perform the Granger causality test. Note that under the assumption of normal iid error terms, this test is nothing but a standard F-test.

3.8.3 Model

We postulate a log-linear specification of the production function. Suppressing the regional subscript i, we have:

[24] See Granger (1969).

$$\ln Q_t = c + a^1 \ln L_t^1 + a^2 \ln L_t^2 + c \ln A_t + l t + e_t,$$

where Q denotes production, L denotes human capital (labour), A is accessibility, and c is a constant which may vary over different regions. Regional human capital is taken up in the form of two variables, the first being equal to the total number of high skilled workers (L^1), the second being equal to the total number of low skilled workers (L^2). Clearly, in this specification accessibility is considered as a form of *public capital*, that is, a publicly available production factor which generates economic worth. As no adequate data are available on private capital, a time trend is taken up in the specification. This term is supposed to take account of technological progress, so that at least a part of capital growth is taken up in the production function specification. Furthermore, population density will be taken up as a control variable, so that the region-specific constant equals:

$$c_i = c_0 + c_1 \text{ pdens}_i$$

The above specified model will be estimated in first differences. This can simply be done by ordinary least squares (OLS). The first alternative estimation method is instrumental variables, which takes place in two stages. First, the accessibility indicator is regressed on a set of instrumental variables Z:

$$\ln A_t = Z'q + u.$$

Then, the predicted values for the natural logarithm of accessibility $\hat{a}_t$ ($a_t \equiv \ln A_t$) are used in the regression in (a) in order to obtain estimates that do not suffer from endogeneity bias. A second modification to the OLS estimation is to allow for heteroskedastic error terms. It is very likely that this is prevalent, as the size of the different regions shows important differences between countries. For example, the German regions are much smaller than the Spanish ones. To take account of heteroskedasticity, the error term e is scaled by regional population. Estimation then takes place by Generalized Least Squares (GLS).

3.8.4 Data

In this study we will make use of a data base consisting of regional data (at the so-called NUTS3 level) for the years 1981 and 1996. Only two waves have been selected for this analysis, in order to obtain a relatively consistent and complete data set. The rather large time period between both waves can be regarded as an advantage, as it allows us to estimate the long-term effect of changes in accessibility.[25] As was already noted in the introduction, it is well possible that the full effect of a change in accessibility is only realised after more than a few years. The definitions of the variables used are exactly as described in earlier documents on the SASI model; also see section 3.1.2 in this document.

3.8.5 Estimations

The model in section 4 has been estimated on first differences between the years 1996 and 1981. That is, the economic growth in the period 1981-1996 is explained from a number of variables, notably:

the change in accessibility over the period 1981-1996

the change in human capital over the period 1981-1996

(the level of) regional accessibility in 1981

(the level of) human capital in 1981

the population density in 1981

regional GDP in 1981

Apart from the dummy variables, all variables enter the specification as log-transformations. It is seen that both regional accessibility and human capital have been entered as *levels* as well as *changes* variables. The 1981 level of GDP has been entered to correct for possible level effects, while population density has been included to control for scale effects (if present).

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[25] A second reason for not including intermediate years (between 1981 and 1996) is that during this period some variables were not reported with sufficient precision. In particular, some observations were constructed by inter- or extrapolation, which makes them unsuitable for the current econometric analysis.

It should be noted that two outliers have been skipped from the regressions, being the regions of Biella (Italy) and Flevoland (the Netherlands). Both these regions have witnessed huge changes during the 15-year period under study, for example in their population size: Flevoland showed an increase of more than 200%, while the population of Biella decreased by more than 50%. Such drastic changes make these regions less suitable for the identification of marginal effects of regional accessibility.

Four different estimations have been performed. First, the production function has been estimated with ordinary least squares (OLS). Second, the instrumental variables (IV) approach was used with the maximum set of instruments based on the distance matrix. Third, the production function was estimated with heteroskedastic error terms (HET), where the weight of each region was set equal to its size in terms of population in 1981. Finally, the fourth estimation was a combination of the instrumental variables and heteroskedastic estimation (IV/HET).

The change in regional production is amongst others explained from the change in accessibility, but also from the past *level* of accessibility. In Table 3.5 it can be seen that both these variables heavily interact with the time trend. First, consider the coefficient for "change in accessibility", which equals the accessibility elasticity of regional production. If no time trend is included in the specification, then this coefficient equals about unity. The addition of a generic time trend however leads to an estimated coefficient which is about halved, while the addition of country specific time trends generates an estimated elasticity which does not significantly differ from zero. The latter case involves a rather messy picture for the point estimates, as signs differ between the different estimation techniques.

On the other hand, the accessibility level at the beginning of the period is positive if no time trend is included, zero with a generic time trend, and negative if country specific time trends are included.

One possible explanation for the above findings is that the correlation between accessibility and regional growth is partly spurious. Clearly, the introduction of a time trend into the model generally leads to a lower magnitude and significance level of the estimated coefficients. This is in line with the findings of Aschauer and the published criticisms on these findings (see section 1). On the other hand, the development of accessibility over time may be adequately described by a linear time trend, implying that in the model of section 4 it is not possible to distinguish between trend growth and growth due to improvements in accessibility.

Table 3.5 Estimated coefficients for the accessibility indicator in the regional production function[a]

	OLS	IV	HET	IV/HET
Simple model				
Change in accessibility	0.99	0.99	1.22	1.29
Level of accessibility (lagged)	0.06	0.05	0.06	0.05
Model with general time trend				
Change in accessibility	0.43	0.42	0.53	0.58
Level of accessibility (lagged)	0.00	-0.01	0.00	0.00
Model with country specific time trend				
Change in accessibility	-0.35	1.08	-0.31	0.19
Level of accessibility (lagged)	-0.07	-0.07	-0.13	-0.13

a Bold values correspond with parameter estimates which are significantly different from zero at a 5% confidence level. OLS corresponds to straightforward estimation of the production function, IV corresponds to the use of instruments for the accessibility variable, while HET implies that a correction has been made for heteroscedasticity.

3.8.6 Conclusion

In this section an attempt has been made to deal with the possible endogeneity of accessibility in a regional production function specification. If accessibility is indeed endogenous, then this is necessary in order to identify the causal effect of accessibility on regional production. If no effort is taken, then the production function would be incorrectly specified, and theoretically all the parameter estimates would be biased. In order to deal with this, the accessibility variable has been instrumented with a number of variables based on the distance matrix. The results have shown that the endogeneity matters to a certain extent, but that far more serious problems are present. The first serious problem encountered concerned the data, which turned out to be insufficient for performing an econometric causality analysis for 'accessibility' in a regional production function. A probable reason is that these data are designed for running a forecasting model (SASI), not for the estimation of structural parameters. For example, some variables in some years were computed simply by (linear) inter- or extrapolation. Such interpolation techniques are inevitable to fill gaps in data, and when one wants to show the model implications for long run developments. However, when the aim is a causal analysis, it is essential to have really observed values instead of interpolated ones. A second problem is that the estimated coefficients for the accessibility variable turned out to heavily depend on the specification chosen. In particular, the introduction of a time trend importantly affected the estimated output elasticities. This could be a sign of spurious correlation between accessibility and regional production. Thus, the final conclusion is that better data are needed to study the issue of causality of accessibility in regional production functions. For an important part, this will just be a matter of patience, as recently collected data appear to be of much higher quality than before.

4 Impacts of Transport and ICT Scenarios

In this chapter the results of forecasting models and analytical methods explained in Chapter 3 are presented. The order is the same as in Chapter 3: First the results of the three forecasting models, the SASI model, the CGEurope model and the STIMA model, are presented. Then the results of the five analytical techniques used to further process and analyse the model results are discussed: the method to calculate Development Potential, the various methods to measure cohesion, the method to measure polycentricity, the method to identify overloaded transport and a discussion of conflicts between the policy goals efficiency and cohesion.

4.1 Socio-economic and Cohesion Impacts

In this section the results of the three forecasting models, the SASI model, the CGEurope model and the STIMA model are presented.

4.1.1 SASI

The specification and calibration of the SASI model was presented in Section 3.1. With the calibrated SASI model the thirteen transport policy scenarios defined in Section 2.2.1 were simulated.

As it was explained there, there are two sets of transport scenarios: the retrospective scenarios A1 to A3 covering the decade between 1991 and 2001 and the prospective scenarios B1 to D2 covering the period between 2001 and 2021 (see Section 2.2.1). Accordingly, two different reference scenarios are needed:

- *References Scenario A0*, in which none of the transport infrastructure projects actually completed between 1991 and 2001 are implemented, is the Reference Scenario for the retrospective scenarios A1 to A3.
- *Reference Scenario 00*, in which no transport infrastructure projects or pricing scenarios are implemented after 2001, is the Reference Scenario for the prospective scenarios B1 to D2.

In this section the results of the thirteen policy scenarios are presented. The presentation always compares accessibility and GDP per capita in the policy scenarios with the corresponding values in the respective reference scenario in the years 2001 for scenarios A1 to A3 and 2021 for scenarios B1 to D2.

The presentation starts with the results of the SASI model for accessibility and then presents the results for GDP per capita. The results of the SASI model with respect to cohesion and polycentricity are presented in Section 4.2 and 4.3, respectively.

Accessibility

Table 4.1 and Table 4.2 show percent differences in accessibility compared with the respective reference scenarios for the present European Union (EU15), Norway and Switzerland (CH+NO), the twelve accession countries (AC12) and the whole ESPON space (EU27+2) in two different versions.

The corresponding results for individual countries are presented in Tables H.1 and H.2 of Annex H.

Table 4.1 shows differences in multimodal accessibility by rail, road and air for travel (in million) as defined in Equations 3.1 to 3.3 in Section 3.1. All infrastructure scenarios show improvements of accessibility, whereas all pricing scenarios except Scenario C1, in which travel costs are reduced, show a decline in accessibility. In Table 4.2 the accessibility indicators are standardised to the average of the whole ESPON Space (EU27+2=100) in order to show also the *relative* winners and losers as if the whole system were a zero-sum game.

Map 4.2 shows the spatial distribution of multimodal accessibility in the NUTS-3 regions in Europe in the Reference Scenario 00 in the year 2021. The gap in accessibility between the regions in the European core and the peripheral regions becomes apparent. With the exception of the regions in the Czech Republic, Hungary and Slovenia, the new member states belong to the least accessible regions in the European Union.

Maps 4.2 and 4.3 show, as examples, the spatial distribution of the differences in unstandardised accessibility for Scenarios B1 and B2.

The results of the accessibility forecasts are as to be expected. Unstandardised accessibility is improved in all A and B scenarios, as these assume infrastructure improvements compared with their respective reference scenarios (Table 4.1). The effects in the retrospective A scenarios are small, which is not surprising because the backcasting period is only ten years long, and the effects are rather equally distributed over the groups of countries distinguished in Table 4.1. The effects are much stronger in the prospective B scenarios and, not surprisingly, they are the stronger the more infrastructure projects are assumed to be built. Now the accession countries gain significantly more in accessibility because of the increased emphasis of the most recent revisions of the TEN and TINA programmes on projects in the new EU member states.

The situation is more complex in the pricing scenarios C1 to C3. Scenario C1, in which rail transport fares are reduced, results in an increase in accessibility, whereas Scenarios C2 and C3, in which transport prices are increased, result in a reduction of accessibility.

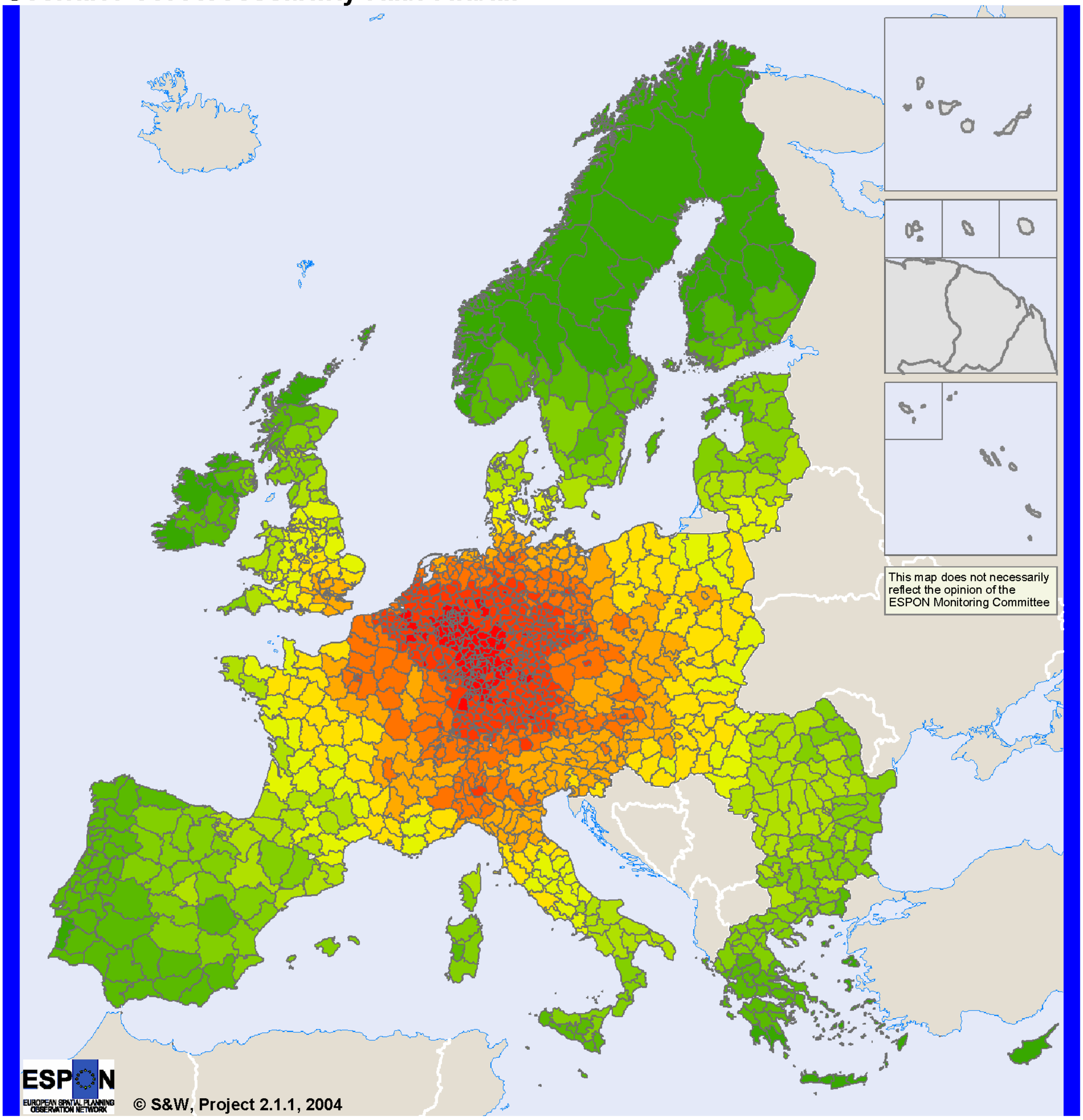
Table 4.1 SASI model: accessibility rail / road / air, travel

Scenario		Accessibility difference between policy scenario and Reference Scenario (%)			
		EU15	CH+NO	AC12	EU27+2
A1	Only rail projects 1991-2001	+3.03	+2.84	+3.98	+3.19
A2	Only road projects 1991-2001	+1.42	+1.38	+1.76	+1.48
A3	Rail and road projects 1991-2001	+4.29	+4.06	+5.50	+4.49
B1	Priority projects	+8.04	+6.51	+7.62	+7.93
B2	All TEN/TINA projects	+13.04	+12.55	+19.75	+14.18
B3	TEN/TINA except cross-border corridors	+11.84	+10.95	+14.34	+12.25
B4	TEN/TINA only cross-border corridors	+3.15	+2.99	+7.25	+3.85
B5	TEN/TINA only in Objective 1 regions	+2.23	+1.22	+8.53	+3.29
C1	Reduction of price of rail transport	+2.17	+2.17	+1.31	+2.02
C2	Increase of price of road transport	–1.68	–1.58	–1.27	–1.61
C3	SMCP of all modes	–6.02	–6.32	–4.00	–5.68
D1	B1+C3	+1.51	–0.14	+3.31	+1.78
D2	B2+C3	+6.33	+5.75	+15.18	+7.84

Table 4.2 SASI model: accessibility rail / road / air, travel (EU27+2=100)

Scenario		Accessibility difference between policy scenario and Reference Scenario (%)			
		EU15	CH+NO	AC12	EU27+2
A1	Only rail projects 1991-2001	–0.16	–0.35	+0.76	0.00
A2	Only road projects 1991-2001	–0.06	–0.10	+0.27	0.00
A3	Rail and road projects 1991-2001	–0.20	–0.41	+0.96	0.00
B1	Priority projects	+0.10	–1.31	–0.29	0.00
B2	All TEN/TINA projects	–1.00	–1.43	+4.88	0.00
B3	TEN/TINA except cross-border corridors	-0.36	–1.16	+1.86	0.00
B4	TEN/TINA only cross-border corridors	–0.68	–0.83	+3.27	0.00
B5	TEN/TINA only in Objective 1 regions	–1.03	–2.01	+5.07	0.00
C1	Reduction of price of rail transport	+0.15	+0.14	–0.70	0.00
C2	Increase of price of road transport	-0.08	+0.03	+0.35	0.00
C3	SMCP of all modes	–0.36	–0.68	+1.76	0.00
D1	B1+C3	–0.26	–1.88	+1.50	0.00
D2	B2+C3	–1.40	–1.94	+6.81	0.00

Scenario 00: Accessibility rail/road/air



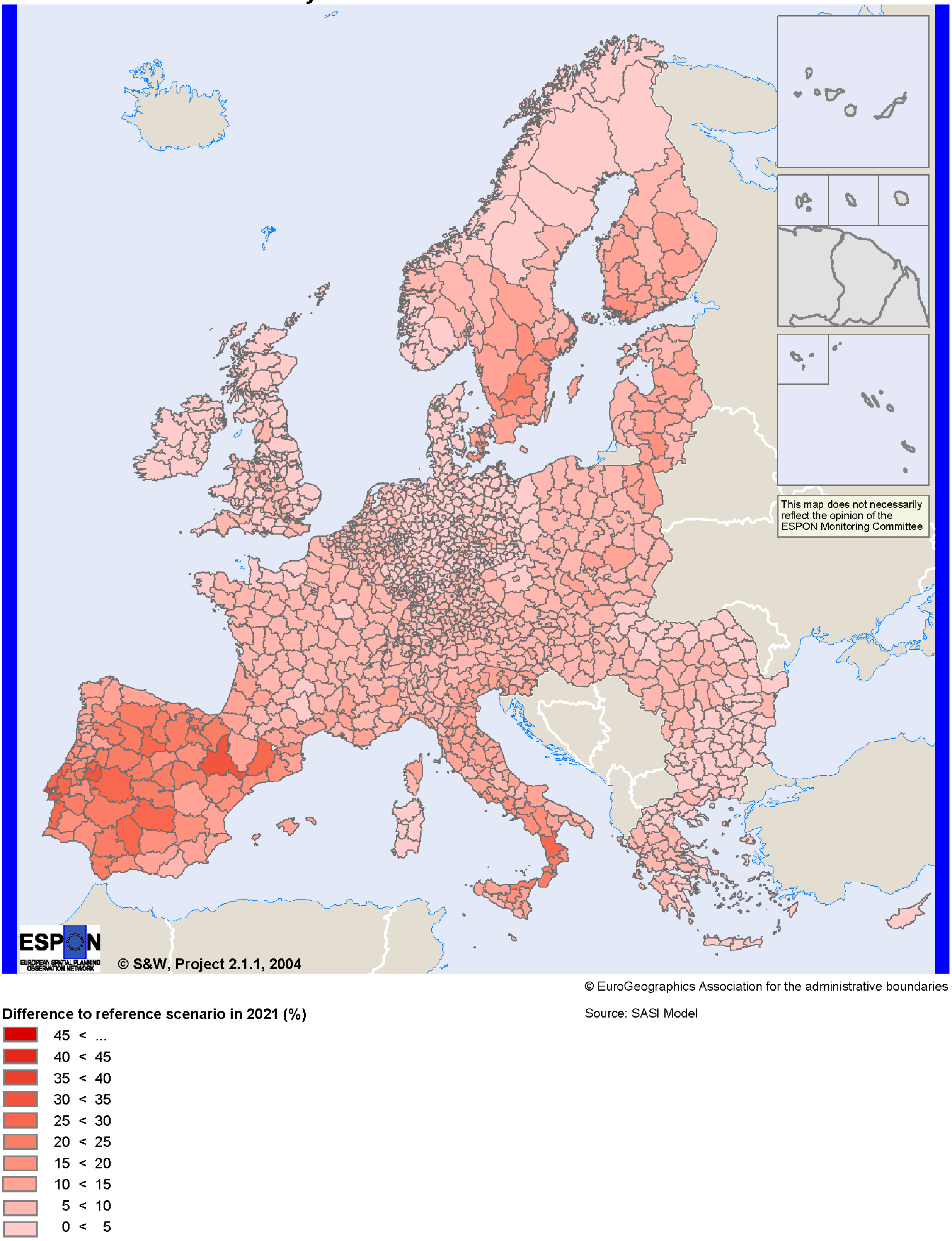
Source: SASI Model

Reference scenario in 2021 (million)

...	< 20
20	< 30
30	< 40
40	< 50
50	< 60
60	< 70
70	< 80
80	< 90
90	< 100
100	< ...

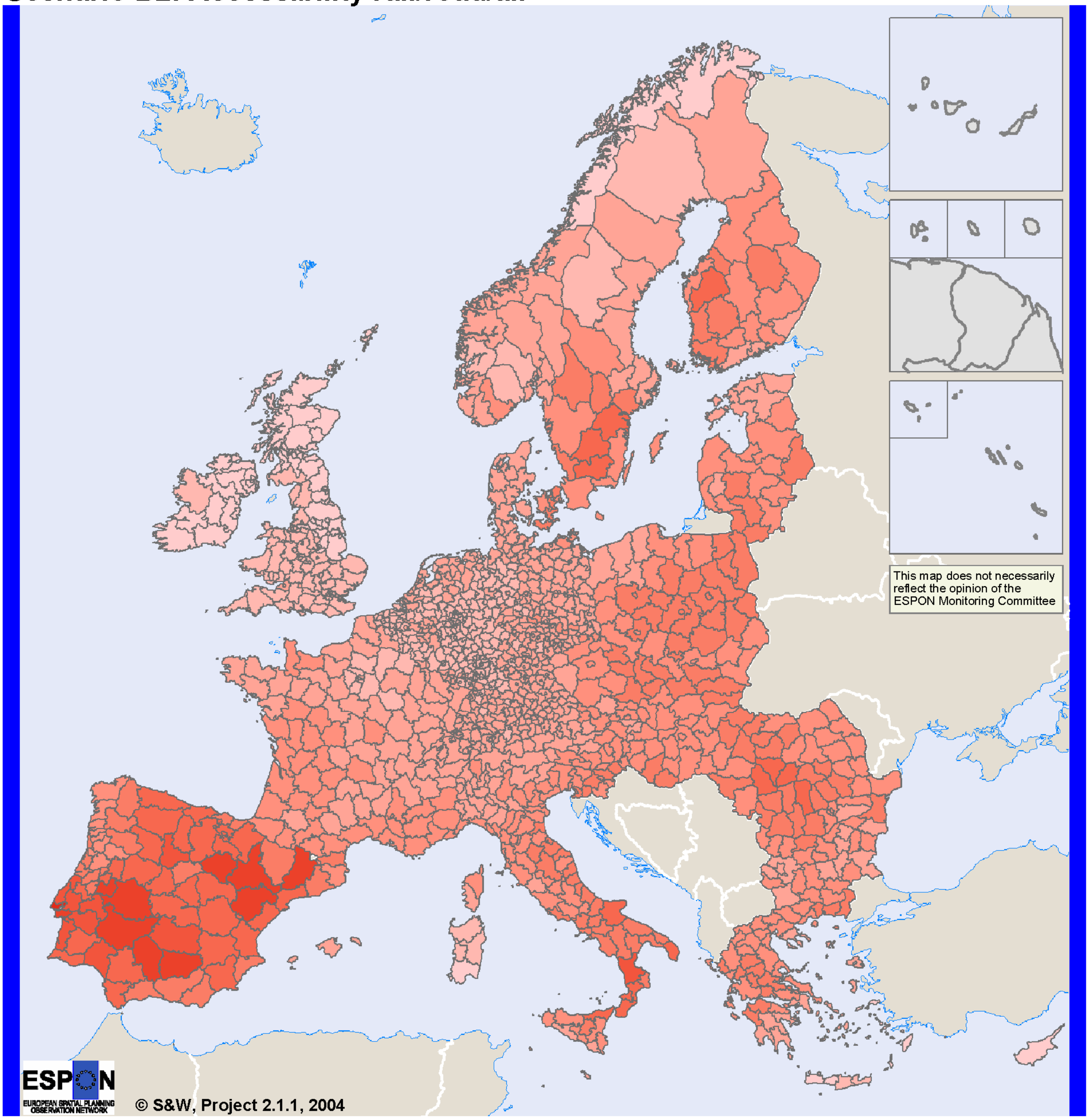
Map 4.1 SASI model: Reference Scenario 00: accessibility rail/road/air, travel (million) in 2021

Scenario B1: Accessibility rail/road/air



Map 4.2 SASI model: Scenario B1 (Priority projects): accessibility rail / road / air, travel, difference (%) to Reference Scenario 00 in 2021

Scenario B2: Accessibility rail/road/air



© EuroGeographics Association for the administrative boundaries

Source: SASI Model

Difference to reference scenario in 2021 (%)

45 < ...
40 < 45
35 < 40
30 < 35
25 < 30
20 < 25
15 < 20
10 < 15
5 < 10
0 < 5

Map 4.3 SASI model: Scenario B2 (all TEN/TINA projects): accessibility rail/road/air, travel, difference (%) to Reference Scenario 00 in 2021

Scenarios D1 and D2 are combinations of infrastructure scenarios B1 and B2, respectively, and social marginal cost pricing scenario C3. Accordingly its net changes in accessibility are somewhere between their gains in accessibility through the infrastructure scenarios and their losses in Scenario C3. In Scenario D1 the net result is positive in the old member states and negative in the accession countries, but as the gains in Scenario B2 are much larger, in Scenario D2 the net result is positive everywhere. It is important to note that these effects are not changes over time but relative differences between the policy scenario and the corresponding reference scenario in the target year 2001 or 2021; over time all regions gain in accessibility.

Table 4.2 shows the relative winners and losers. In the retrospective A scenarios the accession countries gained slightly more, although EU transport policy in the past concentrated on western Europe. This is because they started from a lower base; in absolute terms the gained less than the old member states. The current list of priority projects (Scenario B1) favours the old member states. The new member states become the relative winners only if all TINA projects (Scenario B2) or parts of them (Scenarios B3 to B5) are included. Of the pricing scenarios, only the most rigorous Scenario C3 is good for the accession countries, because the countries in the highly congested European core suffer more from social marginal cost pricing.

Figures 4.1 and 4.2 present the same information for the prospective scenarios in graphical form. Figure 4.1 shows the development of accessibility between 1981 and 2021 in the old EU member states (EU15), Figure 4.2 the same for the twelve accession countries (AC12). Each line in the diagram represents the development of accessibility in one scenario, the heavy black line the Reference Scenario 00. All prospective scenarios are identical until the year 2001. The lines are colour-coded to indicate 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 about 20 percent lower than in the old EU member states as a whole (see Map 4.1). However, there remain large differences in accessibility both between the old member states and between 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 trend of the Reference Scenario.

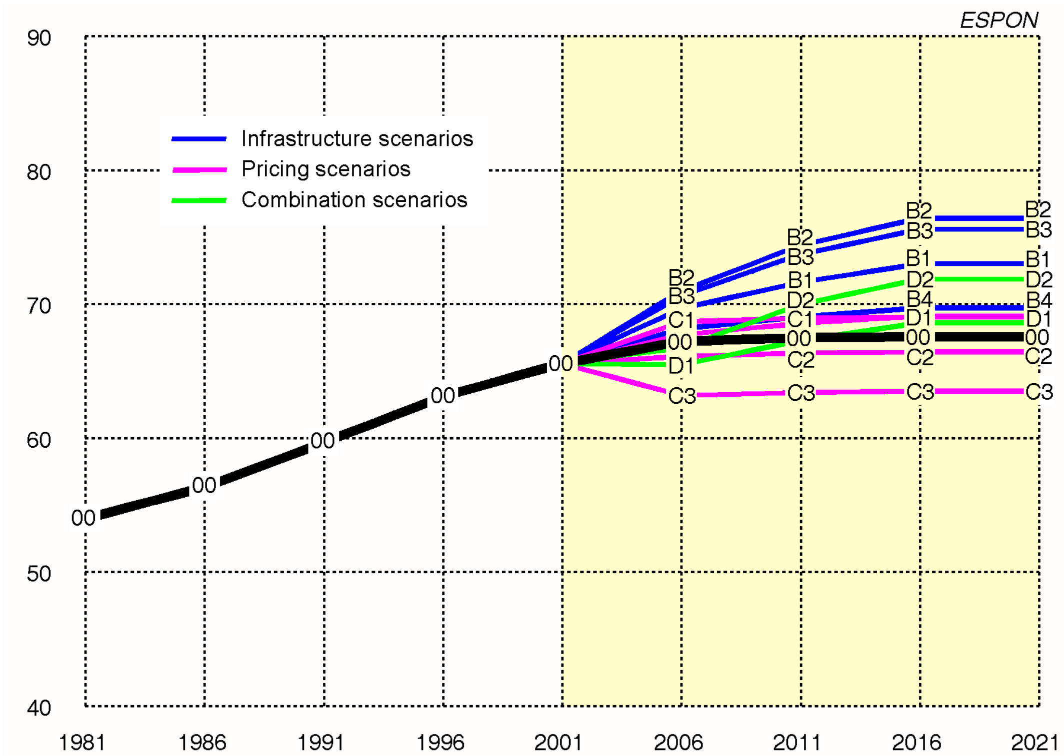


Figure 4.1 SASI model: Accessibility rail/road/air, travel in EU15 1981-2021

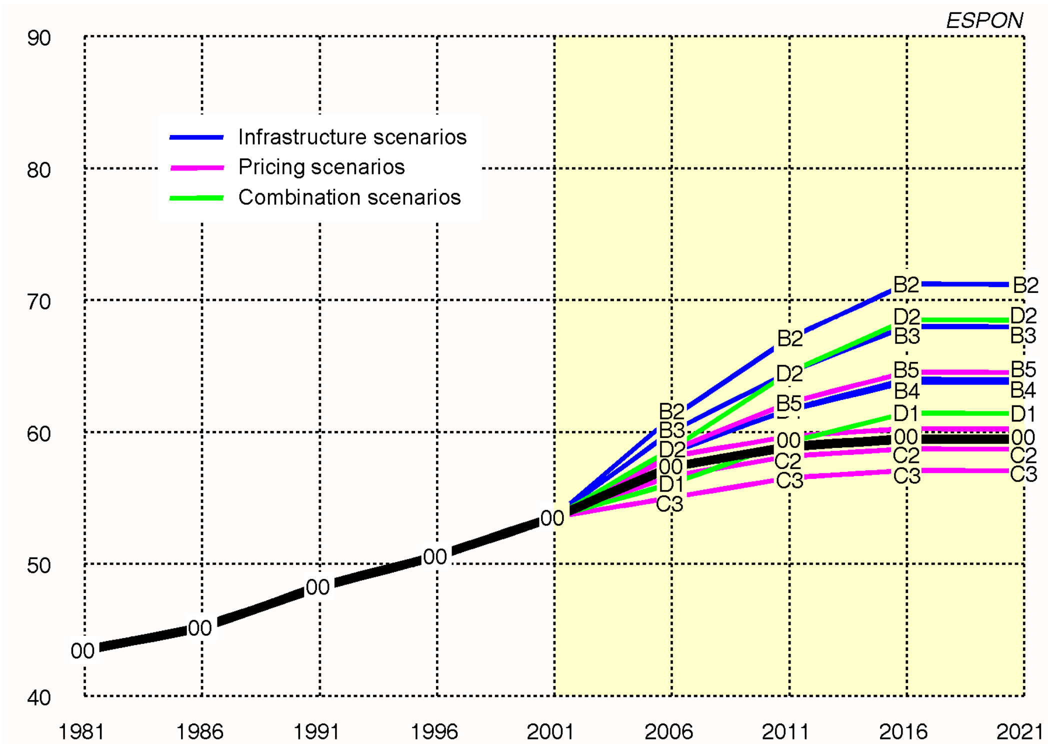


Figure 4.2 SASI model: Accessibility rail/road/air, travel in AC12 1981-2021

GDP per capita

Tables 4.3 and 4.4 show differences in GDP per capita compared with the respective reference scenarios for the present European Union (EU15), Norway and Switzerland (CH+NO), the twelve accession countries (AC12) and the whole ESPON Space (EU27+2). Again, as in Tables 4.1 and 4.2, two different versions are presented, one unstandardised and one standardise to the European average.

The corresponding results for individual countries are presented in Tables H.3 and H.4 of Annex H.

Table 4.3 shows differences in unstandardised GDP per capita. In Table 4.4 GDP per capita is standardised to the average of the whole ESPON Space in order to show also the *relative* winners and losers as if the whole system were a zero-sum game. In other words, Table 4.3 shows GDP effects with generative effects and Table 4.4 without generative effects, i.e. only distributional effects.

Maps 4.4 to 4.10 show, as examples, the spatial distribution of differences in standardised GDP per capita for selected scenarios.

The first thing to note is that the relatively large differences in accessibility (Tables 4.1 and 4.2) translate into only very small differences in GDP per capita (Tables 4.3 and 4.4). No region gains more than a few percent in GDP per capita. The huge investments for the trans-European transport networks in the past have not brought much overall economic growth to the member states of the present European Union (EU15) in the past (Scenarios A1-A3), nor are they likely to do so in the future (Scenarios B1-D2). The effects for Switzerland and Norway (CH+NO) and for the accession countries (AC12) are much larger and will be even larger in the future because of the implementation of the TINA projects. The overall effects for the whole ESPON Space (EU27+2) are, of course, the weighted average of the effects for the three groups of countries. The very small differences have to be seen in relation to the overall growth in GDP per capita, which between 1991 and 2021 is assumed to more than double.

However, the spatial pattern of effects is similar. In the retrospective A scenarios, the contribution of transport infrastructure to regional economic development in the last decade has been rather equally distributed across Europe. The TEN priority projects (Scenario B1) mostly benefit the old EU member states; only if all TINA projects in eastern Europe are included, the effects shift towards the new member states. The largest overall effects are connected with Scenario B2, in which all TEN and TINA projects are implemented.

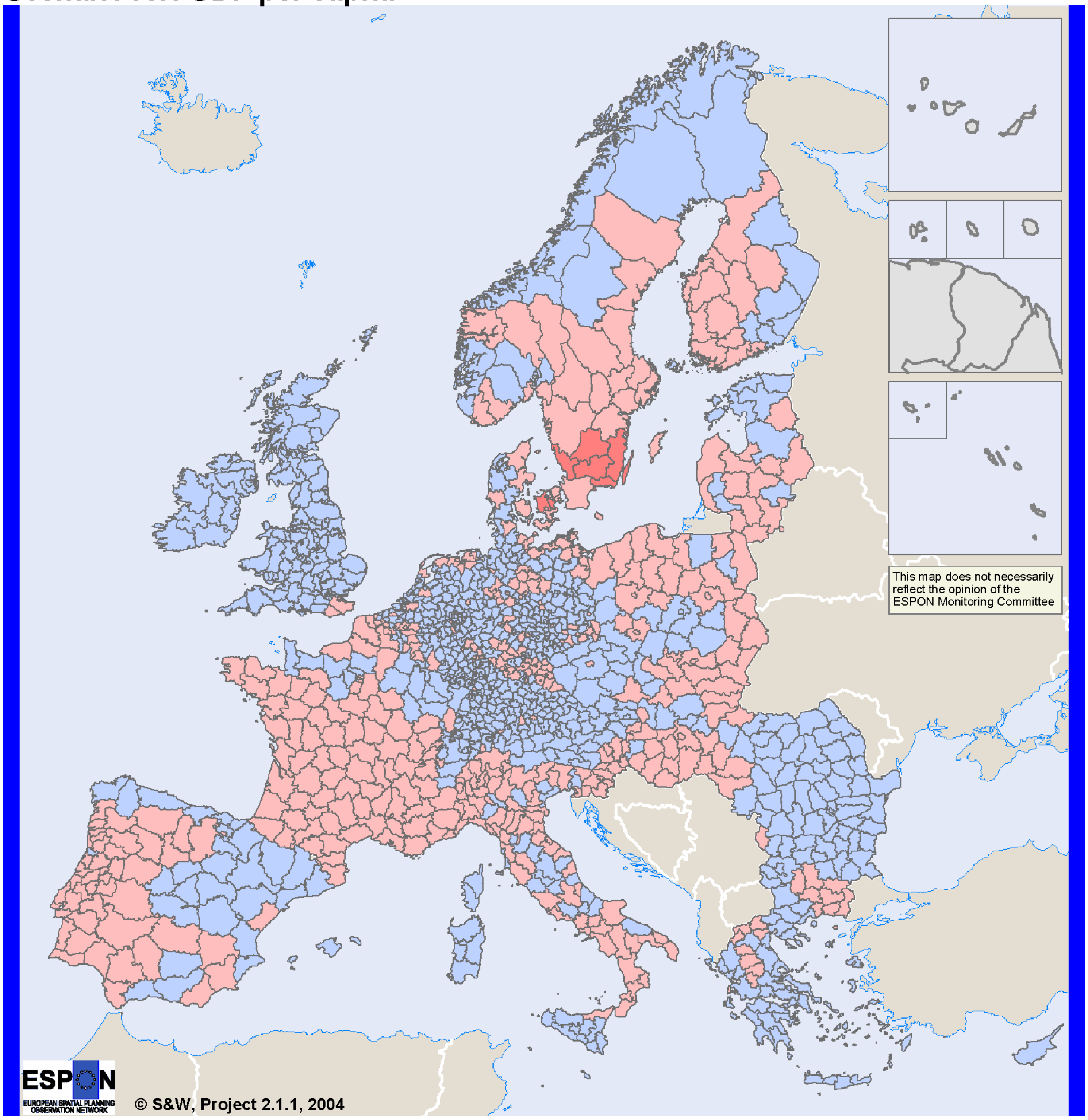
Table 4.3 SASI model: GDP per capita with generative effects

Scenario		GDP per capita difference between policy scenario and Reference Scenario (%)			
		EU15	CH+NO	AC12	EU27+2
A1	Only rail projects 1991-2001	+0.45	+0.40	+0.44	+0.45
A2	Only road projects 1991-2001	+0.21	+0.21	+0.21	+0.21
A3	Rail and road projects 1991-2001	+0.63	+0.59	+0.63	+0.63
B1	Priority projects	+1.65	+1.26	+1.17	+1.60
B2	All TEN/TINA projects	+2.62	+2.39	+3.06	+2.62
B3	TEN/TINA except cross-border corridors	+2.38	+2.09	+2.19	+2.36
B4	TEN/TINA only cross-border corridors	+0.63	+0.51	+1.16	+0.65
B5	TEN/TINA only in Objective 1 regions	+0.44	+0.21	+1.19	+0.46
C1	Reduction of price of rail transport	+0.51	+0.53	+0.28	+0.50
C2	Increase of price of road transport	–0.42	–0.39	–0.35	–0.41
C3	SMCP of all modes	–1.42	–1.75	–1.01	–1.42
D1	B1+C3	+0.18	–0.50	+0.14	+0.14
D2	B2+C3	+1.14	+0.64	+2.05	+1.16

Table 4.4 SASI model: GDP per capita without generative effects (EU27+2=100)

Scenario		GDP per capita difference between policy scenario and Reference Scenario (%)			
		EU15	CH+NO	AC12	EU27+2
A1	Only rail projects 1991-2001	0.00	–0.05	–0.01	0.00
A2	Only road projects 1991-2001	0.00	0.00	+0.01	0.00
A3	Rail and road projects 1991-2001	0.00	–0.04	0.00	0.00
B1	Priority projects	+0.04	–0.34	–0.43	0.00
B2	All TEN/TINA projects	–0.01	–0.23	+0.43	0.00
B3	TEN/TINA except cross-border corridors	+0.02	–0.26	–0.17	0.00
B4	TEN/TINA only cross-border corridors	–0.02	–0.14	+0.51	0.00
B5	TEN/TINA only in Objective 1 regions	–0.02	–0.25	+0.73	0.00
C1	Reduction of price of rail transport	+0.01	+0.03	–0.22	0.00
C2	Increase of price of road transport	0.00	+0.02	+0.06	0.00
C3	SMCP of all modes	0.00	–0.33	+0.42	0.00
D1	B1+C3	+0.04	–0.64	0.00	0.00
D2	B2+C3	–0.01	–0.51	+0.88	0.00

Scenario A3: GDP per capita

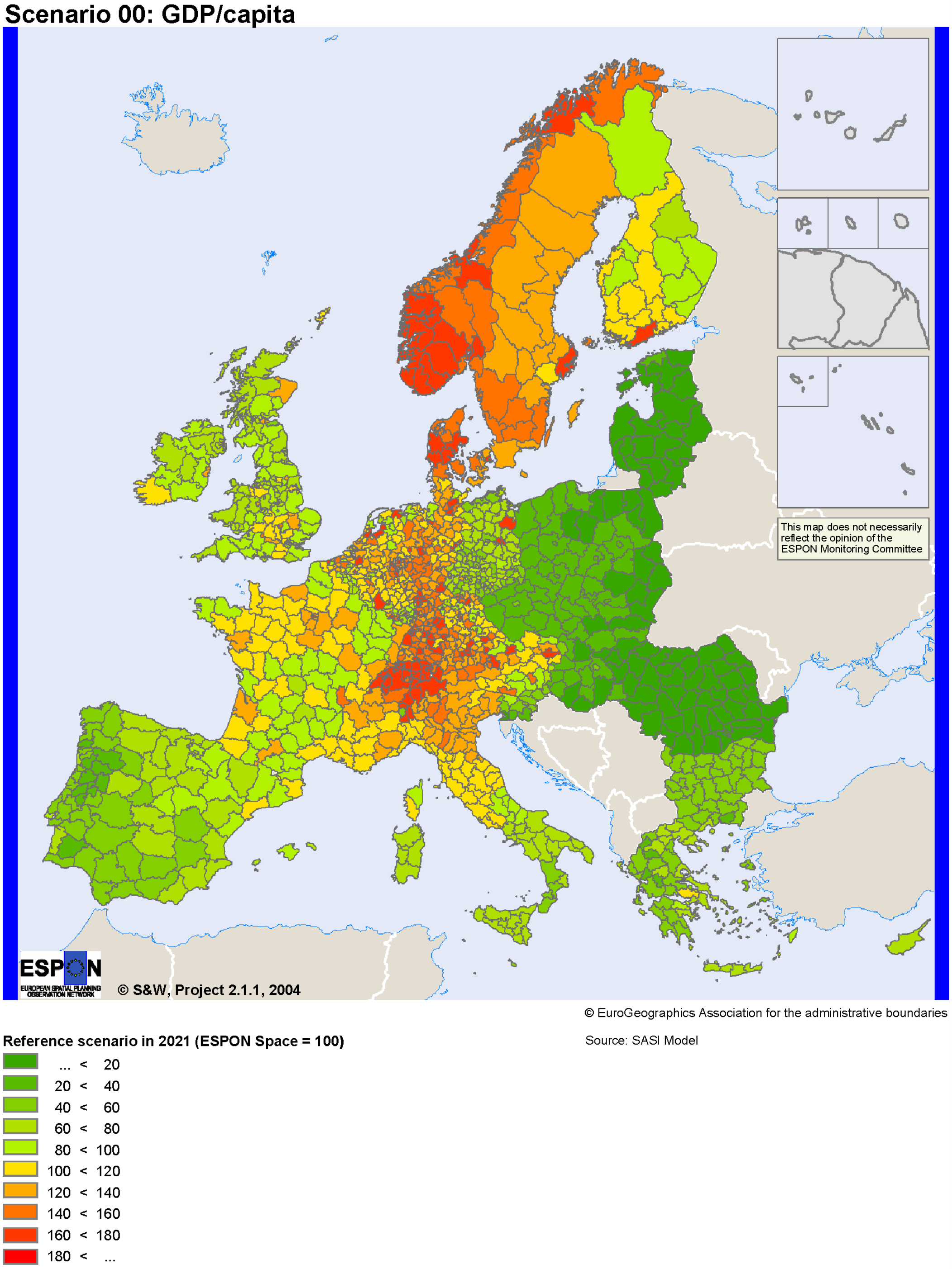


Source: SASI Model

Difference to reference scenario in 2001 (%)

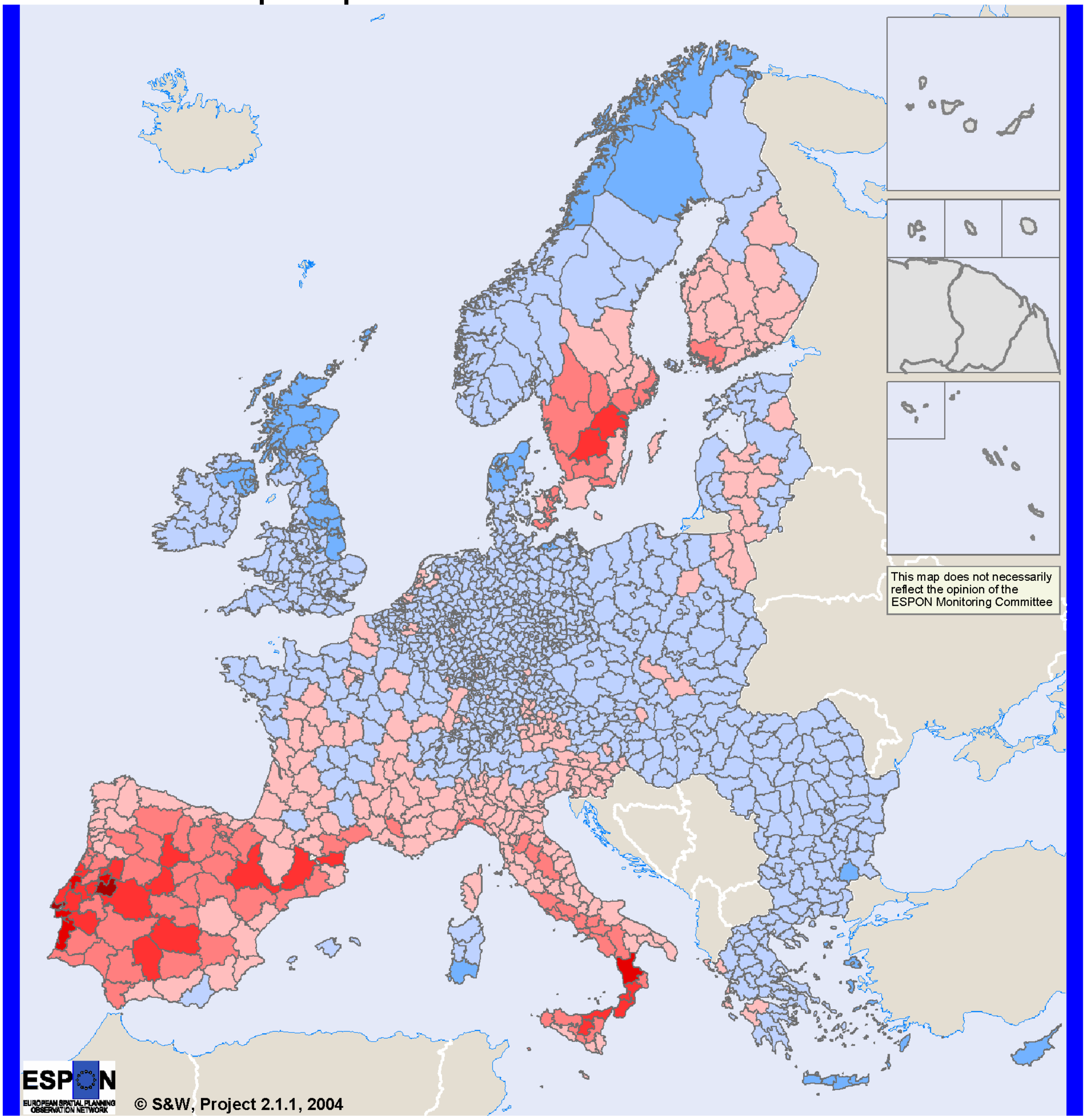
- 4.0 < ...
- 3.0 < 4.0
- 2.0 < 3.0
- 1.0 < 2.0
- 0.0 < 1.0
- -1.0 < 0.0
- -2.0 < -1.0
- -3.0 < -2.0
- -4.0 < -3.0
- ... < -4.0

Map 4.4 SASI model: Scenario A3 (Rail and road projects 1991-2001): GDP per capita difference (%) to Reference Scenario A0 in 2001



Map 4.5 SASI model: Reference Scenario 00 for prospective scenarios B1 to D2: GDP per capita without generative effects (EU27+2=100) in 2021

Scenario B1: GDP per capita



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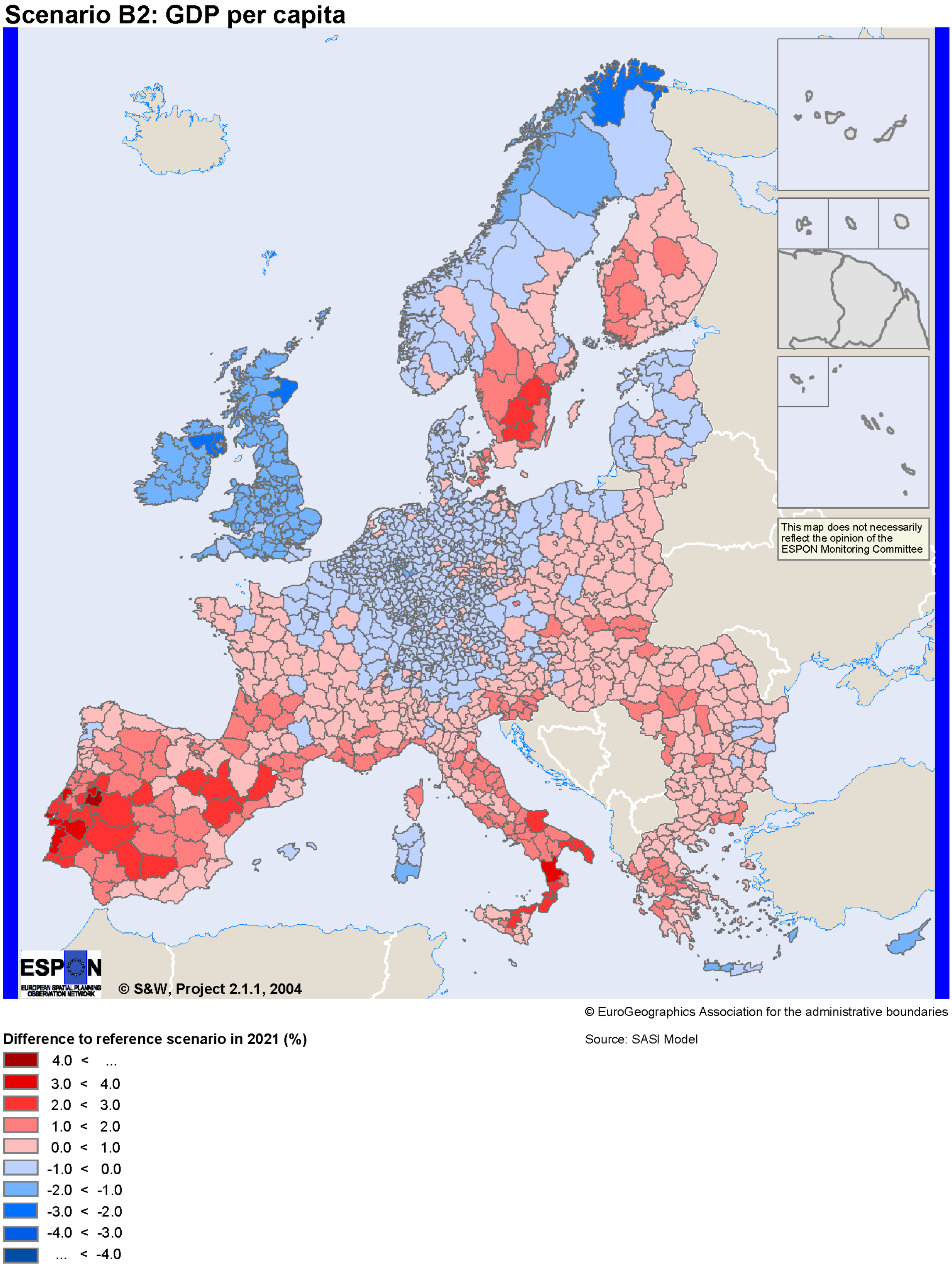
Source: SASI Model

Difference to reference scenario in 2021 (%)

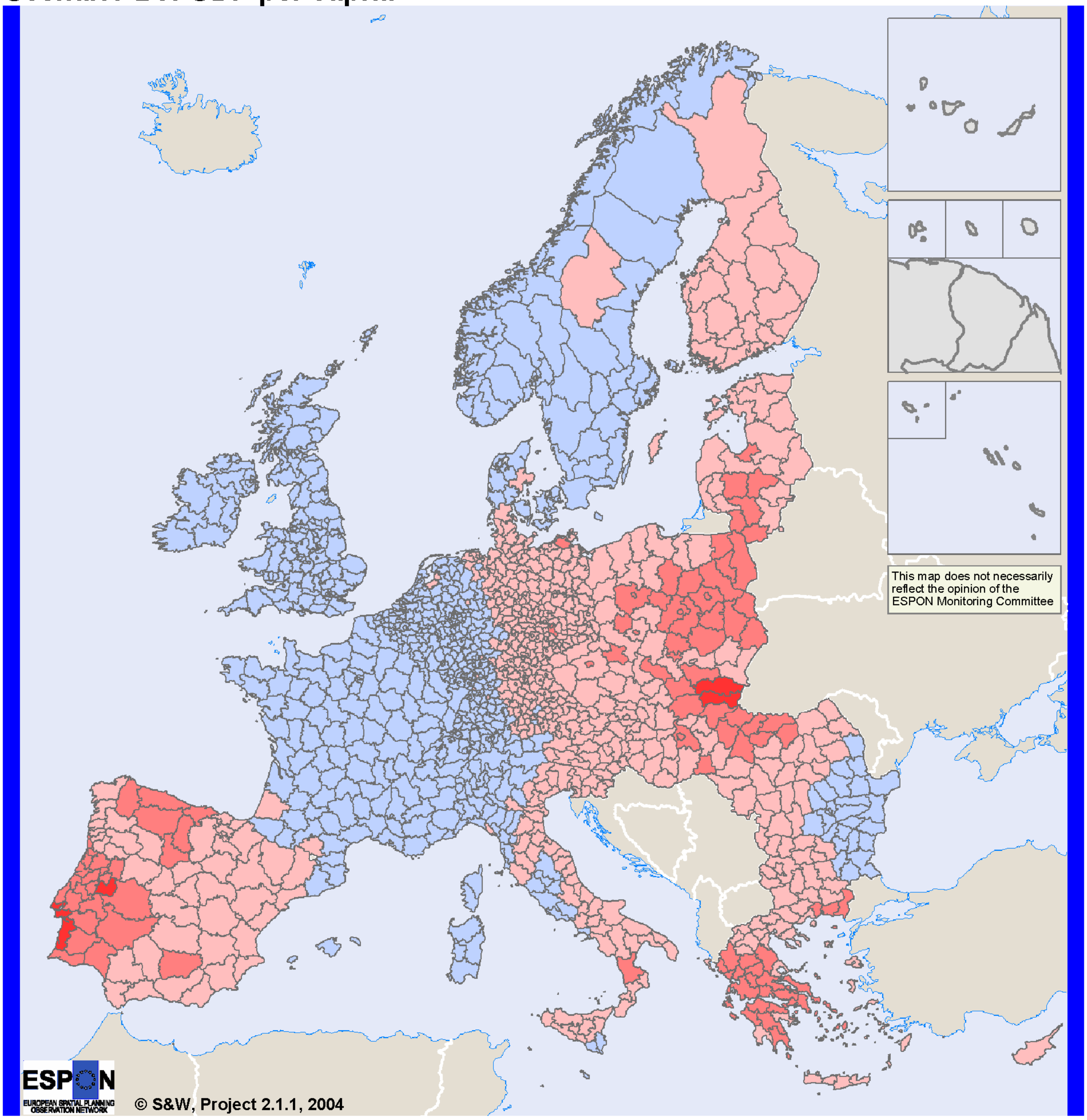
4.0 < ...
3.0 < 4.0
2.0 < 3.0
1.0 < 2.0
0.0 < 1.0
-1.0 < 0.0
-2.0 < -1.0
-3.0 < -2.0
-4.0 < -3.0
... < -4.0

Map 4.6 SASI model: Scenario B1 (Priority projects): GDP per capita difference (%) to Reference Scenario 00 in 2021



Map 4.7 SASI model: Scenario B2 (all TEN/TINA projects): GDP per capita difference (%) to Reference Scenario 00 in 2021

Scenario B5: GDP per capita



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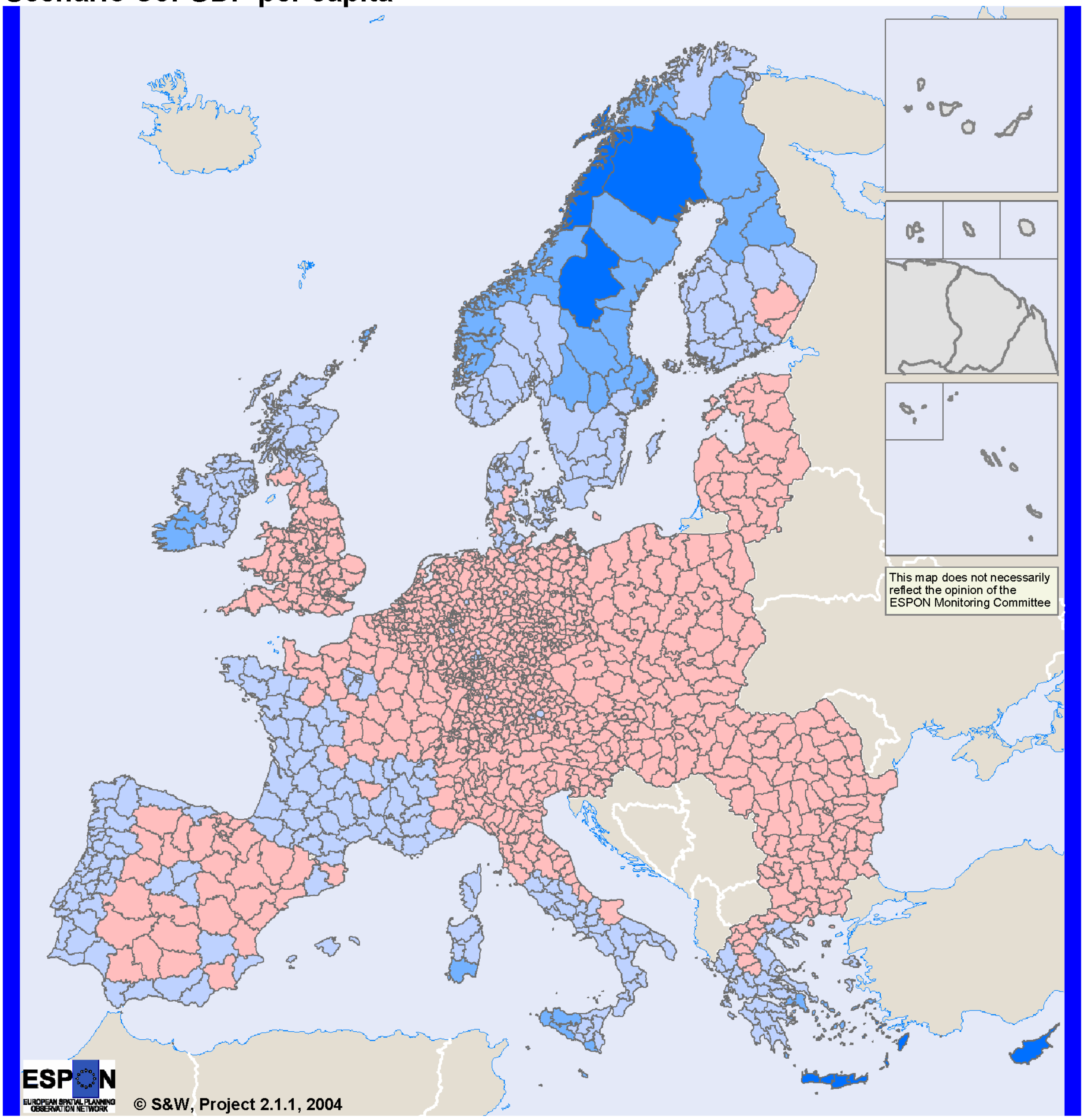
Source: SASI Model

Difference to reference scenario in 2021 (%)

	4.0 < ...
	3.0 < 4.0
	2.0 < 3.0
	1.0 < 2.0
	0.0 < 1.0
	-1.0 < 0.0
	-2.0 < -1.0
	-3.0 < -2.0
	-4.0 < -3.0
	... < -4.0

Map 4.8 SASI model: Scenario B5 (TEN/TINA only in Objective 1 regions): GDP per capita difference (%) to Reference Scenario 00 in 2021

Scenario C3: GDP per capita



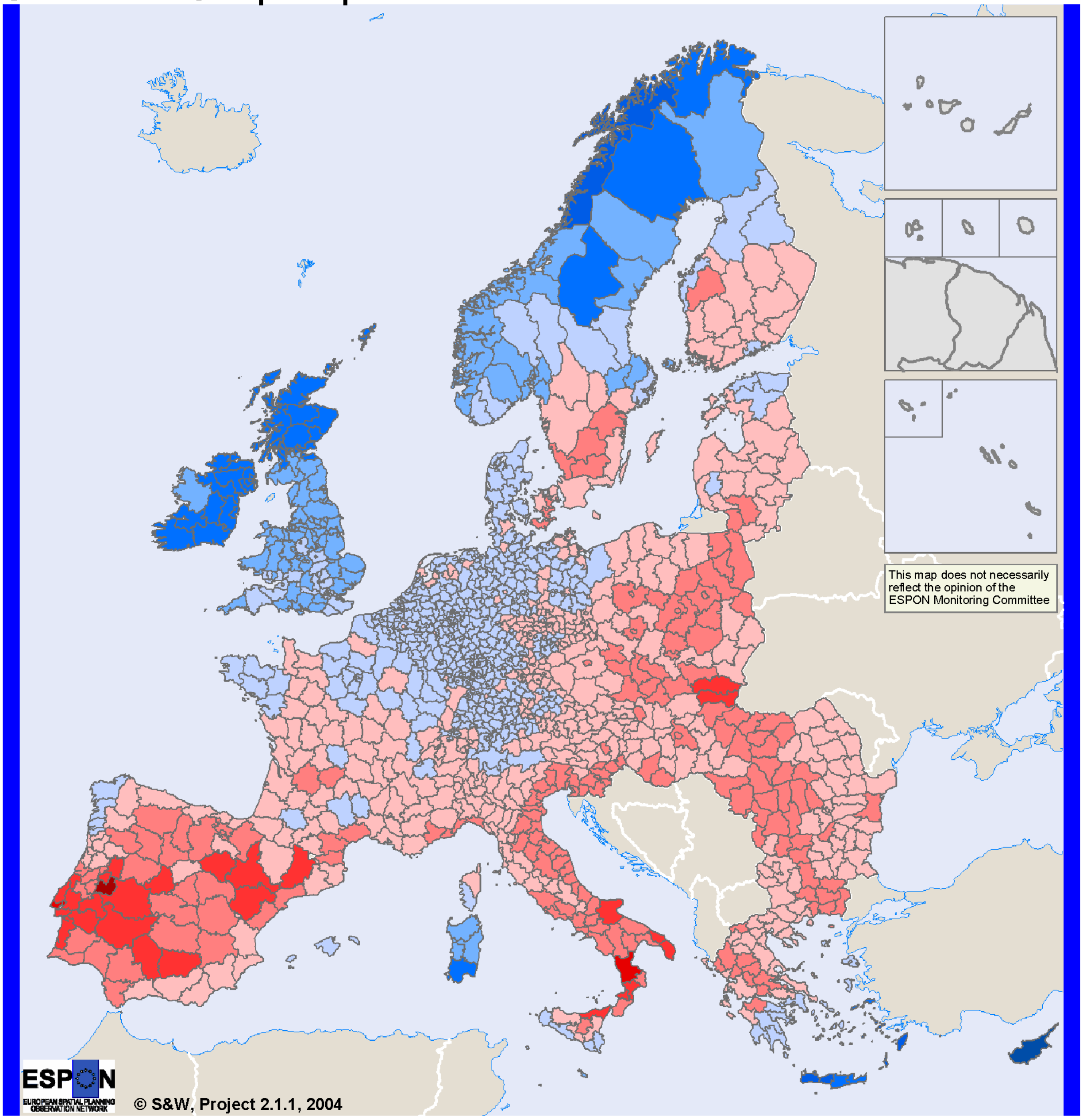
Source: SASI Model

Difference to reference scenario in 2021 (%)

4.0 < ...
3.0 < 4.0
2.0 < 3.0
1.0 < 2.0
0.0 < 1.0
-1.0 < 0.0
-2.0 < -1.0
-3.0 < -2.0
-4.0 < -3.0
... < -4.0

Map 4.9 SASI model: Scenario C3 (SMCP of all modes): GDP per capita difference (%) to Reference Scenario 00 in 2021

Scenario D2: GDP per capita



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Source: SASI Model

Difference to reference scenario in 2021 (%)

- 4.0 < ...
- 3.0 < 4.0
- 2.0 < 3.0
- 1.0 < 2.0
- 0.0 < 1.0
- -1.0 < 0.0
- -2.0 < -1.0
- -3.0 < -2.0
- -4.0 < -3.0
- ... < -4.0

Map 4.10 SASI model: Scenario D2 (TEN/TINA projects plus SMCP of all modes): GDP per capita difference (%) to Reference Scenario 00 in 2021

Scenarios B3 to B5, in which only a subset of the projects of Scenario B2 in selected areas are implemented, have smaller overall effects. In Scenario B3 (TEN/TINA projects except cross-border corridors) the effects are almost as large as in Scenario B2, but the effects of projects in cross-border corridors (Scenario B4) or Objective 1 regions (Scenario B5) are much smaller. However, the Scenarios B4 and B5 benefit the accession countries more than the old member states.

The pricing scenarios C1 to C3 are partly positive and partly negative for the regional economies depending on their direction. A reduction of rail fares (Scenario C1) has a small positive effect in the old member states and an even smaller one in the new member states. Road pricing (Scenario C2) and social marginal cost pricing of all modes of transport (Scenario C3) have a negative economic effect because they make transport and mobility more expensive. The effects of Scenario C3 are stronger and more pronounced in the old EU member states because the richer regions spend more on transport. However, these results might be different if the subsidies needed for Scenario C1 and the revenues achieved in Scenarios C2 and C3 were taken into account.

Scenarios D1 and D2 combining infrastructure (Scenarios B1 and B2) and pricing policies (Scenario C3) have positive overall effects, but different effects on the different groups of countries. If only the TEN priority projects are implemented, the effects are small and negative for the affluent countries Norway and Switzerland. If all TEN and TINA projects are implemented the effects are much larger and positive everywhere.

If only distributional effects are looked at, as in Table 4.4, the retrospective A scenarios suggest that the distributional effects of transport infrastructure in the past have been minimal. As noted, the current TEN priority projects (Scenario B1) mostly benefit the old member states, whereas the new member states are the winners if all TEN and TINA projects are implemented (Scenario B2). This shift would be even stronger in the unlikely case that only projects in cross-border corridors (Scenario B4) or Objective 1 regions (Scenario B5) were implemented. The strongest redistribution effect from the old to the new member states would occur in combination scenario D2, in which all TEN and TINA projects are implemented and the countries in the European core carry the bulk of social marginal cost pricing of all modes.

Summary

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 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.

The retrospective scenarios show that the impacts of European transport policy on regional economic development have been small and their distributional effects minimal. The prospective scenarios suggest that the socio-economic impacts of transport policy may be larger if the ambitious plans of the TEN and TINA programmes will be actually implemented – however, the experience of the recent past has shown that large delays in implementation are not unlikely.

If the different types of policies are compared, the results can be summarised as follows:

- Infrastructure policies have larger effects than pricing policies, and the magnitude of the effect is related to the number and size of projects.

- Significant positive economic effects for the new EU member states can only be expected if the TINA projects linking the new member states to the major centres of economic activity in western Europe are implemented.

- The effect of pricing scenarios depends on their direction: scenarios which make transport less expensive have a positive, scenarios which make transport more expensive, a negative economic effect. However this result might need to be qualified if the subsidies or revenues associated with the policies were taken into account.

- Negative effects of pricing policies 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.

Further important results of the simulations with the SASI model refer to the impacts of transport policies on cohesion and polycentricity. These results are presented in Sections 4.2 and 4.3.

Cohesion Effects of the SASI Model Results

Tables 4.5 to 4.8 summarise the cohesion indicators calculated by the SASI model for the thirteen scenarios examined. Each pair of tables shows the effects of the thirteen scenarios on cohesion with respect to accessibility and GDP per capita. The information is simplified: a plus sign indicates a pro-cohesion effect or convergence, i.e. spatial disparities in accessibility or GDP per capita decrease. A minus sign indicates an anti-cohesion effect or divergence; i.e. spatial disparities in accessibility or GDP per capita increase. The tables refer to the whole ESPON Space (EU27+2) and the twelve accession countries (AC12).

Tables 4.5 and 4.6 show that, if the whole ESPON Space is considered, all scenarios contribute to cohesion in terms of accessibility, except the two pricing scenarios C2 and C3 in which transport costs are increased – if one applies one of the first four indicators, coefficient of variation, Gini coefficient, geometric/arithmetic mean or relative correlation. However, if one consults the fifth indicator, absolute correlation, the sign of the indicator is reversed, i.e. the rich regions are gaining more.

Tables 4.7 and 4.8, which look at cohesion in the accession countries only, show that only infrastructure scenarios which strengthen the corridors between eastern and western Europe improve accessibility in all accession countries; all other infrastructure projects widen the gap between the capital cities and rural regions in these countries. In terms of GDP per capita, more scenarios are pro-cohesion in relative terms, but in absolute terms the general pattern is divergence as in the whole ESPON Space except for the pricing scenarios which make transport more expensive.

It is also remarkable that there are more plus signs at the European level than if only the accession countries are considered. This indicates that scenarios which reduce the disparities between the old and new member states may do so at the expense of larger disparities within the accession countries. This would probably be even more pronounced if the analysis were conducted at the level of individual countries, because in many accession countries the infrastructure improvements are primarily directed at the capital cities.

Table 4.5 SASI model: accessibility cohesion effects in EU27+2

Scenario		Accessibility cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	+	+	·	+	––
A2	Only road projects 1991-2001	+	+	+	+	–
A3	Rail and road projects 1991-2001	+	+	+	+	––
B1	Priority projects	+	+	++	++	–
B2	All TEN/TINA projects	++	++	++	++	–
B3	TEN/TINA except cross-border corridors	++	++	++	++	–
B4	TEN/TINA only cross-border corridors	+	+	+	+	–
B5	TEN/TINA only in Objective 1 regions	+	+	+	+	–
C1	Reduction of price of rail transport	+	+	+	++	––
C2	Increase of price of road transport	–	–	–	––	++
C3	SMCP of all modes	–	–	––	––	++
D1	B1+C3	+	+	+	+	++
D2	B2+C3	+	+	++	+	+

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. llevel

Table 4.6 SASI model: GDP/capita cohesion effects in EU27+2

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	–	–	·	–	––
A2	Only road projects 1991-2001	–	–	·	–	––
A3	Rail and road projects 1991-2001	–	–	·	–	––
B1	Priority projects	+	+	·	–	––
B2	All TEN/TINA projects	+	+	·	+	––
B3	TEN/TINA except cross-border corridors	+	+	·	+	––
B4	TEN/TINA only cross-border corridors	+	+	·	+	––
B5	TEN/TINA only in Objective 1 regions	+	+	+	+	–
C1	Reduction of price of rail transport	–	–	·	–	––
C2	Increase of price of road transport	+	+	·	+	++
C3	SMCP of all modes	+	+	·	+	++
D1	B1+C3	+	+	·	·	·
D2	B2+C3	+	+	+	+	––

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. llevel

Table 4.7 SASI model: accessibility cohesion effects in AC12

Scenario		Accessibility cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	–	–	·	–	––
A2	Only road projects 1991-2001	–	+	·	–	––
A3	Rail and road projects 1991-2001	–	–	·	–	––
B1	Priority projects	–	–	·	–	––
B2	All TEN/TINA projects	+	+	·	+	––
B3	TEN/TINA except cross-border corridors	–	–	·	–	––
B4	TEN/TINA only cross-border corridors	+	+	·	+	––
B5	TEN/TINA only in Objective 1 regions	–	–	–	–	––
C1	Reduction of price of rail transport	–	–	·	+	––
C2	Increase of price of road transport	–	–	·	+	++
C3	SMCP of all modes	–	–	–	–	++
D1	B1+C3	–	–	–	––	+
D2	B2+C3	–	–	·	–	––

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. llevel

Table 4.8 SASI model: GDP/capita cohesion effects in AC12

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	+	+	·	+	––
A2	Only road projects 1991-2001	–	–	·	–	––
A3	Rail and road projects 1991-2001	–	+	·	+	––
B1	Priority projects	–	+	·	++	–
B2	All TEN/TINA projects	–	–	·	+	––
B3	TEN/TINA except cross-border corridors	–	+	·	+	––
B4	TEN/TINA only cross-border corridors	–	–	·	–	––
B5	TEN/TINA only in Objective 1 regions	+	+	·	++	–
C1	Reduction of price of rail transport	–	+	·	++	–
C2	Increase of price of road transport	+	–	·	––	++
C3	SMCP of all modes	+	+	·	++	++
D1	B1+C3	–	+	·	++	++
D2	B2+C3	–	+	·	+	–

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. llevel

Summary

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 tend 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 poor 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.

The impacts of the thirteen transport scenarios on cohesion can be summarised as follows:

- If the whole ESPON Space is considered, all scenarios contribute to convergence in relative terms in both accessibility and GDP per capita, except pricing scenarios which make transport more expensive. However, in absolute terms the opposite holds: All scenarios increase the gap between in accessibility and GDP per capita between the rich regions in the European core and the poorer regions at the European periphery.
- If only the accession countries are considered, only infrastructure scenarios which strengthen the corridors between eastern and western Europe improve accessibility in all accession countries; all other projects widen the gap between capital cities and rural regions. For GDP per capita, the general pattern is absolute divergence as in the whole ESPON Space except for the pricing scenarios which make transport more expensive
- Scenarios which reduce the disparities between the old and new member states may do so at the expense of larger disparities within the accession countries.

The analysis of cohesion effects confirms that different cohesion indicators give different results and that in particular the distinction between relative and absolute convergence or divergence is important. The analysis also shows that the spatial level at which cohesion is measured matters. It is therefore of great importance to clearly state which type of cohesion indicator at which spatial level is used.

4.1.2 Evaluation of Transport Policy Scenarios: CGEurope

In this chapter the results of the economic impact modelling of the transport policy scenarios are presented. As presented in chapter 3.2, the model used, GGEurope, is a spatial computable general equilibrium model of goods transport and business passenger flows, which evaluates the impacts of changes of relative transport prices on regional welfare. Changes in transport prices transform into changes in goods prices and enhancements of business opportunities through less expensive business travel. The market form, in which goods are supplied in each region, is monopolistic competition. Goods are transported by road, rail, air transport and ship. The impact of modal shifts is included, so that the share of a transport mode in overall transport rises if it gets cheaper relative to other means of transport. This achieved by calculating weighted logsum transport cost for each region pair.

The labour stock is fixed. So, the results can be regarded as short termed effects of the analysed policy bundles. The indicator which is the output of the model is the change of the equivalent variation, an economic welfare measure, which is closely related to the household income, but also takes account of the changes in the prices of goods, which are consumed by the household. It is also closely related to the consumer surplus, a measure often used for assessing the benefits of policy measures in a cost-benefit analysis. The equivalent variation has the feature that one can measure the impact on the households' welfare in a region as a monetary amount. Equivalent variations can be looked at in relative or absolute terms that means as percentages of the GDP in our reference year (which is 1997) or as the equivalent variation of income per capita. The dimension of the latter is € per annum. For a complete description of the model, the reader is referred to Bröcker (1998), Bröcker (2001), Bröcker (2002) and Bröcker et al. (2004).

The 13 scenarios are subdivided into 4 subtypes: retrospective transport infrastructure development (A scenarios), future infrastructure development (B scenarios), infrastructure pricing policies (C scenarios) and combined future infrastructure development and pricing are examined. Their exact composition and the infrastructure, which is represented in each scenario, are presented in chapter 2.2.1.

Table 4.9 and Table 4.10 show the impacts of the scenarios aggregated on the ESPON space, the EU15 and the 12 accession countries. All numbers are to be regarded as relative changes compared to the “without-case” in percentage points. Furthermore, the results are aggregated by the types of regions, which were defined in chapter 2.4. The aggregated values are useful to judge, which kind of regions are affected most by each policy bundle and which are less affected. The aggregated values are presented in Table 4.11, 0 and Table 4.13.

Finally, Table 4.14, Table 4.15 and Table 4.16 show the tendency of 5 cohesion indicators for each policy scenario for the ESPON space, EU-15 and the 12 accession countries.

Table 4.9 Aggregated changes of equivalent variation by policy scenario

	A1	A2	A3	B1	B2	B3	B4
EU27+2	0.049	0.115	0.158	0.144	0.262	0.237	0.042
EU15	0.049	0.116	0.159	0.144	0.251	0.231	0.038
AC12	0.048	0.096	0.138	0.165	0.504	0.365	0.136

Table 4.10 Aggregated changes of equivalent variation by policy scenario (continued)

	B5	C1	C2	C3	D1	D2
EU27+2	0.058	0.048	-0.285	-0.362	-0.212	-0.092
EU15	0.046	0.049	-0.285	-0.363	-0.214	-0.103
AC12	0.325	0.038	-0.281	-0.336	-0.168	0.174

Table 4.11 Impacts of transport policy scenarios by region type

	A1	A2	A3	B1	B2	B3	B4
Objective 1 regions	0.059	0.127	0.179	0.210	0.402	0.357	0.062
Objective 2 regions	0.048	0.127	0.168	0.133	0.248	0.224	0.042
High rurality	0.049	0.161	0.201	0.166	0.348	0.317	0.053
Medium rurality	0.056	0.201	0.248	0.146	0.316	0.271	0.057
Low rurality	0.048	0.096	0.138	0.137	0.233	0.212	0.038
Pentagon	0.042	0.075	0.113	0.093	0.176	0.157	0.030
Coastal regions	0.066	0.168	0.224	0.206	0.331	0.308	0.045
Border regions	0.048	0.142	0.183	0.136	0.297	0.252	0.060
Lagging regions	0.074	0.120	0.187	0.269	0.493	0.443	0.072
Potentially lagging regions	0.054	0.117	0.166	0.145	0.304	0.275	0.055
Non-lagging regions	0.044	0.114	0.152	0.122	0.210	0.190	0.034

Table 4.12 Impacts of transport policy scenarios by region type (continued)

	B5	C1	C2	C3	D1	D2
Objective 1 regions	0.178	0.060	-0.304	-0.406	-0.193	0.003
Objective 2 regions	0.025	0.048	-0.282	-0.357	-0.218	-0.10
High rurality	0.081	0.057	-0.330	-0.423	-0.253	-0.067
Medium rurality	0.067	0.051	-0.318	-0.398	-0.246	-0.073
Low rurality	0.050	0.045	-0.271	-0.342	-0.199	-0.1
Pentagon	0.023	0.038	-0.270	-0.327	-0.228	-0.141
Coastal regions	0.065	0.066	-0.294	-0.407	-0.195	-0.068
Border regions	0.066	0.046	-0.311	-0.384	-0.242	-0.077
Lagging regions	0.249	0.066	-0.328	-0.432	-0.158	0.070
Potentially lagging regions	0.063	0.050	-0.312	-0.390	-0.237	-0.075
Non-lagging regions	0.023	0.045	-0.269	-0.342	-0.214	-0.124

Table 4.13 Impacts of transport policy scenario by settlement type in NUTS-3 region

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9
A1	0.049	0.037	0.053	0.05	0.064	0.045	0.043	0.060	0.049
A2	0.080	0.062	0.070	0.096	0.129	0.095	0.172	0.250	0.186
A3	0.124	0.096	0.119	0.140	0.186	0.135	0.207	0.295	0.225
B1	0.169	0.088	0.153	0.161	0.125	0.110	0.092	0.183	0.189
B2	0.241	0.147	0.258	0.268	0.274	0.210	0.265	0.356	0.377
B3	0.223	0.134	0.241	0.242	0.245	0.184	0.233	0.331	0.335
B4	0.041	0.026	0.031	0.052	0.041	0.036	0.038	0.049	0.063
B5	0.056	0.02	0.075	0.074	0.048	0.033	0.070	0.076	0.081
C1	0.046	0.037	0.050	0.048	0.052	0.042	0.041	0.065	0.063
C2	-0.252	-0.252	-0.298	-0.315	-0.285	-0.284	-0.317	-0.307	-0.326
C3	-0.326	-0.312	-0.375	-0.386	-0.363	-0.346	-0.377	-0.416	-0.437
D1	-0.15	-0.22	-0.215	-0.22	-0.234	-0.232	-0.28	-0.227	-0.243
D2	-0.076	-0.158	-0.107	-0.11	-0.081	-0.128	-0.104	-0.051	-0.053

Table 4.14 CGEurope: cohesion effects in EU27+2

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	.	.	+	+	-
A2	Only road projects 1991-2001	+	+	+	+	-
A3	Rail and road projects 1991-2001	+	+	+	+	-
B1	Priority projects	+	+	+	+	-
B2	TEN/TINA projects	+	+	+	+	-
B3	TEN/TINA except cross-border corridors	+	+	+	+	-
B4	TEN/TINA only cross-border corridors	+	+	+	+	-
B5	TEN/TINA only in objective-1 regions	.	+	+	+	+
C1	Reduction of price of rail transport	-	.	+	+	-
C2	Increase of price of road transport	-	-	-	-	++
C3	SMCP of all modes	-	-	-	-	++
D1	B1+C3	+	+	+	+	+
D2	B2+C3	+	+	+	+	+

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. level

Table 4.15 CGEurope: cohesion effects in EU15

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	+	.	+	+	-
A2	Only road projects 1991-2001	+	+	+	+	-
A3	Rail and road projects 1991-2001	+	+	+	+	-
B1	Priority projects	+	+	+	+	-
B2	TEN/TINA projects	+	+	+	+	-
B3	TEN/TINA except cross-border corridors	+	+	+	+	-
B4	TEN/TINA only cross-border corridors	+	+	+	+	-
B5	TEN/TINA only in objective-1 regions	+	+	+	+	+
C1	Reduction of price of rail transport	-	+	+	+	-
C2	Increase of price of road transport	-	-	-	-	++
C3	SMCP of all modes	-	-	-	-	++
D1	B1+C3	+	+	+	+	+
D2	B2+C3	+	+	+	+	+

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. level

Table 4.16 CGEurope: cohesion effects in AC12

Scenario		GDP/capita cohesion effects (+/–)				
		CoV	Gini	G/A	RC	AC
A1	Only rail projects 1991-2001	-	+	-	+	--
A2	Only road projects 1991-2001	+	-	-	+	-
A3	Rail and road projects 1991-2001	.	-	-	+	--
B1	Priority projects	.	+	-	+	-
B2	TEN/TINA projects	+	+	+	+	-
B3	TEN/TINA except cross-border corridors	+	+	-	+	-
B4	TEN/TINA only cross-border corridors	+	+	+	+	-
B5	TEN/TINA only in objective-1 regions	+	+	-	+	-
C1	Reduction of price of rail transport	-	+	-	+	--
C2	Increase of price of road transport	-	+	-	-	++
C3	SMCP of all modes	-	+	-	-	++
D1	B1+C3	-	+	-	-	++
D2	B2+C3	+	+	+	+	-

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

CoV Coefficient of variation (%)
Gini Gini coefficient (%)
G/A Geometric/arithmetic mean
RC Correlation relative change v. level
AC Correlation absolute change v. level

A-Scenarios

The A-scenarios have been defined for evaluating the impact of transport policy in Europe within the last decade. The results compare the factual infrastructure in 2001 with the situation that would have prevailed if the level of infrastructure was still in the state of 1991. In other words, the cost changes modelled in this scenario represent changes in the quality of infrastructure during the decade 1991 to 2001. This set of scenarios has already presented in the Third Interim Report. The change in the results presented here is that the effects of these scenarios also take account of sea transport as an alternative to road, rail and air transport. Specific sea transport policy measures are not modelled in the A-scenarios, but the sea port infrastructure of 1991 is available as a means of transport for freight and passengers.

The results of the three scenarios represent the isolated effects of the transport cost savings due to road and rail infrastructure projects, which have been completed in the period from 1991-2001 in EU-27. We analyse the effect of rail infrastructure projects in scenario A1, the effect of road projects in scenario A2 and the combined effect of both types of infrastructure in the scenario A3.

The overall impact of rail infrastructure changes is small compared to the impact of the road infrastructure scenario. One third of the impact in the A-scenarios is due to changes in rail infrastructure. The average combined impact of both in the entire ESPON space is 0.158 % of GDP. The spatial pattern of effects in A3 representing the combined rail and road effect is mostly explained by the impact of roads, as can be seen from the correlation between A3- and A2-effects (0.97). So, what is said here for scenario A3, also applies for scenario A2.

The A3 scenario combines both types of projects, rail and road, and gives the complete picture of the impacts of road and rail infrastructure investments in the period from 1991-2001. The impact of the scenario on the regions is displayed in Map 4.11.

As long as we concentrate on relative impacts, A3 shows a pro-cohesion tendency, that means the effects tend to be higher in less developed, poorer and more peripheral regions. They correlate slightly negatively with GDP per capita in the reference year (-0.04) across the entire ESPON space. However, the average impact has a slightly higher magnitude in EU15 than AC12 (0.158 % and 0.138 %, respectively).

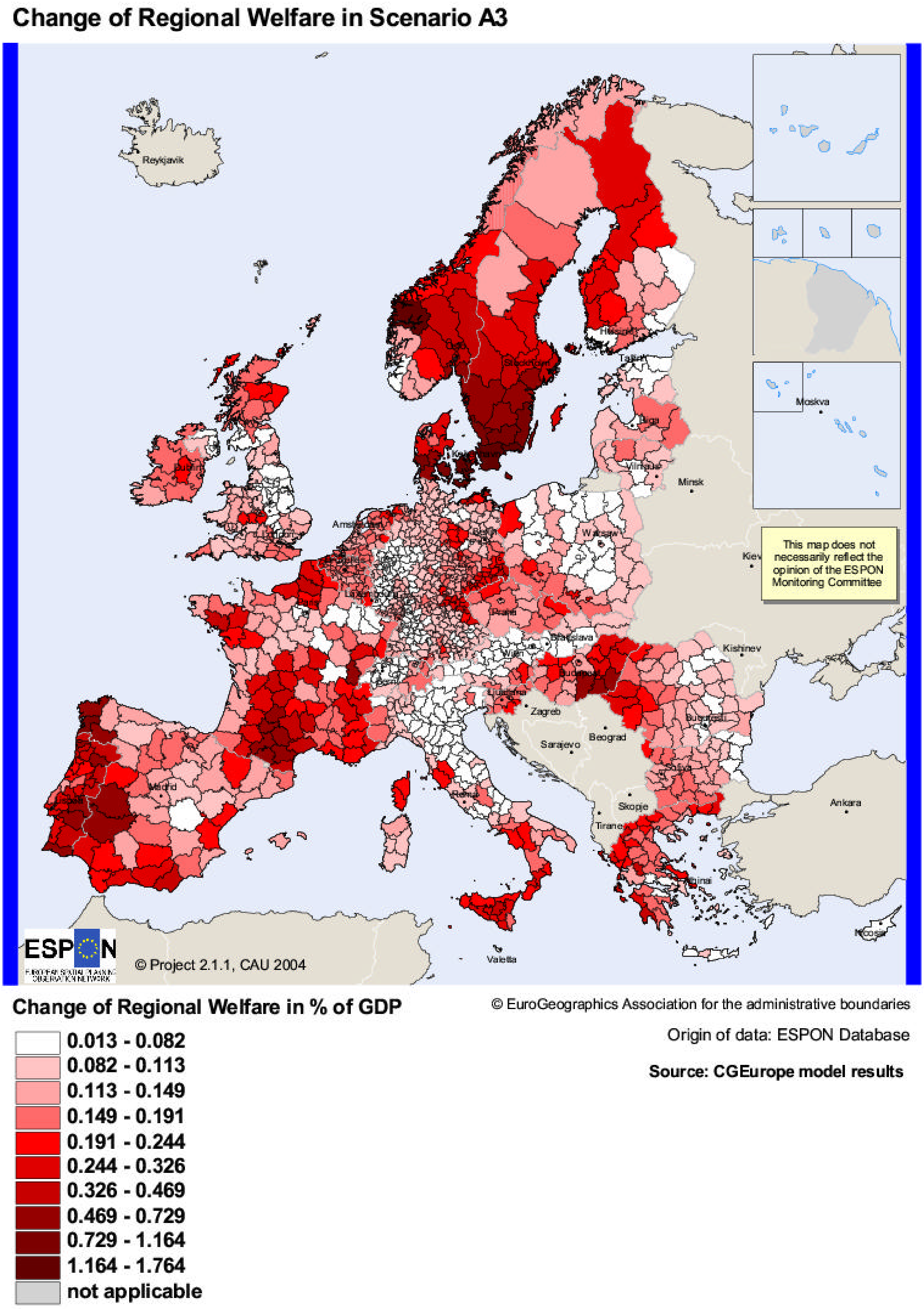
That means that the pro-cohesion tendency is mainly caused by infrastructure development within the EU15 that has favoured poorer regions more than richer ones. This is confirmed by the inequality measures. As expected, equality is highest within EU15. The distribution of GDP per capita is considerably more unequal within AC12 and even slightly more unequal in the whole ESPON space due to the large income differentials between the present EU and the candidate countries. Scenario A3 makes the inequality index decrease, even though this decrease is very small: the index decreases in the whole area, decreases even more in EU15 and increases in the new member states. Note that such a small change is visible only in the third digit in the inequality index. Nothing else can be expected, because infrastructure development does not change the spatial distribution of GDP per capita dramatically.

The pro-cohesion tendency of past infrastructure development can also be seen from the fact that effects are on average considerably higher in lagging and objective-1 regions (0.187 % and 0.178 %). Furthermore, they are significantly higher than in highly and medium rural regions than in the average of EU27+2.

Finally, one should note that the tendencies just described totally rely on relative rather than absolute per capita measurements. Note that a policy raising the overall income level while leaving the income distribution unaffected would in absolute terms give more to the rich ones than the poor ones. Even though the A3-scenario makes the regional income distribution a little bit more equal, this is not sufficient to generate higher effects in poorer regions in absolute per capita terms. This is why absolute per capita effects correlate positively with GDP per capita in the ESPON space (correlation of 0.56). This is even more so in the candidate countries (correlation of 0.75).

Regarding polycentricity, scenario A3 can be said to favour polycentricity. On the macro scale, the fact that the Pentagon is favoured less (0.113 %) than the average points towards shows a gain in polycentricity. A tendency in favour of polycentricity on the meso scale can be inferred from the observation that the impact is smallest in very densely populated regions (0.096 %), medium in urbanised areas (0.186 % and 0.135) and largest in rural regions (0.295% and 0.225 %).

The spatial pattern of the A1-scenario, representing the impact of rail investments during the last decade, is different. There is virtually no correlation between relative effects and GDP per capita, except from AC12, where the correlation is slightly positive. That means that within AC12 gains are a bit higher in richer regions, so that the distribution is made more unequal. But this impact is so small that one can not assign any political importance to this fact. Remember that the average impact on GDP is only 0.049 % percent of GDP for EU 15 as well as for AC12. There is little systematic variation of impacts by type of region. The only observation worth mentioning is that gains are above average in objective-1 regions (0.059 %) and in lagging region (0.074 %). This can be regarded as a hint to some, though only tiny impact in favour of cohesion. Differentials by type of settlement structure do not point to any systematic tendency with regard to polycentricity, neither in one nor in the other direction.



Map 4.11 Changes of regional welfare in scenario A3

B-Scenarios

The B-scenarios have been defined for evaluating the impact of transport policy in Europe within the two decades to follow. The results compare the factual infrastructure in 2001 with the situation that would have prevailed if the level of infrastructure was already in the state of 2021. In other words, the cost changes modelled in this scenario represent changes in the quality of infrastructure to be expected during the two decades 2001 to 2021. Only transport cost changes for road and rail are taken into consideration. They have been extended since the Third Interim Report. To deepen the impact analysis of the future investments in European transport infrastructure, we have added 4 scenarios. The first scenario is an impact analysis of the new list of TEN priority projects including the motorways of the sea[26]. On Map 4.12 the spatial distribution of the impacts is displayed. In this scenario the least number of policy measures is included, the list of priority projects consists of 29 projects. The biggest impacts mainly follow the track of the projects, so the effects of transport projects are in relatively short range of the project. The map furthermore shows that there are projects with significantly higher impacts than others. Especially, it can be seen, that the impact of the projects on the Iberian Peninsula, Southern Italy, Greece, Denmark and South Sweden show high positive impacts in the regions, in which they are implemented. However, the benefits that arise from these projects is limited in range and is limited to those regions, in which they are built and the nearer surrounding.

The overall effect of the policy package is relatively small, a benefit of 0.144% of GDP of the EU27+2 area. The effect of the projects in Central and Eastern Europe, that have been added in the latest revision[27], benefit most of the extended EU, especially Poland, the Czech Republic and Romania. The cohesion indicators show that the effect of the scenario is pro-cohesive for EU-15 and EU-27. However, it shows an anti-cohesive tendency within the accession countries, an effect that might stem from the fact, that the newly added projects at most connect the capitals and thus the more well-off regions of Eastern Europe.

The policy package furthermore benefits most the objective-1 regions (0.210%) and lagging regions (0.269%). With respect to polycentricity, one can roughly say that it is in favour on the macro scale, as the Pentagon gains below average (0.093 %). Furthermore, it benefits regions which are in the rural settlement type category, urbanised areas gain below average, which also shows a tendency to favour polycentricity on the meso scale.

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[26] See High Level Group (2003)

[27] See European Commission (2003)

The scenario B2 shows the effect of the completion of the complete list of the TEN and TINA projects. The spatial distribution of its impacts is displayed in Map 4.13.

We begin the description of the spatial pattern again with the total effects for both modes. Like the A3-scenario, the B2-scenario is pro-cohesion. The effects correlate negatively with GDP per capita for the whole ESPON space (-0.43) as well as for EU15 (-0.27) and for AC12 (-0.11). It is more in favour of cohesion for the whole area than for the two subspaces, because the cohesion effect is partly caused by the impacts in the accession countries, which are more than twice as large in the poorer accession countries than in the richer EU15. This corresponds to the observation that the inequality measure decreases by 0.21 % for the ESPON space, by 0.28 % for EU15, and 0.09 % for AC12. Again one should have in mind that this equality enhancing effect, though clear cut, is small and appears only in the third digit of the inequality index.

The pro-cohesion tendency of the prospective infrastructure development can also be seen from the fact that effects are on average considerably higher in lagging and potentially lagging regions (0.493 % and 0.304 %) than in non lagging regions (0.21 %). They are also considerably higher in objective-1 regions (0.402 %) then in the whole space (0.262 %).

Regarding polycentricity, scenario B2 can be said to favour polycentricity on all three scales, macro, meso and micro. On the macro scale, the fact that the Pentagon is favoured less (0.176 %) than the average points towards a gain in polycentricity. The same conclusion can be drawn from looking at effects by regions classified according to macro scale accessibility: effects of B2 are lowest in central regions, medium in medium regions highest in peripheral regions.

A tendency in favour of polycentricity on the meso scale can be inferred from the observation that the impact is smaller than average in agglomerated and urbanised areas and largest in rural regions. On the micro scale we infer a certain tendency towards strengthening of smaller centres from looking at effects by subtypes of the BBR settlement structure typology. Within the agglomeration class the effects are lower in the cores and very high density parts than in the rest of these areas, whereas in the rural class the order is reversed: the more densely populated subtype of regions within rural areas gains more (0.356 %) than the average, and also the less densely populated subtype of regions within rural areas gain the most (0.377 %).

The B3 and B4 scenario are two subsets of the B2 scenario, in which the TEN/TINA networks are split into investments in cross-border (scenario B4) projects and investments in infrastructure projects not crossing borders (scenario B3) to isolate the effect of both kinds of projects.

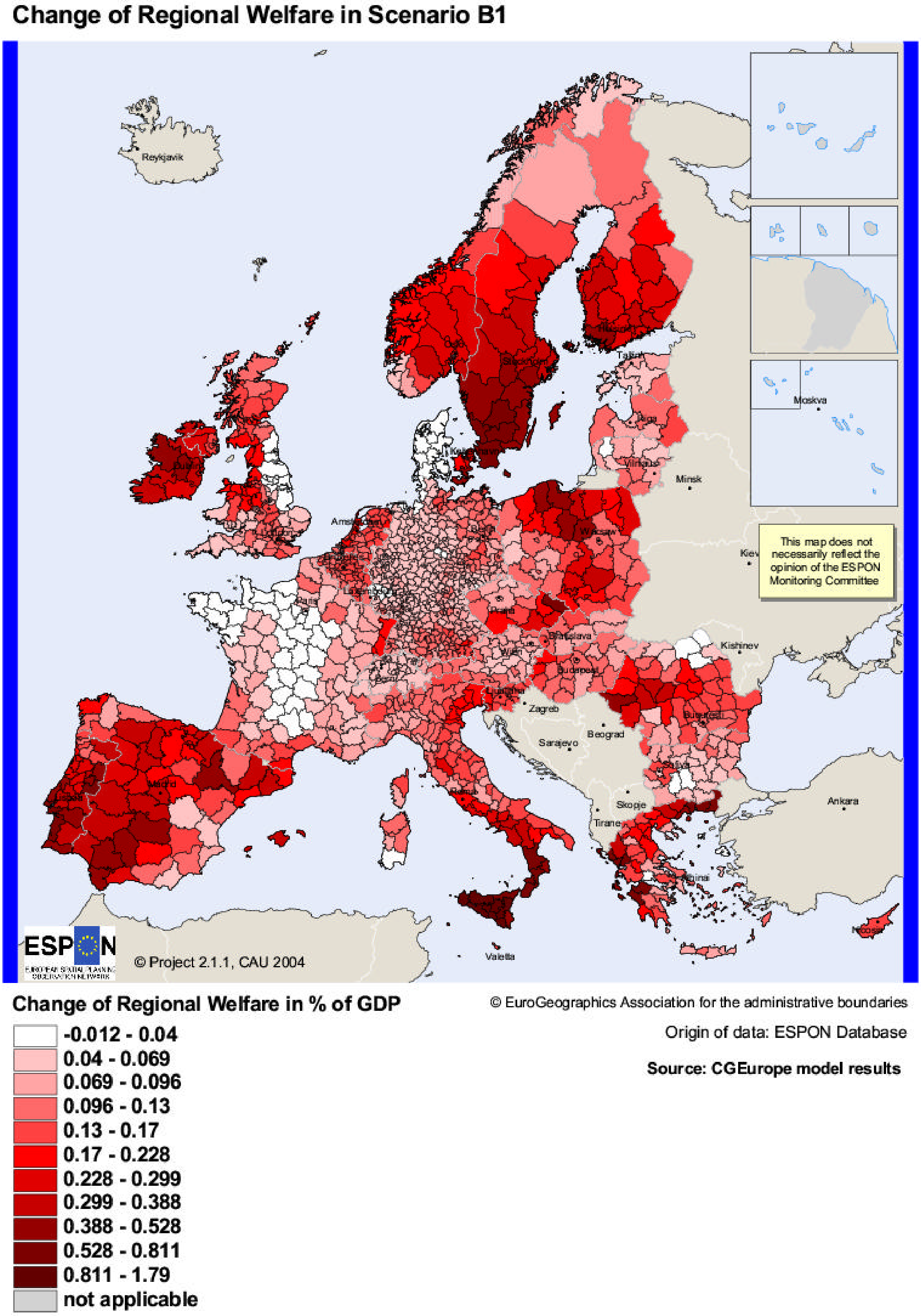
The effect of the scenario of the transport projects within countries has a higher impact than the cross-border projects, an effect that was clear, because the majority of the European networks do not cross borders. As regards cohesion and polycentricity, most of what has already been said for the B2 scenario also applies for the B3 scenario. The gains for objective-1 and lagging regions (0.357% and 0.493%) are considerably higher than the average for the ESPON space (0.237%). The cohesion indicators show the same tendency towards pro-cohesion in relative terms for this scenario. The typology of regional dominant settlement structures shows that the scenario benefits most rural and densely populated urbanised regions.

The B4 scenario has a lower overall impact of 0.042% with an impact of 0.038% for EU15 and 0.136% in AC12, which alone suggests a pro-cohesive tendency of this scenario. The magnitude of the effects on regional scale suggests that the impact on the Eastern European regions is considerably higher than in the EU15, the border projects between Bulgaria, Greece and Romania have very high positive impacts for the border regions in these countries. The biggest number of cross-border projects is located in the area of Poland, Czech Republic, Slovakia and Hungary, which account for most of the benefits in this scenario.

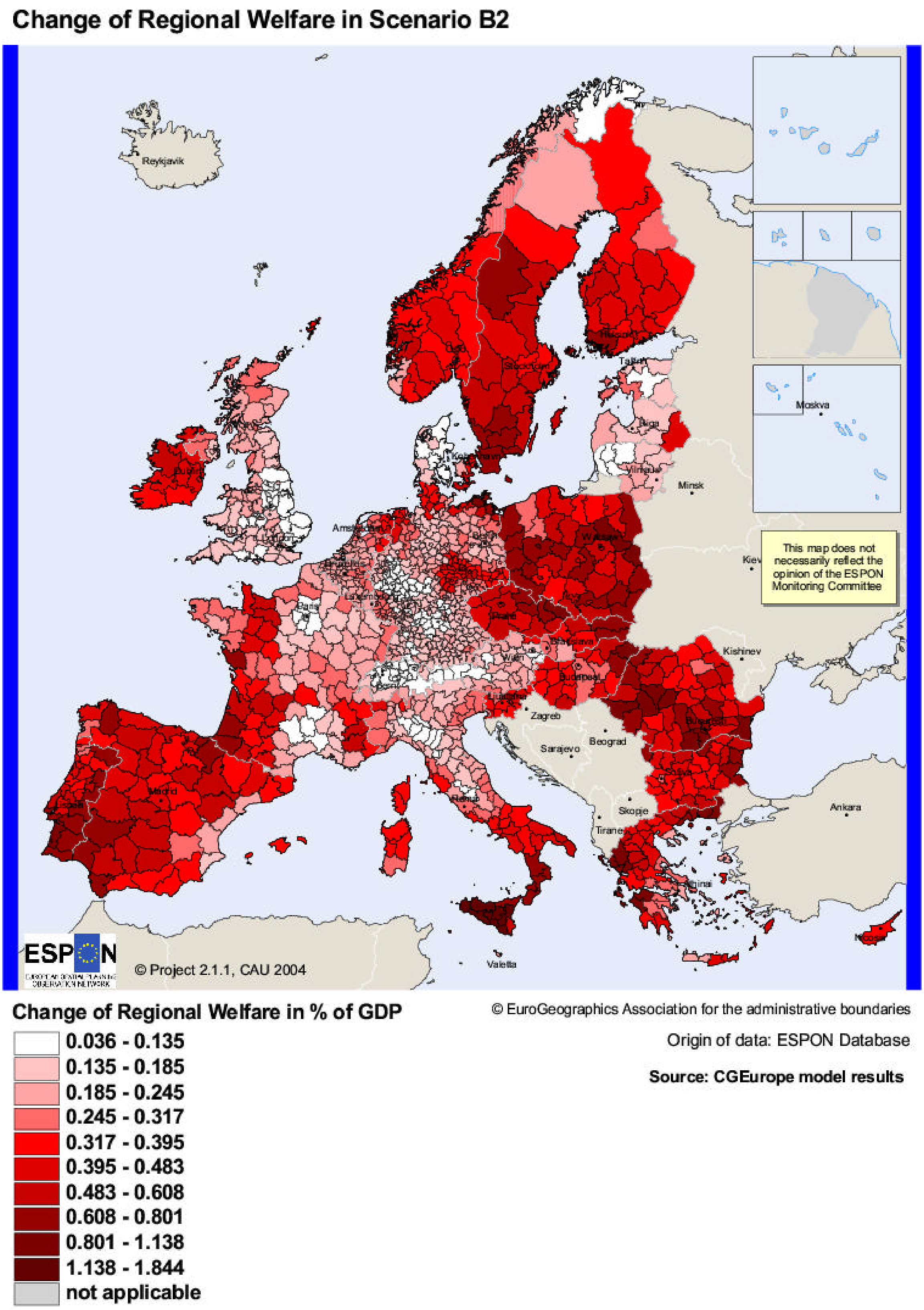
Compared to this, the effects in the area of France, Germany and Benelux are relatively small. Nevertheless, these projects do benefit most of the area of the Benelux. What is also worth mentioning, is that the benefits of the projects between Spain and Portugal mostly fall into the area of Portugal and the benefits of the projects between France and Spain mostly fall into the area of Northern Spain.

What can finally be said, is that the B4 scenario is also favourable for cohesion in relative terms. The biggest winners of this scenario are beside the objective-1 (0.062%) and lagging regions (0.072%) also the border regions (0.060 %). This conclusion is also confirmed by all relative measures of cohesion in relative terms. However, the measure for cohesion in absolute terms tends toward an anti-cohesion tendency.

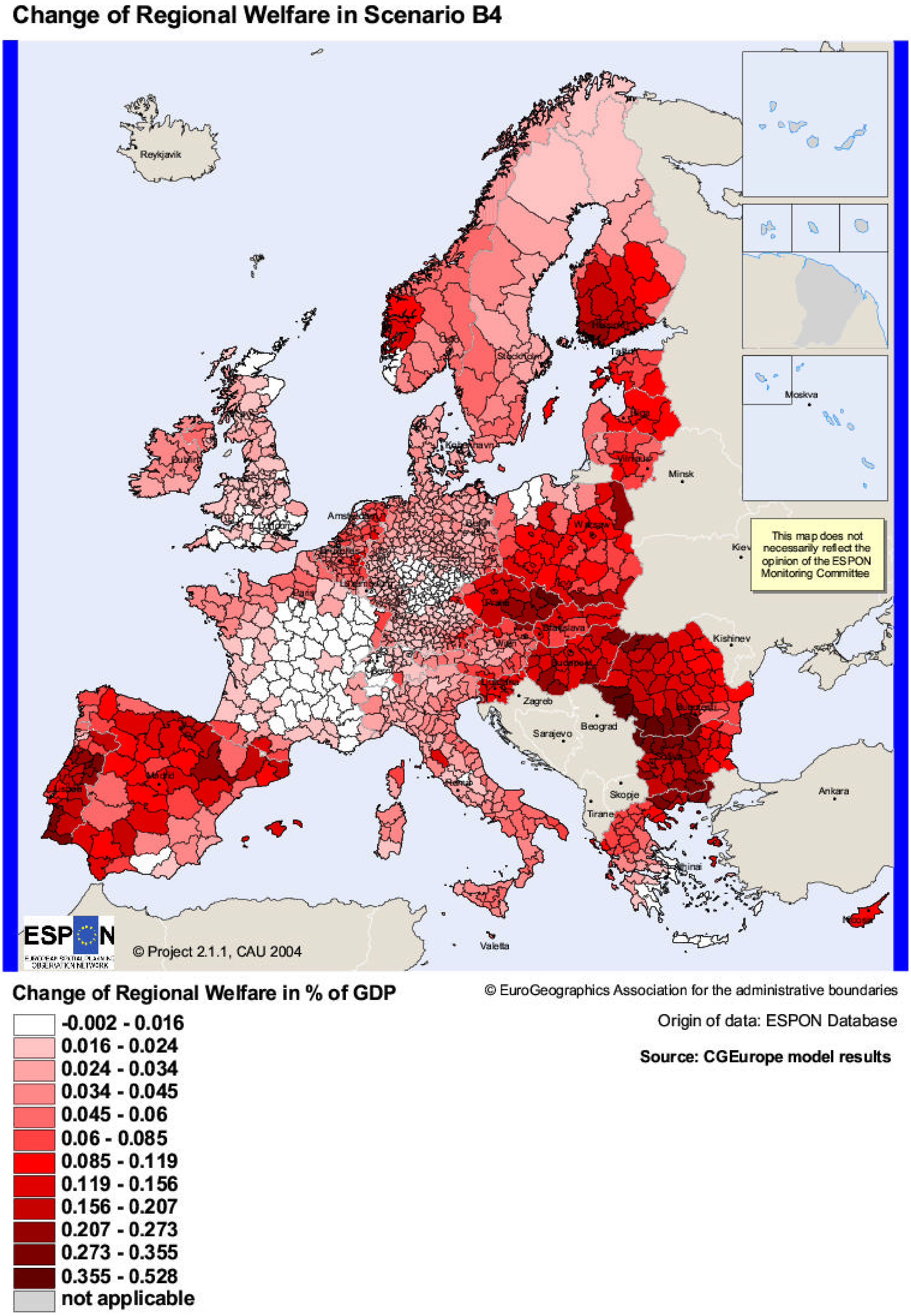
Scenario B5 describes the impact of the infrastructure development in objective-1 regions. The effect of this scenarios is, of course, pro-cohesive within the ESPON space and the EU15, the effect in the accession countries also tends to be positive, but not absolutely clearly, because the changes of the Gini-coefficient and the ratio of the geometric and arithmetic mean show a slight anti-cohesion tendency. The effect in the regions classified as lagging is even higher than in the objective-1 regions, which is due to the fact that not all objective-1 regions are necessarily lagging regions, but can also be potentially lagging, according to the definition used in this context. This tendency shows that these investments benefit the least well-off of the objective-1 regions. The biggest winners in the classification of dominant settlement types are rural regions and agglomerated regions with densely populated regions in NUTS-2 and rural regions in NUTS-2 type.



Map 4.12 Changes of regional welfare in scenario B1

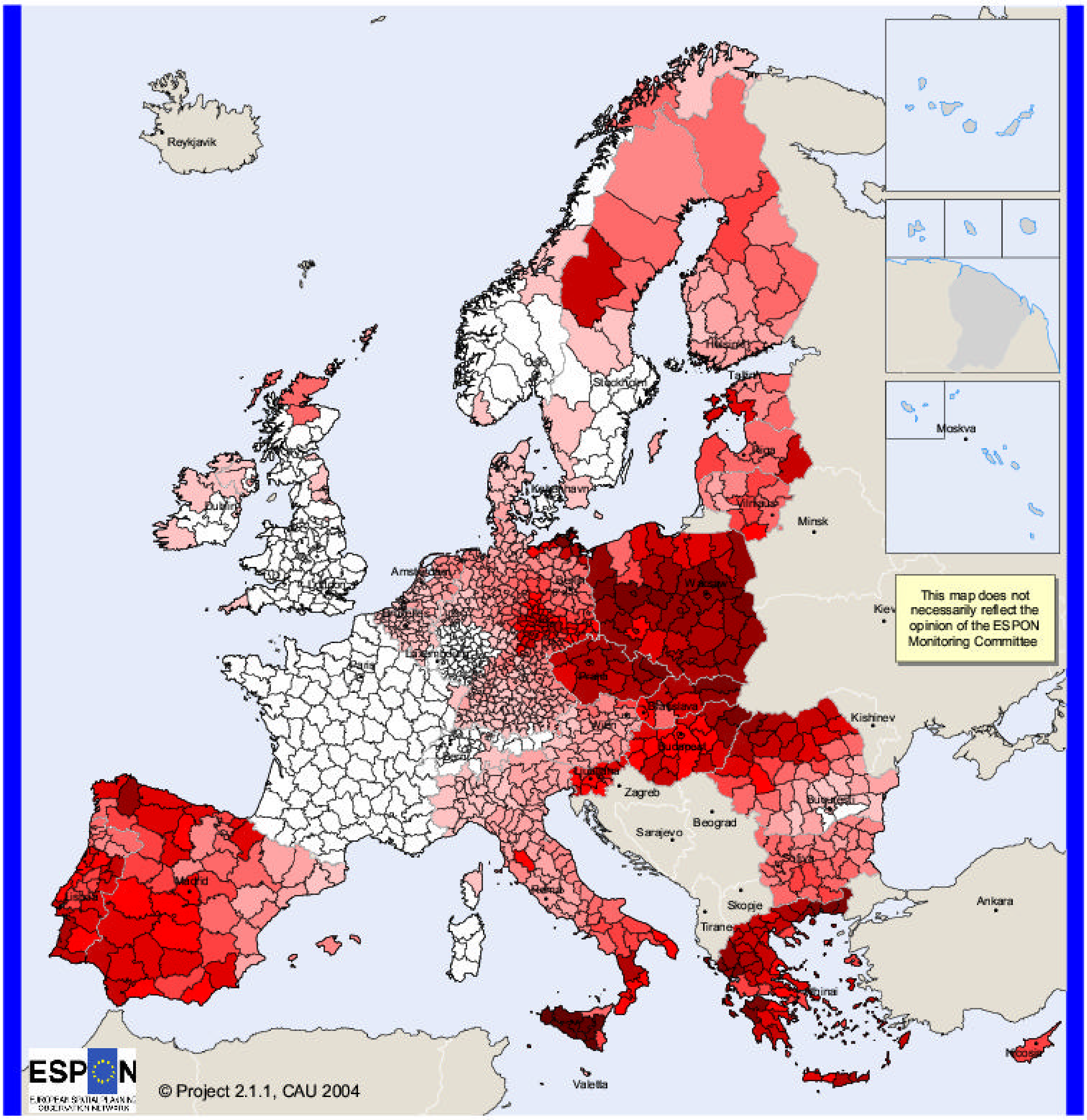


Map 4.13 Changes of regional welfare in scenario B2



Map 4.14 Changes of regional welfare in scenario B4

Change of Regional Welfare in Scenario B5



Change of Regional Welfare in % of GDP

- -0.015 - 0.013
- 0.013 - 0.028
- 0.028 - 0.045
- 0.045 - 0.07
- 0.07 - 0.102
- 0.102 - 0.14
- 0.14 - 0.187
- 0.187 - 0.252
- 0.252 - 0.343
- 0.343 - 0.46
- 0.46 - 0.613
- 0.613 - 0.841
- 0.841 - 1.299
- not applicable

Origin of data: ESPON Database

Source: CGEurope model results

Map 4.15 Changes of regional welfare in scenario B5

C scenarios

The C-scenarios have been defined for evaluating the impact of pricing policies. Pricing policies under discussion in Europe may affect all modes of transport in a similar way, or they may discriminate between modes of transport. As the likely developments with regard to pricing policies are still open, it is useful to see what happens if prices change for all modes as well as what happens if modes are affected differently. Hence, C1 assumes that prices are reduced for rail transport, because rail transport is comparatively less damaging the environment. C2 assumes that prices increase for road transport only. This reflects a tendency in policy such as in the case of the German Maut for road freight to increase taxes or other kinds of fees for making road users pay for externalities generated by road transport. Finally, C3 assumes that all three modes included in the model, road, rail and air, are affected by a price increase. It is important to note that none of the C-scenarios includes the effects of a possible redistribution of higher taxes. The implicit assumption is that this redistribution is made in a way that is completely neutral with respect to the spatial distribution effects under consideration.

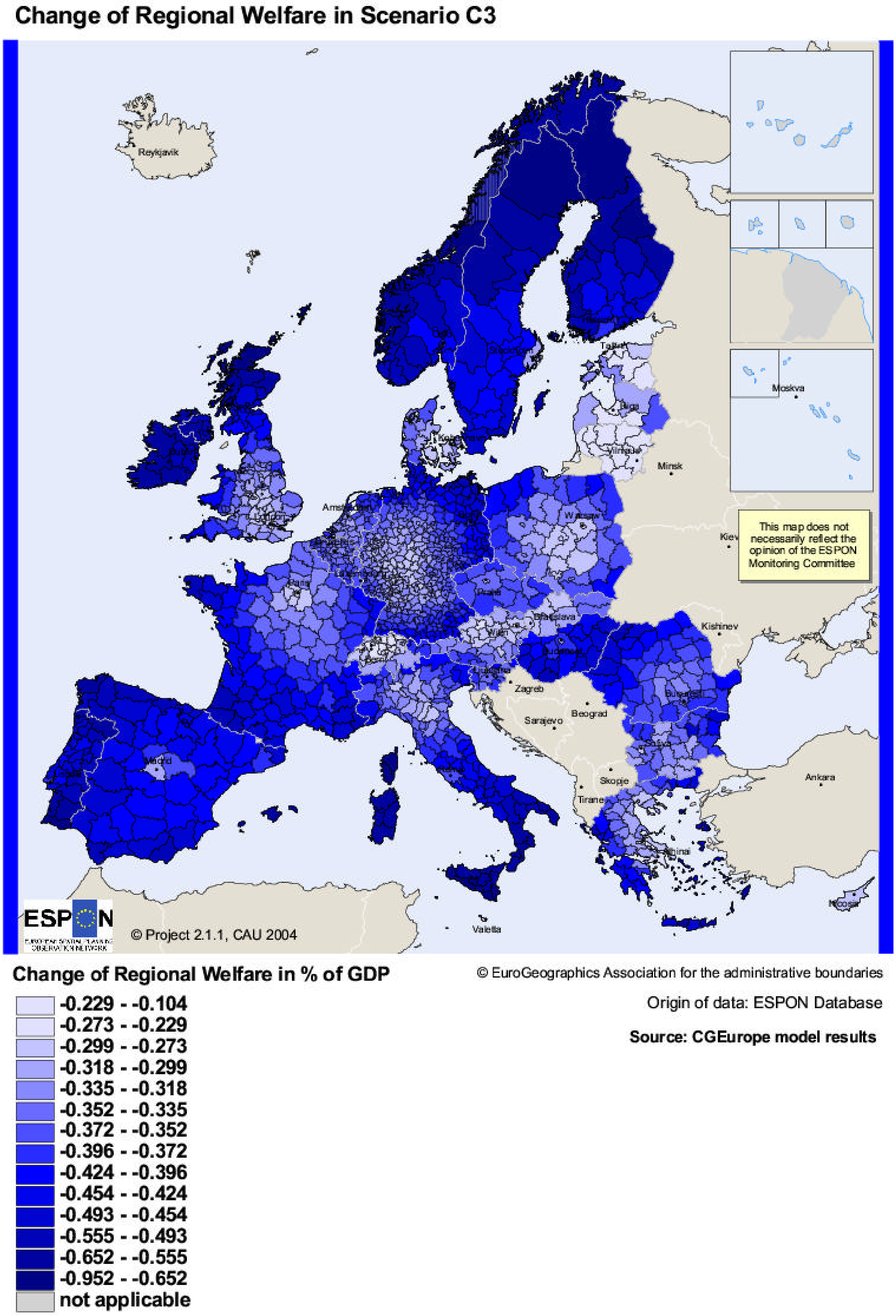
Let us begin with the impact of reduced rail costs, which could result from subsidization as well as from higher cost efficiency due to deregulation. With respect to cohesion, this would be neutral except for AC12, where it would be anti-cohesion; that means it would favour rich regions more than poor ones within AC12. On the other hand, objective-1 regions would gain more than the average (0.060 % versus 0.048 %) and lagging regions would gain more than non lagging ones (0.066 % versus 0.045 %). Hence, results for the spatial income distribution are mixed.

The centre-periphery pattern of effects is however clear cut. Gains are below average in the Pentagon-regions, and they are the larger, the more peripheral a region is. With regard to settlement structures, we observe above average gains in the rural type of regions. Hence, at least on the macro as well as meso scale a reduction in rail costs can be confirmed to enhance polycentricity.

The opposite tendencies are observed for pricing policies increasing transportation cost, irrespective of whether this concerns road transport only or all three modes under consideration. This is revealed by the results of scenarios C2 and C3, which show a similar spatial pattern; the correlation is 0.82. Both are inequality increasing, as shown by the positive correlations of the effects with GDP per capita for EU15 (0.27 and 0291 for road and all modes, respectively), for AC12 (0.47 and 0.44 for road and all modes, respectively). This corresponds to the observation that the inequality indices increase in both scenarios, the whole space and the two subspaces. The fact that losses in lagging and potentially lagging regions as well as in objective-1 regions significantly exceed the average also fits with this general picture.

The centre-periphery pattern is also very clear. Losses are below average in the Pentagon, smallest in agglomerated regions, medium in urban regions and highest in rural regions. Furthermore, the better the accessibility in the reference situation, the smaller are the losses. It is furthermore well visible from Map 4.16, that there are two overlaying centre-periphery patterns, a national and a European one. The national pattern is due to the fact that spatial interaction is much more intense within countries than between them. Hence, not only regions in the European periphery, but also regions in the periphery of their respective national markets suffer from increasing transportation costs, because their interaction with the markets is more dependent on transportation than that of more central regions. This also explains why losses in border regions and coastal regions are also above average.

Summarising these observations, pricing policies increasing private transportation costs can very clearly be said to work against the general objectives of cohesion and polycentricity.



Map 4.16 Change of regional welfare in scenario C3

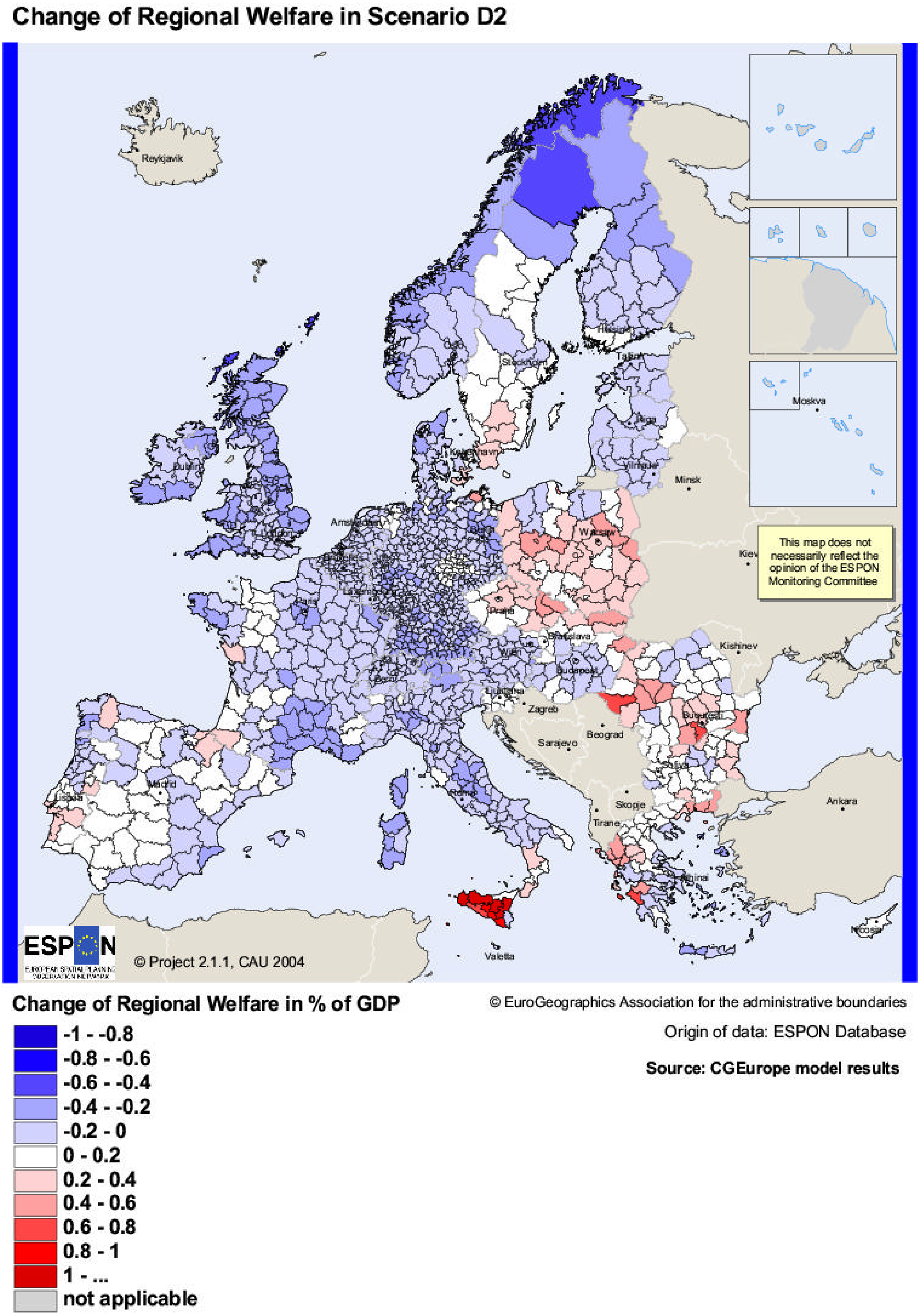
D Scenarios

Two combined pricing and infrastructure scenarios are analysed to analyse if there are interactions between both kinds of policies. The D1 scenario includes all projects of the TEN priority list and pricing of all modes of transport, which is a combination of scenarios B1 and C3. It shows what combined impact two big policy packages of the EU have on the spatial distribution of regional incomes. The overall effect of the pricing component overweighs the positive impact of the priority projects, as can be seen from the negative overall impact (-0.212%). However, the distribution of the impacts has a higher correlation with the pattern of the B1 scenario (0.81) than with the C3 scenario (0.32).

The D2-scenario is the attempt to describe a transport policy for the next two decades that can be regarded as realistic. It combines social marginal cost pricing implying a tendency to increasing private transportation cost as well as decreases of transportation cost due to improved infrastructure. It is natural that the conclusions from this scenario can not be so clear as for the others, because two patterns overlay: the pattern resulting from better infrastructure, which is by and large pro-cohesion and pro-polycentricity, and the pattern resulting from pricing policies, which is just the opposite. The correlations of this one with the other scenarios shows higher coefficient for the infrastructure scenario. That means that the pattern is more influenced by the infrastructure policy than the pricing policy, and hence some degree of cohesion and polycentricity enhancement can be expected.

In fact, the scenario shows a negative correlation with GDP per capita for the whole ESPON space as well as for EU15, but not for AC12. This corresponds to the changes of the inequality index: It decreases for the whole space and for the EU15, but not for AC12. The increase of equality in the whole area is largely due to the fact the AC12 gain 0.27 % on average, while the EU15 loses 0.07 %. Gains in objective-1 regions (0.003 %) and lagging regions (0.070 %) fit with the general picture of a pro-cohesion tendency.

The impact on polycentricity on the macro scale is not so clear. The Pentagon suffers from a loss slightly above average. The classification by settlement structure also supports this view: agglomerations suffer from the highest losses, urbanised regions from medium ones and rural regions from the lowest ones. Hence, there is some tendency of this scenario to favour polycentricity on the meso scale, but not on the macro scale. No clear micro pattern can be identified; the picture is too diverse due to the overlay of the two conflicting tendencies of pricing and infrastructure policies.



Map 4.17 Change of regional welfare in scenario D2

Table 4.17 Comparison of absolute income effect and welfare effect

	Absolute effect in Euro/capita			Welfare effect in Euro/capita		
	EU27+2	EU15	AC12	EU27+2	EU15	AC12
A1	9	11	2	7	10	2
A2	21	25	4	16	24	4
A3	29	35	6	22	33	5
B1	46	55	12	41	57	11
B2	86	97	40	83	100	35
B3	77	89	28	71	92	24
B4	14	15	12	16	15	10
B5	18	18	23	27	22	19
C1	16	19	3	12	18	2
C2	-93	-110	-27	-74	-104	-20
C3	-118	-139	-28	-95	-133	-24
D1	-70	-82	-15	-53	-74	-13
D2	-30	-39	13	-9	-31	11

After having documented spatial distribution effects in depth, a final qualification has to be emphasized regarding the socioeconomic importance of these effects. As a matter of fact, all transportation scenarios have an impact on the level of incomes as well as on the distribution. Our results are confined to distribution in space. How important is the distributional dimension as compared to the impact on average levels? This question can only be answered if a welfare index is at hand allowing to weight the level effect and the distributional effect against each other.

A welfare measure has been suggested in Chapter 3.5 This welfare measure, just as any welfare measure, is implicitly based on a value judgement about inequality aversion. The suggested welfare measure counts Euros gained by a certain scenario with a weight that varies inversely proportional with income of the affected average inhabitant of the respective region. A Euro for an inhabitant of a rich region counts proportionally less than a Euro gained by an inhabitant of a poor region. Now we can compare welfare gains of a representative inhabitant with average monetary gains. Welfare gains are made comparable to monetary gains by translating them into equivalent monetary amounts. If welfare gains and average per capita gains deviate much (little), the distributional dimension plays a large (small) role in the net benefit of a scenario.

The results are shown in Table ... They clearly indicate a rather moderate role of the distributional dimension. Though we discuss the impact of transport policy on spatial distribution at length in this report, one also has to keep in mind that efficiency in terms of net average income gains or losses are much more important than the issue of distribution, at least judged on the basis of the suggested welfare indicator. The corresponding calculations have also been performed for the results of the SASI model, leading to the same conclusion. They are not documented in this report.

4.1.3 STIMA

This section contains the estimate results of the STIMA model, presented in section 3.3.1.

The estimated model is the following (Table 4.1)[28]:

L_gdp99p = f (L_acc, L_fixtel, L_intcon, L_cabsat, L_totemp, L_hitech)

where the prefix "L_" indicates the conversion in natural logarithm (ln) and[29]:

gdp99p = per capita GDP 1999
acc = accessibility 1999
fixtel = percentage of households with a fixed telephone in 1999
intcon = percentage of households with a Internet connection in 1999
cabsat = percentage of households with a cable or satellite TV in 1999
totemp = total employment in 1999
hitech = high tech employment in 1999

Interesting enough, in model 1 all ICTs variables are significant and present the expected positive sign. The same applies for model 2, where the high tech employment variable is substituted with the 1995-1999 mean of high

---

[28] First of all, to make comparison possible, and to avoid distortion derived from the size of the regions, we weighted all our indicators by regional population, creating "per capita" variables. Secondly, we decided to estimate a loglinear model, by substituting the natural logarithm to the indicators. Some preliminary results concern the innovative capacity (expressed by patents or by high-tech patents) and the level of economic development (expressed by the per capita GDP at 1995): these variables are both strictly related with the level of economic development, as expected. However, from a statistical point of view, this relationship was so strong that it hides all the others, making them not significant. Thus, once acquired this result, we decided to exclude these indicators from the model, in order to highlight the relationships between GDP and ICTs indicators, that is our primary aim.

[29] The estimate of the model is based on 1999 data. This choice has been made for the lack of data on GDP at 2002, which did not allow to use the new 2002 ICTs INRA data. This aspect has not been perceived as a problem since it the estimate is based on a structural relationship, which does not change much in two years difference.

tech employment in each region. The fit of the second model is quite good, with a R^2 index around 0.67, and it allows the use of a greater number of observations and a better fit of most variables. Consequently, we rely on model 2 for the analyses which follow.

However, when working with spatial data, as regional data in our case, a problem of *spatial dependence* between the observations may arise. It means that the value of a variable x for the observation at location i depends on the values of *x* for observations located near *i*[30].

Table 4.18 Estimated models: regression results

Indicator	Model 1	Model 2
Observations	128	185
R^2	0.67	0.58
Constant	0.596 (0.52)	-3.386 (3.38)**
L_acc	0.032 (1.86)	0.042 (2.38)**
L_fixtel	0.530 (2.25)*	0.733 (4.09)**
L_intcon	0.065 (2.67)**	0.049 (2.45)**
L_cabsat	0.096 (4.13)**	0.107 (5.30)**
L_hitech	0.085 (1.32)	-
L_hitech2	-	0.061 (1.96)*
L_totemp	0.861 (5.68)**	0.535 (3.75)**
Dependent variable: L_gdp99p		

In brackets T-Test values.
* = significant with $p < 0.05$
** = significant with $p < 0.01$

There are two types of spatial dependence:

spatial interactions (or spatial lag), which means that the behaviour of one individual affects another individual, like spillover or externalities effect;

spatial autocorrelation in the stochastic perturbation (or spatial error), that implies the presence of measurement errors in different individual's values, correlated with each other.

[30] For more details concerning the spatial dependence problems, see Anselin (1988), Anselin (1992), Anselin and Hudak (1992), Anselin et al. (1996).

If there is spatial dependence, a simulation model based on ordinary least squares regressions (OLS) may produce a biased or inefficient estimator, because an explanatory variable has been omitted (spatial lag) or because the errors are correlated (spatial error). So, some statistical tests have to be run to detect the presence of spatial dependence. In order to do this, an indicator of the closeness of our observations has to be built: the spatial weights matrix[31] W whose elements w_{ij} express the presence or absence (binary weights matrix) or the degree (non-binary weights matrix) of potential spatial interaction between each possible pair of locations[32]. Once W is built, we can run tests to detect spatial dependence.

The spatial autocorrelation tests for our model showed the presence of both spatial lag and spatial error[33]. However, the first is more important, as it shows higher indexes (Table 4.19).

Table 4.19 Tests for spatial autocorrelation

Test	Statistics	Df	p-value
Spatial error			
Moran's I	7.621	1	0.000
Lagrange multiplier	40.385	1	0.000
Robust Lagrange multiplier	2.695	1	0.101
Spatial lag			
Lagrange multiplier	51.264	1	0.000
Robust Lagrange multiplier	13.574	1	0.000

[31] Through a GIS software (ArcviewGIS 3.0, with two extensions for building centroids and distance matrix), we identified the centroids of each European region, and we built a distance matrix for them. However, in our analysis, we need a matrix of spatial contacts, a spatial weights matrix. To transform our distance matrix into a weights matrix, we assumed as near, and thus “influencing”, the regions whose centroids are nearer than 300 km: the cells of our binary W matrix assume value 1 if the distance is less than 300 km, and 0 otherwise.

[32] Pisati (2001).

[33] The most important tests for a multivariate regression model are the Moran's I, the Lagrange Multiplier and the Robust Lagrange Multiplier. These tests assume higher and significant values when there is positive spatial autocorrelation in the dependent variable (lag) or in the errors. For calculating the spatial autocorrelation tests and the spatial lag model, we used STATA 7 with the extensions for spatial analysis (Pisati, 2001).

In order to correct the spatial dependence in the dependent variable (spatial lag), a new regression model has been built that introduces a variable, called *?*, to take this relationship into account. The new estimated model is a *spatial lag model* (Table 4.20):

Table 4.20 Spatial lag model: spatial regression results

Indicator	Spatial lag model
Observations	185
Constant	-3.552
	(-4.07)**
L_acc	0.051
	(3.31)**
L_fixtel	0.574
	(3.61)**
L_intcon	0.037
	(2.07)*
L_cabsat	0.061
	(3.13)**
L_hitech2	0.004
	(0.12)
L_totemp	0.457
	(3.65)**
?	0.437
	(5.14)**
Dependent variable: L_gdp99p	

In brackets Z-Test values.
* = significant with $p < 0.05$
** = significant with $p < 0.01$

L_gdp99p = constant + $ß_1$ * L_acc + $ß_2$ * L_fixtel + $ß_3$ * L_intcon + $ß_4$ * L_cabsat + $ß_5$ * L_hitech2 + $ß_6$ * L_totemp + ? * W * L_Y

where Y is the difference between the regional GDP 1999 and the European mean.

The variance ratio and the squared correlation are both over 0.6 (respectively, 0.612 and 0.668), witnessing that the fit of the model improves by introducing the spatial lag term (*?*).

Finally, in order to obtain a better fit with the real data, the model was calibrated as shown in Table 4.21.

Table 4.21 Calibration of the spatial lag model

Indicators	Estimated coefficients	Calibrated coefficients	Differences
Constant	-3.552	-3.552	0.000
L_acc	0.051	0.055	+0.004
L_fixtel	0.574	0.650	+0.076
L_intcon	0.037	0.037	0.000
L_cabsat	0.061	0.070	+0.009
L_hitech2	0.004	0.005	+0.001
L_totemp	0.457	0.640	+0.183
?	0.437	0.300	-0.137
Dependent variable: L_gdp99p			

4.1.3.1 Forecasting results

Applying the forecasting methodology described in section 3.3.4., the following results were achieved:

1st step: European countries investments in ICTs (Table 4.22)

2nd step: EU investments in ICTs

EU investments are 2% of the EU countries , what roughly amounts to 1 billion € annually. Assuming a constant annual investment it corresponds to roughly 20 billion € for two decades.

This seems quite a reasonable hypothesis, when compared to the results of other studies[34].

In the 3rd step, we assume different allocation of funds corresponding to three different scenarios (see section 2.2.2).

The 4th step, as stated in the methodological section, concerns the estimate of the marginal efficiency. Regression models between the ICTs factors and capital invested in ICTs have been run. Capital invested in ICTs has been calculated by cumulating the investments 1990-2000 at 2000 prices. The results of the three regressions are presented in Table 4.23. Given the fact that regressions are run on the logarithms of the variables, the result obtained are the elasticity of respectively accessibility, internet connections and high tech employment to investments, and therefore they can be compared. Even at a first look, it is evident that investments in Internet connections prove to be much more efficient; 1% increase in financial resources devoted to internet connections provides an increase in Internet

[34] Technopolis et al. (2002). However, no precise data on financial resources devoted to ICTs exist.

connections of 0.96%, while it generates only an increase of 0.22% and of 0.26% of respectively high-tech employment and accessibility[35].

Table 4.22 European countries investments in ICTs (1st step)

Country	**Average annual investments in ICTs 1995-2000 (in billion € at 2000 prices)**
Austria	1.564
Belgium	1.158
Denmark	0.742
Finland	0.792
France	6.443
Germany	13.288
Greece	0.793
Ireland	0.397
Italy	7.699
Luxembourg	0.090
Portugal	1.276
Spain	3.949
Sweden	1.208
The Netherlands	2.162
United Kingdom	8.777
Total	**50.338**

Once the marginal efficiency of investment for each action is multiplied by the regional investments level allocated to each region and each action, the increase in levels of Internet connections, accessibility and high tech employment by region is forecasted for the next 20 years. Their future level determines the future increase in GDP ($?Y_{rt}$), depending on their geographical distribution and their distribution among ICTs factors.

The growth rates over the 20 years period of per capita GDP in the different scenarios are presented in Table 4.24[36], in which both the total growth rates forecasted in the three scenarios, and the growth rates divided between

[35] Once the elasticity of Internet connections, accessibility and high tech employment to financial investments have been calculated, the marginal efficiency of investments is easily obtained by multiplying the elasticity value for the ratio of each dependent variable (Internet connections, accessibility and high tech employment) on the independent one (invested capital).

[36] In our model, the GDP growth is caused only by ICTs policies. Consequently, the do-nothing scenario does not envisage any growth. We are aware that our results present quite high growth rates, due to the high marginal efficiency of the three policies and to the high level of investment. Our focus, however, is mainly on the differences among scenarios A, B and C, than between A, B, C and do-nothing scenario.

lagging and advanced regions in the three scenarios are reported. The maps presented in the following pages represent the growth rates for GDP, for accessibility and Internet connections in the next 20 years for each region in the different scenarios (Map 4.18 - Map 4.26). As already mentioned, our do-nothing scenario is zero; thus, if no ICTs investments are spent, GDP growth is equal to zero.

Table 4.23 Elasticities of ICTs to financial investments

Dependent variable	**1° model**	**2° model**	**3° model**
Accessibility (ln)	0.26 (2.3)*		
Internet access at home in 2002 (% of households) (ln)		0.98 (12.7)**	
High tech employment (%) (ln)			0.22 (2.13)*
Independent variable: Invested capital 1990-2000 (ln)			

In brackets T-Test values.
* = significant with $p < 0.05$
** = significant with $p < 0.01$

Table 4.24 Per capita GDP growth rate in the next 20 years in the scenarios

Scenarios	Pc GDP growth rate in 20 years		
	Lagging regions	Non lagging regions	Total
0 - Do-Nothing	0.00	0.00	0.00
A - Indiscriminate	0.12	0.016	0.033
B - Efficiency	0.012	0.04	0.037
C - Cohesion	0.14	0.00	0.023

In the indiscriminate scenario (A), the GDP growth rate is 0.033%; in this scenario an evident higher effect is shown in lagging regions (+0.12%) than in non-lagging ones (+0.016%). Fig. 5a shows that the GDP growth rate is very much distributed in most regions, with some peaks (positive or negative) that in most cases can probably be explained by statistical effects. Most of the regions show per capita GDP growth rates between 0.012% and

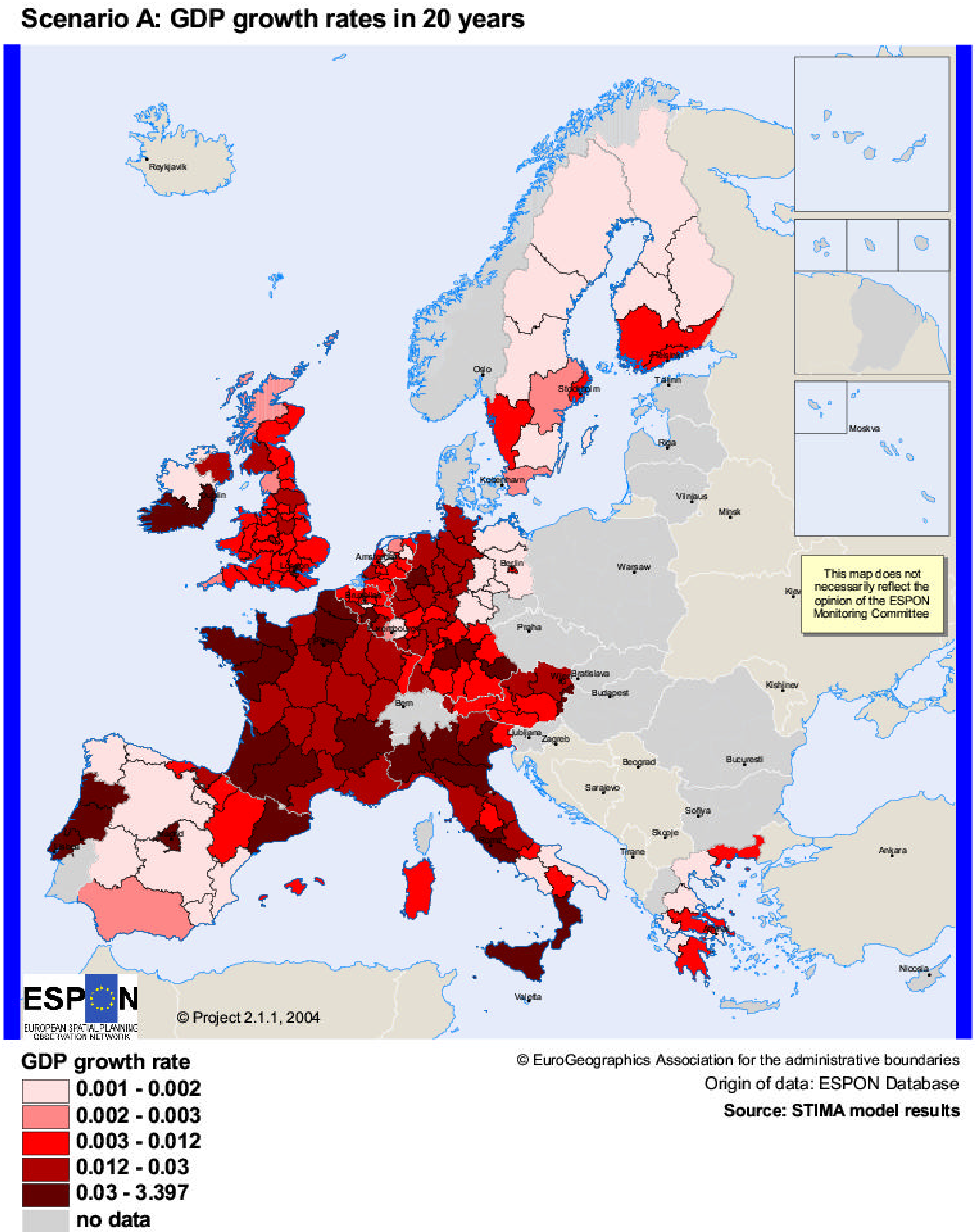
0.03%. Thus, as expected, this scenario affects all regions more or less in the same way.

A look at the changes in accessibility growth rates in 20 years shows an increase in less peripheral regions, most of them in the Mediterranean area (like Spain, Italy and Greece), and some in North of Europe, especially in Finland and Ireland (Map 4.19). In this scenario, accessibility will increase especially in lagging areas, decreasing their geographical peripherality. Internet connections growth rates presented in Map 4.20 do not show strong regional differences, with the exception of Portugal, some regions in Italy and France, and in Southern Ireland.

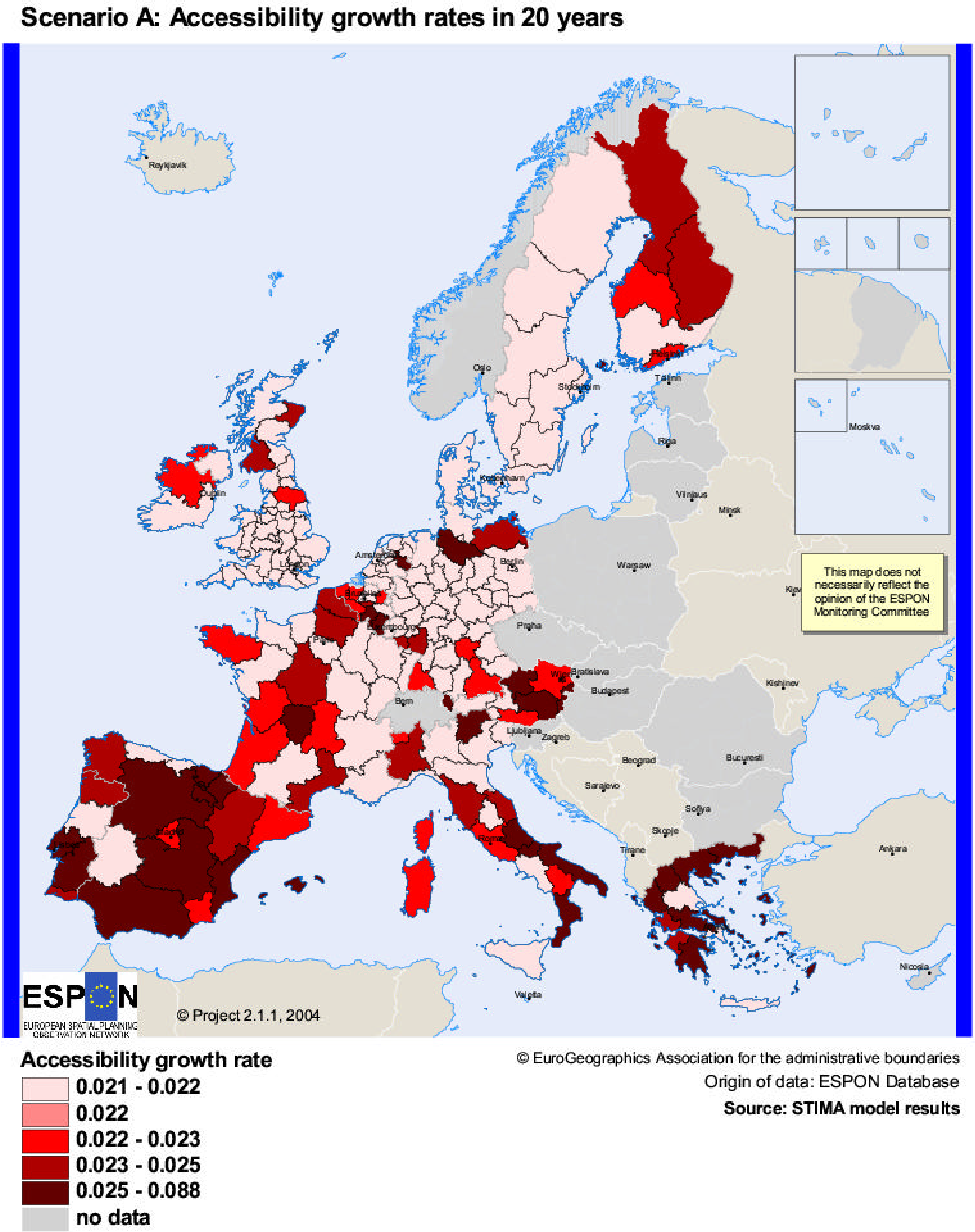
In the efficiency scenario (B), as expected, the growth rate in per capita GDP turns out to be stronger than in scenario A. Fig. Map 4.21 is directly comparable with Map 4.18; the difference is a stronger GDP growth rate in some non-lagging regions, like the regions belonging to the so-called Blue Banana (The Netherlands, Belgium, Luxembourg, and French regions near the Reno River) and to the Sunbelt (southern regions of France and Spain and Northern Italy). The efficiency scenario produces the highest per capita GDP growth rate, as expected (+0.037%), most of which in advanced regions (+0.04%), leaving to lagging regions only 0.012% of increase.

The highest growth rates in accessibility are registered in lagging regions, as the result of the division of funds between actions and regions. Of the 20% of investments devoted to lagging regions, 90% was in fact used in accessibility increase; as a result, all Southern Italian regions, Portuguese, Spanish and Greek regions register the highest growth rates (Map 4.22).

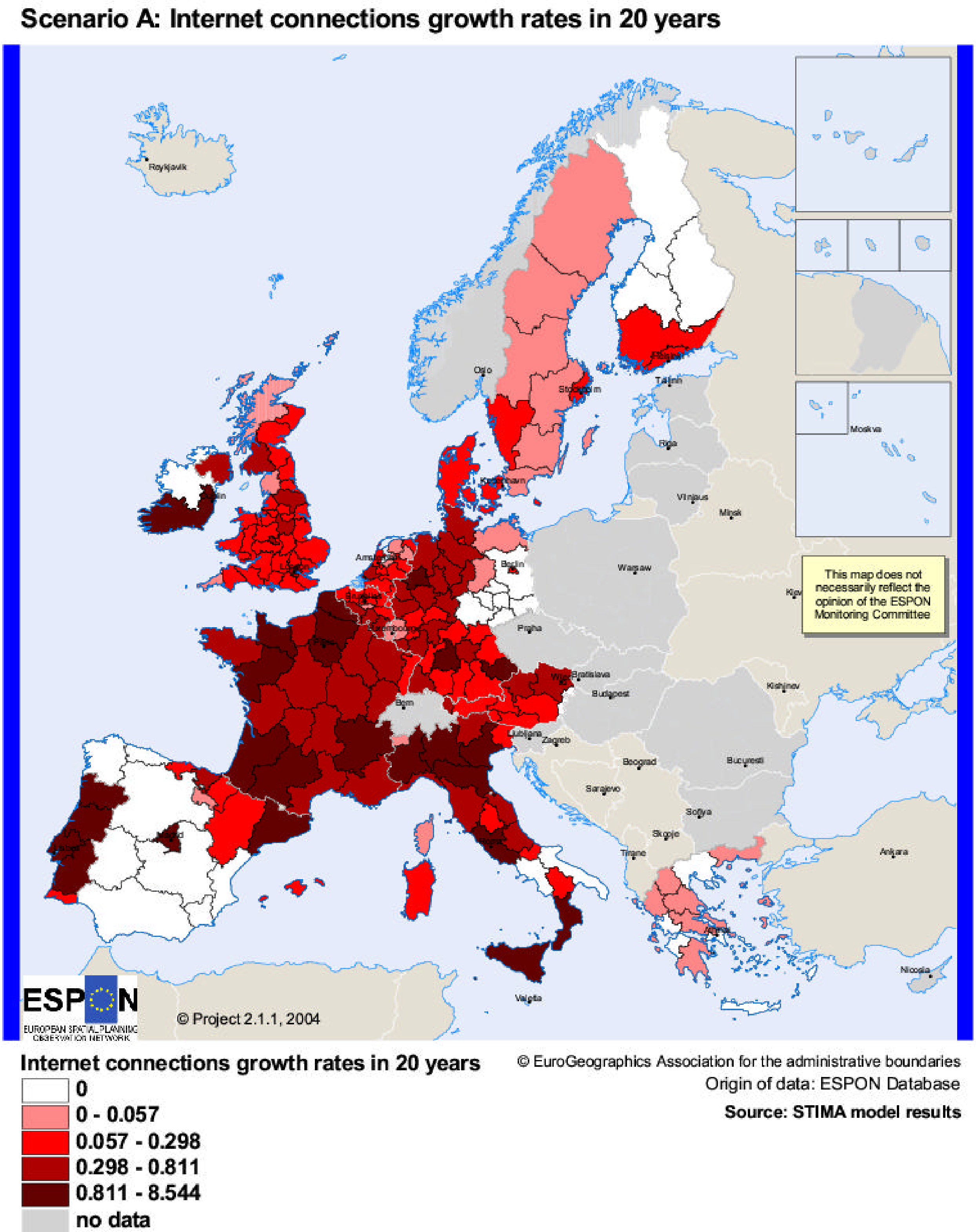
Internet connections increase strongly in the non-lagging areas like Northern Italy, Southern UK, The Netherlands and Belgium, where the presence of congestion of the existing network explains the high marginal efficiency of investments and, consequently, the higher GDP growth rates (Map 4.23).



Map 4.18 Scenario A: GDP growth rates in 20 years

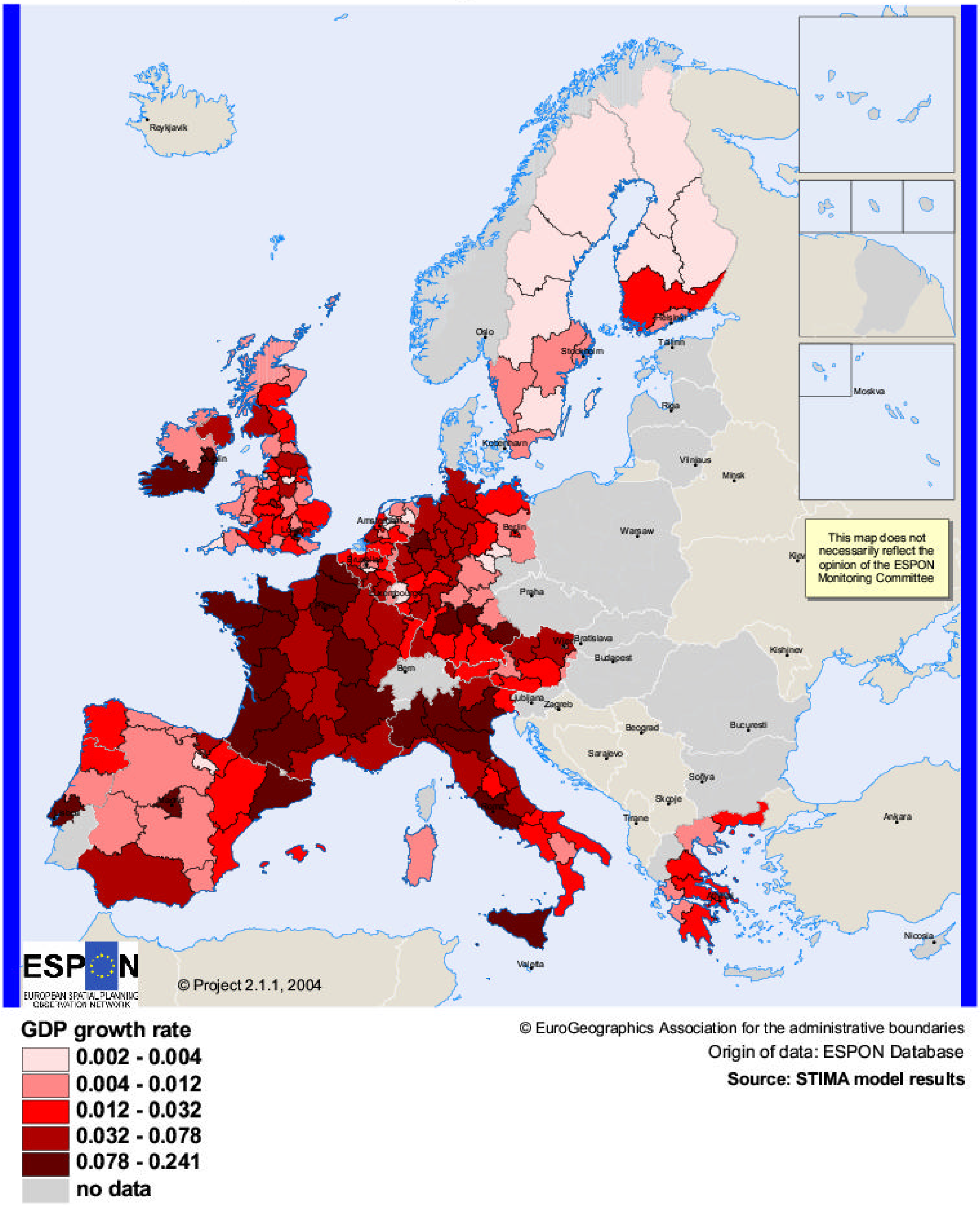


Map 4.19 Scenario A: Accessibility growth rates in 20 years

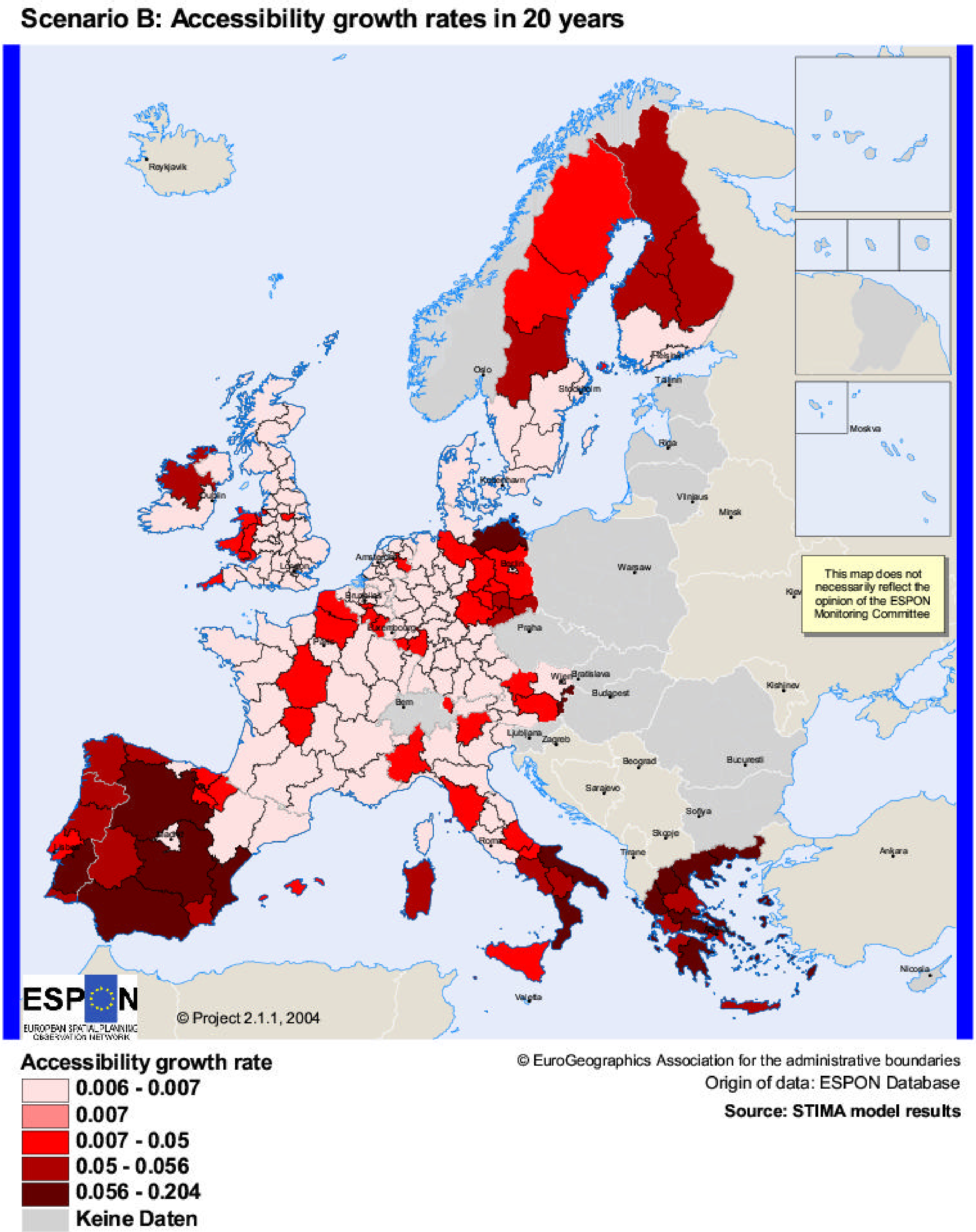


Map 4.20 Scenario A: Internet connections growth rates in 20 years

Scenario B: GDP growth rates in 20 years

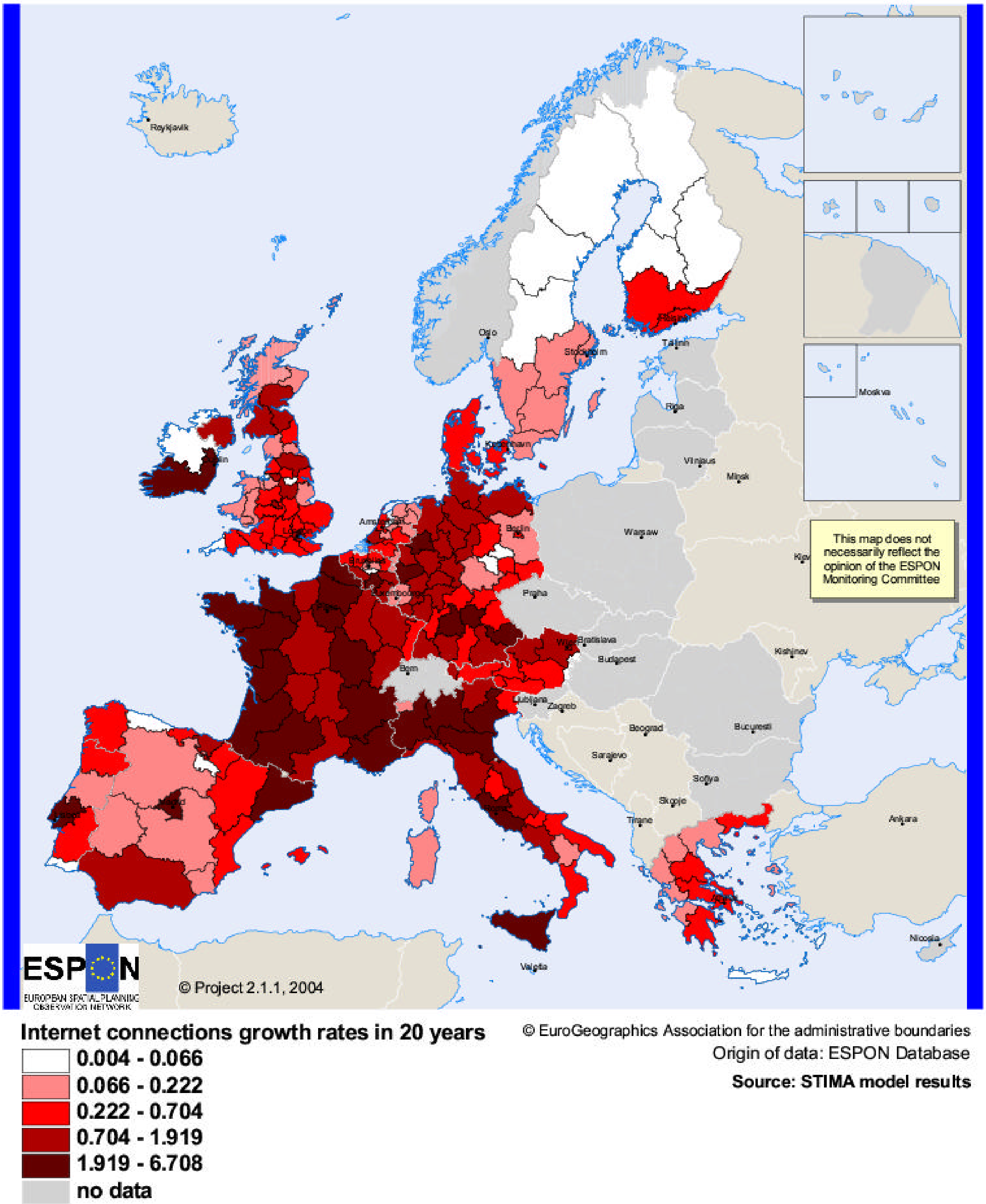


Map 4.21 Scenario B: GDP growth rates in 20 years

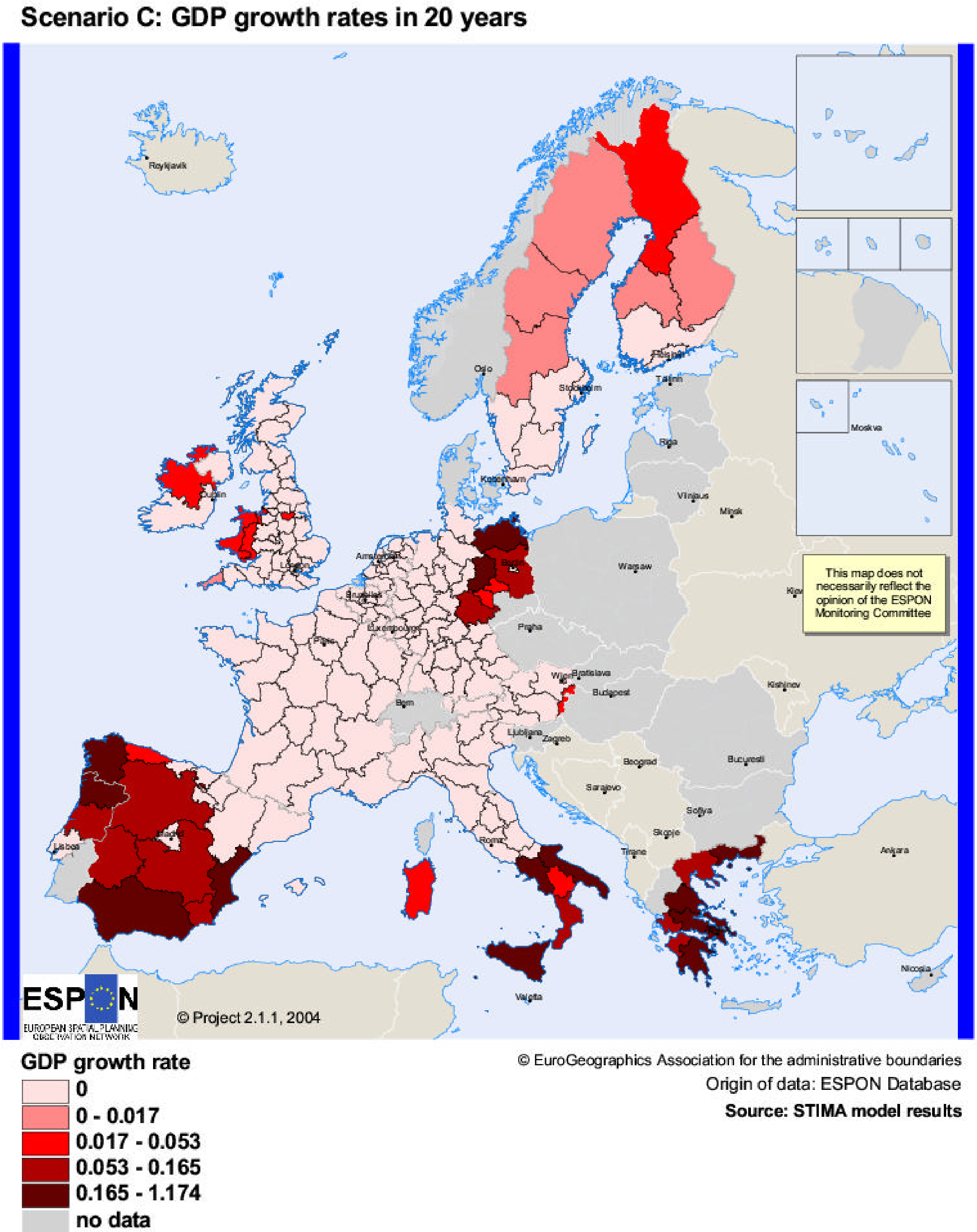


Map 4.22 Scenario B: Accessibility growth rates in 20 years

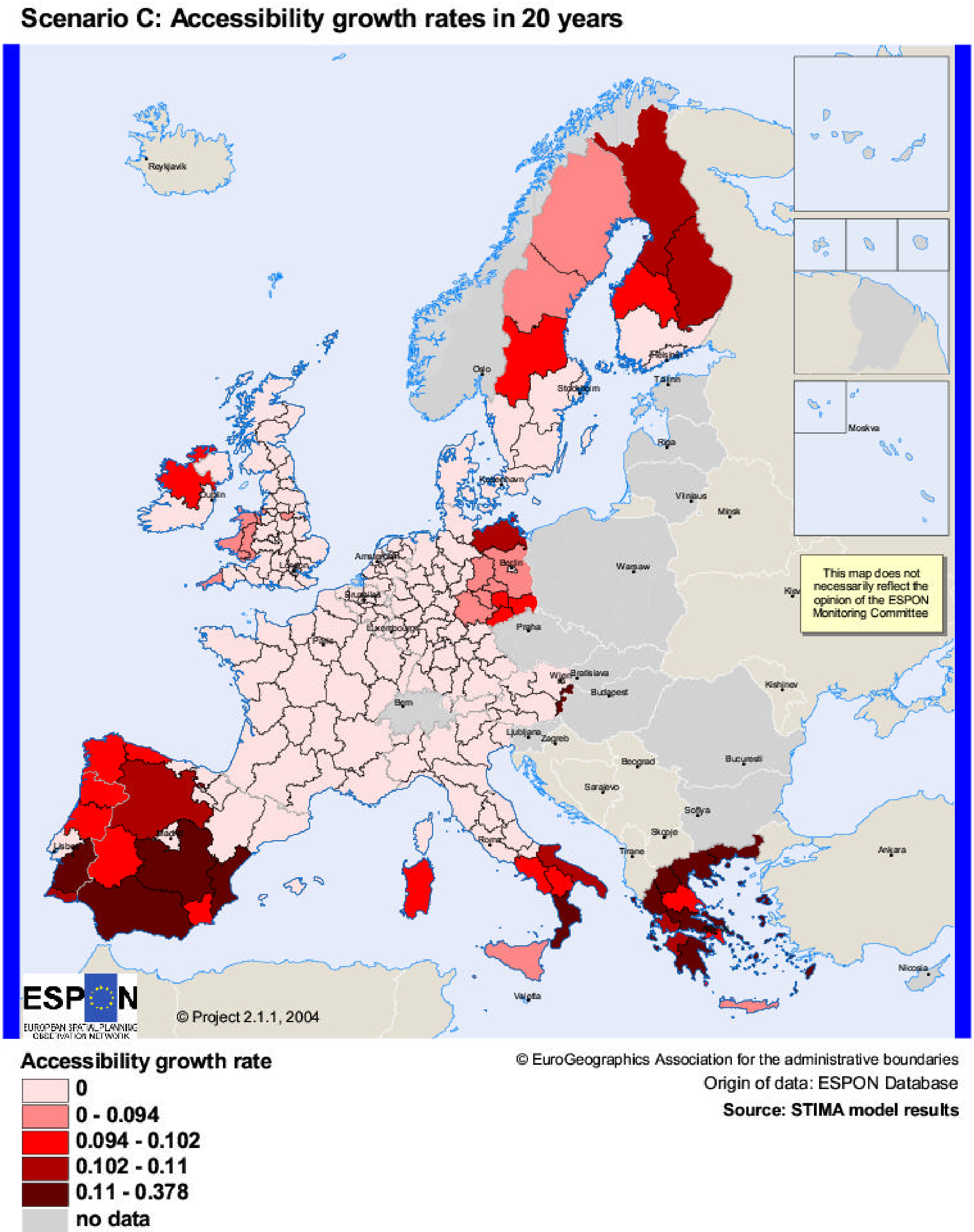
Scenario B: Internet connections growth rates in 20 years



Map 4.23 Scenario B: Internet connections growth rates in 20 years

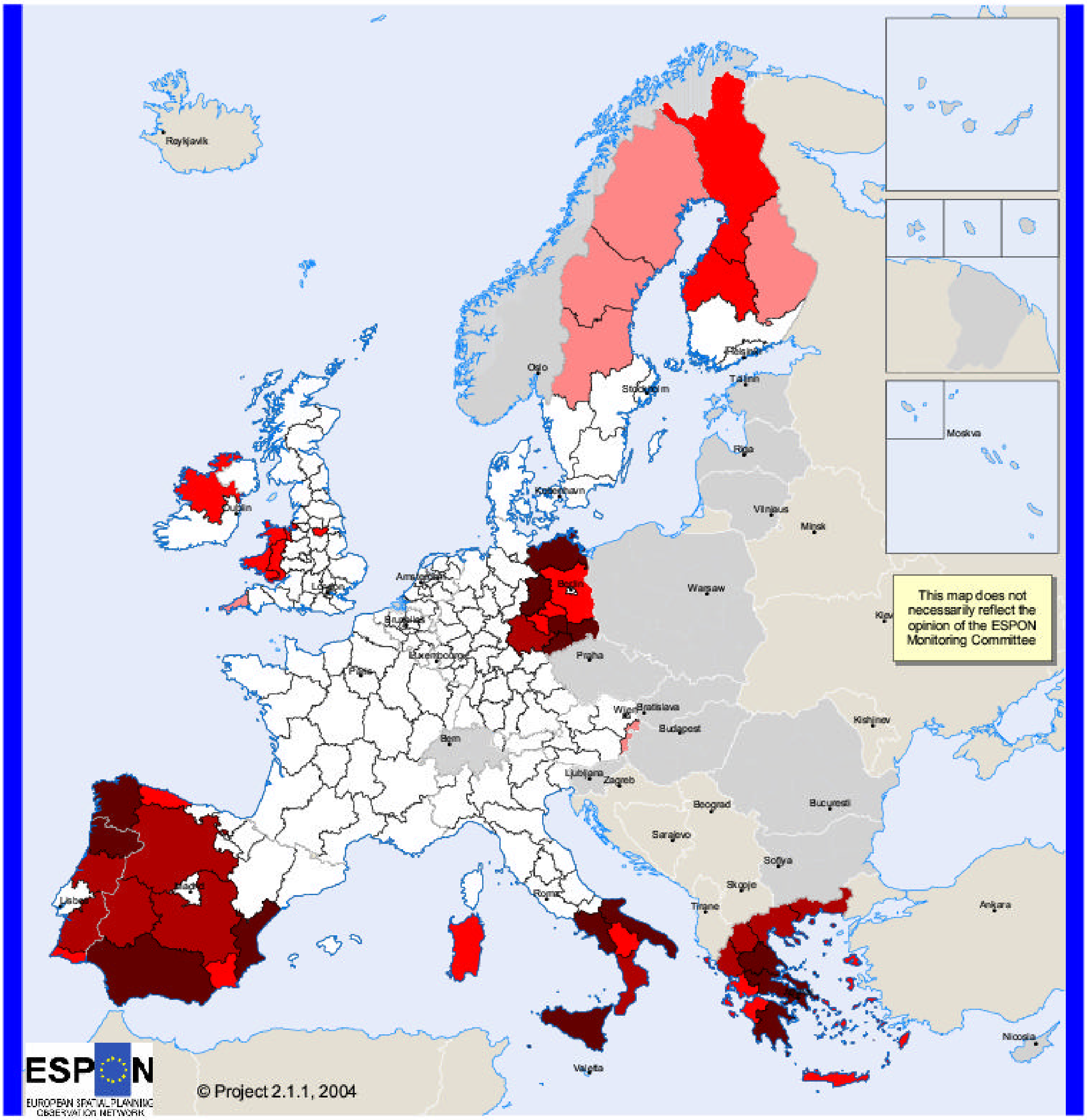


Map 4.24 Scenario C: GDP growth rates in 20 years



Map 4.25 Scenario C: Accessibility growth rates in 20 years

Scenario C: Internet connections growth rates in 20 years



Internet connections growth rates in 20 years

- 0
- 0 - 0.302
- 0.302 - 1.865
- 1.865 - 4.247
- 4.247 - 36.706
- no data

Origin of data: ESPON Database
Source: STIMA model results

Map 4.26 Scenario C: Internet connections growth rates in 20 years

In scenario C, all financial resources are devoted to lagging regions, which record the highest growth rates compared to the other scenarios. Thanks to the concentration of investments, we see that not only GDP, but also accessibility and Internet connections increase in Objective 1 areas (Map 4.24 - Map 4.26).

Summing up, from the point of view of efficiency (i.e. of economic growth), scenario B is obviously the most appropriate, while A and C register losses in terms of economic growth. In the cohesion policy scenario the loss of growth is rather high; if an efficiency option is chosen, in fact, the increase in per capita GDP reaches a 0.037%, compared to 0.023% when a cohesion policy is chosen. The indiscriminate policy also registers a loss in efficiency gains (0.033% increase compared to 0.037% increase of the efficiency policy), which is, as expected, less severe than the one obtained with the cohesion policy. However, the European Union has another important goal, beside efficiency: equity, or cohesion. Section 4.2 deals with this issue.

4.1.3.2 Regions by Type of Impact

This section deals with the creation of a typology of regions according to the different impacts of ICTs policies applied. In fact, from the analyses presented above it is quite evident that advanced regions behave differently in their reaction to ICT investment policies. Some are more able to grasp the opportunities offered by exogenous policies, others are more inclined to react only if policies are directly concerned with particular local needs. The same holds for backward regions, where the capacity to react to ICT policy opportunities differs substantially among regions, irrespective of the policy choice made.

A way to isolate common behaviours with respect to ICT policies is by running a *cluster analysis*, a statistical technique able to group observations (in our case the regions) according to their similarities in the values of some selected variables (in our case, per capita GDP growth and GDP values in 2020).

The cluster analysis detected four different clusters, mapped in Map 4.27. The subdivision of regions among clusters is rather interesting. Nearly 50% of both lagging and advanced regions do not react in a decisive way to ICTs policies (Cluster 3). The reasons are probably different in lagging and advanced regions; in the former the reasons may be found in the limited level of knowledge and learning capacity in exploiting ICT networks. In the case of advanced regions, the reasons may be related to the already high endowment of ICTs that limit the effects of additional investments on the performance of these regions.

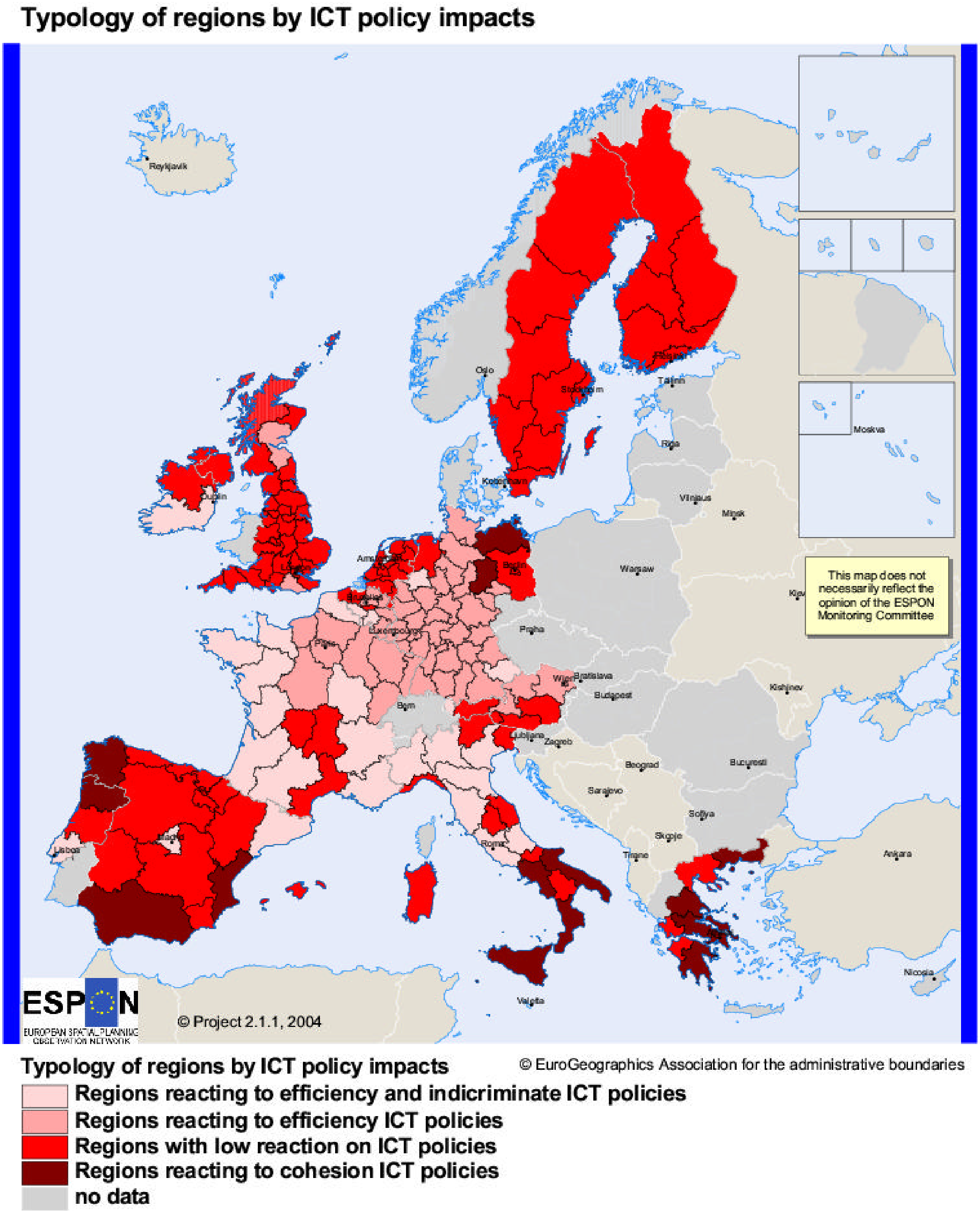
Another large group of lagging regions (37%) reacts only to the cohesion policy scenarios, while a very limited number of backward regions (7.5%) are able to grasp growth opportunities offered by an efficiency policy scenario; interestingly enough, no lagging region gains a lot from an indiscriminate ICTs policy (Table 4.8).

On the other way, advanced regions react either to efficiency policy only (31.9%), or to indiscriminate and efficiency policies (18.1%) (Table 4.25).

Map 4.27 indicates the regions belonging to the four clusters. Advanced regions reacting to both indiscriminate and efficiency policies are those of Northern Italy and of the Western part of France. Regions reacting to efficiency policies are first of all German regions (where the Country effect is strong enough to make efficiency policies be useful also for the Eastern regions of Germany), part of French regions, and some Scottish ones. Regions reacting to cohesion policies only are most of the Greek regions, part of Spain, Southern Italy. Regions which do not react strongly to any ICTs policy belong to the UK, to Spain, and to the Scandinavian Countries.

Table 4.25 Regions by type of impact of ICTs policies: cluster analysis results

Indicator	Cluster 1 Regions reacting to efficiency and indiscriminate ICT policies	Cluster 2 Regions reacting to efficiency ICT policies	Cluster 3 Regions with low reactions to ICT policies	Cluster 4 Regions reacting to cohesion ICT policies	Mean
Number of cases	26	49	94	15	184
Scenario A indicators					
Per capita GDP (thousands of euro)	13.37	44.95	13.80	13.72	22.19
Pc GDP growth rate	0.035	0.014	0.007	0.09	0.016
Scenario B indicators					
Per capita GDP (thousands of euro)	13.38	44.96	13.80	13.72	22.19
Pc GDP growth rate	0.095	0.038	0.016	0.022	0.035
Scenario C indicators					
Per capita GDP (thousands of euro)	13.37	44.94	13.80	13.76	22.19
Pc GDP growth rate	0	0.004	0.013	0.28	0.029
% of lagging regions	0	7.5	55	37.5	21.7
% of non lagging regions	18.1	31.9	50	0	78.3



Map 4.27 Typology of regions by ICTs policy impacts

4.1.3.3 Cohesion Effects in ICTs Policy Scenarios

In this section, we compare the three different ICTs scenarios from the point of view of cohesion goals, in terms of per capita GDP; the level of cohesion in accessibility and Internet connections reached by the three scenarios will also be taken into consideration.

By comparing the new levels of regional income to the 1999 ones, or the differences in regional income growth, we can assess the impact of ICTs policies on regional disparities, that reflects the equity (or cohesion) goal of European Union. We can follow this purpose by drawing maps showing the difference between the regional per capita growth rate and the EU per capita growth rate in 20 years: in this way, we can identify regions that are able to grow the most in relative terms.

Scenario A records some peaks, mainly for statistical effects, like the low density of population in Scandinavian Countries or the low level of GDP in some Countries. However, in general very few regions present consistent differences from the EU mean (Northern Italy, some regions in France, some in Portugal) (Map 4.28).

In scenario B, the highest relative growth rate of regions with respect to the European growth rate are in two French North-South corridors, in Northern Italy and in Southern Ireland, although also Germany, Central Italy, Belgium and The Netherlands demonstrate a good relative per capita growth rate (Map 4.29).

Scenario C, on its turn, shows the highest relative per capita GDP growth rate in lagging regions like parts of Southern Italy, of Greece, of Spain (Map 4.30).

A very useful indicator to measure the size of regional disparities is Gini's concentration index (R), calculated as:

$$R = 1 - \frac{2}{n-1}\sum_{i=1}^{n-1} Q_i \qquad \text{with } i = (1,n) \qquad [4.1]$$

where
n = number of cases

$$Q_i = \frac{\sum_{j=1}^{i} x_j}{T} \qquad \text{with} \quad j = (1,i);$$

$$T = \sum_{j=1}^{n} x_j \qquad \text{total intensity} \qquad \text{with } j = (1,n)$$

In this case, we use the regional per capita GDP as x. A higher R coefficient implies a more uneven distribution of regional income, i.e. higher regional imbalances. If R=0, then each region has the same per capita income level, and there are no regional disparities. A graphic representation of the change in regional disparities can be made through the Lorenz curve.

The Gini coefficients for the different scenarios are presented in Table 4.8. Concerning GDP distribution, scenario A shows a similar coefficient to the current situation, as expected, while scenario B worsens regional disparities and scenario C improves them; the magnitude of the effects is very limited given the very limited change in the level of per capita GDP that we are forecasting. These results can be represented through a Lorenz curve. Given the very limited degree of difference in the GINI coefficients, curves of the different scenarios are very close to each other; the zooming area helps in this respect to have a greater look at the differences. However, we must remember that this change in regional disparities is the result only of investments in ICTs policies, so it is showing a great impact, compared to the few factors considered.

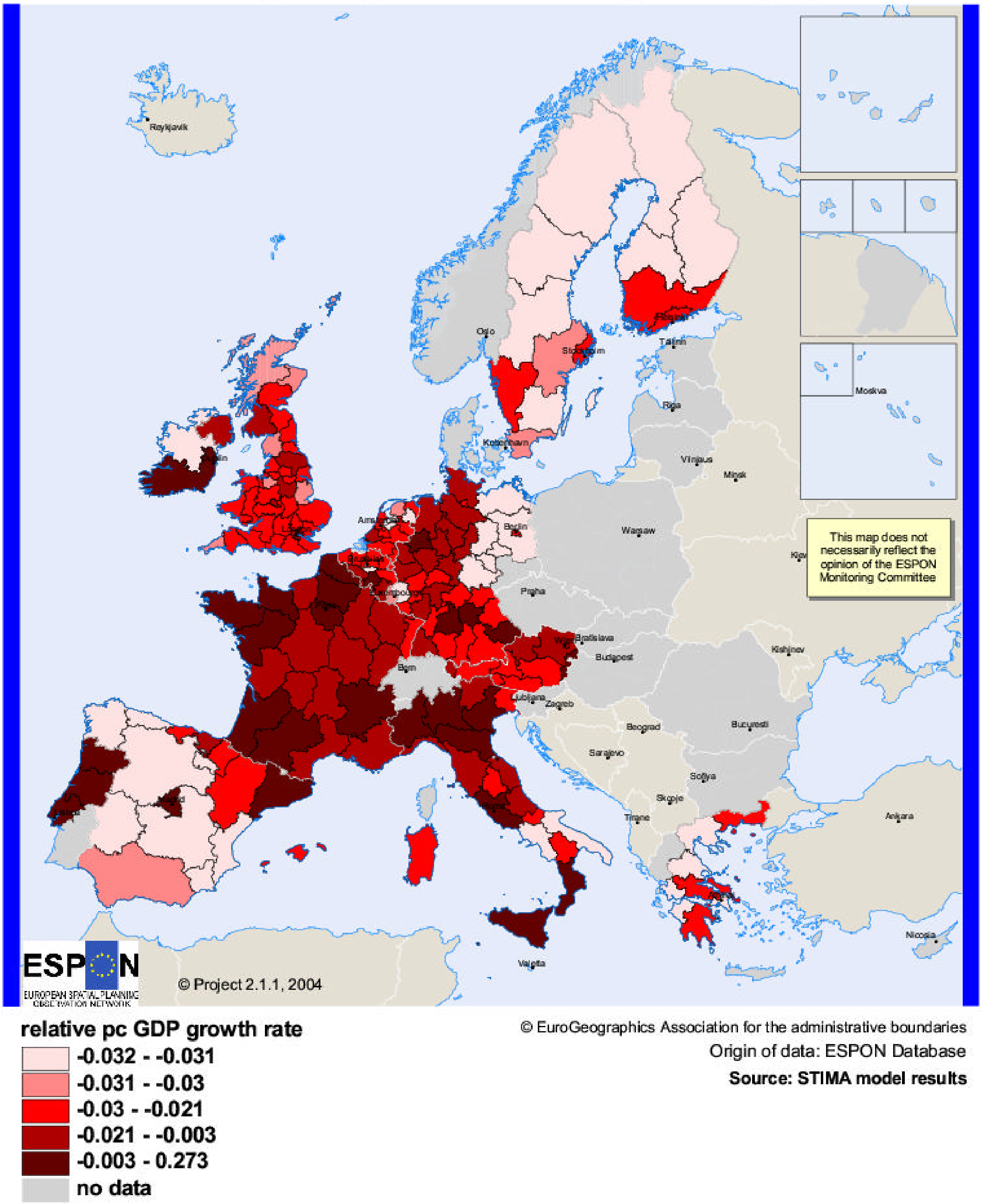
Interestingly enough, the efficiency scenario does not worsen regional disparities too much when compared to the present situation; instead, present regional imbalance is very much higher than the cohesion scenario.

The same results are presented in Fig. 4.8; scenario C, obeying to its cohesion objective, reduces regional disparities, by creating a more equal distribution. Scenarios A and B show quite similar curves; as we can see in the zooming area, the efficiency scenario shows a lower Lorenz curve, a signal of the worsening of income distribution. The curve of the current situation lays exactly behind the Scenario A curve, so it is not visible neither in the zooming area.

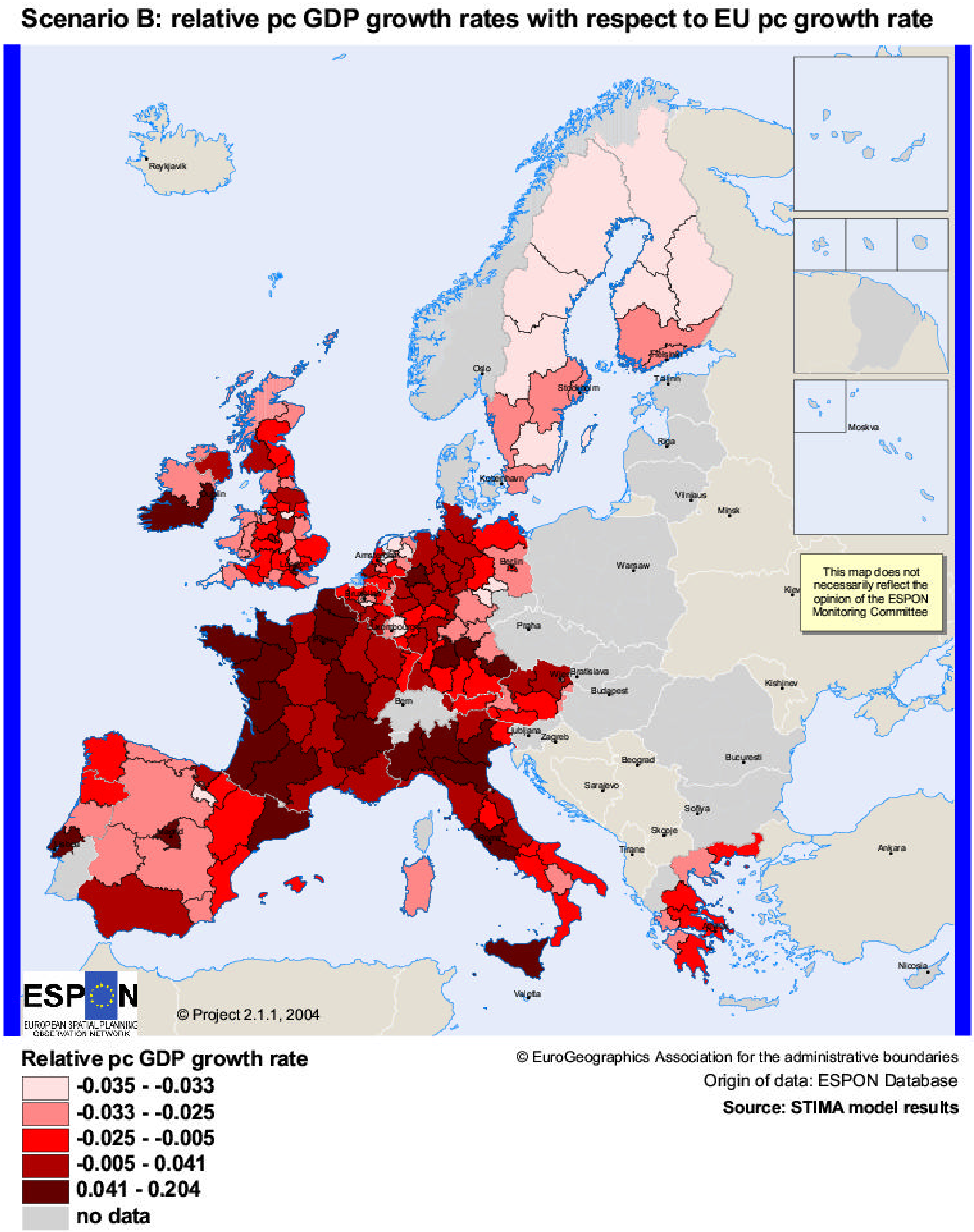
Table 4.26. Gini coefficients

Scenarios	Per capita GDP	Accessibility	Internet
Current situation	0.37170	0.3992	0.22558
Scenario A	0.37170	0.4383	0.24562
Scenario B	0.37173	0.4382	0.24379
Scenario C	0.37161	0.4381	0.22354
Equal distribution	0.000	0.000	0.000

Scenario A: relative pc GDP growth rates with respect to EU pc growth rate

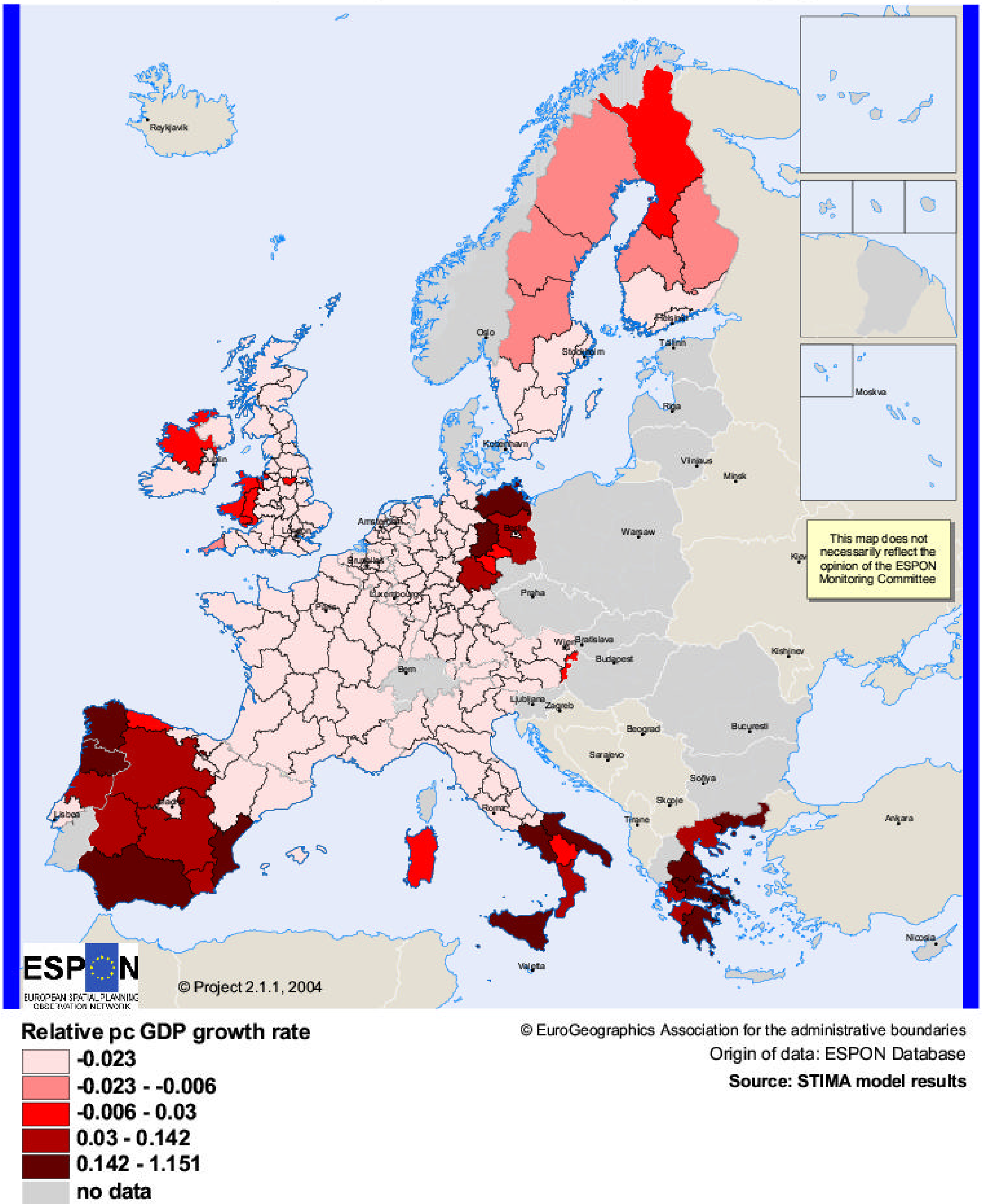


Map 4.28 Scenario A: relative pc GDP growth rates with respect to EU pc growth rate



Map 4.29 Scenario B: relative pc GDP growth rates with respect to EU pc growth rate

Scenario C: relative pc GDP growth rates with respect to EU pc growth rate



Map 4.30 Scenario C: relative pc GDP growth rates with respect to EU pc growth rate

Concerning the effects of ICTs policies on the regional distribution of Internet connections, we achieve similar conclusions to the ones obtained with the per capita GDP distribution: both internet connections and accessibility will be more equally distributed in scenario C, while the efficiency scenario registers the highest regional dispersion (Figure 4.6).

Regional distribution of accessibility, on the contrary, will be more equally distributed in indiscriminate the scenario and in the efficiency scenario, while the cohesion scenario is also in this case the worse, although the magnitude of changes of the GINI coefficients, and therefore of the regional distribution, is extremely limited. This result does not surprise: given the low marginal efficiency of investment in accessibility, its weight on scenarios is much more limited than the one of internet connections (0).

Figure 4.5 Lorenz curve on per capita GDP in 20 years

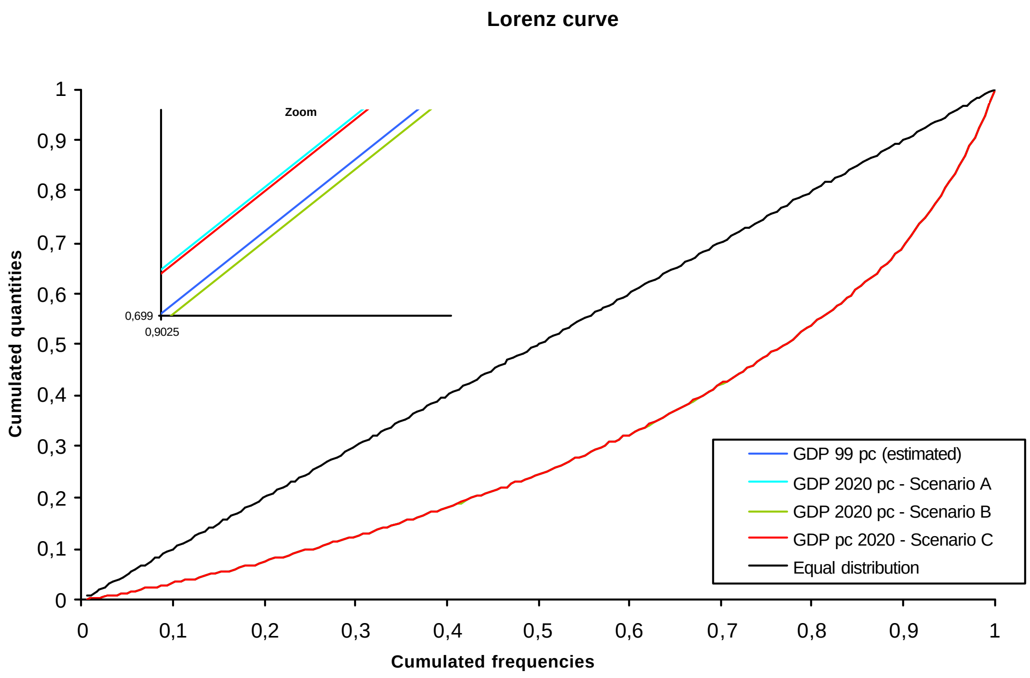


Figure 4.6 Lorenz curve on Internet connections

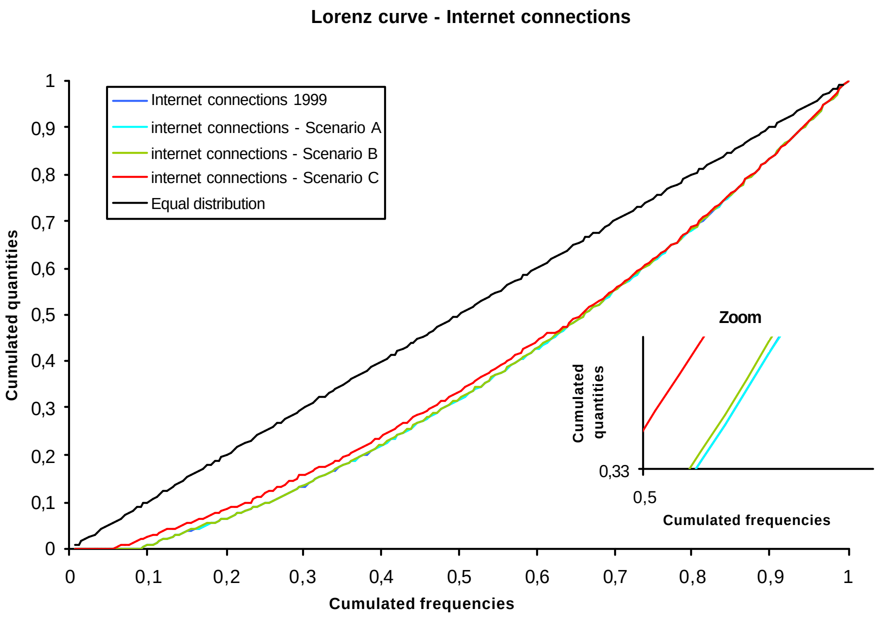
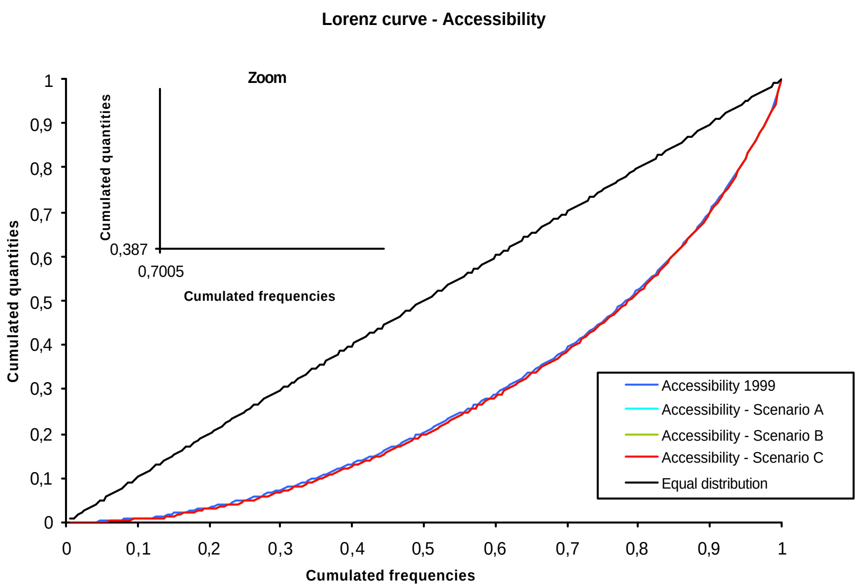


Figure 4.7 Lorenz curve on Accessibility



4.1.3.4 Concluding remarks

This report describes the methodology and the results of the estimation and forecasting of the territorial impact of ICTs policies.

The main results can be summarised as follows:

1. The role of ICTs is very important for the creation of GDP, its growth and distribution. Therefore, EU policies in this sector are extremely relevant, both for future efficiency (GDP growth) and for cohesion (GDP distribution). The different regional levels of ICTs endowment, in fact, imply a relevant policy impact on cohesion;
2. ICTs investments have different marginal efficiencies, depending on the infrastructure or services (ICTs factors) in which they are spent. The choice of infrastructures and services has a critical role on the territorial impact of ICTs policies;
3. ICTs policies suggested by the eEurope Action plan could lead to very different scenarios, depending on the regional distribution of funds. Our hypothesis envisages three scenarios, very different from the point of view of policy actions, of regional funds distribution and therefore of impacts on GDP: the indiscriminate scenario (A) shows a GDP growth rate in 20 years equal to 0.033%, while the efficiency scenario (B) shows a higher rate (0.037%), as expected, and the cohesion scenario (C) shows the most limited growth rate (0.023%)[37];
4. the way in which lagging and non-lagging regions take advantage of ICTs policies is very different in the three scenarios, as expected. Lagging regions register the highest growth rate in the cohesion scenario, as expected, but are able to react and grow in the indiscriminate scenario; on the contrary, their growth rate is very limited in the efficiency scenario. Advanced regions, on their turns, gain a lot in the efficiency scenario, and to a much more limited extent in the indiscriminate scenario;
5. one interesting result is the demonstration that within different typologies of regions (Objective 1 regions vs. advanced regions), different reactions to a specific ICTs policy exist. Within non-lagging regions, some are able to react to efficiency and indiscriminate ICTs policies, while some of them have a very low reaction in front of all kinds of ICTs policies. Lagging regions, on their turns, either grow for cohesion policies, or have a very low reaction to each ICTs policy; a very limited number of lagging regions (7.5%) takes advantage from efficiency policies.

[37] For more details on the GDP growth in the different scenarios, see Table 4.7.

4.1.4 Development Potential

Scenarios Considered

With the aim of a focused presentation, the following discussion is confined to one retrospective and five prospective scenario comparisons, based on the SASI results. Those scenarios are the A3 scenario(Effects of transport investments 1991-2001), scenario B1 (Effects of priority transport investments 2001-2021), scenario B2(Effects of TEN/TINA/national transport investments 2001-2021), scenario C3 (Effects of marginal cost pricing of all modes), scenario D1(Combined effects of priority transport investments and marginal cost pricing of all modes) and scenario D2 (Combined effects of TEN/TINA/national transport investments and marginal cost pricing of all modes).

Impacts on total development potential and total GDP

Transport investments induce positive impact on total GDP, while an increase of transport costs, simulating marginal cost pricing, results in a smaller negative impact, see Table 4.27. The combined effects of investments and marginal cost pricing on total GDP are weakly to moderately positive. The total impacts on GDP are small, however, for all scenarios (between –1.5% and +2.6%). It is also important to observe that the scenarios reflect pure impacts of investments or cost increases without any assumptions on how funding investments or spending revenues from marginal cost pricing affect the socio-economic development.

All policies lead to larger impacts on total development potential (sum of development potential over all NUTS 3 regions) than on total GDP. The impacts range between –2.6% and +5.1%. The first combined scenario (D1) leaves the total development potential and the total GDP almost unaffected as compared to the reference scenario. The second combined scenario, however, results in positive impacts on both total development potential (+2.5%) and total GDP (+1.2%).

Furthermore, the effect of the scenario on two inequity measures are shown:

1. the ratio between the arithmetic and geometric means (A/G) for developmentpotential in the horizon year (2001 or 2021) (measures relative differences);
2. Difference between maximum and minimum zonal development potential in the horizon year (2001 or 2021) (measures absolute differences).

Table 4.27. Impacts of policy scenarios on total GDP and total development potential (percentage change as compared to the relevant reference scenario) and inequity measures of development potential

Indicator	Scenario					
	A3	B1	B2	C3	D1	D2
Total GDP	+0.63	+1.60	+2.62	-1.42	+0.14	+1.16
Total development potential	+1.68	+2.88	+5.13	-2.59	+0.20	+2.45
Inequity (A/G) Development potential (3.)	-0.30	-0.66	-2.27	+0.47	-0.32	-1.98
Inequity (Max-Min) Development potential (4.)	+1.74	+3.45	+4.71	-2.89	+0.47	+1.78

Spatial distribution of absolute impacts on development potential

The resulting spatial patterns of absolute impacts of the prospective policy scenarios on development potentials are shown in Map 4.28 - Map 4.32.

According to Map 4.28 and Map 4.29 transport investments have considerable positive effects on the development potential of many regions outside the "Pentagon" (defined by the metropolises of London, Paris, Milan, Munich and Hamburg). Large positive impacts are observed in north-eastern Spain and along the coastal region to Italy, in many Italian regions (particularly on the east coast) and in southern Scandinavia.

The marginal cost scenario leads to least negative absolute impacts on the development potential in the eastern part of EU27, in the Iberian Peninsula and in parts of Wales and Scotland, see Map 4.30. The most negative impacts in absolute terms are found in a dispersed set of highly urbanised and mainly metropolitan regions, many of which are located in the European core region.

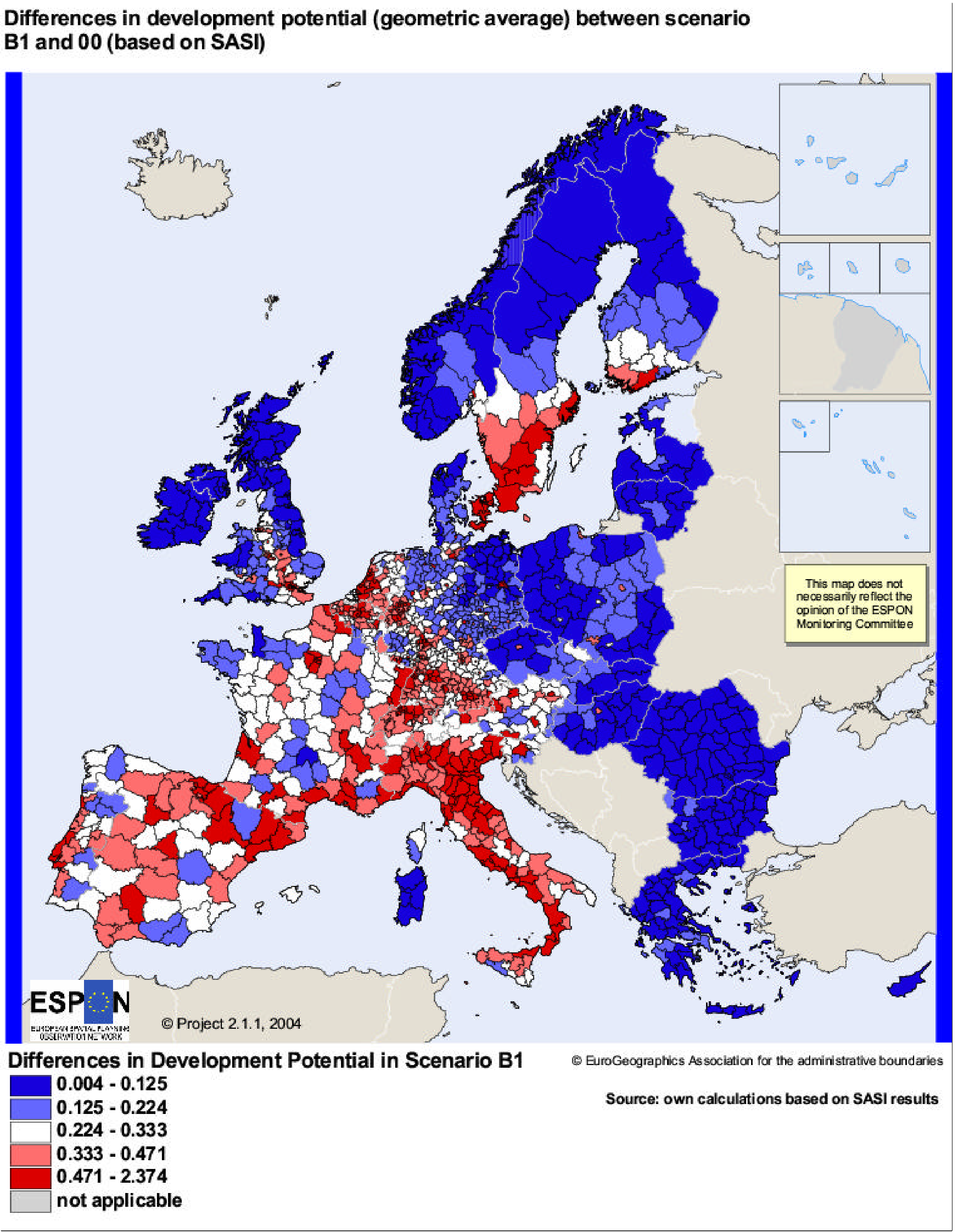
Finally, the effects of the combined investment and marginal cost pricing scenarios (Map 4.31 - Map 4.32) are similar to the impacts of investments but with relatively improved positions of regions in East Central Europe.

It can be concluded that marginal cost pricing improves the relative position of some peripheral regions and most accession countries in terms of development potential. The transport investments improve the relative position of semi-central regions, mainly outside the “Pentagon”. The combined investment and marginal cost pricing scenarios mainly extends the regions with improved relative position from transport investments to areas in the eastern part of the “Pentagon” and East Central European regions outside the “Pentagon”. The results indicate that transport policy (investments and/or pricing) can potentially be used to encourage various forms of polycentric development.

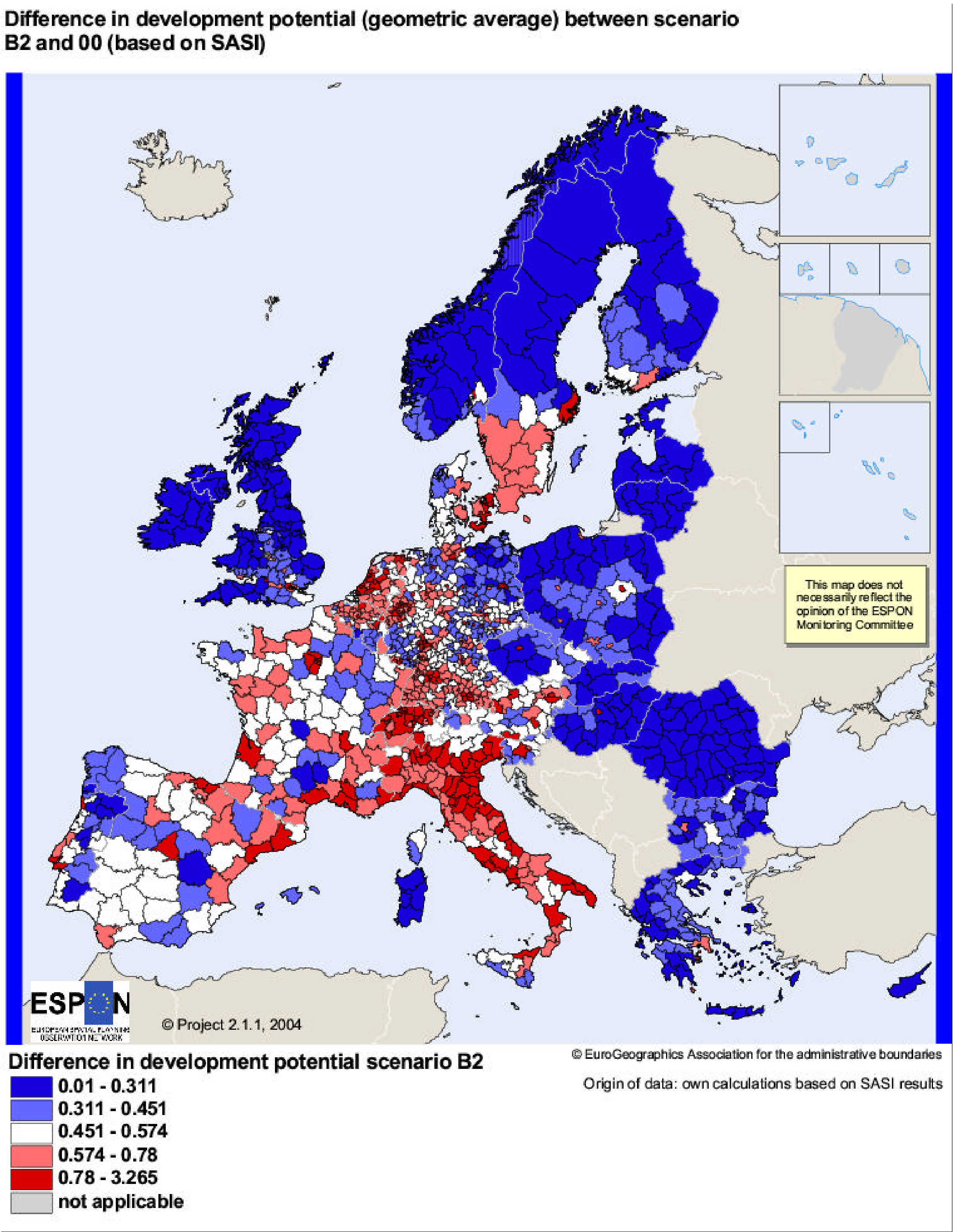
Table 4.28 summarises the share of the total development potential located within the “Pentagon” and the share located in regions with various degree of rurality for the different scenarios. The typology of relative rurality has been defined by ESPON 1.1.2. The table mainly shows a high stability in these aggregate shares. There is a weak decentralisation trend (reduced share for the Pentagon and for urban regions), which is reinforced by transportation investments and slightly counteracted by marginal cost pricing.

Spatial distribution of relative impacts on development potential

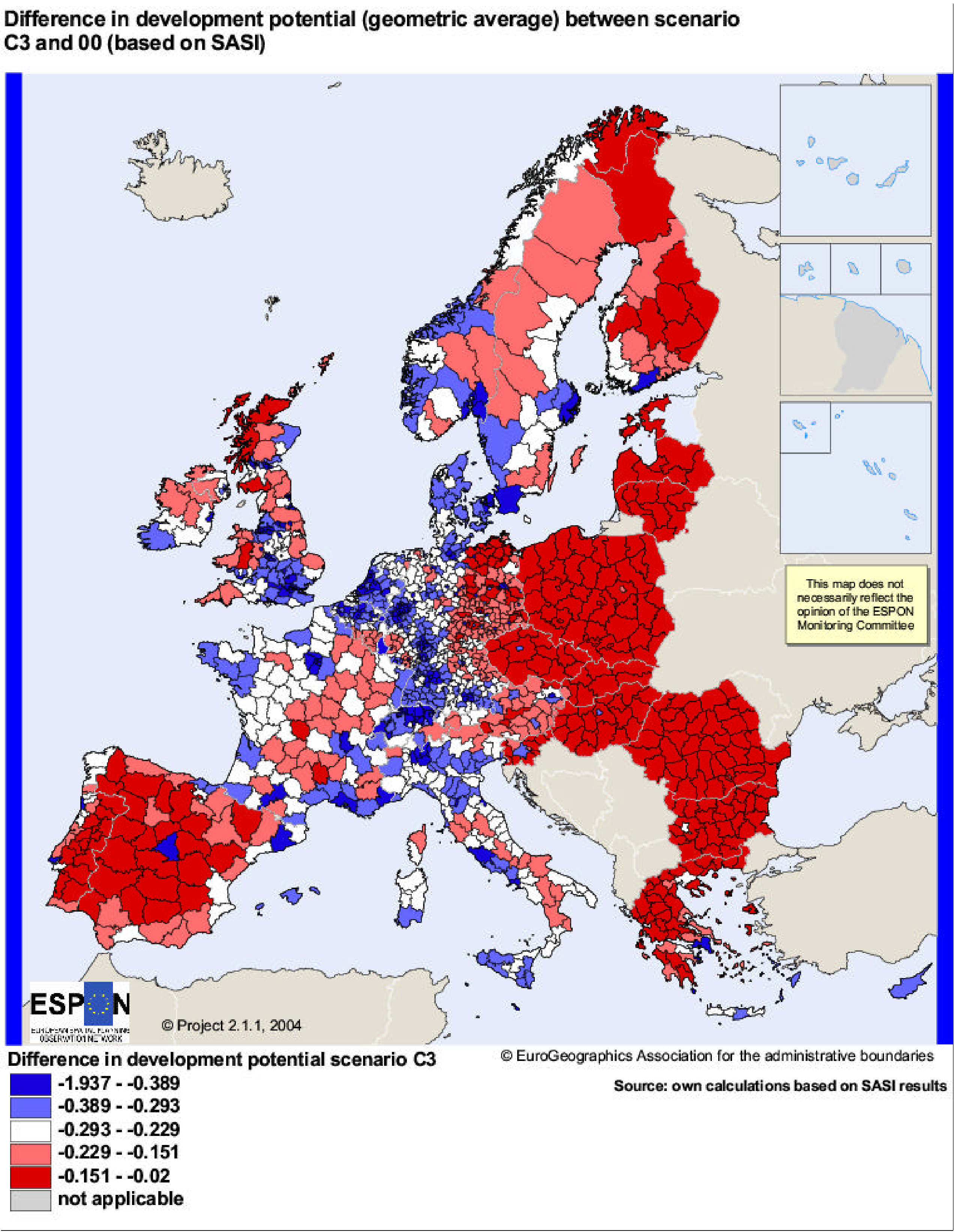
When analysing the impacts on development potential in relative terms (percentage change of zonal values in relation to the relevant reference scenario), a quite different picture emerges. The impacts of the investment scenarios are more decentralised, in particular to southern and eastern Europe



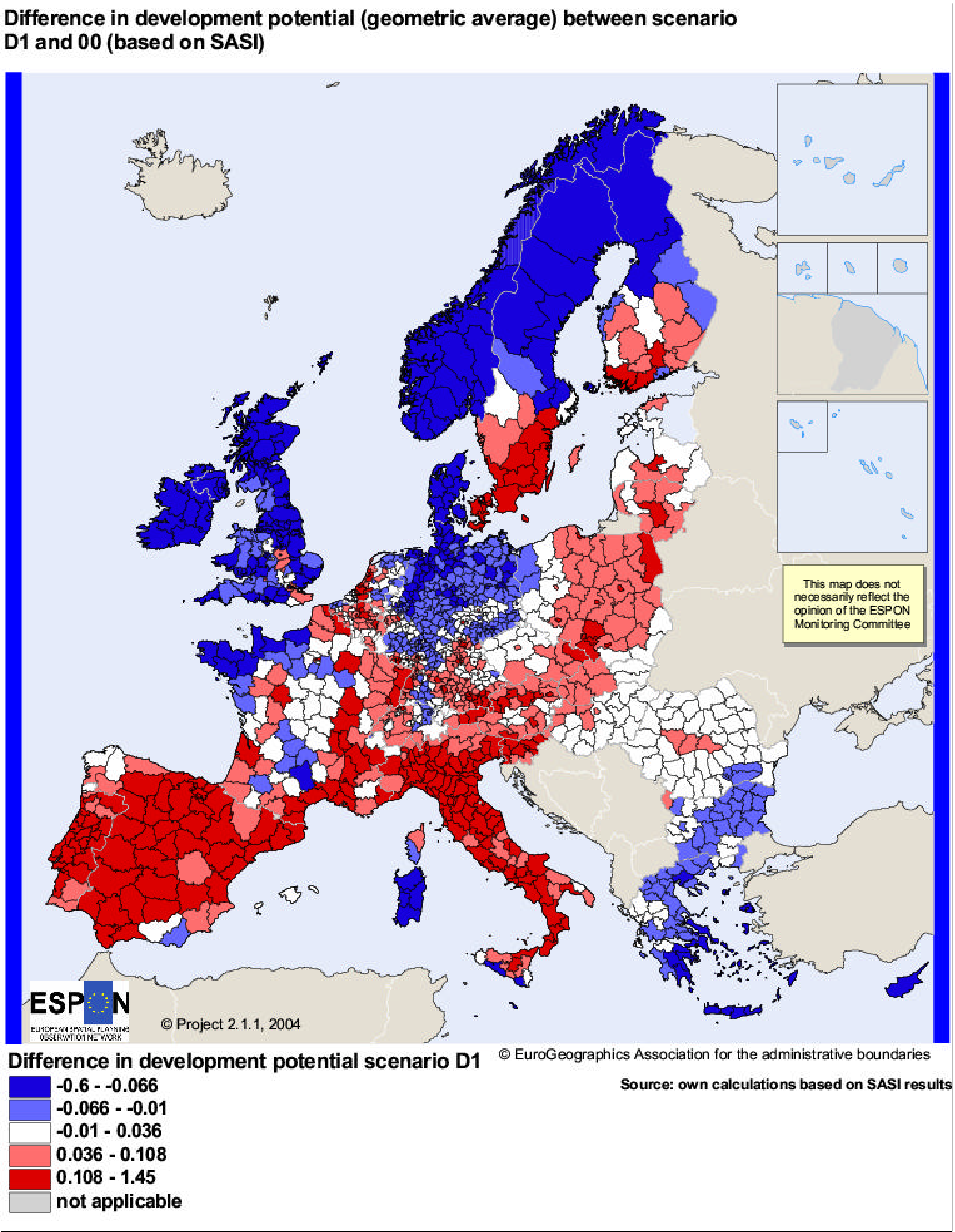
Map 4.28 Differences in Development potential in scenario B1



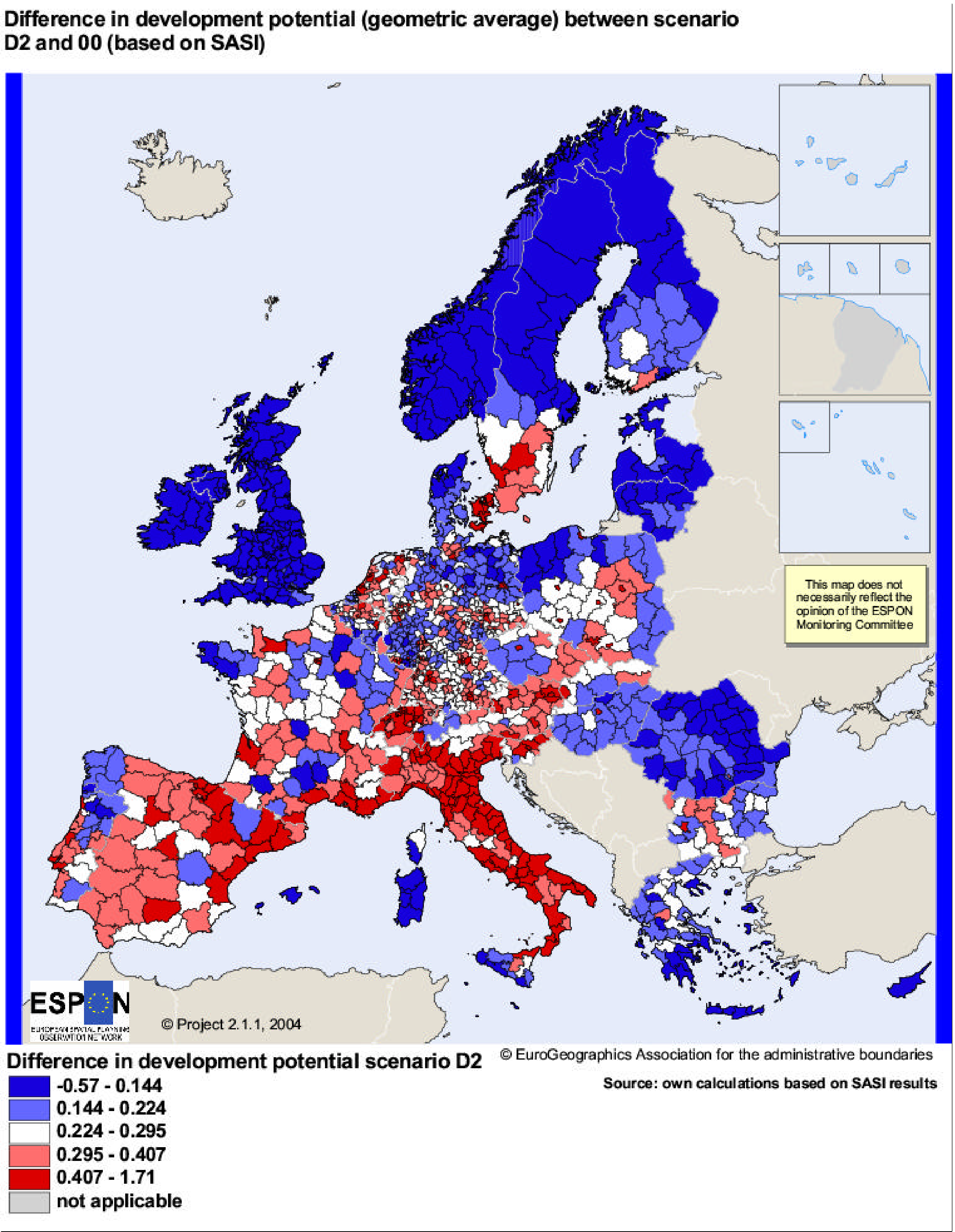
Map 4.29 Differences in Development potential in scenario B2



Map 4.30 Differences in Development potential in scenario C3



Map 4.31 Differences in Development potential in scenario D1



Map 4.32 Differences in Development potential in scenario D2

Table 4.28. Share of total development potential located in certain region types in reference and policy scenarios (percentage of total development potential)

Region	Scenarios							
	A0	A3	00	B1	B2	C3	D1	D1
Pentagon	57.41	57.37	57.14	56.98	56.83	57.27	57.10	56.94
Low rurality	64.15	64.11	63.87	63.83	63.69	63.91	63.86	63.72
Medium rurality	4.70	4.71	4.77	4.78	4.80	4.76	4.77	4.80
High rurality	31.15	31.18	31.36	31.39	31.50	31.33	31.36	31.48

The marginal cost pricing leads to the least negative impacts in east Europe and in the eastern past of central Europe. The combined scenarios lead to the worst outcome for many of the “Pentagon” regions and for UK, Ireland and northern Scandinavia, while most regions in the southern and eastern part of Europe experience highly positive relative impacts.

Comparisons with spatial distribution of relative impacts on welfare and GDP/capita

The impacts on regional welfare (CGEurope) and GDP/capita (SASI) resulting from the models are displayed in relative terms in Sections 4.1.1 and 4.1.2. The results are structurally similar to the spatial distributions of relative impacts on development potential. This is especially true for the SASI results, on which the analysis of relative impacts on the development potentials is based.

Cohesion effects in development potential

Table 4.27 indicates that there are trade-offs between efficiency and the indicator of absolute inequity (max-min). Transport investments increase both efficiency and inequity in comparison with the reference scenarios. Marginal cost pricing decreases both efficiency and inequity. The combined policies behave like the transport investment scenarios but the conflicts are milder. The percentage impact of policy scenarios on efficiency is, in most cases, about the same size as the percentage impact on absolute inequity.

If instead measured by the indicator of relative inequity (ratio between arithmetic and geometric means) the results become different. With only a few exceptions all policy scenarios lead to higher degrees of cohesion (diminishing inequity) than the corresponding reference scenarios. The main exception is the impact of marginal cost pricing (C3) on the distribution of development potential. Only when considering the impact of marginal cost pricing on GDP and GDP/capita, there is a goal conflict between efficiency and cohesion if inequity is measured in a relative sense.

Two aspects should be kept in mind when judging these results. First, the SASI model is basically redistributive which may lead to underestimation of the impacts on efficiency. Second the funding of transport investments and the utilisation of income from pricing policies are not taken into account in the models. This tends to overestimate the impacts on efficiency.

4.2 Polycentricity Impacts

4.2.1 Evaluation of Scenarios

The present degree of polycentricity of the urban systems in the countries of the ESPON Space was studied in ESPON 1.1.1 and is presented in the Final Report of ESPON 1.1.1. It is shown there that on average the urban systems of the accession countries are more polycentric than those of the old member states of the European Union and that (leaving aside the special case of Cyprus) Slovenia, Ireland and Poland are the most polycentric countries in Europe, whereas Finland and Norway are the least polycentric.

Here the development of polycentricity over time and the impacts of transport policies on polycentricity of the urban systems of Europe at large and of European countries are discussed. The method used to forecast these impacts with the SASI model were explained in Section 3.6.

Table 4.9 shows the impacts of the thirteen scenarios on the polycentricity of the European urban system at the highest spatial level of the 75 largest metropolitan areas defined in ESPON 1.1 1 as metropolitan European growth areas, or MEGAs, in the old EU member states (EU15), the twelve accession countries (AC12) and the whole ESPON Space (EU27+2).

Table 4.29. SASI model: polycentricity at the European level: MEGAs

Scenario		Polycentricity difference between policy scenario and Reference Scenario (%)		
		EU15	AC12	EU27+2
A1	Only rail projects 1991-2001	+0.16	–0.09	+0.02
A2	Only road projects 1991-2001	–0.04	+0.26	+0.23
A3	Rail and road projects 1991-2001	+0.13	+0.14	+0.22
B1	Priority projects	+0.06	+0.87	+0.94
B2	All TEN/TINA projects	–0.34	+1.45	+1.43
B3	TEN/TINA except cross-border corridors	–0.46	+1.44	+1.20
B4	TEN/TINA only cross-border corridors	0.00	+0.33	+0.48
B5	TEN/TINA only in Objective 1 regions	–0.46	+0.69	+0.87
C1	Reduction of price of rail transport	0.00	–0.13	–0.17
C2	Increase of price of road transport	0.00	0.00	+0.03
C3	SMCP of all modes	+0.09	–0.71	–0.49
D1	B1+C3	+0.12	+0.73	+0.60
D2	B2+C3	–0.29	+0.95	+1.10

The retrospective scenarios show that at this highest spatial level the European urban system has become more polycentric: rail, road and air connections have linked mainly the largest cities, and this has benefited also the national capitals and other large cities outside the 'Pentagon'. And according to the prospective scenarios this is likely to continue. In particular in the accession countries the differences between the national capitals in population, economic performance and accessibility will level off, and also as a group these cities will catch up with the large cities in the old EU member states. However, within the old member states the urban system will become more polarised as the largest cities attract even more people and jobs.

A different picture emerges as one moves down to the level of national urban systems. Table 4.10 shows the impacts of the thirteen scenarios on the polycentricity of the urban systems in the old EU member states (EU15), Switzerland and Norway (CH+NO), the twelve accession countries (AC12) and the whole ESPON Space (EU27+2).

Table 4.30. SASI model: polycentricity at the national level: FUAs

Scenario		Polycentricity difference between policy scenario and Reference Scenario (%)			
		EU15	CH+NO	AC12	EU27+2
A1	Only rail projects 1991-2001	–0.09	–0.02	–0.12	–0.10
A2	Only road projects 1991-2001	+0.06	–0.17	–0.06	+0.03
A3	Rail and road projects 1991-2001	–0.05	–0.17	–0.19	–0.08
B1	Priority projects	–0.54	–0.68	–0.77	–0.58
B2	All TEN/TINA projects	–0.15	–0.69	–1.58	–0.44
B3	TEN/TINA except cross-border corridors	–0.19	–0.43	–1.14	–0.37
B4	TEN/TINA only cross-border corridors	–0.10	–0.40	–0.76	–0.23
B5	TEN/TINA only in Objective 1 regions	+0.08	–0.03	–0.40	–0.01
C1	Reduction of price of rail transport	+0.04	–0.08	–0.10	–0.05
C2	Increase of price of road transport	–0.08	+0.07	0.00	–0.06
C3	SMCP of all modes	+0.08	+0.55	+0.87	+0.24
D1	B1+C3	–0.50	–0.13	+0.08	–0.38
D2	B2+C3	–0.12	–0.13	–0.99	–0.29

Table 4.9 shows that in the past all infrastructure scenarios have contributed to polarisation of national urban systems, and that this likely to continue in

the future, except in Scenario B5, in which only projects in lagging regions are implemented. Lower rail fares (Scenario C1) are also bad for polycentricity at this level, whereas making transport more expensive (Scenarios C2 and C3) contributes to polycentricity at the national level, in particular in the accession countries.

Figures 4.3 and 4.4 show the development of the Polycentricity Index in the prospective scenarios between 1981 and 2021 calculated by the SASI model for national urban systems.

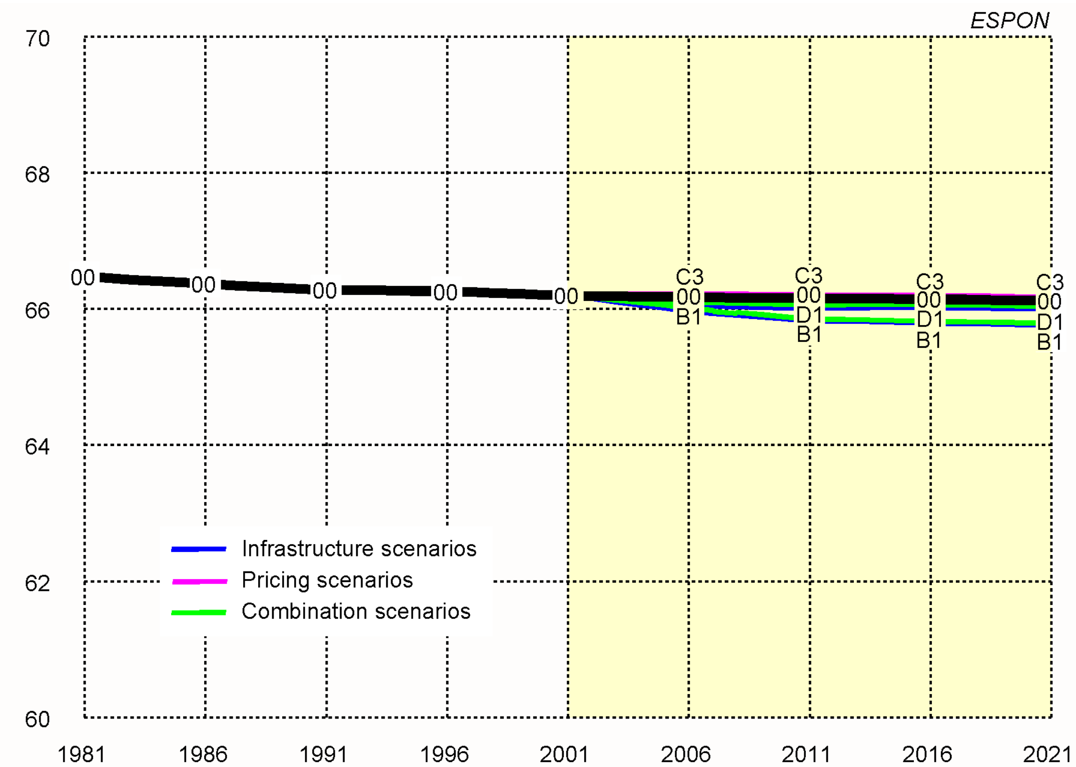


Figure 4.3 Development of polycentricity of national urban systems in the old EU member states (EU15) 1981-2021

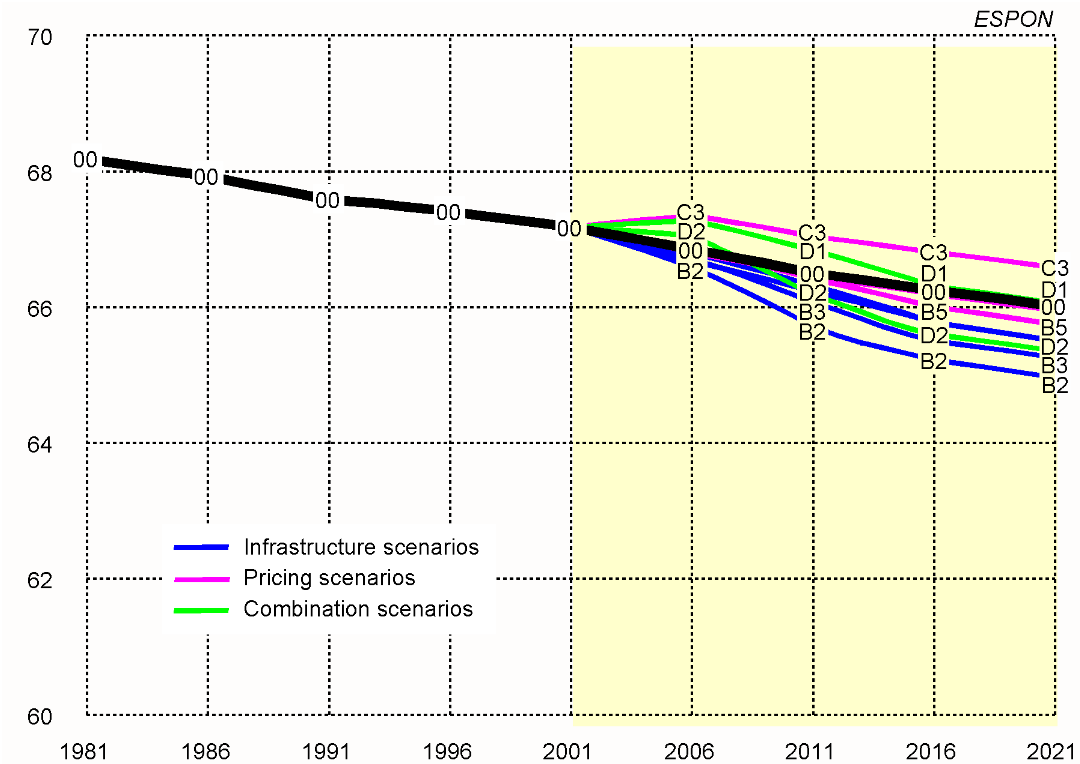


Figure 4.4 Development of polycentricity of national urban systems in the accession countries (AC12) 1981-2021

The two heavy black lines in Figures 4.3 and 4.4 represent the development of the Polycentricity Index between 1981 and 2021 averaged over the countries of EU15 and AC12, respectively, the thinner lines indicate how the transport policy scenarios deviate from the Reference Scenario 00 after 2001. The lines are colour-coded to indicate scenario groups.

The diagram confirms that the urban systems of the accession countries at present are on average more polycentric than those of the old member states. According to the backcast, they were even more polycentric in the past, probably because of their history as planned economies in which there was no market-driven spatial development. However, if the forecasts of the model are correct, polycentricity in the accession countries will decline due to market forces and in the medium-term be even lower than that of the old member states. Polycentricity in the old member states declines, too, but much slower than in the accession countries because of their longer experience with market-driven spatial development, and in the long run comes to a halt. This is possibly also the reason why the infrastructure improvements in the scenarios have only little effect on polycentricity in the old member states. Another reason may be that the transport networks in the old member states are already highly developed and can only marginally be improved.

However, in the accession countries there is still a great demand for transport infrastructure and so infrastructure improvements have much larger effects. As it has already been observed in the discussion of cohesion, infrastructure improvements, in particular in the accession countries, tend to be oriented towards the largest cities where transport demand is highest, with the effect that polycentricity goes down in proportion to the volume of infrastructure improvements in the scenarios.

Summary

The results of the forecasts of polycentricity of the European and national urban systems with the SASI model can be summarised as follows:

- The polycentricity of the *European* urban system has increased in the past and is likely to continue to increase in the future as large cities in the accession countries catch up with cities in western Europe.
- However, polycentricity of the European urban system will mainly grow in the accession countries, whereas it will decline in western Europe because of the continued growth of the largest cities.
- Polycentricity of *national* urban systems in Europe has declined in the past and is like to continue to decline in the future.
- All transport infrastructure policies examined accelerate the decline in polycentricity of national urban systems because they tend to be directed at primarily connecting large urban centres.
- Transport pricing scenarios which make transport less expensive have the same effect as infrastructure improvements.
- Transport pricing scenarios which make transport more expensive in general strengthen the polycentricity of national urban systems.

The comparison of polycentricity of MEGAs at the European level and polycentricity of FUAs in individual countries shows that, as with cohesion indicators, the spatial scale at which the analysis is conducted, matters. Transport policies which reinforce polycentricity at the European level, may increase the dominance of capital cities within their national urban systems and so contradict the goal of the ESDP to achieve a balanced polycentric urban system. It will be the task of further research to point towards rational trade-offs in this goal conflict.

4.2.2 Polycentric Links

The construction of links that connect central places across the ESPON space was introduced in chapter 3.7.1. The link system is designed as a testing raster for an additional impact analysis of transport and TEN policies. Following the "polycentric links" approach it has to be analysed for accessibility deficits, the relation to regional economic backwardness and finally for expected transport policy scenarios impacts on priority links.

Accessibility Deficiencies

Due to the dependence on the system of FUA centres, the links have different functions with varying distances and corresponding accessibility standards. The length average for links connecting MEGAs is above 300 km. Links from national cities to MEGA cities and between national cities are about 150 km on average, the average for links from regional to national centres is about 70 km.

In both road and railway mode, the mean of straight-line speeds declines with the importance of their end point centres: Links with a MEGA city have average straight-line speeds of 47 km/h for road travelling and 56 km/h by rail in spite of the fact that the links abstract from topographic barriers. The high-speed railway Paris - Dijon has the top straight-line speed value of 165 km/h. At this MEGA level, rail speeds are higher than road speeds. At the regional level, the straight-line speeds to the nearest national/regional centre average 40 km/h (road) or 37 km/h (rail).

To meet the differentiated link type velocity profiles and the disparities of road and rail transport modes, the definition of substandard accessibility thresholds is based on percentiles. The worst quintile is defined as high grade "substandard", the second worst as "substandard". All other links are set to "standard" accessibility quality. This concept leads to the following accessibility deficit classes for ground-level transport services:

Table 4.31. Classification of Accessibility Deficits

	Link type	Standard	Substandard	High grade substandard
		v: straight-line speed in km/h 2001 (rounded)		
I	Neighboured MEGA cities	Rail: v > 48 Road: v > 41	Rail: 40 < v <= 48 Road: 35 < v <= 41	Rail: v <= 40 Road: v <= 35
II	Transnational/national cities to MEGA cities	Rail: v > 44 Road: v > 55	Rail: 34 < v <= 44 Road: 40 < v <= 55	Rail: v <= 34 Road: v <= 40
III	Neighboured transnational/national cities	Rail: v > 37 Road: v > 39	Rail: 32 < v <= 37 Road: 34 < v <= 39	Rail: v <= 32 Road: v <= 34
IV	Regional/local cities to transnational/national cities	Rail: v > 31 Road: v > 35	Rail: 27 < v <= 31 Road: 31 < v <= 35	Rail: v <= 27 Road: v <= 31

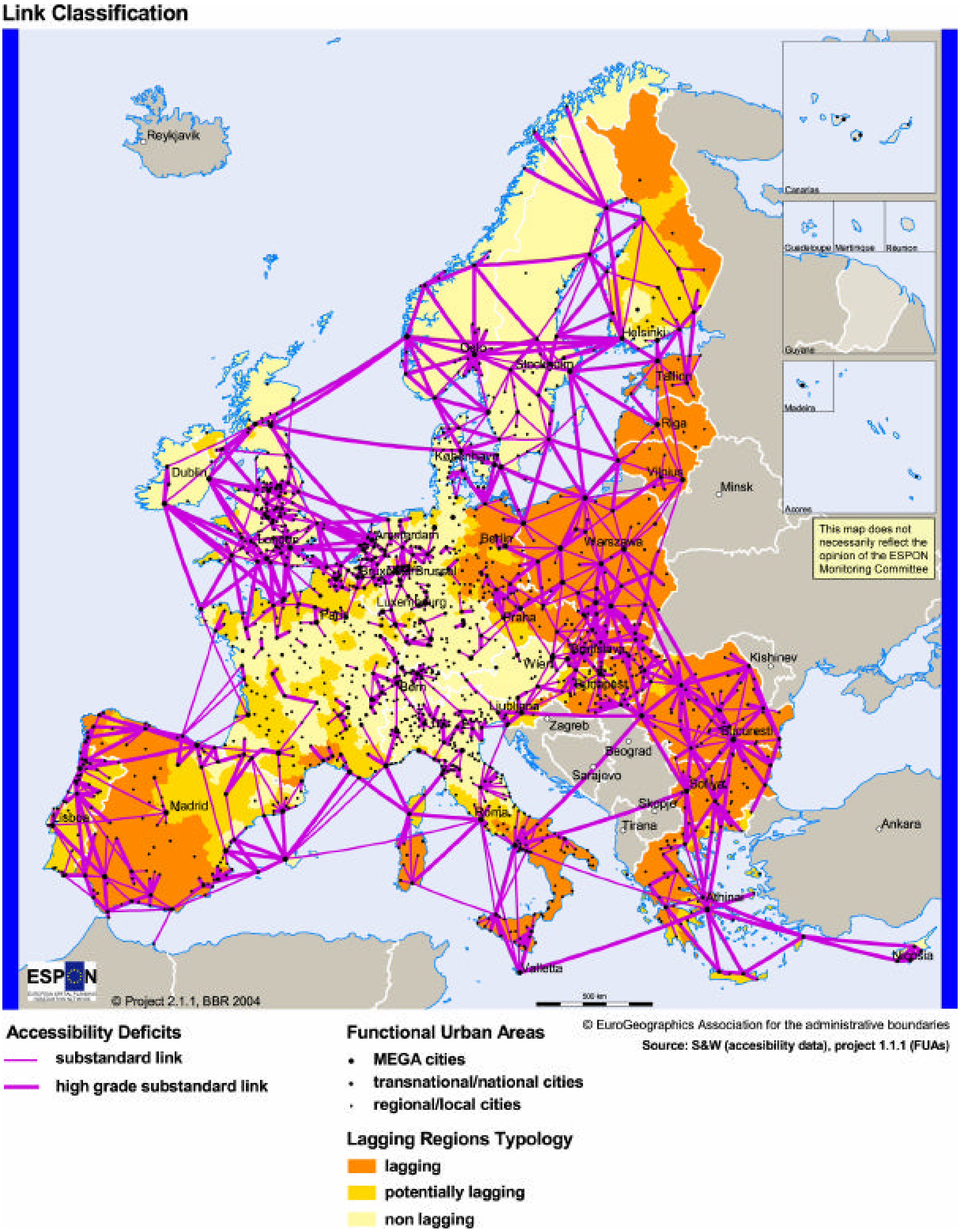
Economic Backwardness

Every link also is classified by the economic backwardness of the two connected centres following the lagging regions typology introduced in chapter 2.4. This typology is directly assigned to the centres by their regional position. The higher backwardness status of both centres is selected as a sort of "most favoured status clause" in each ambiguous case. Nearly half of the total of 2,817 links receives higher priority based on the economic criteria.

Table 4.32. Classification of Economic Backwardness

Links with end points by lagging regions typology	**Link classification**		
	non-lagging	potentially lagging	lagging
Non lagging - non lagging	1,303		
Potentially lagging - non lagging		381	
Potentially lagging - potentially lagging		266	
Lagging - potentially lagging			263
Lagging - non lagging			110
Lagging - lagging			494
Sum (total of 2817 links)	1,303	647	867

Map 4.33 Polycentric Links: Link Classification



The combined attributes, the quality of accessibility today compared to a specific average standard level and the classification of the connected regions reflecting their economic strength is scaled and weighted for each link in an evaluation matrix. Weighting can reach a four-point priority maximum in case of coincidence of accessibility deficits with regional economic backwardness.

Table 4.33. Evaluation Matrix for Priority Links

	Economic backwardness		
Accessibility deficit	Non lagging	Potentially lagging	Lagging
Standard link	????	????	????
Substandard link	????	????	????
High grade substandard link	????	????	????

By focussing on the resulting priority links with high weights not only accessibility improvements can be shown but also the degree in which the transport policy meets regional development needs. There is no guarantee for resulting economic growth but at least accessibility deficits as one limiting factor can be reduced.

Transport Policy Scenario Impacts

Finally, rail and road projects represented by two infrastructure-related scenarios (B1 and B2) are checked for a significant improvement of straight-line speeds compared to the actual reference scenario (year 2001). The first B1 scenario assumes the implementation of the priority projects (new list) 2001-2021 and the second B2 scenario includes all TEN/TINA projects 2001-2021. After the comparison of the current status (the “without” scenario) to the status after the realisation of TEN policies (“with” scenarios), two viewed B1 and B2 scenarios are compared to each other.

To separate marginal link improvements from significant link improvements that are noticeable for transportation system users, increases of straight-line speeds are filtered by a general threshold of ?v = 5 km/h. With this filter for all 2,817 links 697 significant rail links improvements (25 %) and 103 road link improvements (4 %) are detected anyhow for scenario B1 and even 1,516 rail link improvements (54 %) and 350 road link improvements (12 %) are detected for scenario B2. The comparison of straight-line speeds shows much more significant cases of link improvement in the rail network than in the road network. This effect is caused by an assumption of an accessibility model application used in TPG 2.1.1, the factor of general technical progress in the rail network infrastructure and controlling. In contrast to this, the differences in links improvements between the B1 and

B2 scenarios are caused by the large extent of the B2 scenario that takes much more projects into account.

Impacts on Priority Links

Priority links are evaluated by point weightings reaching from 1 to 4 points. The sum of these points improved for scenario B1 links reaches 758 points for rail and 227 points for road network improvements. The B2 scenario achieves more than twice as much. The improved rail links make 1,728, the road network link improvements make a total of 704 points. Due to the assumed broad rail network improvements by technical upgrading, the concentration on priority links is much higher for modelled road network impacts. Average priority points per road link are above 2, per rail link just above 1 point. Road network impacts of scenario B1 are slightly more concentrated on priority links than the extended B2 scenario.

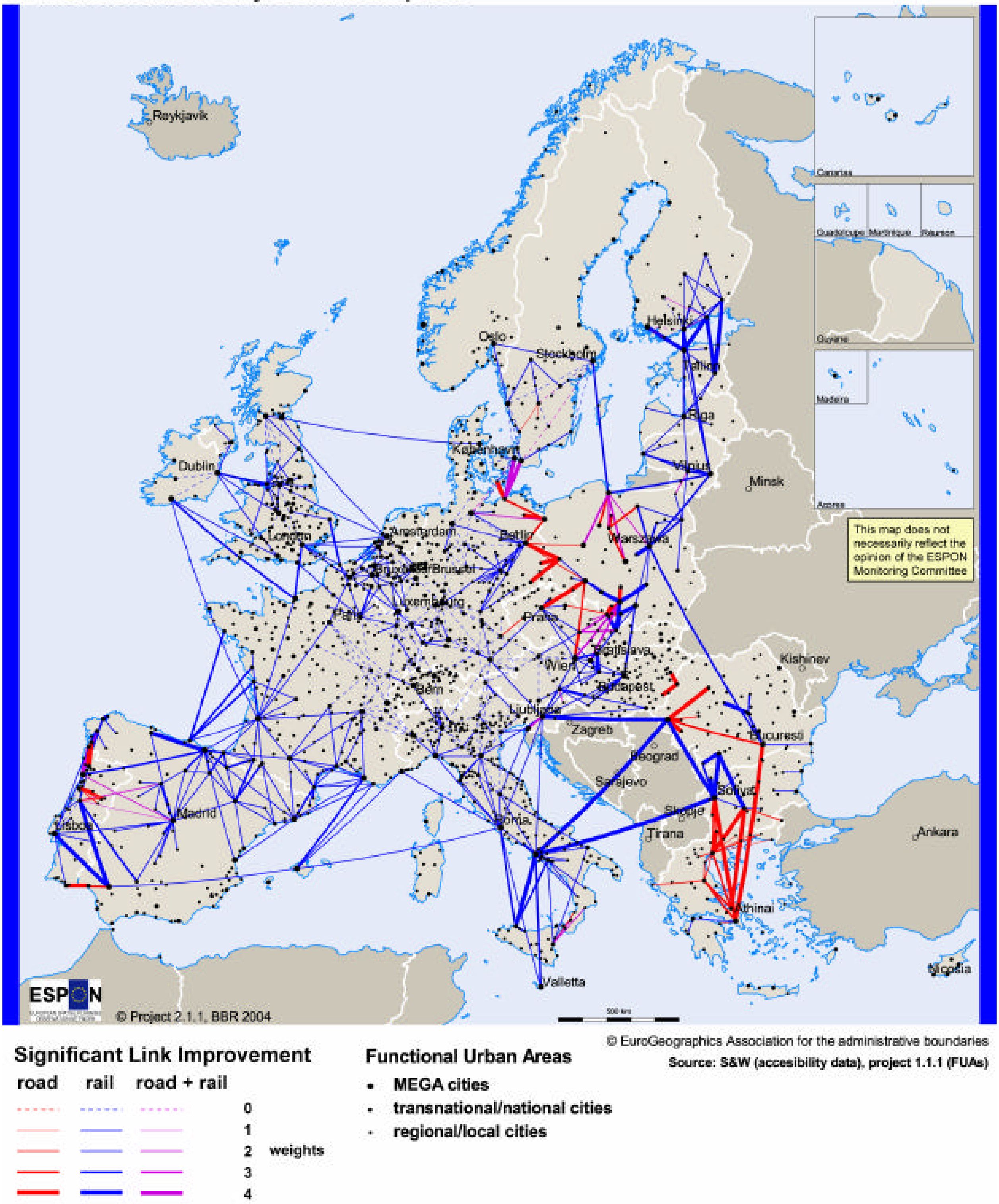
Impacts by Link Type

The absolute number of link improvements is higher for the lower level link types owing to the large number of links tested on lower levels. But it is obvious that the European transport and TEN policy addresses higher level link types first. Thus, the share of improved links of all links of a type declines from the MEGAs to lower level link types connecting regional centres.

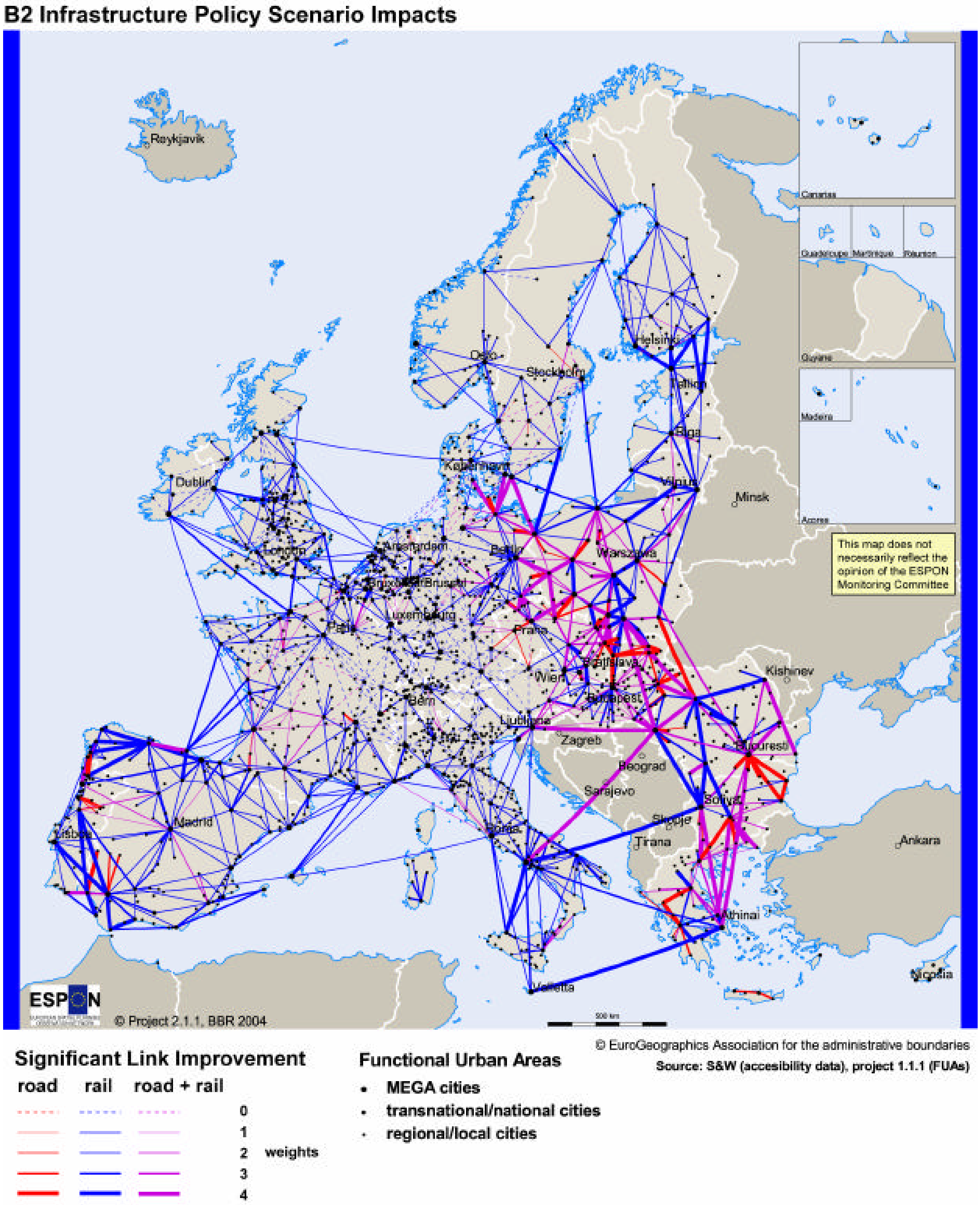
Mapping of Policy Scenario Impacts

The infrastructure policy scenario impact-maps show all improved polycentric links identified over the time period from 2001 to 2021 by evaluation priority and transport mode. Due to the focus on priority links, improved links without priority point (weight = 0) are plotted by dashed line symbol only. These non-priority links accumulate in the more central European core regions. Compared to the maps of the scenario projects, the scenario impact maps show the spatial congruence of infrastructures and related impacts in the polycentric settlement system.

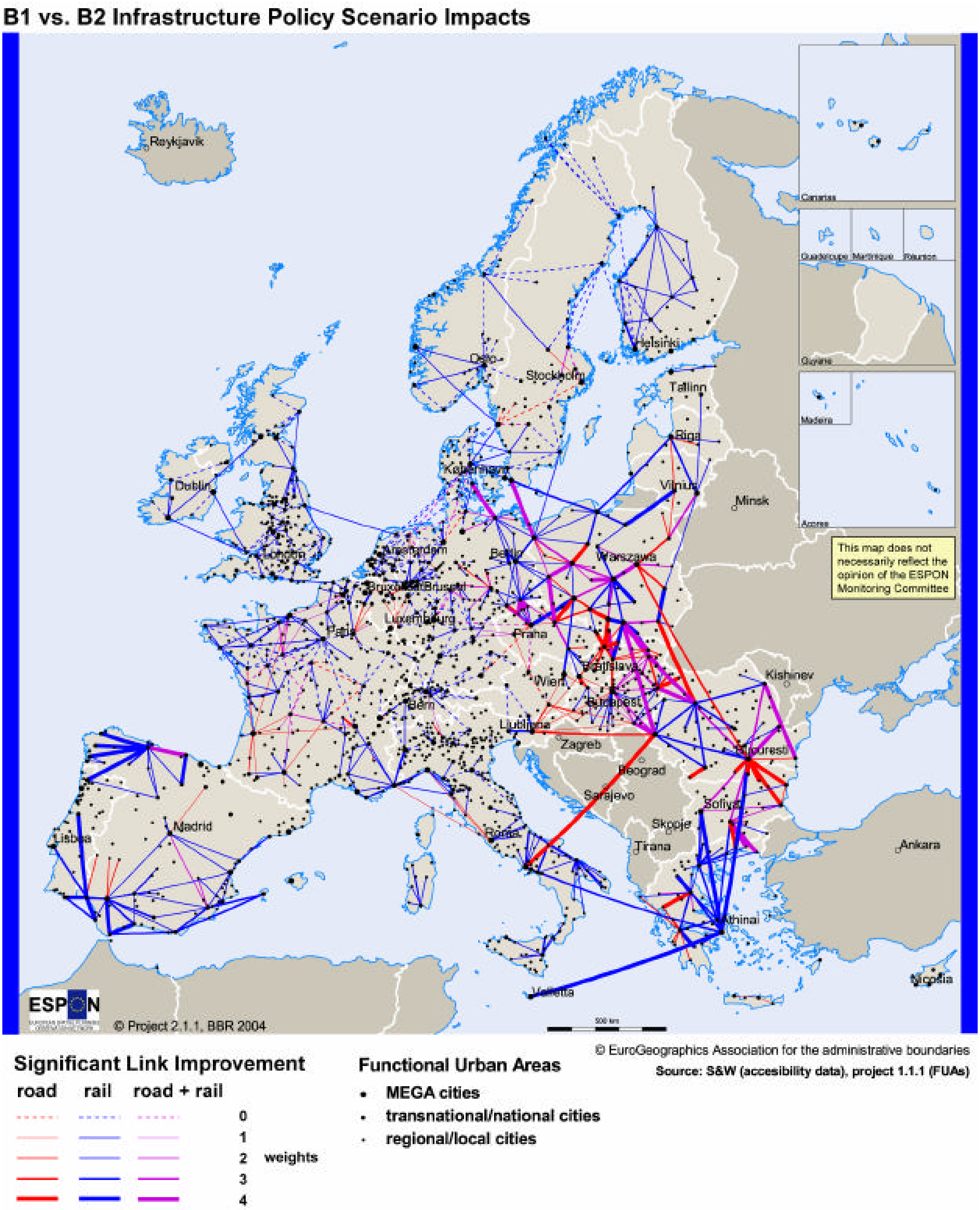
B1 Infrastructure Policy Scenario Impacts



Map 4.34 Polycentric Links: B1 Infrastructure Policy Scenario Impacts



Map 4.35 Polycentric Links: B2 Infrastructure Policy Scenario Impacts



Map 4.36 Polycentric Links: B1 vs. B2 Infrastructure Policy Scenario Impacts

Conclusions

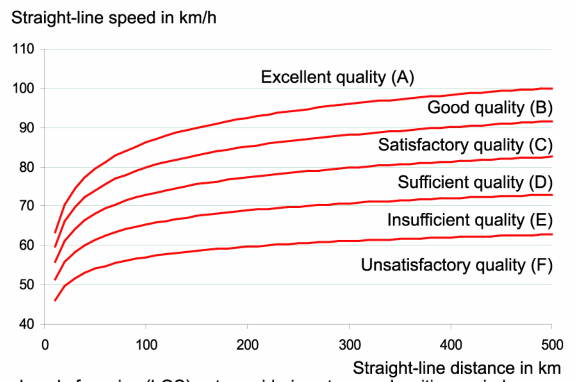
Transport and TEN policies are important for the spatial development policy. The polycentric link analysis tries to verify fundamental aims of spatial planning given in the ESDP for transport and TEN policy scenarios. It leaves monetary terms behind and focuses on the consideration and operationalisation of a balanced polycentric development to complement cost benefit aspects of transport planning. The accessibility conditions in the area of the ESPON space are measured from the European down to the regional level in an understandable way. The results are presented in the form of general maps in order to indicate deficits in accessibility for disadvantaged cities and regions.

Two future infrastructure-related scenarios (2001-2021) are compared to the reference scenario (2001): priority projects (new list) as B1 scenario and TEN/TINA projects as B2 scenario. As expected, it turns out that the accession countries and some parts of southern member states show accessibility deficits and economic backwardness mostly related to the two evaluation criteria. This applies especially to the implementation of all TEN/TINA projects 2001-2021 strengthening economic and social cohesion.

Besides the scenario evaluation, some interim results are useful, too. For an integrated network design this approach shows the point axial settlement structure based on the distribution of central places and defines minimum accessibility standards. It can also help to identify developable cross-border links.

Recently, a “Guideline for Integrated Network Design (RIN)” has been developed by the Research Society for Roads and Transport (FGSV) in Germany. The objective values of the RIN for the evaluation of transport prescribe two main minimum standards of accessibility for linkages at different functional levels between locations in the central place system.

Figure 4.5 Level of Service Standards Example



Level of service (LOS) not considering stops and waiting periods

Source: Rahmenrichtlinie für die integrierte Netzgestaltung (RIN)
Draft version of 05.12.2003

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Of course, velocity is only one criterion of accessibility. Other service quality attributes are taken into account like the number of departs in a given time frame as a measure of activity of public transport or the required number of changes between means of public transport.

Transport and spatial planning authorities of different levels have two general options in the context of polycentric links, to develop centres or to improve accessibility. In order to improve accessibility in the right locations, it is reasonable to use a link construction principle defining a priory axial system of links relevant for spatial planning. This includes international/transnational relations and border-crossing trade areas. Further research is needed to develop a set of approved normative accessibility standards for different functional levels of links connecting centres.

4.3 Impact on Transportation Flows

For the analysis of "overloaded transport corridors", introduced in section 3.7.2, the TEN-STAC study results are used for classification and mapping of transport corridors and for a brief empirical analysis of the long distance transportation flows at the regional level. A basis of the transportation flow analysis is the road transport mode as a main polluter. At the regional level, two aspects are illustrated: the regional disparities of the impacts of road transport flows and the expected changes of these impacts.

Transport Flows Development in the ESPON Space

According to the EUROPEAN+ TEN-STAC scenario the road transport flows for the year 2020 in comparison to the base year 2000 have grown by almost 43 percent (ESPON space without Cyprus). At the same time, the rail transport flows are increasing disproportionately. The Rail passenger flows have gained about 78 percent, the rail freight transportation volume has even gained about 133 percent. These key data show that, in spite of an expected modal shift to rail transport, the increase of road transportation flows will not be compensated within the ESPON space.

The following two maps present a roughly estimated classification of overloaded corridors for both the actual state (2000) and the future state according to the EUROPEAN+ scenario 2020. This classification of overloaded corridors is based on a 10 kilometre buffer zone along the road network. Within these (partly overlapping) zones, the total of travelled kilometres is aggregated for each square kilometre tile covered. Corridors can be formed by several lines following the same route or defined by highly urbanised regions with a high network density and activity.

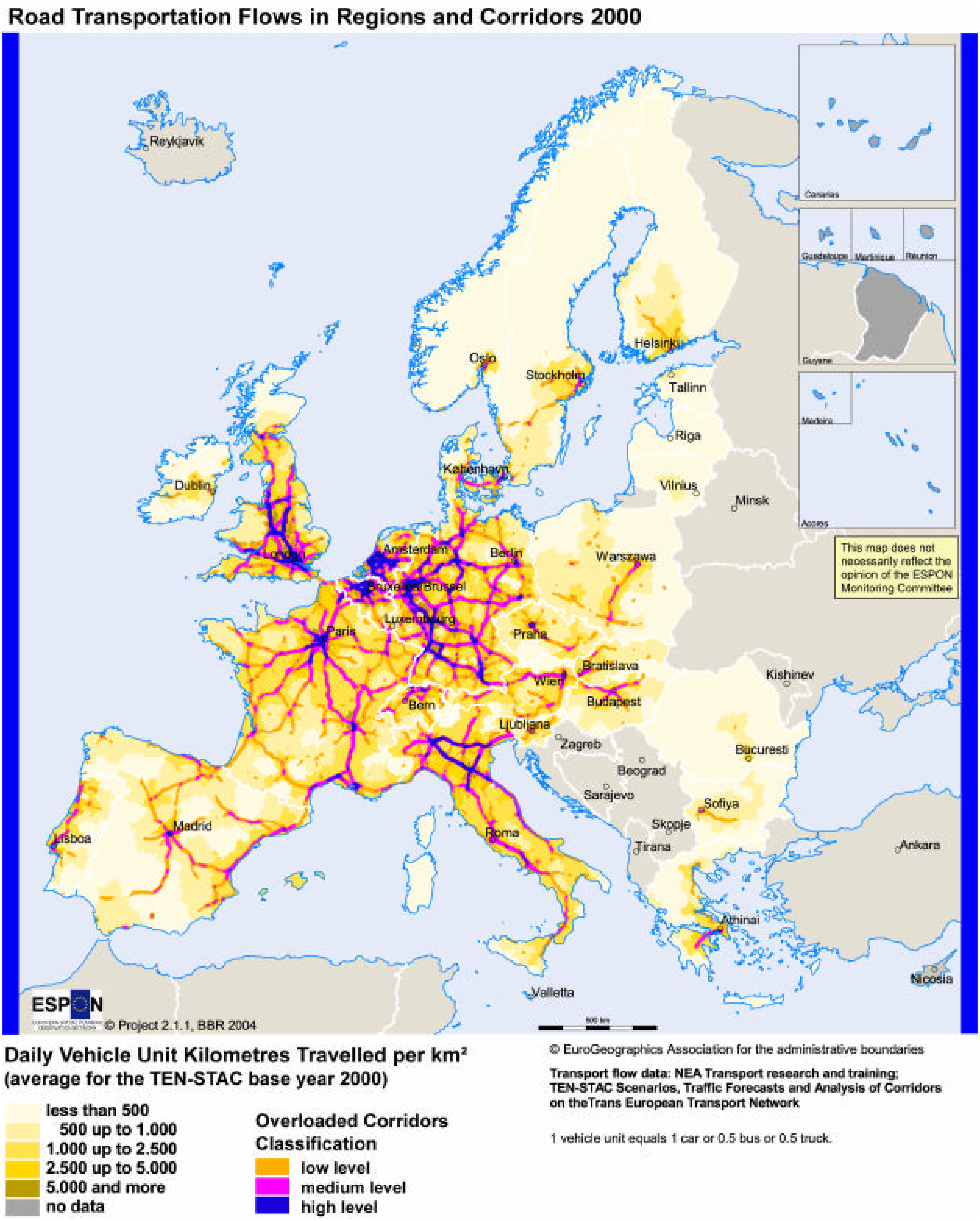
The transportation corridors are classified for visualisation purposes into three levels.

Table 4.34. Overloaded Corridors Classification

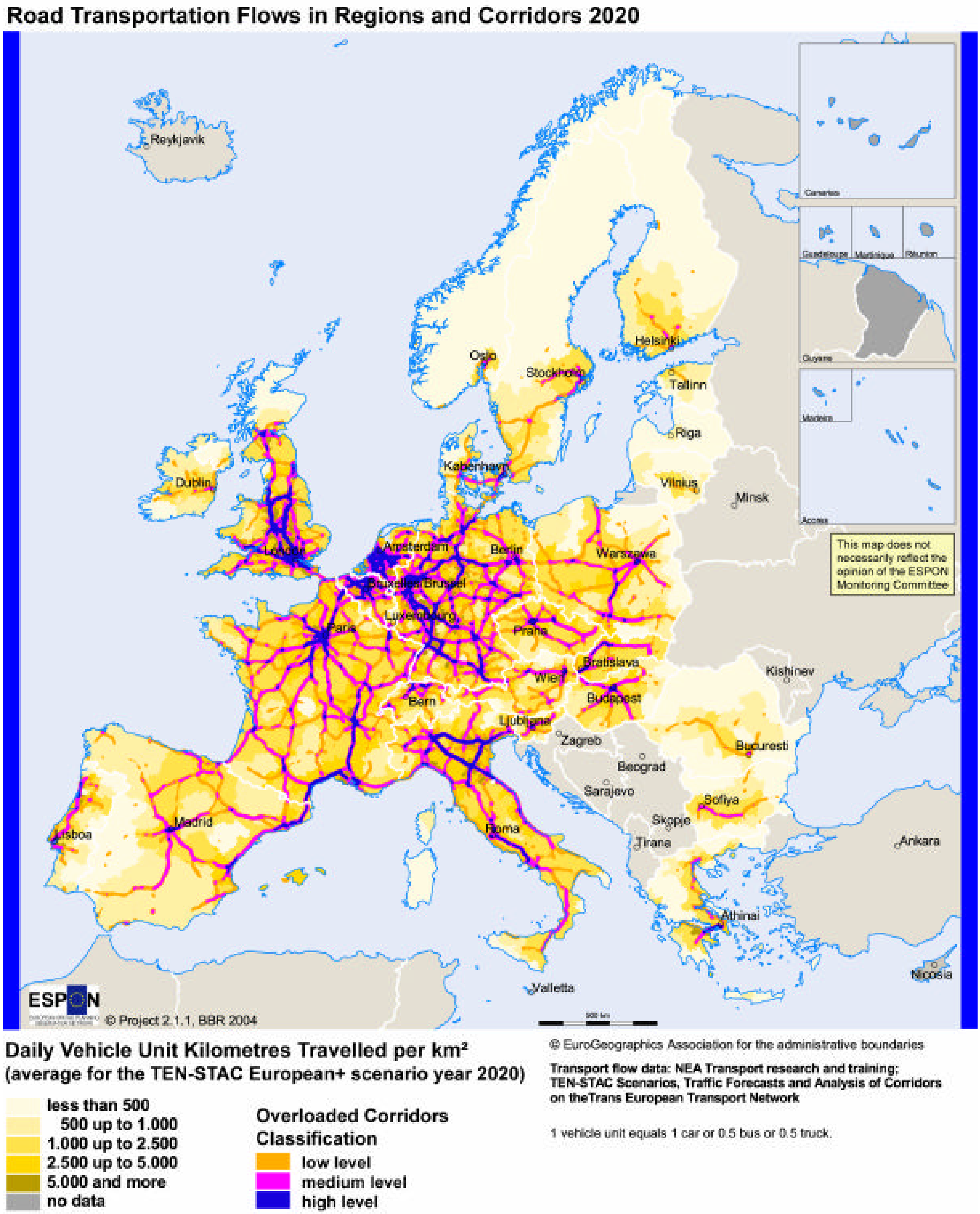
Road transportation load	Total of vehicle units travelled km per day within 10 km buffer zone
Low level	600,001 up to 1,200,000
Medium Level	12,000,001 up to 2,400,000
High Level	more than 2,400,000

The indicator used for the regional analysis of transport flow network data is the density of kilometres travelled within the road network at the NUTS-3-level. This regional level was chosen to meet the ESPON programme regional analysis standard. With this regional raster the problem occurs (like in other contexts) that regions in the core region of Europe are smaller than the peripheral regions. Due to this heterogeneity, measured transport flow densities in the core region are differentiated more sharply. As transportation flows often concentrate on fractions of regions, the corridors are displayed atop the regional shading for illustration purposes.

Map 4.37 Road Transportation Flows in Regions and Corridors 2000



With the exception of some regional/local bypasses the road transportation owing to planned measures like in Germany (Kassel region) or in Sydsverige that cause bypasses, flow volume increases all over the study area. In comparison of time, overloaded corridor zones sprawl away from highly urbanised areas to a growing extent. Some new major transport flows, for instance in Poland, are pronounced.



Map 4.38 Road Transportation Flows in Regions and Corridors 2020

The distribution of transport flow volumes interacts strongly with the spatial structure of Europe. Spatial interactions that generate traffic concentrate on urbanised regions and on networks between major centres. They cross rural areas that are the carrier of transportation infrastructure.

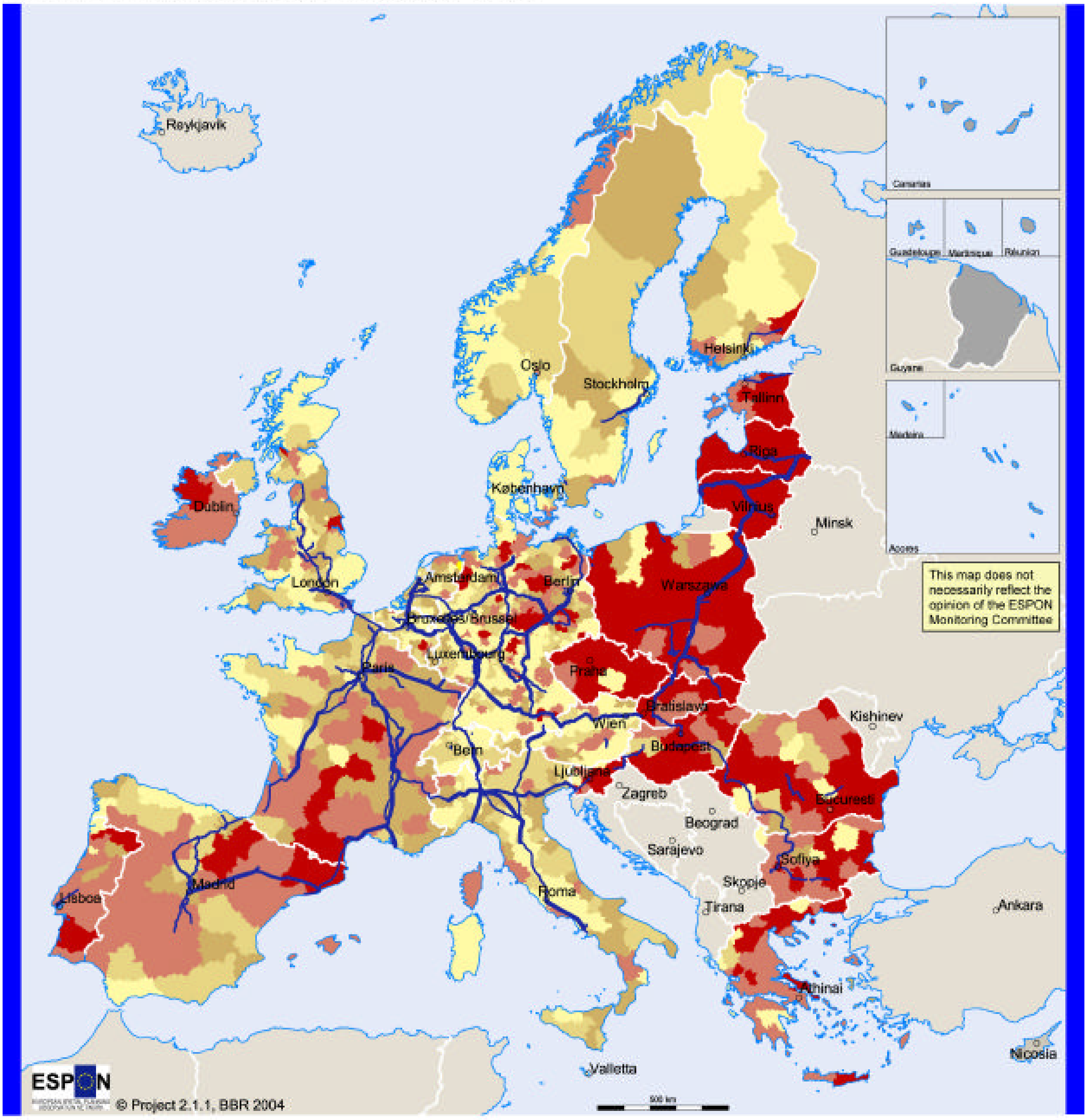
Table 4.35. Average Road Transport Flows for Selected Regional Typologies

	Vehicle units travelled km per day and km² in 2000	Vehicle units travelled km per day and km² in 2020	Increase of transport flows 2000-2020 in %
PENTAGON			
Inside Pentagon	3313	4267	29
Outside Pentagon	746	1132	52
URBAN-RURAL TYPOLOGY			
Urban, high human intervention	3017	4099	36
Rural, high human intervention	1087	1721	58
Urban, medium human intervention	1351	1848	37
Rural, medium human intervention	716	1196	67
Urban, low human intervention	833	1248	50
Rural, low human intervention	422	612	45
LAGGING REGIONS TYPOLOGY			
Non lagging regions	1524	1999	31
Potentially lagging regions	1179	1708	45
Lagging regions	523	927	77
Total	1071	1529	43

The Pentagon holds currently a share of approximately 39 percent of kilometres travelled in almost the whole ESPON space, until 2020 this share will decline to around 35 percent. Inside the Pentagon densities of transportation flows occur that are even higher than in urban regions with a high degree of human intervention according to the urban-rural typology provided by the 1.1.2 TPG.

The two criteria, population density and the degree of human intervention in land use, determine the transportation flow density. Urban regions are more burdened by the load of traffic. However, rural areas take over the load more and more. The goes to the "lagging regions" have the highest relative gain in road transportation due to the low-level transportation in the base year 2000 followed by the integration process.

Change of Transportation Flows 2000 - 2020



Regional Change of Vehicle Unit Kilometres Travelled
TEN-STAC base year 2000 vs. European+ scenario 2020

- up to 25 %
- 25 % up to below 33 %
- 33 % up to below 43 %
- ESPON space total change rate
- 43 % up to below 70 %
- 70 % and more

Markedly Increasing Railway Transport Flows

- 2.5 up to 5.0 million passengers or 10.0 up to 20.0 million tonnes
- 5.0 up to 7.0 million passengers or 20.0 up to 30.0 million tonnes
- more than 7.0 million passengers or more than 30.0 million tonnes

(per year, difference 2000-2020)

© EuroGeographics Association for the administrative boundaries

Transport flow data: NEA Transport research and training; TEN-STAC Scenarios, Traffic Forecasts and Analysis of Corridors on theTrans European Transport Network

1 vehicle unit equals 1 car or 0.5 bus or 0.5 truck.

Map 4.39 Change of Transportation Flows 2000 - 2020

Near to railway corridors that take over a great amount of transportation volume, regions obviously show disproportional lower relative transportation flow increases than other regions.

An explanation for the dramatic increase of road transportation flows in Poland as well as in the Czech Republic might be the fact that there are no markedly increasing rail transportation capacities in the east-west direction. However, the higher relative gain is of course, caused by the low level of transportation flows in the initial situation of the base year in all of the accession countries.

In areas and corridors of high traffic density, the conditions for a modal shift to environmentally friendly modes of transport such as railways and waterways furthermore should be improved. This aim does not only address the natural heritage, where overloaded corridors cause spatial fragmentation and environmental pressure, but also built-up areas and the people who live there.

5 Institutional Issues and Policy Interactions

5.1 The Institutional Determinants of Transport and TEN Policies

5.1.1 Institutional Structure of the EU for Transport Policy Making

Transport policy is a problematic area within the institutional structure of the EU. From the Treaty of Rome onwards there has been a requirement for a Common Transport Policy for the EU and it is clear that the concept of TENs has been articulated at an EU level. However, the implementation of much of transport policy has been at the level of the national governments, or even at a lower regional or local government level.

That there should be a Common Transport Policy at EU level is not under serious question. Transport involves significant spillovers between member states such that a degree of coordination is required. These spillovers involve both externality and competitive interactions. The pollution impacts of transport do not respect national boundaries and hence require common action. Similarly, there is a need for common regulations to ensure interoperability between countries: this affects such factors as vehicle weights, track gauges, safety and signalling systems, but increasingly will need to deal with charging systems for infrastructure use.

A common market in transport is also seen as an essential pre-requisite for a single market in goods and services. This is a more difficult and potentially controversial dimension. At a basic level, EU involvement in setting minimum social standards such as on drivers' hours has been seen as essential both to ensuring safety and protecting markets from social dumping with the advent of cabotage. However, transport markets are affected by a wide range of other policies given the historical involvement of governments in the provision of transport services, both as direct provider and as regulator. Over the past decade and a half there have been progressive attempts in most member states, and with the active encouragement of the Commission, to move the provision of both transport services and infrastructure away from direct public sector provision and to implement de-regulation and liberalisation as a means of increasing competition and reducing costs, especially to the public sector. However, national governments have used the transport sector as a major source of tax revenue, both for the provision of publicly funded infrastructure and as a general source of revenue. The tax position has encouraged many member states to resist further harmonisation in the field of transport.

Transport thus provides a perfect case study of the potential conflict between two models of development of the EU.[38] On the one hand the 'intergovernmental' or 'state-centric' model would argue that only those relatively few matters on which cross-border agreement is needed should be resolved at EU level. In this model a strict version of subsidiarity is applied. On the other hand the 'supra-national', 'federal' or 'multi-level governance' model would seek to assign specific functions to different levels on the basis of where they could be most efficiently administered and, most importantly, to establish institutional structures which would enable both multi-level decision-making and the policing of such decisions.

Because transport has a specific status as far as the Treaties are concerned, and this applies particularly to the TENs which represent a particular aspect of building the European Union, transport more than most policy areas has a fundamentally multi-level governance character. The EU defines the broad parameters of policy: defines networks, establishes principles such as 'fair and efficient pricing', attempts to ensure inter-operability. Member states, and in many cases their regional or local governments, are left to implement the policy. TENs are little more than concepts at EU level for which member states (together with the private sector) are expected to secure necessary permissions and legislation and, above all, finance. It is for this reason that both the initial Essen list of Transport TENs and the more recent Van Miert list[39] concentrated on projects which were already mature in their development: they represent essentially a selection of projects which have emanated bottom-up from the member states and not a planned top-down network to the extent that, for example, the often quoted parallel of the US Interstate Highway system was developed.

Transport policy, and the emergence of TENs in particular, appears to address two fundamental concerns of the EU: the development of a world class competitive economy (especially as conceived following the Lisbon Council) and the drive for increased cohesion within and between the member states. In this there are two inherent dangers. One is that the ubiquitous nature of transport leads to expectations that policy initiatives in transport can secure objectives that are more directly the concern of other policy areas: macroeconomic policy, spatial development policy or microeconomic policies towards enhancing competitiveness. The second is that policy implementation at lower levels 'refracts' the intention of policy at the EU level in order to secure particular advantages or to meet specific perceived needs. In this chapter we refer to these two concerns as

[38] E.g. see L.Hooghe and G Marks (2001), *Multi-Level Governance and European Integration*, Rowman and Littlefield, Lanham, MD.

[39] High Level Group on the Trans-European Transport Network, Report, June 2003

horizontal and vertical conflicts which are dealt with in sections 5.2 and 5.3 respectively.

Horizontal issues arise at the EU level to some extent because of the inter-governmental character of the EU. Policy-making depends on the interaction of the Council, the Commission and the Parliament and whilst the Commission is able to take a concerted view of the way that policies in different policy areas may overlap or conflict such concerns are often less pronounced in the Council. Although we concentrate on horizontal issues at the EU level, it is also clear that such concerns can arise equally within member states.

Similarly, the existence of vertical conflicts is heightened by the inter-governmental character of the EU. The blurring of responsibilities between the different levels of government provides scope for the blurring of policy objectives and their manipulation to suit the particular needs of each level of government. In the absence of the sort of controls, fiscal and other, which would exist within a more formal federal structure, this requires policy to be articulated effectively and in a way which enables lower level policy makers to implement clear policy rules consistent with higher levels of policy advice with less scope for refraction.

5.1.2 Institutional Structure and Modelling the Impacts of Transport Policies

Why does the institutional structure of the EU matter for the purposes of modelling? The models used in this research depend on assessing the impact of changes in accessibility cost on the economic interaction between regions. All transport policy impacts ultimately on both the relative costs of transport by different modes and the absolute costs of accessibility. Where different policies are being applied by different government authorities this means that we cannot rely on a simple relationship between distance, type of infrastructure and transport cost.

As described in Chapter 2.2 above we have used a set of policy scenarios to simulate the impacts of alternative policy futures. These concentrate on various combinations of infrastructure provision and pricing, in particular the attempt to move the prices of individual transport modes closer to their marginal social costs. Although most governments have made some moves towards the liberalisation of transport markets, policies have been introduced with different degrees of enthusiasm. Even increasing the basic transparency of accounting practices such as envisaged by Directive 91-440 for the rail sector, has been interpreted in different ways.

It is expected that liberalisation should lead to prices being charged which are more directly related to the marginal *private* costs of service provision. However, at the same time there has been pressure to ensure that all modes of transport cover their full costs including external costs by introducing marginal *social* cost pricing. The normal expectation would be that liberalisation would result in lower prices as a result of competition whilst marginal social cost pricing would raise the price of some modes (notably road and air) relative to others. The problem is that the degree of divergence from marginal social cost differs for different countries depending on the degree of regulation, the nature of the liberalisation and the extent of externalities remaining to be internalised. The net effect on prices charged is therefore initially ambiguous, since it is not possible simply to assume a given percentage change from the current prices. The situation is further complicated by the different tax regimes in use in different member states which also distort the relative position.

The basic message is hence that there is no simple and straightforward way of incorporating a measure of liberalisation into the modelling. Whilst the simplest approach might be to assume that full liberalisation implies that prices approach marginal private costs and then derive an index of the degree of liberalisation achieved in each member state, the discussion above suggests that such an approach could be misleading as there is no firm evidence that liberalisation generally has this effect. It is not immediately clear that any alternative could provide a significantly different impact from the alternative scenarios already used and hence these have been used as the basis of the modelling.

5.2 Interaction between Transport and TEN Policies and other Relevant Policies

5.2.1 Framework for Analysis of Horizontal Policy Interaction

In this section we explore the horizontal interaction of policies at the EU level and the potential for conflict between them. In particular we assess the extent to which transport policy instruments are being used towards the achievement of policy goals in other policy areas and how far these are taken into account when setting both transport policy and non-transport policies.

A previous study for the European Commission[40] assessed a range of Community policies for their impact on spatial development. This study, however, concentrated solely on the policies with an overtly spatial content, namely the agriculture, transport and environment policies, with a primary focus on the impacts on rural regions. Looking at the spatial distribution of expenditures under each of these EU policy areas (i.e. only expenditure under the relevant European policy was identified, no account was taken of national expenditures), the study identified, on the basis of Lorenz curves, that all three policy areas were strongly redistributive. A substantially higher percentage of expenditure on each policy area went towards regions which were poorer in terms of GDP per capita. Transport expenditure showed relatively the strongest redistributive impact with a high concentration in poorer regions. The one exception to this was TEN expenditure which was modestly regressive in this context.

However, this previous study did not look at the extent to which expenditure within each policy area might conflict with that in other policy areas. Although each policy was on average redistributive, each policy may be favouring different types of regions and hence policies may not just fail to support each other, but actually work counter-productively. An obvious case of this is where environmental policy may be negated by increasing transport provision and use. The second problem, which is particularly relevant to transport expenditures, and TEN developments in particular, is that looking at expenditure (inputs) may not give an accurate picture of impacts on income or economic welfare (outputs). The spatial incidence of expenditure does not necessarily imply the actual spatial impact in terms of economic and social development. Infrastructure enhancements in one region may have greater impacts on other regions.

In this study we have looked at a much wider range of policy areas, but then used induction to judge where potential conflicts might arise in the impacts of those policies, rather than examine expenditure resulting from policies. This is necessary because, with the exception of the three policy areas mentioned above, the majority of EU policies do not have a specifically spatial distribution; the spatial impacts arise from the policies rather than being a focus of their action. Furthermore, expenditure in policy areas is a measure of input rather than output, and only one measure of input. Our primary concern is the way that policies may impact on the GDP and welfare measures used in the modelling exercises. In the case of transport this may arise just as much from measures relating to market structure which do not

[40] *Spatial Impacts of Community Policies and Costs of Non-Co-ordination*, by Agence Européenne "Territories and Synergies", EURE-CONSULT S.A., Nederlands Economisch Instituut, Quaternaire Portugal for DG Regio, 2001

involve direct expenditures. Table 5.1 lists the relevant policy areas and identifies the key policy objectives of each policy area (together with the key documents defining those policies).

To analyse the interaction of policy we developed an interaction matrix (Table 5.2). This takes the stated objectives and policy instruments defined in each policy document and assesses how these might interact. For example, transport policy objectives which raise the cost of road transport to reflect the external effects of transport would have positive impacts on environmental policy, but would raise the costs of transport to transport-intensive industries and thus have a negative impact on agriculture or industries in peripheral regions. Liberalisation in the air transport sector would lead to significant increases in air travel with negative impacts on the environment, but potentially positive impacts on peripheral regions. The development of new TENs infrastructure could have significant impacts on the location of industry and on both competition and competitiveness, but with ambiguous effects on spatial development and meeting regional policy objectives.

Table 5.1 Summary of Spatially Relevant EU Policies

Policy Area	Objectives	Policy Documents
Transport	Infrastructure Regulation Pricing	Fair Payment for Infrastructure Use, COM(1998)466 final High Level Group on Transport Infrastructure Charging: Final Report on Options for Charging Users Directly for Transport Infrastructure Operating Costs, September 1999b European Transport Policy for 2010, Time to Decide, 2001
Regional and Cohesion Policies	Structural Fund Objectives 1, 2 and 3 Cohesion Fund Community initiatives Fisheries	Sixth Periodic Report on the socio-economic situation and development of the regions of the European Union, 1999 Second Report on Economic and Social Cohesion, 2001 First progress report on economic and social cohesion, COM(2002) 46 final Second progress report on economic and social cohesion, COM(2003) 4 final
Environmental Policy	Climate change; Nature and biodiversity; Environment and health; Natural resources and waste	Sixth Environment Action Programme (Decision 1600/2002/EC, 22 July 2002)
Common Agricultural Policy	Enhance the competitiveness of EU agriculture Promote a more market oriented, sustainable agriculture Provide a better balance of support and strengthen rural development	Mid-Term Review of the Common Agricultural Policy, COM(2002) 394 final Guidelines For The Evaluation Of Leader+ Programmes, DOCUMENT VI/43503/02-REV.1, January 2002 Evaluation of rural development programmes 2000-2006, DOCUMENT VI/8866/99-REV., 1999 Explanatory memorandum: A long-term policy perspective for sustainable agriculture, COM(2003) 23 final
Internal Market and Competition Policies	Facilitating the free movement of goods Integrating services markets Ensuring high quality network industries Reducing the impact of tax obstacles Expanding procurement opportunities Improving conditions for business Meeting the demographic challenge Simplifying the regulatory environment Enforcing the rules Providing more and better information	Fourth Annual Report on Economic Reform (Cardiff Process) December 2001. The Impact and Effectiveness of the Single Market, Communication from the Commission to the European Parliament and Council 30 October 1996. Economic Reform : report on the functioning of community product and capital markets COM(2002)743 final Internal market: mixed results in meeting implementation targets for 2002 (IP03/40) Internal Market Strategy, Priorities 2003 – 2006 COM(2003)238

Table 5.1 (continued)

Stability and Growth Policies	National budgetary policies support stability oriented monetary policies Medium-term objective of budgetary positions close to balance or in surplus Government deficit within reference value of 3% of GDP.	Co-ordination of economic policies in the EU: a presentation of key features of the main procedures, Euro Papers No 45, July 2002
European Spatial Development Perspective	Polycentric spatial development and a new urban-rural relationship; Parity of access to infrastructure; Wise management of the natural and cultural heritage	European Spatial Development Perspective: Towards Balanced and Sustainable Development of the Territory of the EU (Potsdam, May 1999)
ICT Policies	Investment in ICT infrastructure Investment in people and skills to support adoption Promotion of use through Internet service development	*e*Europe 2002 Action Plan

Table 5.2 Analysis of Horizontal Policy Interactions

Opportunities / Risks	Transport Policy	Regional, Structural and Cohesion Policies	Environmental Policies	Common Agricultural Policy	Internal Market and Competition Policies	Stability and Growth Policies	European Spatial Development Perspective
Implementing White Paper on Transport Policy	+++ ---	++ --	+++ --	++ --	++ -	+ -	+++ ---
Implementing Transport TENs	++ --	+++ ---	+++ ---	+ -	++ -	+ -	+++ ---
Implementing GALILEO	+++ --	++ --	++ -	+ -	+ -	+ -	++ --
Implementing ICT guidelines	++ -	+++ --	++ --	+ -	++ -	+ -	++ --

Code: + indicates potential policy synergy; - indicates potential policy conflict (see text for detailed description)

Table 5.2 summarises these interactions. These are indicated as either positive (where policy objectives reinforce each other) or negative (where they conflict). The strength of the potential impact is indicated by the number of plus or minus signs. Most interactions between policy areas, as suggested in the examples above, create the possibility of both positive (opportunities for synergy) and negative (threats of conflict) interactions. The strongest of these interactions are indicated by the shaded cells in Table 5.2.

5.2.2 Horizontal Policy Linkages

In this section we look in more detail at the key interactions identified in Table 5.2. We concentrate on the transport policy measures outlined in the 2001 White Paper *European Transport Policy for 2010: The Time to Decide* together with the statement of current TENs policy contained in the 2003 *Report of the High Level Group on the Trans-European Transport Network*. We also include a specific consideration of GALILEO because of its importance as a an element both of the implementation of transport policy and as an example of ICT policy and a more general consideration of ICT policies and their interactions. In the following section we look in detail at the role of national transport policies.

The detailed analysis of the relevant policy documents reveals the unsurprising finding that there is very little attention paid to interactions between policies except where they address the same principal objective. As seen in the previous study of the EU's overtly spatial policies there is some recognition of the impact which transport will have on the spatial distribution of activity, or of environmental policy on transport and vice versa, and of agricultural policy on the economic and social development of rural regions. We can add to this ICT policy which has clearly been seen as having an impact on regional development and thus has become an instrument of cohesion policy. Once we move away from these policy areas the interaction becomes less obvious, but the scope for conflict correspondingly greater. The nature of most interaction is therefore of unintended consequences.

5.2.2.1 Transport and General Economic Policy

If we look at the main economic policy areas, relating to the internal market, economic reform, macroeconomic policy coordination and the Stability and Growth Pact, there is a clear two-way impact with transport policy and TENs development in particular. A clear message from recent reports on progress with achieving the internal market and economic reform as part of the

Lisbon process is that there are still substantial barriers to the free movement of goods and services.[41] Improvement of the EU's physical infrastructure plays a clear role in addressing these objectives of policy. Similarly, a long-term objective of transport policy has been to ensure that, through the harmonisation of market conditions relating to the relative position of each transport mode, transport contributes to the removal of barriers. The increasing emphasis on the service and high technology sectors, which require faster but also more reliable ("just-in time") transport services, highlights the importance of consistency in transport policy (an issue to which we shall return in chapter 5.3 below).

There are potential risks to be faced in this interaction, however. Transport is a major consumer of public funds for infrastructure development and for the support of unprofitable public transport services which meet a public service obligation of the State towards disadvantaged groups, whether defined on a personal or spatial level. Use of public funds to support unprofitable services leads to conflict with the basic presumption of competition policy which lies behind the internal market programme (and this extends to the question of public support to manufacturing industry supplying vehicles to, for example, the rail and airline markets). Public expenditure on capital infrastructure projects, either directly or indirectly through State guarantees to private sector financing of projects, runs the risk of being constrained by the squeeze on public budgets occasioned by the Stability and Growth Pact requirements for dealing with excessive deficits, especially in a period of stagnant economic growth. Infrastructure is frequently a short-term casualty of public expenditure cut-backs since capital expenditure on infrastructure only has longer-term consequences whereas direct spending, for example on social policy, has more immediate economic and (more particularly) political impacts. The High Level Group on the TENs[42] has noted the small number of the priority projects identified in the 1994 Essen list which would be expected to be in full operation by 2007 (five out of 14), despite these having initially been defined as being well advanced at the time. A key factor in this has been the problem of funding.

Although there is no unambiguous long-term impact of transport infrastructure investment on economic growth, there is general evidence of a positive effect in terms of the enhancement which such infrastructure provides to the productivity of private capital and the potential for lowering

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[41] See for example André Sapir (Chairman), *An Agenda for a Growing Europe: Making the EU Economic System Deliver* Report of an Independent High-Level Study Group established on the initiative of the President of the European Commission (Oxford University Press, 2004).

[42] High Level Group on the Trans-European Transport Network, Report, June 2003

labour costs through the thickening of labour markets.[43] Hence TENs policy may be seen to be generally supportive of economic growth and of the Lisbon agenda to promote a more flexible economy. There is here a serious issue of potential risk whereby reduced levels of expenditure occasioned by the budgetary problems of governments may be reducing the long-term prospects for both growth and greater efficiency.

Despite these potential benefits and conflicts we have identified that is likely to be a mildly positive impact of transport policies on these general economic policy areas. Since these impacts are largely indirect and there is continuing ambiguity as to their size we have not scored these as the strongest interactions in Table 5.2.

5.2.2.2 Transport and Spatial Policy

Turning to the stronger effects, we have identified these as occurring within the group of spatial policies (including agriculture). The strongest links occur within transport policy itself as here we see the potential for both the greatest supporting role of different policy measures and instruments, but at the same time the greatest scope for inconsistency and risk in policy interaction. Within transport policy the main interaction is between the development of infrastructure (especially the addition of capacity to networks) and the regulatory and pricing mechanism for the use of these networks. The basic problem is that infrastructure enhancements reduce the perceived price of transport by that mode at the same time that there is an attempt to make users more aware of the real resource costs of transport. This affects not just the modal balance of traffic, indeed there is a general presumption in both the 2001 *White Paper* and the TENs strategy in favour of the removal of bottlenecks and promotion of new links in favour of modes such as rail and short-sea shipping where there is potential to absorb some of the pressure from the road and air networks, but it also affects the total level of mobility by altering the price of transport relative to other goods and services. Imbalance in the implementation of transport policy, most particularly the failure to implement policy in its totality, can carry serious risks of making the situation worse. Strategic investment in the infrastructure networks, coupled with pricing based on the true marginal social costs of each mode, makes for a consistent policy; any departure from this may result in overloaded networks, increasing congestion and higher total costs of transport to the detriment of the long-term benefits. Hence we see that even within transport policy there are threats and it is not sufficient

[43] See for example E. Quinet and R. Vickerman, *Principles of Transport Economics* (Edward Elgar, 2004), Chapter 1, for a more detailed discussion

simply to identify the policy aspirations, but also to be able to monitor the implementation of policy.

The second most strong set of policy linkages occur between transport and environment policy since transport as a sector is the largest single contributor to a number of environmental problems. Again we have a problem in identifying the actual outcome since this will depend critically in the extent to which current transport policy measures are introduced. Implementation of the proposals in the White Paper across the EU would have mixed effects. The pricing proposals designed to make users face the true resource costs of their transport, including full recognition of environmental externalities would lead to transport policy making a strong positive contribution to environmental policy goals. On the other hand, objectives which seek either directly to promote mobility would have a negative impact. To the extent that infrastructure developments reduce the costs of travel and transport they promote mobility. Improving the accessibility of lagging regions is likely to lead towards an upward equalisation of mobility across the EU; this is particularly relevant in the case of the new member states where mobility is typically much lower, especially by the less environmentally sustainable modes of road and air transport (for both personal and goods transport). Furthermore, the use of transport policy to promote polycentricity would be likely to lead to increased transport for any particular level of economic activity in the same way that the movement to hub-and-spoke networks increases total transport.

We have concentrated on the negative consequences of transport on the environment, but it is of course possible that the positive benefits of creating new transport opportunities will lead to a higher level of economic activity which will outweigh the negative aspects. The current danger in transport policy implementation is that the failure to implement the entire package will reduce the positive benefits and increase the negative consequences.

The interactions with the structural and cohesion policies, with regional policy in particular, and with the ESDP most specifically, are clearly central to this discussion. We do have to take care, however, in assuming that all the impacts are clear and in a specific known direction. Transport policy changes, whether pricing/regulation-related or infrastructure-related, have an ambiguous impact on spatial development. This is clearly revealed by the results from Chapter 4, showing that promoting mobility by improved infrastructure supports polycentricity, while the opposite is true for externality pricing policies. The modelling results also show that the spatial impact of improving the infrastructure can critically depend on the details of implementation. The impacts of infrastructure development in the past decade as well of that planned for the next two decades is predominantly decentralising in Europe. This is not the case for all modes, however. The decentralising impact is due to the development of road network improvements. No such tendency can be observed for rail investments.

It should also be noted that the modelling exercises leave many structural details unconsidered. Increase of private transport costs due to social marginal cost pricing, for example, may affect firms differently, depending on the transport intensity of their respective inputs and outputs and on the extent of their respective markets. This type of policy initiative would therefore put a pressure on structural policies to complement transport policies in order to support firms in disadvantaged sectors and regions, such that they can better cope with the burden resulting from these policies.

Finally we turn to the interaction with agriculture policy. Transport's role in promoting the internal market is also significant in its relationship with increasing the efficiency of the agricultural sector. More important however is the role of transport in sustaining and promoting the economy and society of rural regions, both as a complement to agriculture and as the means by which rural regions, and particularly remote rural regions and mountainous regions, can attract alternative sources of employment. The modelling results in Chapter 4 show that infrastructure development, both that in the past and that planned for the future, generally favours peripheral rural regions more than less peripheral non-rural ones, while externality pricing has the opposite effect. Again we have to enter a caveat. A policy based solely on reducing transport costs does carry risks that remote rural regions are insufficiently competitive to be able to withstand competition from more central regions when transport costs are reduced. Furthermore lower transport costs may encourage continuing out-migration of the potential labour force.

Thus it is suggested that even within the spatial policy areas we can identify the potential for conflict; furthermore, even within transport policy we see that although there are strong positive elements for reinforcing the spatial objectives, there are considerable risks that policy conflicts may arise. The above discussion is based on induction from a close consideration of the way policy objectives are set and what evidence we can infer from previous studies of the wider economic impacts of both transport infrastructure policies and transport policies affecting price. A key issue to raise is that there are some effects which we know with greater certainty than others; this does not mean that the effects are necessarily greater. Table 5.2 has provided a basic framework in an attempt to allocate some overall interaction effect based on both the likelihood and the strength of any interaction.

5.3 Vertical Interaction between EU and National Transport Policies

5.3.1 Framework for Analysis of Vertical Policy Interaction

In section 5.2 above we have only identified the interactions between policies at the EU level. Most EU policies have to be implemented through national legislation. In the case of transport, despite the common transport policy, most policy intervention is at a national or local level and a large part of policy, for example that which involves taxation, is in any case reserved to national governments under the terms of the Treaties. Although the Council, Commission and Parliament may develop clear policy directions, the actual impact of policy depends critically on the way in which the member states enact legislation to affect the policy objectives. The effect of the legislative process in each member state is to refract the policy measure, that in each member state develops a specific interpretation of the policy.

However, it is more complex than this since it is not just a case of members states interpreting EU policy in their own way, there are large parts of transport policy which are reserved to the member states. Hence the transport policy statement of each member state reflects a particular balance of EU and national objectives. The balance between these may differ between member states such that in some cases EU policy interests may dominate whereas in others it is national policy interest which dominates, even to the extent that these outweigh the EU interests and present vertical conflicts. Even where this does not happen, differing balances between policy objectives in geographically adjacent member states may lead to potential horizontal conflicts, for example if different priorities are attached to the development of different modes or to infrastructure development and pricing policies. These potentials for conflict can be replicated within member states between national and regional or local governments.

Some of these difficulties in the implementation of the TENs have been dealt with in an earlier EU project. The TENASSESS project[44] was primarily concerned with infrastructure planning and identified four "ideal type" transport policy frameworks:

'Traditional' transport planning approach – which concentrates on the role transport can play in addressing structural problems such as traditional regional problems, in which infrastructure plays a major role;

'Modern' transport planning approach – which allows a greater role of the private sector but with the same broad objectives;

[44] ICCR *et al*. (1999) *Euro: TEN-ASSESS Final Report*, European Commission Transport RTD 4th Framework Programme

Liberal market approach – which concentrates on regulation through economic instruments such as pricing and taxation;

Ecological approach – which concentrates on controlling the negative aspects of transport through strict regulation.

This framework was felt to be rather too restrictive given the need to consider all aspects of transport policy, and not just those relating to infrastructure objectives. In order to provide a framework for the analyses of members states' transport policies in the context of EU policy priorities of concern, we have followed the same basic methodology as for the horizontal policy interaction of examining the content of relevant national policy documents for references to major themes of EU transport policy. The grid shown in Table 5.3 illustrates the range of these considerations and this has been completed for all the countries of the EU29 for which a current national transport policy statement could be identified.[45]

This can only provide a very partial analysis of the actual policy interactions and was designed principally to identify the extent to which any national policy measures may subvert the assumptions in the modelling exercises. It is clear, for example, that national policy statements, even where comprehensive ones exist, do not necessarily represent the actual policy measures implemented. Policy documents which lay down investment criteria or define possible national infrastructure networks cannot prejudge which individual projects will meet investment (and other) criteria. These other criteria may be formal ones such as Environmental Impact Assessments or less formal such as the need to meet local political considerations.

[45] A list of identified web-sites is listed in appendix 8.6

	Page/section ref.	Nature of reference: direct link, supportive, contradictory	Additional comment
Reference to EU TENs policy			
Reference to infrastructure charging			
Reference to ESDP: polycentricity, accessibility etc.			
Environmental priorities			
Reference to cohesion			
Reference to competitiveness			
Link to other sectoral policies, e.g. agriculture, energy, etc			
Reference to macro and stability policies			
Concern with missing links: international/national			
Framework for regional/urban transport policies			
Other issues			

Table 5.3 EU/National Policy Interaction Summary

Policy statements also do not reflect the way that individual elements of policy are actually implemented, the emphasis placed for example on each element in the operation of policy, or the extent to which policy objectives change within the period of validity of a policy for reasons of both political expediency or changing external circumstances. Such changes can only be identified by in-depth surveying of individual policies for example by interviewing responsible officials. The resources available did not permit such an approach and the need to make some assessment for all 29 countries meant we have had to rely on general published policy statements.

This itself poses problems because very few countries have a clear single statement of transport policy. Even in a country like the UK which does have something approaching a single statement in the 1998 White Paper *A New Deal for Transport*, and the subsequent *Ten Year Plan* of 2000, getting a complete statement of current policy is difficult since the White Paper is a set of general aspirations, supported by a number of "daughter" documents detailed individual mode policies. Furthermore, virtually all countries for which any documentation could be identified separate general policies towards transport from current infrastructure plans. In some member states, such as France and Germany, there is an overall plan, usually for individual modes such as the French *Schémas Directeurs* or the German *Bundesverkehrswegeplan*. In other member states, the UK for example, road network development is based more on the evaluation on a scheme by scheme basis without an overall plan framework.[46] Where there has been a substantial involvement of the private sector in infrastructure development (again the UK provides the most advanced example in the rail sector) there is no government policy statement, but plans for network development do have to be approved by the government's agencies and regulator given the need for public financial support.

In some countries the relative involvement of national and regional governments in transport policy makes it difficult to obtain a clear statement of the overall position.

Our primary impression from sifting this large quantity of information is of the following broad situation:

- EU15:
  - little direct use is made of EU policy or TENs in formulating national policy priorities;

[46] Although the UK has seen some changes of policy towards road building with an initial presumption of the current government that there should be no further major road building, to one which acknowledges the need for selective road building and widening of some existing routes.

    - some use of similar concepts across countries, e.g. with respect to environment, regional impacts and cohesion;
- Accession countries:
    - strong emphasis on TENs and EU priorities in formulation of national policies;
- Other countries (e.g. CH):
    - strong emphasis on links between European and national policy priorities given key location

Essentially EU15 members pay little overt attention to EU policy in setting their own priorities. This does not of course mean that member states' policies are in conflict with EU policy, which is after all effectively set by the member states, simply that EU policy is not used as a support for policy. This is perhaps surprising in some areas since EU policy is frequently used in some policy areas as the rational for unpopular actions and we were somewhat surprised not to find policy on charging in this category. Where infrastructure is planned which is consistent with EU policy, then it is not surprising that the member states wish to take the credit for this.

Perhaps it is also not surprising to find the accession countries giving greater recognition to EU policy. First, the process of accession itself has placed them more directly in an ongoing bargaining situation with the EU than the existing member states and they will see stronger elements of quid pro quo in acceding to current EU policy initiatives, especially where there may be fewer current vested interests in transport. Secondly, the accession countries clearly have much to expect to gain from infrastructure policies in particular, since they are more likely to be able to gain financial support for projects than existing member states, either directly or indirectly through EIB and EBRD support.

Finally, Switzerland is, in some senses, in the opposite situation, being able to dictate to some extent, transport policy to the EU because of its sensitive geographical location. However, Switzerland too needs to negotiate its position carefully to ensure an appropriate balance between gains and potential losses. This leads to it taking very close cognisance of the EU policy stance.

We analyse some of these findings in a little more detail against the main issues highlighted in Table 5.3

5.3.2 EU TENs Policy

TENs policy plays a relatively small role in setting national policy priorities, although as the most visible EU transport policy it is highly likely to be used as support for national priorities. Although we have not been able to complete a survey of regional policies on any consistent basis our strong impression is that TENs have been even more important in determining regional policies, or where regions do not have sole competence over infrastructure, regional pressure on national governments. Regions have shown a strong interest in the designation of TENs as part of the pressure to be “on the network”, which is seen to carry a high value.

Member States which serve as transit routes or which have considerable needs to overcome problems of regional remoteness emphasise the importance of TENs, so for example we observe their importance in recent policy documents in France and Italy, but also particularly in small countries both within the EU15, such as Luxembourg, outside such as Switzerland, and amongst the accession countries such as Hungary. Bulgaria and Romania place considerable emphasis on infrastructure development to meet EU standards and integrate with the European networks.

5.3.3 Infrastructure Charging

Whereas national policies are clear on the usefulness of European networks as a means of underwriting national needs for both network development and structural support, there is less common interest in adopting any move towards unified charging rules on efficiency grounds. Charging is seen more as a means towards raising revenues necessary for future infrastructure investments. Only in more recent policy statements made in countries like France and Germany do we begin to see references to the need to rebalance costs and the price paid by the users in contexts other than that of environmental damage.

Although most of the discussion relates to the main road and rail networks, there are increasing signs of concern over setting the appropriate price for air traffic and interest in the potential of short-sea shipping networks.

5.3.4 ESDP: Polycentricity, Accessibility etc.

Accessibility issues occur frequently in discussions of infrastructure investments. In most cases these relate to the role of accessibility in meeting some clear regional needs, and do not relate directly to the more general issues raised by the ESDP. Thus reference is typically to peripheral regions rather than to the balanced development of regions within an overall polycentric development. There are clear examples of furthering national rather than EU interests, which appear in the context of attempting to meet European interests through promoting national interests. An obvious case here is that of airport development where several member states are promoting the development of the major European hub airports (London, Paris, Amsterdam, Frankfurt), although recent French policy discussion surrounds the relative role of rail and air in this development.

The more peripheral countries place particular emphasis on maintaining and developing links to the ultra-peripheral regions (e.g. Sweden, Ireland).

5.3.5 Environmental Priorities

It is clear that environmental issues have dominated discussions of transport policy for some time and most national policies relate to this. There is not always a balanced discussion of all the environmental impacts, and the emphasis varies between member states, some place more emphasis on noise, some on safety and accidents, some on greenhouse emissions, some on local air pollution and some on congestion. This seems to be affected by location (and arguably also by geographical structure). Thus more peripheral countries (Denmark, Ireland, Sweden) which are less affected by congestion (certainly the congestion caused by transit traffic) seem to place more emphasis on global environmental issues, as do some of the smaller member states – issues which they can typically only affect marginally, but where they have some need to influence the decisions of their bigger neighbours. In the Netherlands a gradual shift in emphasis can be observed in policy documents from global environmental themes towards local and regional ones.

There is still a strong belief across national policies that technical solutions to the pollution problem, emissions controls etc. will meet the needs rather than a comprehensive policy which effectively prices the different environmental consequences and allows users to make informed decisions.

5.3.6 Cohesion

National policy clearly addresses national cohesion issues and not EU cohesion issues. The primary concern relates to the accessibility problems of peripheral regions within countries and not the way that one country's policy can help to ameliorate the economic and social problems of other countries. This is problematic for EU cohesion policy because decisions relating to infrastructure in one member state may have a more substantial impact on the economy of another (not necessarily adjacent) member state and the mechanism by which this can be addressed is largely missing.

A good example of this is the Benelux-Ireland link, one of the original 14 projects in the Essen list of top TENs. This is vital to improving the accessibility of Ireland to the core of the EU, but involves virtually no conventional infrastructure in Ireland. The most needed developments of infrastructure are actually likely to be in the UK, but in regions of the UK which would not receive priority on their own. The problem for the policy (both at EU and member state level) is how to establish a mechanism which can recognise that there are benefits which would not normally be counted by the member state making the decisions. In theory transferring projects to the private sector could overcome some of the problem of a government being seen to make decisions which essentially benefit the residents of another country without being able to expropriate a fair return for that benefit. Some work for the European Commission as part of the TRENEN project[47] showed that there are incentives for regions to try and impose additional burdens on transit traffic in the hope of capturing rent from this traffic.

5.3.7 Competitiveness

For many EU countries' national policy competitiveness has been seen more as preserving the competitiveness of national transport operators than using transport as a means of enhancing either national or EU competitiveness of industry as a whole. Thus we find individual member states seeking to ensure that ports, airports, rail operators and, above all, airlines and road haulage companies can compete effectively in the European markets. In some cases this is set against the problems which individual member states' governments face with respect to their budgets; that reductions in public budgets threaten the drive to seek continuing increases in competitiveness.

5.3.8 Other Sectoral Policies, e.g. Agriculture, Energy, etc

The main link to other sectors is to research and development. Transport is seen as requiring continuing inputs of innovation to ensure continuing development. This is a two-edged concern. On the one hand, research and development is seen as a means of overcoming some of the negative problems of environmental impacts, on the other hand research is an essential means of ensuring the competitiveness of domestic transport vehicle producers (road and rail) in the integrating European market, and more especially in third country markets. These include the burgeoning markets of the accession countries as well as the need for new forms of transport in rapidly developing countries such as China. The competition between the main European train makers for potential high speed rail

[47] See De Borger, B. and S. Proost (ed.) (2001) *Reforming Transport Pricing in the European Union*, Cheltenham: Edward Elgar.

markets globally has been a major feature of the past few years. Here transport is essentially seen as an instrument of general industry policy, even for technicality which is not widely adopted domestically as in the case of the Transrapid.

The other main concern has been that of energy, particularly the energy dependency of transport in market which is facing potential energy shortages. This is not just a question of reducing dependence on oil for the internal combustion engine, but of energy generally to maintain the level of mobility which is expected.

5.3.9 Macroeconomic and Stability Policies

A number of countries make the link between transport and economic growth although it is not always fully developed, and there is a tendency to make it an act of faith. The way in which transport can achieve this is largely not considered and the assumption is typically that the link is through infrastructure development. Most member states have not revised their transport policies to take full cognisance of the problems imposed by the need to meet constraints set by the Stability and Growth Pact, although as we noted above in the context of competitiveness, member states do see the problems which may arise from difficulties over maintaining public expenditure to support individual modes.

5.3.10 Missing Links: International / National

Concerns at national level are much more to do with national missing links than international ones, except in the case of a number of the more peripheral member states, and the accession countries, where international links which are seen as most critical. Missing links are seen as part of the general problem of the accessibility of more peripheral regions. However, it is difficult to identify this as a major concern of policy, it is rather a justification for individual projects.

5.3.11 Regional and Urban Transport Policies

The extent to which member states incorporate a framework for lower levels of government varies between countries, and reflects to some extent the degree of decentralisation. A number of countries, France, Germany, UK, in different ways, have handed to regions or local authorities the responsibility for managing public service obligations in transport. To some extent this is consistent with ensuring that decisions are taken at the most appropriate level, but it is also a way of devolving budgetary and management responsibilities; this features strongly in recent French policy discussions. In some cases this devolution is coupled with the ability to generate and use revenues locally within the transport sector - in the UK for example local authorities are allowed to use the proceeds of road congestion charging for support to public transport.

There is a dimension to local transport which is not widely exploited and this is the redistributive effect envisaged in a number of EU documents such as citizens networks. Transport has a powerful tendency to be regressive in that many groups are excluded from mobility; policy should be more addressed at redressing this imbalance. The transport disadvantaged are not very highly visible in most national transport policies, one important exception is Sweden.

5.3.12 Other Issues

There were no issues which emerged as common across a number of countries. Individual countries highlighted specific issues of particular concern to them. For example, Ireland makes much of the problems occasioned by its peripherality and sees issues relating to the support of low cost carriers as a key to its policy. Other countries, which are more central in Europe such as France, are more interested in the promotion of intermodality, not just as a transport policy on efficiency grounds, but also because there is seen to be some advantage in that approach for the member state itself or for its national economy.

5.4 Conclusions and Recommendations on the Co-ordination of EU and National Policies

In this chapter we have set out some of the issues arising from the interactions between different EU policies and between EU transport and TENs policies and national policies. We have seen that in terms of both the horizontal interactions (between policy areas) and vertical interactions (between different levels of policy making) there are potential conflicts of both objective and impact. These conflicts arise because the way in which transport itself interacts with other sectors and the way in which transport policies, both infrastructure policies and pricing/regulation policies are poorly understood – or at least open to different interpretations. Thus transport as an agent of economic growth conflicts with transport as a destination of public funds. Transport as an agent of enhancing competitiveness conflicts with transport as an agent of improving accessibility and cohesion. Transport as a source of welfare through mobility conflicts with the need to control harmful effects on the environment.

Transport policy itself is however full of conflicts, not least the potential conflict between the use of infrastructure as a means of competing networks, improving accessibility and enhancing mobility with the need to regulate the use of networks to reduce congestion and make users generally more aware of the full resource costs of the transport they consume.

The results of the modelling analyses discussed in Chapter 4 have shown us that despite the expectations of transport policy documents, the impacts on GDP or welfare of significant infrastructure investments or of substantial changes in the structure of transport pricing are quite small. This is true at both national and regional level. However, although this is true on average, the impacts of individual projects can be significant and changes to pricing structures could have significant impacts especially in the longer term. Similarly, the relative impacts on spatial structure could also be more substantial if a longer-term and more dynamic view were taken. The modelling approach used here depends on incorporating policy scenarios as changes in accessibility costs. This assumes that all policy instruments can be interpreted as changes in such costs and that cost changes from any source have the same impact on transport interaction between any two regions. This has three implications for policy design: it assumes that the responses to cost changes are symmetrical (users respond the same way to cost reductions and to cost increases); that responses are smooth and monotonic (users respond proportionately to the change in costs, in practice small changes may lead to little or no change in behaviour whereas large changes may result in significant shifts and discontinuities in behaviour) and that changes in direct costs (e.g. kilometre related user charges) are perceived in the same way as changes in indirect costs (e.g. licence fees or fuel taxes) which are more difficult to relate to specific journeys.

At the level of the individual project it would be revealing to assess the extent to which different overall policy regimes, either towards transport or towards those policy areas which interact with transport, lead to significant differences in impact. The difficulty of reducing complex policy documents to simple parameters has precluded this in this research; attempts to identify any quantitatively significant links at an aggregate level have not been successful. However, there are some general indications of the way policy may be having an effect.

At the EU level, the 2001 *White Paper* is a good start on making transport policy more rational since it brings together both infrastructure and regulation/pricing ideas. But there is still a gap in implementation and it is not clear that the Report of the High Level Group on the TENs does sufficient to integrate the need for coherence across the whole policy area. Infrastructure policy is still too dominated by the concept of completing networks and responding to the special pleading of individual regions to be on a network. Courage is needed to ensure the adoption of a substantive regime which relates the prices faced by transport users to the real resource costs incurred by society.

With regard to the wider links of transport policy to other policy areas, there is a concern that issues of spatial development have been allowed to drive the transport policies implemented. Transport has been used very much as an agent of structural and spatial development policy without regard for its other consequences, or for the less positive implications for spatial development. This and the well-known interaction with environmental policy are two clear areas for greater integration. We have identified that transport does have clear linkages with the more general economic policies of the EU, relating to the internal market, economic reforms and stability and growth. We do not believe these are critical to the same extent nor that either the potential gains or threats are as large as the interactions with spatial development or environmental policy, but they could nevertheless be significant enough to encourage greater cooperation. This involves seeking a more definitive view on the benefits of transport to the efficiency of other sectors (the microeconomic links) and to overall and regional growth (the macroeconomic links). Similarly the risks occasioned by restrictive spending on transport also need closer definition.

However, it is the inconsistency in policy making by national, regional and local governments across the EU which is the source of the greatest potential set of problems. This arises in part because of the subsidiarity accorded to much of transport policy despite the treaty commitment to a common transport policy. However the lack of clarity in EU transport policy in the past has left a void which national policies have had to fill. The need for consistent pricing policy raises further problems since transport is a substantial source of tax revenues for most national governments. Any move to an efficient charging policy would imply a shift from more arbitrary tax based charges to resource based user charges. It is important that charges for environmental damage, the sue of congested roads etc are seen as economic prices for the use of resources and not taxes in the conventional sense, but there will be difficult issues to resolve in getting agreement on how revenues raised from such charges can be used and the appropriate level to reflect economic values and not fiscal needs.

Conflict also arises because of the problem in identifying the spatial distribution of both benefits and costs from any particular policy. Thus lower level governments may only be interested in schemes which appear to have local benefits within their jurisdiction because of their inability to capture the rent gained by other users. There is a surprising lack of reverence to wider EU interests except where such interests can be used to support a particular project, not least where there is potential funding aid either directly from the EU via e.g. structural of cohesion funds, or indirectly though EIB loans.

At the national level, transport has also been seen as an important sector for R&D, it acts as a very visible showcase for national industrial sectors. Although there has been a substantial change though the application of EU rules on procurement, which affects parts of the transport sector substantially, there is still the potential for substantial wasteful competition between national supply industries.

The existing distribution of competences on transport policy makes it difficult to see how some conflict can ever be avoided. Transport is such a visible sector that user and voter pressure will always be felt, and particularly at the most immediate (local) level. However, the complexity of conflicts does suggest that improving the clarity with which transport policy is communicated could have strongly beneficial effects. Within the scope of the 2001 White Paper it is important to continue prompting the debate and seeking agreement on both priorities and appropriate values (e.g. for environmental damage, statistical life etc.) for adoption across the EU. That involves getting agreement on the relative use of pricing/regulation policy and infrastructure policy, and in particular recognition that optimal investment requires prices much closer to their optimal efficient level than hitherto. However, the most important message is that a comprehensive transport policy cannot be adopted in parts; it is a package of interacting measures. It is particularly vital that EU transport policy is not seen to consist of a menu of measures from which lower level jurisdictions can pick and mix; it must be a coherent single policy.

6 Conclusions and Recommendations

The ESDP puts forward a series of spatial development objectives that any policy with a spatial impact should contribute to. One of the conclusions to be drawn from this study, however, is that the different objectives often are tending to be in conflict with one another, and that policy instruments well suited to pursue one of the objectives may run counter the other. It is therefore essential for politics to be aware of the so-called Tinbergen-principle stating that for a set of n objectives one usually needs no less than n instruments for achieving them. One cannot expect one single design of transportation policy to be optimized for contributing to competitiveness, efficiency and growth of the entire EU area, for environmental sustainability, social equity and a balanced spatial development at the same time.

If it is observed that a transportation policy option favours efficiency and growth but at the same time aggravates spatial imbalances, there are different political choices: (1) transportation policies could be revised in a way mitigating imbalances of spatial development, with a certain cost in terms of economic efficiency; (2) the transportation policy is left unchanged, but is accompanied by a suitable bundle of compensation measures devoted to reducing negative impacts on less favoured regions; (3) some compromise between these choices is pursued.

Even though conflicting goals and trade-offs exist in many cases, the empirical results also show that certain transportation infrastructure developments in the past or those planned for the future are desirable from different perspectives and in the light of more than one objective. The initiatives that induced these developments are good examples for policy measures to be recommended for the future.

The scenarios studied in this project as well as the analysis of policy interactions in chapter 5 point to the risk of conflict between three fundamental political goals:

(1) economic efficiency

(2) spatial equity, and

(3) environmental sustainability.

These goals give rise to three types of conflicts, one between economic efficiency and spatial equity, the second between spatial equity and environmental sustainability, and the third between economic efficiency and environmental sustainability.

We deal with the first two of these fields of potential conflict in turn in the context of transportation and ICT policy.

a) Efficiency versus equity

If infrastructure investments are planned without any spatial equity considerations there is a high risk of aggravating spatial imbalances, because standard cost benefit analysis assigns high profitability to projects generating intensive use. As these are predominantly concentrated in central and agglomerated regions, most beneficial projects are concentrated in these centres as well, if spatial considerations play little or no role in project evaluation.

Fortunately, even though this tendency of spatial imbalance is usually seen as one of the major risks in infrastructure policy, it turned out to be less virulent during the last decade than suggested. Simulations of the so-called A-scenarios, that is of the ex-post scenarios representing infrastructure development in Europe within the decade 1991 to 2001 reveal a spatial pattern of economic benefits which is more or less neutral with respect to objectives of a spatially balanced development. With the exception of rail projects in the accession countries, all results of the CGEurope model point to a slight decrease of the spatial inequality, above average effects in objective 1 regions, lagging regions and rural regions, and below average effects in the Pentagon. SASI estimates of accessibility effects go into the same direction, while GDP effects show a more mixed pattern. From this we conclude that a complete reorientation of infrastructure policy is, from a spatial development point of view, not required.

There are two caveats, however. The first is a methodological one: all measures quantifying the spatial pattern as referred to so far are relative measures. A region is said to gain more if it gains more in percentage terms. Still, a poor region gaining more in percentage terms than a rich one may nevertheless gain less than the rich one in per capita terms, because the higher percentage applies to a lower base. In absolute terms the above pattern of an increase in spatial equity is reversed. High income regions are facing higher gains than low income regions in per capita terms. Whether one focuses on absolute or relative measures is largely a matter of value judgement. Commonly preferred measures such as the Gini-coefficient or the Lorenz-curves look at relative measurement. If we accept this common practice, the above optimistic statement with regard to the spatial distribution impact of transportation infrastructure development applies.

The second caveat is that infrastructure projects of the analysed decade may have been non problematic with regard to spatial impact just by coincidence. It may be that the nineties saw a completion of the networks in peripheral areas, while an infrastructure policy neglecting the spatial dimension runs the risk of re-concentrating on the highly congested central regions that are threatened by a collapse of traffic due to capacity restraints and missing pricing mechanisms for adjusting demand to limited capacity. This risk can in fact not be denied. It is therefore proposed to monitor systematically the spatial distribution of benefits generated by newly installed infrastructure capacity. The best way to do so is to launch a standard framework for obligatory cost benefit analysis that includes an estimate of the spatial distribution of all predicted net benefits of a project.

As a case in point, this study reports estimates of the spatial impact of the current TEN and TINA projects of transport infrastructure investments. It turns out, that by and large these investment plans are also in favour of a balanced spatial development in Europe, with one important exception: Some indicators point to spatial inequality within accession countries enhanced by the TEN and TINA projects. Though the picture is somewhat mixed, there is at least a risk that in these countries, where spatial inequality problems will be most pronounced during the decades to come, infrastructure development reinforces rather than mitigates a tendency of polarised economic development. The projects within accession countries contribute to growth in these countries as a whole, thus favouring a more balanced development in the entire European area by speeding up the catching-up process of accession countries. At the same time, however, these projects tend to improve accessibility in the agglomerations with relatively high income more than in the periphery within the accession countries. This risk is a typical case in point for a conflict between competing goals. There is a consensus in recent regional growth literature that catching up of lagging countries in Europe is inevitably polarised within these countries to a certain degree. In order to compete with higher developed European centres, these countries have to exploit economies of agglomeration, such that a movement towards cohesion on the European scale encounters a loss of cohesion on the national and local scale.

In our opinion, this should not be taken as a reason to revise TEN and TINA plans such that centres are favoured less. Instead, it is regarded as vital to equip these countries with financial means to develop their secondary networks in a way allowing their peripheries to gain from the spread effects of more rapid growth in the centres. As the spatial impact of investments in the secondary networks is national or local in scope, the decision should also be assigned to the national and local level. It has to be clearly understood, that these types of investments, though less visible on a European scale, are nevertheless an indispensable complement of TEN and TINA investment activities.

The efficiency-equity trade-off turns out to be more pronounced in ICT policy than in transportation policy. With the STIMA model and our forecasting methodology, we estimated GDP growth and its spatial distribution in alternative policy scenarios, and calculated costs in terms of loss of efficiency and reduced cohesion; a cohesion scenario has a rather large impact in terms of loss of potential GDP growth rate, decreasing per capita GDP growth rate from 0.037 to 0.023. By the same token, an efficiency scenario registers, on its turns, a worsening of the present level of regional disparities.

In front of this clear trade-off, the tendency could be to choose an indiscriminate policy option; as it is also witnessed by our results, this policy presents limited costs in terms of both reduced efficiency and cohesion. Our impression, however, is that this choice would not be the most appropriate one, since it would limit not only costs but also advantages in terms of both efficiency and cohesion.

A more appropriate way to deal with the trade-off would be to put attention to the different ICTs policy actions, and act on the most appropriate according to regional needs. We recall here the long lasting debate on the fact that ICTs policies should be tailored upon each adopter's needs, avoiding indiscriminate policies and reinforcing specific needs and requirements of each local area.

Even regions similar from the economic point of view, like lagging or advanced regions, should not be treated as single homogenous entities, when ICTs policies are concerned; their capacity to grasp economic advantages stemming from ICTs policies is extremely different since it depends on the degree of network endowment and on the capacity to exploit these technologies, unevenly distributed even in local economic systems similar in terms of economic development.

ICTs policies are far from being only a decision on the spatial distribution of financial resources. A call for tailored policy actions is our main concern: policies which should avoid the discrimination between "imitative regions" and "advanced technological regions", and support instead the development of "adaptive regions", in which ICTs adoption reflects industrial vocations of the local area.

b) Spatial equity versus environmental sustainability

The risk of conflicting goals regarding a balanced polycentric pattern of economic development on the one hand and protecting the environment on the other comes to the fore in our simulation results for the so-called C-scenarios. There is a wide consensus in science and increasingly also in the political domain that pricing instruments are the most attractive means of managing negative environmental externalities generated by transport.

As all modes damage the environment, pricing policies shall not only shift the modal split in favour of modes that are relatively less damaging, but they also shall restrict the overall level of transport. This inevitably implies increased private transportation cost. But this in turn is unfavourable for lagging regions, rural regions and peripheral regions. SMCP for all modes aggravates accessibility discrepancies according to all indicators (except the AC-indicator focusing on absolute changes) in the SASI results. The same is true with respect to the welfare effects estimated by the CGEurope model.

Again, caveats have to be kept in mind. First, some GDP estimators of the SASI model do not point in the same direction: SMCP for all modes seems to be in favour of cohesion, judged upon GDP effects estimated by the SASI model. Second, as before, the conclusion hinges upon the distribution indicators to be based on relative rather than absolute effects. In terms of absolute per capita effects, losses are smallest in the lagging regions rather than highest. Third, the variation of effects by type of regions is by no means dramatic. Forth, a draw-back of our results is that congestion fees varying by the level of congestion are not accounted for. Neglect of these fees biases the results towards too small cost increases in highly agglomerated regions, that is towards an overestimation of an anti-cohesion tendency.

The political conclusion is that pricing measures should be accompanied by compensating transfers to those regions that would definitely suffer from losses. Externality pricing initiatives should be accompanied by more detailed spatial incidence studies in order to identify potential losers. We strictly advise against abandoning pricing instruments because of potentially undesired spatial side effects. An instrument mix of pricing plus compensation is the right way to protect the environment and to avoid undesired spatial imbalances.

An attractive feature of an ICT policy scenario such as our cohesion scenario is that it runs little or no risk of generating undesired environmental side effects. Hence, support of ICT resources and use in lagging regions is strongly recommended as an instrument to foster balanced growth in Europe.

Beyond the trade offs discussed so far, it also turns out that the objective of a balanced spatial development in itself bears conflicting goals. The ESDP regards cohesion and polycentricity as largely harmonising with one another. Unfortunately, the evaluation of transport policy scenarios in Chapter 4.2.1 shows that polycentricity on the EU level and national level may be conflicting. The TEN priority projects for example enhance polycentricity on the EU level but clearly do the opposite an the national level. What is even more surprising is that there are many cases where a policy scenario enhances spatial equality according to a measure of relative equality/inequality such as the Gini-coefficient, but at the same time reduces polycentricity either on the national or EU level, or even on both levels. For example, most of the B-scenarios representing infrastructure development in the decades to come, are in favour of relative spatial equality for the whole ESPON space as well as for the EU15, but at the same time run counter the objective of national polycentricity for both groups of countries. It is therefore recommended that the Commission translates the vague concepts of cohesion, balanced development and polycentricity to more operational indicators. It will then be possible to set clear priorities within the political process and to evlauate policies on the background of these priorities.

A final trade off that policy makers have to be aware of is that between centrtal co-ordination required for pushing transport policy towards more spatial equity on the one hand and the principle of subsidiarity on the other. It has been stressed that there is a clear risk of spatial imbalances within accession countries to be aggravated by a transport policy mainly focusing on transeuropean links. Largely negative impacts of infrastructure scenarios on national polycentricity clearly point in this direction. This makes it necessary to develop the secondary networks within the respective countries. Though this is an indispensible complement of TEN policies, the responsibility for this policy is on th national and local level rether than the EU level. A shift of responsibilities to higher decision levels is not recommended, however. We rather opt for a better communication between local, national and European levels in order to develop the complementary networks.

Similar conflicting goals between central co-ordination and subsidiarity exist in the domain of environmental policy as well as pricing and regulation policy. Again, awareness of conflicts that have been analysed in Chapter 5 rather than a shift of responsibilities is the way to go in this respect.

7 Future Research

The work of ESPON 2.1.1 has shown that meaningful forecasts of the impacts of European transport and ICT policies can be made.

The models and analytical techniques used have produced plausible and policy-relevant results. From a methodological point of view, the models and techniques have proved to be sufficiently sensitive to policy input at different spatial scales and degrees of temporal resolution but at the same time sufficiently robust in the face of serious but unavoidable deficiencies of and gaps in the available data. The results presented have been sufficiently comparable to allow for cross-validation between models and analytical techniques.

Nevertheless there remain questions that could not be answered during this project and which require further research.

7.1 Research questions

At first a number of substantive research questions to which no final answers could be given in the project but which need to be addressed in future work are listed:

- *Socio-economic impacts*. Can we identify a stable impact of transport and ICT policies on GDP and economic welfare? Are there network effects, i.e. is the impact of large policy programmes greater than the sum of the impacts of the development of individual links? Are GDP per capita or GDP based indicators such as equivalent variation sufficient as measures of regional well-being, or should more meaningful indicators of quality of life be included in the analysis?
- *Cohesion*. How do we measure the contribution of transport and ICT policies to cohesion? How can the theoretical questions of relative and absolute convergence, appropriate indicators and conflicts between efficiency and cohesion goals encountered in the project be resolved?
- *Polycentricity*. How do we measure the contribution of transport and ICT policies to polycentricity? What is the trade-off between scale economies of concentration and lower transport costs encouraging dispersion? Do lower transport costs always encourage dispersion, is there an optimum level of transport or transport intensity in the economy? At what spatial level should polycentricity be assessed, and how can the conflicts between polycentricity at different levels be resolved?
- *Pricing*. How have results on pricing policies to be modified, if redistribution of revenues is taken account of?

- *Governance*. What is the appropriate institutional structure to ensure the efficient delivery of transport and ICT policy consistent with the needs of EU spatial policy? How much government at which level? How can policy be communicated between different levels of decision making?

7.2 Research needs

The need to answer these four substantive research questions leads to three broad areas of research: improving modelling, introducing policy into models and designing optimal institutional arrangements for policy.

Improving modelling

The strategy of using different regional economic models in parallel in one project has proved to be a great advantage for cross-validating the results and give them so more credibility.

The three forecasting models applied in ESPON 2.1.1 represent different strands of contemporary thinking in region economic modelling. Whereas CGEurope is an example of a state-of-the art spatial computable general equilibrium (SCGE) model, SASI and STIMA emphasise dynamics at the cost of economic closure in the form of market clearing. All three models incorporate ideas of the New Economic Geography which focus on the interplay between (growing) economies of scale and (decreasing) transport cost under conditions of incomplete market competition.

Nevertheless there are directions into which each type of model could be further developed to become more policy-sensitive and policy-relevant:

- SASI. The efforts to include suitable variables representing the size and diversity of regional labour markets into the production function of the SASI model will be continued. In future versions of the model, regional sectoral labour productivity will be endogenously forecast as a function of accessibility and other variables instead of using exogenous productivity forecasts. Work is underway to forecast migration flows as a function of regional employment and/or unemployment and other indicators expressing the attractiveness of the region as a place of employment and a place to live instead of the present net migration. With the migration flows, the interaction between the population, migration, labour force and unemployment submodels will be reviewed and re-calibrated. Further model extensions include regional tax competition and the effects of national migration constraints.

- CGEurope. One important extension is to include further market imperfections into the modelling framework, in particular regarding the labour market and possibly also the land market. Another extension is to take account of revenues from pricing policies and different redistribution schemes.

An important issue for future model development is in how far the three models used in ESPON 2.1.1 can, or should, be integrated. Integration between the SASI and STIMA models would be straightforward because of their very similar theoretical structure; in fact such integration has already been discussed. A more complex issue is the integration between dynamic models, such as SASI or STIMA, and equilibrium models, such as CGEurope – the challenge would be to find out which processes in the real world are nearer to equilibrium and which are far from it.

Other issues on the modelling research agenda include issues, such as the trade-off between complexity, performance and ease of use, how far models need to be specific or generic, problems of aggregation and spatial and temporal detail and how to deal with network economies and the already mentioned problems of identifying appropriate cohesion and polycentricity indicators. Last, but not least, the deficiencies of NUTS-3 data urgently need to be resolved: there is still much to be done with respect to the stability of data definitions of time and the harmonisation of data collected in different countries, in particular in the new member states and future accession countries.

Introducing policy into models

The three forecasting models used in ESPON 2.1.1 have in common that they translate all policy input into transport cost changes, for instance by using exogenously established values of time. This implies that all types of policy can be interpreted as cost changes.

However, it is not clear what cost changes are to expect from social marginal cost pricing and liberalisation of transport markets and how these can be entered into the models. Moreover, similar policy changes could have different effects in different national contexts depending on their starting point and the size of the change. The assumption that all users treat changes in cost/price, e.g. changes in fuel tax and directly charged road tolls equally and symmetrically needs to be empirically examined. It is well known that elasticities are not symmetric: users respond differently to price increases and price reductions, and this may lead to different responses of spatial activity patterns, locations etc.

Designing optimal institutional arrangements for policy

The work of ESPON 2.1.1 has frequently pointed to potential conflicts between different EU policy areas. Lack of consistency in policy objectives and instruments between different sectors and levels of policy making leads to conflicts in the implementation of EU transport and ICT policies.

If it is assumed that there will be no changes in the institutional arrangements concerning the delivery of transport and ICT policy, i.e. that the Common Transport Policy and common ICT policy will be formulated at the EU level but its delivery will remain mainly through national and regional governments under the principle of subsidiarity, it becomes necessary not only to forecast but also evaluate the likely impacts of transport and ICT policies.

For this the development of unambiguous indicators becomes paramount. Such indicators need to be capable of assessing the extent to which national and regional policies conform to agreed EU policy goals and through which national and regional policies can be designed to ensure a greater degree of horizontal consistency between policy fields and between countries and regions across the EU territory.

Annex

8 Annex

8.1 List of Figures, Maps and Tables

List of Figures

List of Maps

List of Tables

8.2 List of Indicators Developed and Datasets Provided to the ESPON Database

Table 8.1. Impact Indicators of the SASI Model

	Source
Impact of 13 transport policy scenarios on GDP	model results
Accessibility rail/road , travel, by policy scenario	model results
Accessibility rail/road/air, travel, by policy scenario	model results
Accessibility road, freight, by policy scenario	model results
Accessibility rail/road, freight, by policy scenario	model results

Table 8.2. Impact Indicators of the CGEurope Model

	Source
Impact of transport policy scenarios on equivalent variation of income, all 13 scenarios	model results

Table 8.3. Impact Indicators of the STIMA Model

	Source
Accessibility 1999 (weighted by population)	Calculation
Internet connections 1999 (% of households)	EOS Gallup 1999
Fixed telephony penetration 1999 (% of households)	EOS Gallup 1999
Cable and satellite TV 1999 (% of households)	EOS Gallup 1999
Total employment 1999 (% of population)	Eurostat Regio
Employment in High Technology Sectors - mean 1995-2000 (% of population)	Calculation on Eurostat Regio data
Per capita GDP 1999	Eurostat Regio
Accessibility absolute growth at 2020 in the three scenarios	Modelling result
Internet absolute growth at 2020 in the three scenarios	Modelling result
Pc GDP average growth rate at 2020 in the three scenarios	Modelling result
Pc GDP average growth rate in the three scenarios - differences from the EU mean at 2020	Modelling result

8.3 List of Abbreviations

Table 8.4. List of Abbreviations

AC12	12 Accession Country
ESDP	European Spatial Development Perspective

ESPON	European Spatial Planning Observation Network
EU-15	Present 15 EU Member States
EU-27	Present 15 EU Member States+12 Accession Countries
EV	Equivalent Variation
GDP	Gross Domestic Product
ICT	Information and Communication Technology
MEGA	Metropolitan European Growth Areas
TEN	Trans-European Networks
TIA	Territorial Impact Assessment
TINA	Transport Infrastructure Needs Assessment
TPG	Transnational Project Group

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Denmark

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Germany

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Spain

- Plan Nacional de Salvamento 2002-2005 12/07/2002 www.mfom.es
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France

- Loi d'orientation sur les transports interieurs n.82-1153 30/12/1982 www.legifrance.fr
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Greece

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8.7 Estimation results of the causality analysis

The explanatory variable is the change in GDP over the period 1981-1996. All variables are in log-transformations.

Table 8.5. Basic specification

	OLS		IV		HET		IV/HET	
	est.	s.e.	est.	s.e.	est.	s.e.	est.	s.e.
?acc	0.061	0.006	0.052	0.006	0.058	0.006	0.053	0.006
?pdens	0.014	0.003	0.014	0.003	0.022	0.003	0.022	0.003
?eduhi	0.050	0.007	0.037	0.008	0.083	0.009	0.078	0.009
?edulo	-0.016	0.006	-0.018	0.006	-0.019	0.008	-0.025	0.008
acc (lagged)	0.987	0.093	0.987	0.100	1.219	0.096	1.287	0.103
eduhi (lagged)	0.163	0.034	0.126	0.035	0.187	0.036	0.164	0.037
edulo (lagged)	0.196	0.087	0.068	0.090	0.174	0.098	0.098	0.102
GDP (lagged)	-0.015	0.006	0.003	0.007	-0.040	0.007	-0.029	0.009

Table 8.6. With time trend

	OLS		IV		HET		IV/HET	
	est.	s.e.	est.	s.e.	est.	s.e.	est.	s.e.
constant	0.825	0.077	0.761	0.079	0.861	0.075	0.783	0.076
?acc	0.000	0.008	-0.005	0.008	0.003	0.007	0.000	0.008
?pdens	0.021	0.003	0.019	0.003	0.026	0.003	0.025	0.003
?eduhi	0.057	0.007	0.042	0.008	0.095	0.008	0.085	0.009
?edulo	-0.047	0.007	-0.047	0.007	-0.050	0.008	-0.054	0.008
acc (lagged)	0.427	0.103	0.422	0.113	0.527	0.109	0.575	0.12
eduhi (lagged)	0.191	0.033	0.154	0.034	0.219	0.035	0.195	0.035
edulo (lagged)	0.374	0.085	0.226	0.088	0.436	0.096	0.294	0.099
GDP (lagged)	-0.015	0.006	0.004	0.007	-0.049	0.007	-0.031	0.009

Table 8.7. With country specific time trends

	OLS		IV		HET		IV/HET	
	est.	s.e.	est.	s.e.	est.	s.e.	est.	s.e.
?acc	-0.072	0.014	-0.068	0.019	-0.132	0.013	-0.131	0.016
?pdens	0.040	0.003	0.045	0.003	0.048	0.003	0.053	0.003
?eduhi	0.072	0.012	0.092	0.018	0.100	0.012	0.124	0.016

?edulo	0.004	0.013	0.038	0.023	-0.003	0.014	0.054	0.024
acc (lagged)	-0.354	0.212	1.075	0.528	-0.307	0.230	0.189	0.488
eduhi (lagged)	0.389	0.094	0.527	0.117	0.655	0.071	0.868	0.099
edulo (lagged)	0.112	0.136	0.37	0.233	0.349	0.118	0.883	0.221
GDP (lagged)	-0.098	0.010	-0.151	0.033	-0.123	0.010	-0.208	0.032
Austria	1.758	0.120	1.437	0.171	2.232	0.117	2.280	0.163
Belgium	1.794	0.112	1.527	0.155	2.274	0.111	2.346	0.148
Bulgaria	1.648	0.104	1.438	0.136	2.084	0.101	2.149	0.128
Switzerland	1.742	0.113	1.487	0.152	2.187	0.110	2.271	0.145
Cyprus	1.613	0.121	1.382	0.150	1.959	0.185	2.035	0.207
Czech Republic	1.598	0.115	1.374	0.150	2.089	0.116	2.132	0.143
Germany	1.769	0.108	1.597	0.133	2.295	0.108	2.436	0.133
Denmark	1.777	0.114	1.491	0.158	2.209	0.114	2.289	0.155
Estonia	1.566	0.106	1.393	0.141	1.963	0.100	1.951	0.121
Spain	1.665	0.117	1.337	0.171	2.064	0.108	2.070	0.154
Finland	1.780	0.101	1.492	0.148	2.188	0.103	2.259	0.145
France	1.848	0.110	1.593	0.151	2.337	0.109	2.401	0.143
Greece	1.562	0.104	1.271	0.152	1.966	0.103	2.004	0.145
Hungary	1.632	0.113	1.375	0.158	2.086	0.109	2.081	0.143
Ireland	1.604	0.115	1.323	0.156	1.978	0.114	2.025	0.152
Italy	1.771	0.114	1.554	0.145	2.207	0.108	2.284	0.137
Lithuania	1.444	0.109	1.166	0.164	1.831	0.103	1.773	0.143
Luxembourg	1.887	0.138	1.624	0.175	2.377	0.167	2.469	0.196
Latvia	1.536	0.111	1.277	0.165	1.921	0.113	1.841	0.149
Malta	1.044	0.118	0.719	0.169	1.408	0.113	1.415	0.158
Netherlands	1.773	0.111	1.501	0.156	2.237	0.110	2.291	0.147
Norway	1.705	0.103	1.437	0.145	2.100	0.104	2.205	0.145
Poland	1.522	0.113	1.293	0.151	1.994	0.108	2.012	0.137
Portugal	1.747	0.111	1.383	0.175	2.208	0.110	2.180	0.164
Romania	1.415	0.110	1.157	0.162	1.839	0.103	1.774	0.140

Sweden	1.851	0.107	1.532	0.160	2.290	0.111	2.368	0.160
Slovenia	1.611	0.116	1.267	0.176	2.109	0.114	2.127	0.162
Slovakia	1.541	0.116	1.310	0.153	2.026	0.121	2.055	0.148
United Kingdom	1.653	0.103	1.457	0.133	2.099	0.099	2.189	0.125

8.8 Scenarios results of the SASI and CGEurope model

This Annex contains tables with detailed results of scenario simulations which could not be accommodated in the main text.

Section 1 contains four tables with results from the SASI model as percentage differences between the policy scenarios and the Reference Scenario in 2001 or 2021, respectively:

- Table 8.8: Accessibility (unstandardised)

- Table 8.9: Accessibility (EU27+2=100)

- Table 8.10: GDP per capita (unstandardised)

-Table 8.11: GDP per capita (EU27+2=100)

Section 2 contains 2 tables with the results of the CGEurope model as percentage differences to the reference situation by country.

- Table 8.12: Change of equivalent variation scenario A1-B4

- Table 8.13: Change of equivalent variation scenario B5-D2

Table 8.8. SASI model: accessibility rail / road / air, travel, difference to Reference Scenario (%)

Country	Scenarios											
	2001			2021								
	A1	A2	A3	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2
AT	+2.57	+1.63	+4.05	+8.33	+15.87	+12.50	+6.06	+4.25	+1.56	–2.02	–5.02	+2.84	+10.18
BE	+3.15	+1.26	+4.24	+6.76	+10.34	+9.08	+2.66	+1.13	+2.32	–1.54	–4.97	+1.34	+4.79
BG	+2.24	+2.50	+4.50	+4.13	+16.38	+8.92	+7.23	+3.02	+0.52	–1.04	–4.58	–0.50	+11.84
CH	+2.90	+1.41	+4.16	+6.67	+12.72	+11.09	+3.28	+1.32	+2.19	–1.68	–5.48	+0.82	+6.73
CY	+0.05	0.00	+0.05	+0.12	+1.65	+1.52	+0.03	+1.20	+0.05	–0.88	–17.57	–17.42	–15.62
CZ	+3.05	+2.16	+5.01	+7.47	+19.20	+14.26	+6.47	+8.24	+1.18	–1.67	–4.03	+3.15	+14.58
DE	+2.55	+1.38	+3.78	+5.40	+10.97	+9.48	+2.58	+2.75	+1.77	–1.85	–4.98	0.00	+5.42
DK	+3.59	+5.09	+8.08	+8.48	+16.24	+14.96	+1.62	+1.82	+2.11	–2.35	–7.72	+0.47	+7.85
EE	+4.13	+0.83	+4.77	+9.84	+14.67	+11.28	+7.21	+6.43	+0.97	–0.94	–5.08	+4.67	+9.46
ES	+3.05	+1.90	+4.74	+19.90	+26.60	+25.99	+8.20	+6.32	+2.37	–1.51	–8.46	+10.46	+16.81
FI	+3.92	+0.52	+4.37	+11.48	+17.47	+14.32	+5.02	+4.20	+1.64	–0.79	–8.92	+2.62	+8.54
FR	+3.92	+1.70	+5.39	+8.05	+13.09	+12.35	+2.90	+1.28	+2.78	–1.95	–6.01	+1.43	+6.25
GR	+2.06	+1.52	+3.50	+4.63	+16.18	+11.37	+4.17	+8.02	+0.67	–1.09	–8.83	–4.17	+7.54
HU	+2.97	+3.23	+5.89	+6.53	+18.08	+12.86	+7.04	+8.36	+1.24	–1.61	–4.50	+1.65	+12.98
IE	+0.40	+0.61	+0.99	+3.31	+3.85	+3.76	+0.11	+0.14	+1.22	–1.18	–11.09	–8.06	–7.56
IT	+4.21	+1.11	+5.14	+11.95	+18.09	+16.46	+5.22	+2.38	+2.42	–1.67	–6.18	+5.13	+11.08
LT	+5.54	+1.60	+6.90	+11.74	+20.27	+15.13	+10.03	+10.88	+1.51	–1.02	–3.60	+7.64	+15.85
LU	+1.62	+2.05	+3.58	+6.05	+9.54	+8.09	+1.66	+1.33	+1.85	–2.04	–4.88	+0.76	+4.15
LV	+5.41	+1.56	+6.70	+11.78	+18.61	+14.10	+9.52	+9.78	+1.41	–1.04	–4.09	+7.32	+13.92
MT	+1.02	+0.01	+1.02	+6.56	+10.63	+10.04	+0.56	+0.88	+0.78	–0.85	–12.93	–6.29	–2.25
NL	+3.24	+1.20	+4.26	+6.41	+10.81	+9.52	+2.92	+1.43	+2.36	–1.49	–5.15	+0.85	+5.11
NO	+2.38	+1.13	+3.38	+5.44	+11.30	+9.89	+0.98	+0.49	+2.00	–0.95	–12.14	–6.81	–1.13
PL	+5.19	+1.25	+6.20	+8.53	+20.49	+16.04	+6.73	+10.74	+1.60	–1.12	–3.61	+4.57	+16.22
PT	+1.42	+5.32	+6.39	+23.14	+27.55	+25.35	+4.45	+11.88	+0.79	–1.83	–8.90	13.51	+17.69
RO	+2.98	+1.32	+4.12	+5.71	+21.19	+12.92	+8.16	+4.94	+1.00	–1.06	–4.07	+1.47	+16.72
SE	+4.16	+5.27	+8.67	+13.17	+18.26	+16.98	+1.59	+1.38	+2.61	–1.65	–10.29	+2.61	+7.40
SI	+4.28	+2.74	+6.66	+11.27	+20.95	+16.27	+7.29	+6.51	+1.86	–1.83	–4.83	+5.84	+15.1
SK	+3.24	+1.88	+4.90	+7.95	+20.07	+15.59	+8.60	+10.27	+1.23	–1.58	–4.01	+3.54	+15.43
UK	+1.91	+0.68	+2.53	+5.37	+7.09	+6.92	+0.68	+0.15	+2.07	–1.16	–6.97	–2.02	–0.38
EU15	+3.03	+1.42	+4.29	+8.04	+13.04	+11.84	+3.15	+2.23	+2.17	–1.68	–6.02	+1.51	+6.33
CH+NO	+2.84	+1.38	+4.06	+6.51	+12.55	+10.95	+2.99	+1.22	+2.17	–1.58	–6.32	–0.14	+5.75
AC12	+3.98	+1.76	+5.50	+7.62	+19.75	+14.34	+7.25	+8.53	+1.31	–1.27	–4.00	+3.31	+15.18
EU27+2	+3.19	+1.48	+4.49	+7.93	+14.18	+12.25	+3.85	+3.29	+2.02	–1.61	–5.68	+1.78	+7.84

Table 8.9. SASI model: accessibility rail / road / air, travel (EU27+2=100), difference to Reference Scenario (%)

Country	Scenarios												
	2001			2021									
	A1	A2	A3	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2
AT	–0.61	+0.14	–0.42	+0.37	+1.48	+0.22	+2.12	+0.93	–0.45	–0.42	+0.70	+1.04	+2.17
BE	–0.04	–0.22	–0.24	–1.08	–3.37	–2.82	–1.14	–2.09	+0.29	+0.07	+0.76	–0.43	–2.83
BG	–0.92	+1.01	+0.01	–3.52	+1.93	–2.96	+3.25	–0.26	–1.47	+0.58	+1.17	–2.24	+3.70
CH	–0.28	–0.07	–0.32	–1.17	–1.28	–1.03	–0.55	–1.91	+0.17	–0.07	+0.21	–0.94	–1.03
CY	–3.04	–1.46	–4.25	–7.23	–10.98	–9.55	–3.68	–2.02	–1.93	+0.74	–12.61	–18.86	–21.76
CZ	–0.13	+0.67	+0.49	–0.43	+4.40	+1.80	+2.52	+4.79	–0.82	–0.06	+1.75	+1.35	+6.24
DE	–0.63	–0.10	–0.68	–2.34	–2.81	–2.47	–1.23	–0.52	–0.25	–0.24	+0.74	–1.74	–2.25
DK	+0.38	+3.55	+3.43	+0.52	+1.81	+2.41	–2.15	–1.43	+0.09	–0.75	–2.16	–1.29	0.00
EE	+0.91	–0.64	+0.27	+1.77	+0.43	–0.86	+3.23	+3.04	–1.03	+0.68	+0.64	+2.84	+1.50
ES	–0.14	+0.41	+0.24	+11.09	10.88	+12.25	+4.18	+2.93	+0.34	+0.10	–2.95	+8.53	+8.32
FI	+0.70	–0.94	–0.12	+3.29	+2.88	+1.85	+1.13	+0.88	–0.37	+0.84	–3.43	+0.83	+0.65
FR	+0.71	+0.21	+0.86	+0.11	–0.95	+0.09	–0.91	–1.94	+0.75	–0.35	–0.35	–0.34	–1.47
GR	–1.09	+0.04	–0.95	–3.05	+1.75	–0.78	+0.31	+4.57	–1.32	+0.53	–3.33	–5.84	–0.29
HU	–0.22	+1.72	+1.34	–1.29	+3.41	+0.55	+3.07	+4.91	–0.76	0.00	+1.25	–0.12	+4.77
IE	–2.71	–0.86	–3.36	–4.28	–9.05	–7.56	–3.60	–3.05	–0.78	+0.43	–5.73	–9.67	–14.28
IT	+0.98	–0.36	+0.62	+3.73	+3.43	+3.75	+1.32	–0.88	+0.40	–0.06	–0.53	+3.30	+3.00
LT	+2.27	+0.12	+2.30	+3.54	+5.33	+2.57	+5.95	+7.35	–0.50	+0.60	+2.20	+5.76	+7.42
LU	–1.52	+0.56	–0.88	–1.74	–4.07	–3.70	–2.11	–1.90	–0.17	–0.44	+0.85	–1.00	–3.43
LV	+2.15	+0.08	+2.11	+3.57	+3.87	+1.65	+5.46	+6.28	–0.60	+0.58	+1.68	+5.44	+5.64
MT	–2.11	–1.45	–3.32	–1.27	–3.11	–1.96	–3.17	–2.33	–1.22	+0.77	–7.68	–7.92	–9.36
NL	+0.04	–0.28	–0.22	–1.41	–2.95	–2.43	–0.90	–1.80	+0.34	+0.12	+0.57	–0.91	–2.53
NO	–0.79	–0.34	–1.07	–2.31	–2.53	–2.10	–2.77	–2.71	–0.02	+0.67	–6.85	–8.44	–8.32
PL	+1.94	–0.23	+1.63	+0.56	+5.53	+3.38	+2.77	+7.22	–0.41	+0.50	+2.20	+2.75	+7.76
PT	–1.72	3.79	+1.82	14.1	+11.71	+11.67	+0.57	+8.32	–1.21	–0.22	–3.41	+11.52	+9.13
RO	–0.20	–0.16	–0.36	–2.05	+6.14	+0.60	+4.15	+1.60	–1.00	+0.56	+1.71	–0.30	+8.23
SE	+0.94	+3.73	+4.00	+4.86	+3.57	+4.22	–2.18	–1.85	+0.58	–0.04	–4.88	+0.82	–0.41
SI	+1.05	+1.24	+2.08	+3.10	+5.93	+3.58	+3.31	+3.11	–0.16	–0.23	+0.91	+3.99	+6.73
SK	+0.04	+0.39	+0.39	+0.02	+5.16	+2.98	+4.57	+6.76	–0.78	+0.03	+1.77	+1.73	+7.03
UK	–1.24	–0.79	–1.88	–2.37	–6.21	–4.75	–3.05	–3.04	+0.05	+0.46	–1.36	–3.73	–7.62
EU15	–0.16	–0.06	–0.20	+0.10	–1.00	–0.36	–0.68	–1.03	+0.15	–0.08	–0.36	–0.26	–1.40
CH+NO	–0.35	–0.10	–0.41	–1.31	–1.43	–1.16	–0.83	–2.01	+0.14	+0.03	–0.68	–1.88	–1.94
AC12	+0.76	+0.27	+0.96	–0.29	+4.88	+1.86	+3.27	+5.07	–0.70	+0.35	+1.78	+1.50	+6.81
EU27+2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8.10. SASI model: GDP per capita, difference to Reference Scenario (%)

Country	Scenarios												
	2001			2021									
	A1	A2	A3	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2
AT	+0.36	+0.21	+0.55	+1.48	+2.73	+2.17	+1.06	+0.71	+0.35	–0.46	–1.08	+0.36	+1.62
BE	+0.46	+0.19	+0.63	+1.43	+2.16	+1.91	+0.57	+0.24	+0.55	–0.39	–1.19	+0.18	+0.91
BG	+0.29	+0.30	+0.56	+0.77	+3.09	+1.72	+1.38	+0.58	+0.15	–0.33	–1.11	–0.33	+2.03
CH	+0.40	+0.21	+0.59	+1.37	+2.58	+2.25	+0.69	+0.27	+0.52	–0.44	–1.32	+0.02	+1.23
CY	+0.10	0.00	+0.10	+0.17	+0.77	+0.71	+0.10	+0.47	+0.15	–0.19	–3.73	–3.55	–2.83
CZ	+0.38	+0.22	+0.59	+1.24	+3.18	+2.39	+1.09	+1.30	+0.28	–0.42	–0.93	+0.30	+2.24
DE	+0.40	+0.20	+0.58	+1.23	+2.35	+2.04	+0.58	+0.55	+0.45	–0.47	–1.26	–0.08	+1.03
DK	+0.58	+0.63	+1.13	+1.73	+3.18	+2.94	+0.34	+0.36	+0.51	–0.56	–1.82	–0.08	+1.35
EE	+0.53	+0.09	+0.61	+1.54	+2.31	+1.79	+1.05	+0.96	+0.22	–0.30	–1.18	+0.40	+1.18
ES	+0.39	+0.19	+0.56	+2.79	+3.67	+3.59	+1.18	+0.91	+0.44	–0.33	–1.44	+1.36	+2.24
FI	+0.64	+0.10	+0.72	+2.19	+3.31	+2.75	+0.95	+0.80	+0.45	–0.25	–2.05	+0.21	+1.35
FR	+0.59	+0.25	+0.80	+1.75	+2.81	+2.66	+0.64	+0.28	+0.68	–0.49	–1.51	+0.16	+1.20
GR	+0.25	+0.17	+0.41	+0.88	+2.99	+2.22	+0.69	+1.55	+0.18	–0.31	–2.10	–1.19	+1.02
HU	+0.40	+0.37	+0.74	+1.26	+3.28	+2.37	+1.29	+1.48	+0.31	–0.41	–1.07	+0.16	+2.19
IE	+0.21	+0.08	+0.28	+0.90	+1.08	+1.05	+0.07	+0.05	+0.47	–0.26	–2.24	–1.34	–1.17
IT	+0.55	+0.16	+0.69	+2.36	+3.52	+3.21	+1.01	+0.47	+0.55	–0.41	–1.44	+0.87	+2.02
LT	+0.62	+0.14	+0.74	+1.63	+2.82	+2.12	+1.39	+1.50	+0.31	–0.31	–0.79	+0.81	+1.99
LU	+0.29	+0.38	+0.65	+1.44	+2.27	+1.93	+0.41	+0.32	+0.49	–0.56	–1.31	+0.06	+0.89
LV	+0.61	+0.15	+0.74	+1.68	+2.58	+1.96	+1.34	+1.38	+0.27	–0.30	–0.86	+0.81	+1.71
MT	+0.33	0.00	+0.33	+1.61	+2.43	+2.31	+0.25	+0.28	+0.36	–0.19	–2.98	–1.26	–0.41
NL	+0.46	+0.16	+0.60	+1.35	+2.23	+1.98	+0.62	+0.30	+0.55	–0.37	–1.22	+0.07	+0.95
NO	+0.40	+0.20	+0.58	+1.08	+2.09	+1.84	+0.22	+0.11	+0.54	–0.31	–2.45	–1.34	–0.30
PL	+0.60	+0.13	+0.70	+1.25	+2.93	+2.32	+0.98	+1.56	+0.32	–0.29	–0.76	+0.47	+2.16
PT	+0.23	+0.61	+0.80	+4.22	+4.93	+4.59	+0.81	+2.26	+0.22	–0.47	–1.89	+2.38	+3.09
RO	+0.32	+0.15	+0.45	+0.93	+3.20	+2.01	+1.22	+0.71	+0.28	–0.41	–1.01	–0.09	+2.21
SE	+0.69	+0.56	+1.17	+2.55	+3.54	+3.29	+0.36	+0.32	+0.66	–0.43	–2.57	+0.04	+1.02
SI	+0.49	+0.32	+0.77	+2.01	+3.86	+2.97	+1.38	+1.17	+0.44	–0.49	–1.16	+0.81	+2.62
SK	+0.43	+0.23	+0.63	+1.43	+3.49	+2.72	+1.49	+1.67	+0.31	–0.42	–0.98	+0.42	+2.49
UK	+0.28	+0.09	+0.36	+0.95	+1.25	+1.22	+0.14	+0.04	+0.43	–0.25	–1.26	–0.34	–0.04
EU15	+0.45	+0.21	+0.63	+1.65	+2.62	+2.38	+0.63	+0.44	+0.51	–0.42	–1.42	+0.18	+1.14
CH+NO	+0.40	+0.21	+0.59	+1.26	+2.39	+2.09	+0.51	+0.21	+0.53	–0.39	–1.75	–0.50	+0.64
AC12	+0.44	+0.21	+0.63	+1.17	+3.06	+2.19	+1.16	+1.19	+0.28	–0.35	–1.01	+0.14	+2.05
EU27+2	+0.45	+0.21	+0.63	+1.60	+2.62	+2.36	+0.65	+0.46	+0.50+	–0.41	–1.42	+0.14	+1.16

Table 8.11. SASI model: GDP per capita (EU27+2=100), difference to Reference Scenario (%)

Country	Scenarios												
	2001			2021									
	A1	A2	A3	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2
AT	–0.09	0.00	–0.08	–0.12	+0.11	–0.18	+0.41	+0.24	–0.15	–0.05	+0.35	+0.22	+0.46
BE	+0.01	–0.02	0.00	–0.17	–0.45	–0.44	–0.08	–0.23	+0.05	+0.02	+0.24	+0.04	–0.25
BG	–0.16	+0.09	–0.07	–0.82	+0.45	–0.62	+0.72	+0.12	–0.35	+0.08	+0.32	–0.47	+0.86
CH	–0.05	+0.01	–0.04	–0.23	–0.04	–0.11	+0.04	–0.19	+0.02	–0.03	+0.11	–0.12	+0.07
CY	–0.35	–0.21	–0.53	–1.41	–1.81	–1.61	–0.55	0.00	–0.35	+0.23	–2.34	–3.69	–3.95
CZ	–0.07	+0.02	–0.04	–0.36	+0.54	+0.03	+0.44	+0.84	–0.22	–0.01	+0.50	+0.16	+1.07
DE	–0.05	–0.01	–0.05	–0.36	–0.27	–0.31	–0.07	+0.08	–0.05	–0.06	+0.17	–0.22	–0.13
DK	+0.13	+0.42	+0.49	0.12	+0.55	+0.57	–0.31	–0.11	+0.01	–0.15	–0.41	–0.22	+0.19
EE	+0.08	–0.11	–0.02	–0.06	–0.30	–0.55	+0.40	+0.49	–0.28	+0.11	+0.25	+0.26	+0.02
ES	–0.06	–0.01	–0.07	+1.17	+1.02	+1.20	+0.52	+0.44	–0.06	+0.08	–0.01	+1.22	+1.06
FI	+0.19	–0.11	+0.09	+0.58	+0.67	+0.38	+0.29	+0.33	–0.05	+0.16	–0.63	+0.07	+0.19
FR	+0.14	+0.04	+0.17	+0.14	+0.18	+0.29	–0.01	–0.19	+0.18	–0.08	–0.09	+0.02	+0.04
GR	–0.19	–0.04	–0.22	–0.71	+0.35	–0.14	+0.04	+1.08	–0.32	+0.10	–0.68	–1.33	–0.13
HU	–0.05	+0.17	+0.11	–0.34	+0.64	+0.01	+0.64	+1.01	–0.19	0.00	+0.36	+0.01	+1.02
IE	–0.24	–0.13	–0.35	–0.69	–1.50	–1.28	–0.58	–0.41	–0.03	+0.15	–0.83	–1.48	–2.30
IT	+0.10	–0.04	+0.06	+0.74	+0.87	+0.83	+0.36	+0.01	+0.05	0.00	–0.02	+0.72	+0.85
LT	+0.17	–0.07	+0.11	+0.02	+0.19	–0.23	+0.73	+1.03	–0.19	+0.11	+0.65	+0.67	+0.82
LU	–0.16	+0.18	+0.02	–0.17	–0.34	–0.42	–0.24	–0.14	–0.01	–0.15	+0.12	–0.08	–0.26
LV	+0.16	–0.06	+0.11	+0.07	–0.04	–0.39	+0.69	+0.91	–0.23	+0.11	+0.57	+0.67	+0.54
MT	–0.12	–0.20	–0.30	0.00	–0.19	–0.05	–0.40	–0.19	–0.14	+0.22	–1.58	–1.40	–1.55
NL	+0.01	–0.04	–0.03	–0.25	–0.39	–0.37	–0.03	–0.17	+0.05	+0.04	+0.20	–0.07	–0.21
NO	–0.05	0.00	–0.05	–0.52	–0.52	–0.51	–0.43	–0.35	+0.03	+0.10	–1.04	–1.48	–1.45
PL	+0.15	–0.08	+0.07	–0.35	+0.30	–0.03	+0.33	+1.09	–0.18	+0.12	+0.68	+0.33	+0.99
PT	–0.22	+0.40	+0.17	+2.57	+2.25	+2.18	+0.15	+1.79	–0.29	–0.06	–0.47	+2.24	+1.91
RO	–0.12	–0.06	–0.18	–0.67	+0.56	–0.34	+0.57	+0.24	–0.22	0.00	+0.42	–0.23	+1.04
SE	+0.24	+0.35	+0.53	+0.93	+0.89	+0.91	–0.28	–0.15	+0.16	–0.02	–1.17	–0.10	–0.14
SI	+0.04	+0.11	+0.14	+0.40	+1.21	+0.59	+0.73	+0.70	–0.07	–0.08	+0.27	+0.66	+1.45
SK	–0.02	+0.02	0.00	–0.17	+0.84	+0.35	+0.83	+1.20	–0.20	–0.01	+0.45	+0.28	+1.31
UK	–0.17	–0.12	–0.27	–0.65	–1.34	–1.11	–0.51	–0.42	–0.07	+0.17	+0.17	–0.48	–1.18
EU15	0.00	0.00	0.00	+0.04	–0.01	+0.02	–0.02	–0.02	+0.01	0.00	0.00	+0.04	–0.01
CH+NO	–0.05	0.00	–0.04	–0.34	–0.23	–0.26	–0.14	–0.25	+0.03	+0.02	–0.33	–0.64	–0.51
AC12	–0.01	+0.01	0.00	–0.43	+0.43	–0.17	+0.51	+0.73	–0.22	+0.06	+0.42	0.00	+0.88
EU27+2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 8.12. Changes of regional welfare by country

	A1	A2	A3	B1	B2	B3	B4
Austria	0.020	0.063	0.081	0.086	0.166	0.124	0.061
Belgium	0.050	0.114	0.158	0.134	0.224	0.178	0.055
Germany	0.036	0.069	0.102	0.078	0.187	0.166	0.027
Denmark	0.058	0.699	0.727	0.174	0.258	0.240	0.027
Spain	0.053	0.144	0.190	0.269	0.423	0.411	0.103
Finland	0.057	0.116	0.166	0.277	0.431	0.346	0.141
France	0.053	0.122	0.170	0.064	0.221	0.205	0.023
Greece	0.030	0.119	0.146	0.186	0.366	0.322	0.046
Ireland	0.115	0.056	0.165	0.345	0.404	0.396	0.039
Italy	0.073	0.042	0.110	0.229	0.327	0.312	0.036
Luxembourg	0.012	0.186	0.195	0.130	0.215	0.193	0.022
Netherlands	0.042	0.117	0.153	0.150	0.251	0.217	0.061
Portugal	0.028	0.315	0.332	0.409	0.545	0.481	0.110
Sweden	0.071	0.584	0.615	0.409	0.524	0.502	0.039
United Kingdom	0.045	0.073	0.114	0.113	0.157	0.149	0.020
Bulgaria	0.024	0.103	0.124	0.078	0.483	0.214	0.212
Cyprus	0.084	-0.010	0.071	0.135	0.337	0.302	0.092
Czech Republic	0.037	0.130	0.162	0.188	0.600	0.380	0.212
Estonia	0.025	0.045	0.066	0.083	0.165	0.105	0.074
Hungary	0.033	0.196	0.223	0.113	0.382	0.228	0.156
Latvia	0.028	0.088	0.112	0.078	0.159	0.101	0.068
Lithuania	0.045	0.062	0.102	0.092	0.197	0.131	0.078
Malta	0.058	-0.001	0.056	0.129	0.163	0.154	0.049
Poland	0.065	0.061	0.121	0.202	0.578	0.475	0.099
Romania	0.028	0.103	0.126	0.158	0.601	0.358	0.184
Slovenia	0.052	0.129	0.172	0.167	0.387	0.285	0.115
Slovakia	0.025	0.064	0.085	0.112	0.419	0.331	0.121
Switzerland	0.033	0.056	0.085	0.056	0.121	0.107	0.020
Liechtenstein	0.028	0.121	0.146	0.066	0.119	0.106	0.020
Norway	0.061	0.268	0.310	0.213	0.345	0.306	0.050
Albania	0.036	0.016	0.047	0.030	0.133	0.117	0.022
Bosnia	0.049	0.086	0.125	0.068	0.251	0.195	0.073
Belarus	0.042	0.106	0.143	0.066	0.244	0.184	0.065
Croatia	0.019	0.059	0.075	0.044	0.126	0.083	0.038
Iceland	0.058	0.004	0.058	0.111	0.254	0.158	0.118
Moldova	0.059	0.134	0.180	0.140	0.519	0.185	0.206
Macedonia	0.018	0.094	0.110	0.049	0.218	0.116	0.142
Russia	0.023	0.030	0.051	0.033	0.246	0.189	0.036
Turkey	0.011	0.063	0.072	0.009	0.118	0.036	0.064
Ukraine	0.026	0.061	0.084	0.024	0.198	0.110	0.058
Yugoslavia	0.010	0.035	0.043	0.020	0.068	0.036	0.035

Table 8.13. Changes of regional welfare by country (continued)

	B5	C1	C2	C3	D1	D2
Austria	0.037	0.024	-0.249	-0.283	-0.190	-0.109
Belgium	0.020	0.046	-0.269	-0.336	-0.195	-0.104
Germany	0.044	0.033	-0.298	-0.345	-0.262	-0.148
Denmark	0.014	0.035	-0.248	-0.310	-0.133	-0.050
Spain	0.126	0.057	-0.328	-0.422	-0.140	0.017
Finland	0.052	0.098	-0.247	-0.480	-0.204	-0.067
France	0.008	0.044	-0.302	-0.361	-0.293	-0.130
Greece	0.262	0.035	-0.222	-0.313	-0.131	0.057
Ireland	0.013	0.209	-0.165	-0.532	-0.185	-0.132
Italy	0.093	0.062	-0.305	-0.396	-0.157	-0.055
Luxembourg	0.013	0.041	-0.315	-0.371	-0.234	-0.146
Netherlands	0.030	0.048	-0.263	-0.340	-0.186	-0.082
Portugal	0.190	0.038	-0.337	-0.454	-0.036	0.095
Sweden	0.021	0.066	-0.301	-0.432	-0.020	0.095
United Kingdom	0.006	0.055	-0.244	-0.335	-0.217	-0.174
Bulgaria	0.072	0.022	-0.275	-0.341	-0.264	0.137
Cyprus	0.129	0.127	0.003	-0.274	-0.144	0.056
Czech Republic	0.416	0.032	-0.311	-0.354	-0.159	0.265
Estonia	0.083	0.016	-0.199	-0.239	-0.158	-0.077
Hungary	0.221	0.043	-0.330	-0.397	-0.278	-0.004
Latvia	0.099	0.019	-0.199	-0.222	-0.146	-0.071
Lithuania	0.119	0.022	-0.193	-0.225	-0.135	-0.036
Malta	0.036	0.052	-0.036	-0.129	0.000	0.031
Poland	0.465	0.039	-0.278	-0.326	-0.120	0.257
Romania	0.121	0.032	-0.318	-0.375	-0.217	0.219
Slovenia	0.169	0.041	-0.302	-0.355	-0.179	0.042
Slovakia	0.305	0.026	-0.271	-0.304	-0.188	0.124
Switzerland	0.009	0.027	-0.211	-0.256	-0.197	-0.129
Liechtenstein	0.013	0.026	-0.246	-0.290	-0.221	-0.164
Norway	0.007	0.090	-0.294	-0.492	-0.277	-0.146
Albania	0.064	0.022	-0.029	-0.059	-0.029	0.076
Bosnia	0.068	0.026	-0.093	-0.124	-0.058	0.120
Belarus	0.180	0.019	-0.051	-0.066	-0.003	0.167
Croatia	0.044	0.015	-0.074	-0.095	-0.051	0.030
Iceland	0.002	0.103	0.021	-0.369	-0.258	-0.144
Moldova	0.051	0.028	-0.151	-0.152	-0.023	0.322
Macedonia	0.062	0.008	-0.085	-0.122	-0.073	0.103
Russia	0.140	0.012	-0.060	-0.136	-0.100	0.132
Turkey	0.023	0.006	-0.066	-0.118	-0.110	-0.008
Ukraine	0.053	0.007	-0.043	-0.057	-0.034	0.136
Yugoslavia	0.029	0.006	-0.032	-0.040	-0.022	0.027

8.9 Cluster analysis

The *cluster analysis* is a statistical proceeding that groups the observations according to some characteristics to be specified from the researcher. Our intention is to use this methodology with the aim of providing a typology of regions, with a high homogeneity within each cluster and with high variations among clusters in terms of ICTs and economic dynamics indicators.

We applied this methodology in two different steps of our analysis, first to develop a cohesion analysis and then to provide a typology of regions according to different ICTs policy impacts.

In the first case, we run one cluster analysis for each scenario, and one for the 1999 situation. From the comparison between the highest and lowest per capita GDP cluster we can take interesting indication on EU cohesion.

Table 8.14. Cluster analyses for the current situation and the different scenarios

Indicator	Cluster 1	Cluster 2 Lowest pc GDP regions	Cluster 3 Highest pc GDP regions	Cluster 4	Mean
Current situation					
Number of cases	37	100	46	2	185
Accessibility 1999	1.27	-0.48	-0.11	5.13	0
Per capita GDP 1999	-0.17	**-0.35**	**0.85**	1.43	0
Internet connections 1999	-0.42	-0.48	1.44	0.22	0
Share of lagging regions	27.0	28.0	6.5	0	22.2
Scenario A					
Number of cases	32	131	20	2	185
Accessibility 1999	1.40	-0.34	0.01	5.13	0
Per capita GDP 1999	-0.31	**-0.29**	**2.40**	0.06	0
Internet connections 1999	1.44	-0.35	-0.06	5.14	0
Share of lagging regions	25.0	**24.4**	**5.0**	0	22.2
Scenario B					
Number of cases	36	127	20	2	185
Accessibility 1999	1.27	-0.36	0.01	5.14	0
Per capita GDP 1999	-0.29	**-0.30**	**2.40**	0.06	0
Internet connections 1999	1.22	-0.36	0.06	5.56	0
Share of lagging regions	13.9	**27.6**	**5.0**	0	22.2
Scenario C					
Number of cases	19	134	21	11	185
Accessibility 1999	2.00	-0.30	-0.02	1.23	0
Per capita GDP 1999	-0.29	**-0.31**	**2.34**	-0.22	0
Internet connections 1999	-0.39	-0.19	-0.24	3.36	0
Share of lagging regions	0	**20.9**	**9.5**	100	22.2

8.10 Indication of Performance Indicators

Table 8.15. Number of Performance Indicators Achieved

Number of spatial indicators employed in addition to priority 1: in total covering the EU territory more than the EU territory	9 3 6
Number of spatial indicators applied: - in total covering - the EU territory - more than the EU territory	61 9 52
Number of EU maps produced	56
Number of sector policies fully addressed	1
Number of charts on the institutional structure of sector policies	0
Number of ESDP policy aims mentioned in the ESDP reference made to by sector study	5