Territorial Impact of EU Transport and TEN Policies

Third Interim Report of Action 2.1.1 of the European Spatial Planning Observation Network ESPON 2006

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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 editing of this report. The responsibilities for the chapters and certain sub-chapters of this report have been partly in the responsibility of the project partners.

The Institute of Regional research had the responsibility for the writing of chapter 3.2, the presentation of the indicator time to market in chapter 2.2 and the writing of the chapter 1, annex A and C.

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1 Executive Summary

1.1 Executive Summary

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.

Policy Scenarios

The evaluation of EU transport policy is conducted via scenario analysis. For this purpose ten scenario have been defined which take as the basis the national policy documents and the TEN and TINA guidelines to model the impact of the identified relevant policies. Table 1.1 gives an overview of the 10 transport policy scenarios. For these scenarios, the socio-economic impacts are evaluated with two economic models, SASI and CGEurope, that have been introduced in the FIR and SIR of this project. The SASI model evaluates the impact of changes in transport cost on accessibility. Changes in accessibility then in turn lead to changes in GDP and employment. This is captured in the model by inserting an accessibility index as a factor of production into an empirically estimated quasi production function. The CGEurope model evaluates the impact of changes in transport and travel cost and travel times on the regional welfare in a spatial computable general equilibrium model, that is constructed on a consistent theoretical basis of microeconomic reasoning. According to the model, cost changes affect the cost of inter firm interaction trough changing cost for goods transportation as well as changing cost for passenger business travel that is assumed to be closely tied to trade flows between firms.

Table 1.1.: Summary of Transport Policy Scenarios

Policy Scenario	Transport Characteristics
A1 Infrastructure	Implementation of all rail projects 1991-2001
A2 Infrastructure	Implementation of all road projects 1991-2001
A3 Infrastructure	Implementation of all projects (road, rail) 1991-2001
B1 Infrastructure	Implementation of all most probable rail projects 2001-2021
B2 Infrastructure	Implementation of all most probable road projects 2001-2021
B3 Infrastructure	Implementation of all most probable projects (road, rail) 2001-2021
C1 Pricing	Reduction of the price of rail transport
C2 Pricing	Rise of the price of road transport
C3 Pricing	Social marginal cost pricing of all transport modes
D Pricing and infrastructure	Implementation of all projects 2001-2021 and marginal cost pricing of all transport modes (B3 + C3)

The first series of three scenarios (series A) analyse transport infrastructure policies conducted in the years 1991 until 2001. The perspective of these scenarios is backward looking. 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. The first scenario in this series (A1) contains only rail projects, while the road infrastructure is left unaffected in its 2001 state. The second (A2) only covers road improvements, leaving rail unaffected, the third (A3) covers the combination of both.

In the three B scenarios, which are forward looking, future policies are analysed that are laid down in the TEN and TINA guidelines until the year 2021, also integrating national policies laid down in national infrastructure plans. The first of the three scenarios again analyses those projects that have been conducted in the field of rail infrastructure, the second analyses all road projects and the third scenarios analyses both types of projects combined. It is important to note that none of the scenarios takes the way of financing the projects into consideration. Just to isolate the impact of infrastructure use the scenarios are handled as if one got the new capacity for free.

For the simulation of pricing policies three scenarios are presented, C1-C3, which simulate the impact of a specific charge on road transport or a subsidy for rail transport and the marginal cost pricing of all modes of transport by a surcharge on all transport costs. Scenario C1 simulates the impact of a subsidy on rail transport, which is the reverse measure to a additional pricing of road transport. In our scenario C2 we simulate the spatial impact of a charge of 10% on all road transport costs, which is currently under discussion by e.g. a recent paper by DG TREN[1] to internalise the external costs of heavy goods vehicles (HGV). These external costs consist of cost due to pollution, congestion, traffic accidents, and the cost of constructing and maintaining the network. These charges are to be collected on a link specific basis as a toll on the use of infrastructure. Therefore in our scenarios these charges have been implemented as link-specific charges. Just as we neglect budget implications of infrastructure building, we also neglect budget implications of pricing policies. They are handled as if the revenue was burned. This is because at present nothing sensible could be said about the likely spatial impact of revenue redistribution.

The C3 scenario simulates the pricing of all modes of transport with a charge of 10 % on transport costs of all modes of transport to tackle the hypothetical spatial impact of social marginal cost pricing of all modes with a surcharge that has not been differentiated by regional characteristics.

Scenario D simulates both, infrastructure and pricing combined, so it is a combination of scenario B3 and C3 to study complementary effects of both types of policies.

Summary of SASI Results

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

[1] See “Proposal adopted by the Commission on 23/07/2003 [COM(2003)488] on alignment of the national systems of tolls and of user charges for infrastructructure use on common principles”, DG TREN, July 2003

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.

For this application in ESPON 2.1.1 the regional production functions of the model were re-calibrated using regional GDP, regional accessibility and regional endowment data of the period 1981 to 1996. With the calibrated model the ten transport policy scenarios defined for ESPON 2.1.1 were simulated. Table 1.2 shows differences in GDP per capita compared with the reference scenario for the present European Union, Norway and Switzerland, the candidate countries and the whole ESPON space.

In both the past and the future the effects of road infrastructure projects (scenarios A2 and B2) are significantly larger than those of rail infrastructure projects (scenarios A1 and B1). The pricing scenarios C1-C3 are in general negative for the economy at large because they increase the costs of trade and mobility. A reduction of rail fares (scenario C1) has only little effect, if anything there is a slight negative effect for the candidate countries. The negative economic effects of road pricing (scenario C2) and general social marginal cost pricing of transport (scenario C3) are stronger and again more pronounced in the candidate countries, As with accessibility, the results for the combination scenario D lie somewhere in between scenarios B3 and C3.

Table 1.2 SASI model results: GDP per capita

Country	GDP per capita differences compared with reference scenario (%)									
	2001			2021						
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
EU15	+0.00	+0.02	+0.02	+0.01	–0.01	+0.00	+0.00	–0.02	–0.01	–0.02
CH+NO	–0.36	+0.32	+0.29	–0.42	+0.65	+0.25	+0.00	–0.94	–1.32	–1.04
CC12	–0.39	+0.48	+0.55	+0.27	+1.72	+1.61	–0.06	–1.07	–0.77	+0.77
EU27+2	–0.04	+0.06	+0.06	+0.00	+0.11	+0.09	+0.00	–0.12	–0.12	–0.03

The results were also analysed with respect to their cohesion effects for GDP per capita. To this end, five cohesion indicators were calculated (i) the coefficient of variation, (ii) the GINI coefficient, (3) the ratio of the geometric and the arithmetic mean, (iv) the correlation between relative change and level and (v) the correlation between absolute change and level. Of the five indicators, four measure relative differences, only the last indicator measures absolute differences. Table 1.3 summarises the results of this analysis. For easier interpretation, indicator values were translated into cohesion effects, with a plus sign indicating more cohesion and a minus sign indicating more polarisation.

Table 1.3. SASI model: GDP/capita cohesion effects

Indicator	GDP/capita cohesion effects (+/–)									
	1991-2001			2001-2021						
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Coefficient of variation	–	+	+	+	+	+	–	–	–	–/+
Gini coefficient	–	+	+	+	+	+	–	–	–	–/+
Geometric/arithmetic mean	–	+	+	+	+	+	–	–	–	–
Correlation, relative	–	–/++	++	+	+	++	–	–	–	+
Correlation, absolute	–	–	–	–	–	–	–	–	—	–

+/++ Weak/strong cohesion effect: disparities are reduced
–/— Weak/strong anti-cohesion effect: disparities are increased
–/+ Short term anti-cohesion and long-term cohesion effect

The table strongly underlines the frequently expressed warning that the assessment of cohesion effects of policies critically depends on the choice of cohesion indicator. In this context it is of particular importance whether relative or absolute changes are considered. For instance, a policy which increases accessibility or GDP per capita in each region by the same percentage, is cohesion-neutral if relative differences are considered but obviously gives a much larger advantage to regions which already enjoy above-average accessibility or GDP per capita if absolute differences are taken into account.

Rail scenario A1 in the past decade favoured mostly central European regions, whereas road scenario A2 had a clear cohesion effect (in relative terms). Because the effects of road infrastructure investments were much stronger, scenario A3, in which both road and rail projects were implemented, is very similar to scenario A2. The prospective infrastructure scenarios have a pro-cohesion effect (in relative terms); with the strongest effects in scenario B3, in which all road and rail TEN and TINA projects are assumed to be implemented. The pricing scenarios are anti-cohesion altogether, even scenario C1, in which rail fares are lowered and disparities in accessibility are reduced. Scenario D, in which both infrastructure and pricing policies are combined, has a long-term cohesion effect after an initial period of increased regional disparities. If absolute differences are taken into account, all ten scenarios are anti-cohesion.

Summary of CGEurope Results

Using the CGEurope model, policy scenarios are evaluated by comparing 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. The analysis is comparative static, that means one compares two equilibria differing with respect to the transport cost scenario only, everything else held constant. The indicator of comparison is the utility change of households in the "with-world" in comparison to the "without-world". The 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. The reference situation is the year 1997 in all cases. The welfare measure takes income as well as price changes and changes in the access to product variety into account. Loosely speaking, one may regard the relative impact as a percentage real income change.

In the retrospective A-scenarios measuring the impact of the past development from 1991 to 2001 the overall impact of rail infrastructure changes is small. No more than on tenth of the entire impact in the A-scenarios is due to changes in rail infrastructure, nine tenth is due to changes in road infrastructure. The average combined impact of both in the entire ESPON space is 0.30 % of GDP. Hence it is obvious that the spatial pattern of effects in A3 representing the combined rail and road effect is almost completely explained by the impact of roads.

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 considerably higher in objective-1 regions (0.41 %) then in the whole space (0.30 %). The pro-cohesion tendency is mainly due to the fact that within EU15 infrastructure development has favoured poorer regions more than richer ones.

Regarding polycentricity, scenario A3 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 than the average points towards a gain in polycentricity. The same conclusion can be drawn from looking at effects by regions classified according to accessibility. Our typology classifies regions by macro scale and meso scale accessibility. With regard to both, macro scale and meso scale accessibility, effects of A3 are lowest in central regions, medium in medium regions and highest in peripheral ones. A tendency in favour of polycentricity on the meso scale can be inferred from the observation that the impact is smallest in agglomerated regions (0.22 %), medium in urbanised areas (0.32 %) and largest in rural regions (0.43 %). On the micro scale we observe a certain tendency towards strengthening of smaller centres.

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.

The spatial pattern of the A1-scenario, representing the impact of rail investments during the last decade, is different. There is virtually no impact on equity, only a slight inequality enhancing effect, mainly within CC12, if anything. Differentials by type of settlement structure do not point to any systematic tendency with regard to polycentricity either, neither in one nor in the other direction. A2 has a similar pattern as A3 and thus needs not be described any further.

The prospective B-scenarios measure the impact of the most likely development of road and rail infrastructure until 2021. Different from the ex-post A-scenario, impacts of rail infrastructure improvements have a similar magnitude as those of road infrastructure improvements in the prospective B-Scenarios. The average impact is 0.12 % for rail, 0.17 % for road and 0.28 % for both modes combined in the ESPON space. In CC12 the rail effect is smaller (0.05 %), but the road effect considerably larger (0.50 %).

Like the A3-scenario, the B3-scenario representing rail and road is also pro-cohesion. It is more in favour of cohesion for the whole area than for the two subspaces, because the cohesion effect is partly due to the fact, that the impact is more than twice as large in the poorer CC12 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 (0.48 % and 0.33 %) than in non lagging regions (0.24 %). They are also considerably higher in objective-1 regions (0.45 %) then in the whole space (0.28 %).

Regarding polycentricity, scenario B3 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 (0.22 %) than the average points towards a gain in polycentricity. The same conclusion can be drawn from looking at effects by regions classified according to accessibility, on the macro as well as on the meso scale: effects of B3 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 smallest in agglomerated regions (0.23 %), medium in urbanised areas (0.29 %) and largest in rural regions (0.40 %). On the micro scale we again observe a certain tendency towards strengthening of smaller centres. Even though the spatial pattern of the ex-post scenario A3 has only some similarity with that of the ex-ante scenario B3, the general conclusions with regard to cohesion and polycentricity are much the same for both scenarios.

Largely the same holds true for B2, which takes only the road effects separately. It is pro-cohesion and also pro-polycentricity on the meso scale, while the tendencies are not so clear on the macro and micro scale. Rail effects as modelled by the B1-scenario are more or less neutral with respect to the spatial income distribution for the whole ESPON space, slightly pro-cohesion within EU15, but interestingly clearly anti-cohesion within CC12. An observation in favour of a cohesion effect is that objective-1 regions gain more (0.20 %) than the average (0.12 %), and that lagging regions gain more (0.23 %) than non lagging regions (0.09 %). There is also a tendency in favour of polycentricity on the macro and meso scale, but the pattern is not as pronounced as for road.

The spatial implications of pricing policies increasing private transportation cost, irrespective of whether this concerns road transport only or all three modes under consideration, are exactly the opposite of those in the A- and B-scenarios. This is revealed by the results of scenarios C2 and C3, which show a similar spatial pattern. 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, the better the accessibility in the reference situation, the smaller the losses. It is furthermore well visible from Fig. 3.15, 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-scenario is a mixture of B and C, and therefore shows a overlay of contradicting tendencies. Regarding spatial income distribution, the pro-cohesion impact of the B-scenarios slightly dominates, but there are no clear patterns with regard to polycentricity.

As a summary of cohesion results and for ease of comparison with SASI results we add Table 1.4 showing 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 model: GDP/capita cohesion effects

	GDP/capita cohesion effects (+/–)									
	1991-2001			2001-2021						
Indicator	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Coefficient of variation	0	+	+	+	+	+	0	–	–	+
Gini coefficient	0	+	+	+	+	+	0	–	–	+
Geometric/arithmetic mean	0	+	+	0	+	+	0	–	–	+
Correlation, relative	0	+	+	0	++	++	0	—	–	++
Correlation, absolute	—	—	—	—	—	—	++	++	++	—

+/++ Weak/strong cohesion effect: disparities are reduced
–/— Weak/strong anti-cohesion effect: disparities are increased

Effects of Transport Policy Scenarios on Development Potential

Polycentric development has emerged as a key concept during the European Spatial Development Perspective (ESPD) process. In ESPD (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.”

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*. 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 forecasted by the SASI model, the effects on the potential for polycentric development may be indicated.

In terms of the development potential marginal cost pricing turns out to improve the relative position of most accession countries. The transport investments (scenario B3) improve the relative position of semi-central regions, mainly outside the “pentagon”. The combined investment and marginal pricing scenario (D) mainly extends the regions with improved relative position 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.

Polycentric Connectivity

This section deals with polycentric and balanced development and urban-rural partnership. This approach is operationalized by a systematic and structured selection of abstract links that connect central places within the polycentric hierarchical system all over the ESPON space. The construction of priority links and the network evaluation is demonstrated with data available from the ESPON data base V2.2 and preliminary passenger road transport accessibility data.

These links of different levels of service can be weighted and scaled by two factors: the quality of accessibility today compared to an average standard level and on the other hand the classification of the connected regions in a typology reflecting their economic strength respectively structural problems.

At last the TEN projects are examined regarding their contribution to improve these links. Whenever an improvement of accessibility is significant (by reduced travel times or higher beeline speeds), the weighted value of each improved relevant link directly can be assigned to the causing scenario or project as a grade.

Overloaded Transport Corridors

This section deals with urbanised regions and sustainable use of infrastructure. In a first step regions and corridors that are highly overloaded with the burden of transport are identified and classified empirically at regional level. Than TEN projects are examined regarding their expected contribution to unburden the concerned regions and corridors. The relocation or transport streams and possibly expected modal shifts from road to rail or waterways could be used as an additional indicator for the reduction of the transport burden. This can be justified by a more sustainable use of infrastructure and lower external costs for these modes. The data necessary for this analysis, however, cannot be calculated from the models used in the 2.1.1 consortium. Therefore this analysis has to rely on external work.

Summary of ICT Policy Assessment

The third interim report describes the methodology and the results of the estimation and forecasting of the territorial impact of ICTs policies. The role of ICTs is very important for the level of GDP, its growth and its distribution. Therefore, the EU policies in this sector are extremely 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.

Different 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), 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.

Using data from Eurostat Regio, ITU and EOS Gallup, we estimate per capita GDP through a model based on accessibility, internet connections, fixed telephony penetration, cable and satellite TV, total employment, high tech employment. We correct the estimate for the spatial dependence problem and calibrate the model. At the end, we are able to forecast the impacts of the three scenarios on future GDP. These impacts are measured by a comparison of the future level of GDP in the respective scenario ("with"-case) with a do-nothing scenario ("without"-case). The percentage deviation of the with-case from the without-case is called the "growth rate" or just "growth" of the scenario. The growth rate of the do-nothing scenario is zero, by definition.

The main results can be summarised as follows:
1. 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.
2. The ICTs policies suggested by the eEurope Action plan can lead to very different scenarios, depending on their regional implementation.
3. Future ICTs policy impact scenarios must therefore be constructed on the basis of hypotheses concerning the allocation of financial resources to ICTs factors and to regions.
4. 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 more innovative infrastructures; the cohesion scenario (C), in which less developed regions take advantage from the allocation of all resources.
5. The three scenarios give rise to very different impacts on GDP: scenario A shows an average (averaged across regions) growth rate equal to 0,99%, while scenario B shows a higher rate (1,1%), as expected, and scenario C shows the highest rate for lagging regions (1,3%).
6. These three scenarios provide a different impact on income distribution, too. While scenario A does not affect the 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.
7. The study is also able to demonstrate that within different typologies of regions (objective 1 regions or more advanced regions), different reactions to a specific ICTs policy exist. Within lagging regions, some areas are able to take advantage from all policies applied, while others react exclusively to cohesion policies; similarly, there are non-lagging regions that react dynamically to ICTs policies, while others seem more static.

Summary of Policy Interaction

Section 5.1 identifies several critical fields of policy interaction between transport policy and other policy fields on the European level. Most notable are the following:

1. Improvement of transport has a key role to play for progress in achieving the internal market. There are still substantial barriers to the free movement of goods and services. Improvement of EU's physical infrastructure has to contribute to their removal. Harmonisation of market conditions within the transport sector also contributes to that removal. Hence, transport infrastructure policy and internal market policies support each other, and there is little risk of conflict.

2. There is considerable risk of conflict between transport policy and the Stability and Growth Pact, however. 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.

3. There are strong interactions between transport and environmental policies. Pricing policies based on social marginal cost can be a strong supporting device for achieving the objectives of environmental policies. But there is also a severe risk of conflict. Even though policies to remove bottlenecks in Europe clearly try to favour modes of transport that are relatively environment friendly, they also increase the level of mobility by reducing the price of transport relative to other goods and services, and therefore may run into conflict with environmental objectives.

4. There is also a conflict between environmental goals and spatial development objectives pursued by transport policies. The use of transport policy to promote poycentricity would be likely to lead to increased transport and hence to more risk of damages for the environment. As supported by the modelling results in chapter 3.1 and chapter 3.2, polycentricity is enhanced most by improvements of the road network. This holds true for improvements in the last decade as well as for those planned for the future. But this is at the same time most problematic from an environment policy perspective. On the other hand, social marginal cost pricing is most desirable from an environmental point of view, but at the same time runs the risk of a concentration effect harming the periphery, which is undesirable from a spatial development point of view.

Section 5.2 deals with interactions between EU policy and national transport policies on a country by country information basis. It turns out that 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, in some senses, 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.

1.2 Presentation of Concepts, Methodologies and Typologies

1.2.1 Methodologies: 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 Methodologies: 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 ten transport policy scenarios.

1.2.3 Methodologies: 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:

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

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.

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:

- Mass: population density in the year 2021
- Competitiveness: gross domestic product (GDP) per capita in the year 2021
- Connectivity: multimodal accessibility in the year 2021
- Development trend: 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:

- Development potential: 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.

1.2.6 Typologies

Typologies were used to classify the predicted impacts by type of regions. Available typologies were used that classify regions as lagging, rural, coastal, border, objective 1 or 2 or by settlement type.

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.

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.

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 part “polycentric connectivity”.)

Unemployment

The Basis of the typology of unemployment is a ranking by the unemployment rate 2000. This indicator is cut into three classes low, medium and high grouping a third of the ESPON space total population each.

Time to market

The time to market indicators building up several regional accessibility classifications based on the time to market (logsum) indicator calculated by CAU. There are two versions, the regional scope with a half-life time parameter of 25 minutes (GDP, meso) and the continental scope with a half-life time parameter of 1000 minutes (GDP, macro). The half-life time measures the travel time reducing spatial interaction to one half of the value attained under a zero distance. The indicator with a half-life time of 1000 minutes is interpreted as a macro scale measure of centrality/peripherality. The indicator with a half-life time of 25 minutes is interpreted as a meso scale measure of centrality/peripherality. A look at figure 2.4 and 2.5 shows that this interpretation is justified. The classes most central, central, medium, peripheral and most peripheral are defined by population quintiles (assuming the overseas as peripheral).

There is also a four class typology (time to market weighted by GDP, micro vs. macro level) which is a combination of the above in a three class version (breaks at 30 percent and 70 percent): Regions with the same class at both micro and macro level are classified as “central” or “peripheral”, regions with one level as central and the other as peripheral are classified as “contrary” and the remaining region are set to “medium”.

Multimodal Accessibility Potential:

This typology 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.).

Furthermore, we developed a typology of regions according to ICTs policy impact. It will be possible to identify more “reactive” regions and more static ones. This typology is presented in section 4.2.

1.2 List of Indicators Developed and Provided to the ESPON Database

Accessibility indicators	*Source*
Time to market by road, weighted by population, h=25 minutes	own calculations
Time to market by road, weighted by population, h=100 minutes	own calculations
Time to market by road, weighted by population, h=1000 minutes	own calculations
Time to market by road, weighted by GDP, h=25 minutes	own calculations
Time to market by road, weighted by GDP, h=100 minutes	own calculations
Time to market by road, weighted by GDP, h=1000 minutes	own calculations
Time to market by rail, weighted by population, h=25 minutes	own calculations
Time to market by rail, weighted by population, h=100 minutes	own calculations
Time to market by rail, weighted by population, h=1000 minutes	own calculations
Time to market by rail, weighted by GDP, h=25 minutes	own calculations
Time to market by rail, weighted by GDP, h=100 minutes	own calculations
Time to market by rail, weighted by GDP, h=1000 minutes	own calculations
Time to market logsum, weighted by population, h=25 minutes	own calculations

Time to market logsum, weighted by population, h=100 minutes	own calculations
Time to market logsum weighted by population, h=1000 minutes	own calculations
Time to market logsum, weighted by GDP, h=25 minutes	own calculations
Time to market logsum, weighted by GDP, h=100 minutes	own calculations
Time to market logsum, weighted by GDP, h=1000 minutes	own calculations

Impact Indicators of SASI	*Source*
Population by age group	model results
Labour force	model results
Net migration	model results
Net commuting	model results
GDP by sector	model results
GDP per capita	model results
Employment by sector	model results
Accessibility rail/road , travel	model results
Accessibility rail/road/air, travel	model results
Accessibility road, freight	model results
Accessibility rail/road, freight	model results

Impact Indicators of CGEurope	*Source*
Impact of transport policies on regional welfare, all 10 scenarios	model results

Impact Indicators of STIMA	*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

1.4 Report on Application of the Common Platform, Integration of Points Raised in the CU Response and Networking Undertaken towards other TPGs

1.4.1 Application of the Common Platform

The common platform has been implemented by adopting the points mentioned in the ESPON Seminar in Crete and the Crete Guidance Paper by ESPON 3.1.

1.4.2 Integration of Points Raised in the CU Response to the Second Interim Report

Data deliveries have now taken place, the indicator time to market as a measurement tool of disparities in access to transport infrastructure and as an indicator of centrality has been provided to the ESPON database. In parallel to the delivery of the TIR, the forecasting results of the modelling teams are provided to BBR to integrate them in the ESPON database.

The analysis of transport and TEN policies have been conducted in a comprehensive form in chapters 2.1 and 5 along with recommendations on the institutional structure for policy decisions in the transport sector.

For the ICT policy scenarios, data have been gathered from the EOS Gallup 1999 survey, these data, which cover the EU-15 on NUTS-2 level have been proved to be the best data available for the purpose of modelling of ICT policy impact.

Transport and ICT policy scenarios are defined according to available policy documents, the selected scenarios are presented in chapter 2.4. The scenarios bundle several policy decisions, to make a comprehensible presentation of the impact of these policies to avoid an unnecessary high number of case studies.

At the moment the definition of combined ICT and transport policy scenarios is not reasonable, so that the SASI and STIMA methodologies have not been merged. In the present version each model for itself produce simulates the impact of transport and ICT policies separately. The definition of scenarios evaluating policies in both fields to evaluate synergies of both policy fields is under discussion in the TPG and is foreseen for the Final Report.

The air network nodes, inland waterway and short sea shipping networks which are the basis for the scenario definition are presented in chapter 2.4. Note, however, that waterways are not yet included but will be integrated in the final versions of the scenarios in the Final Report. Through the participation of the Norwegian Institute of Transport Economics additional knowledge has been integrated in the TPG to include information on short sea shipping in the further simulation of transport policies.

1.4.3 Networking Undertaken towards other TPGs

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. Score measures based on the typology of MEGAs of ESPON 1.1.1 have been calculated by KTH for selected scenarios. The accessibility measures and the measurement of disparities in transport infrastructure are harmonised with the approach used in project 1.2.1. For the gathering of ICT data the partner in Milan held close contact with ESPON 1.2.2 for the exchange of data in the field of telecommunication and impact analysis of ICT policies. As stated also in the SIR, MIL encountered serious problems in finding data concerning ICTs endowment and use for the European regions. Consequently, MIL maintained long telephone calls and frequent e-mails with Ranald Richardson of CURDS (lead partner of ESPON 1.2.2) on availability of ICTs data. Professor Camagni attended to the ESPON meeting in Crete, in May, where he talked to other ESPON partners on this theme. This networking, at last, proved to be useful: MIL and CURDS agreed on the lack of non-survey data, but the EOS Gallup 1999 Survey proved to contain the best data, even if they are only at Nuts-2 level.

2 Setting the Scene

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

Transport and communications sit at the centre of developments in the European economy and plays a critical role in enlargement. Efficient and effective communications are essential to the competitiveness of European industry and commerce, to the cohesion of the European economy and to 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 these 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 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. 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 interchange 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 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. Nevertheless, this is a two way process and transport policy has to be acceptable at the level of the individual user 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.

The policy framework can be represented as shown in Table 2.1 which shows the way in which specific policy areas impact on each other and which demonstrates the complexity of defining the policy scenarios to inform the work on impacts.

Table 2.1 Policy interactions

EU transport policies	EU non-transport policies	National transport policies	Regional transport policies	Local transport policies
Infrastructure polices - TENs - 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 is clear from previous work on TENs policies in the TENASSESS project[2] there is no easy classification of policy stances and the way in which EU policies are refracted through national and lower level policies

[2] ICCR *et al*. (1999) *Euro: TEN-ASSESS Final Report*, European Commission Transport RTD 4th Framework Programme

differs considerably from member state to member state (see Chapter 5 for further discussion of this point).

The White Paper on *European Transport Policy for 2010: The Time to Decide* recognises that the main policy instruments are infrastructure, regulation and pricing. We use these to establish a set of broad policy scenarios (summarised in Table 2.2) from which the modelling work can derive more specific set of parameters.

At the simplest level we can define infrastructure policy in terms of the development of networks. This is likely to be comprehensive at EU level, and reasonably comprehensive at 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 TENs[3] illustrates that only 2 of the initial 14 Essen list projects were in operation by 2003, and only a further 3 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. 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; 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.[4] 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 C-scenarios used in this report should be regarded as typical policy examples, which are however not likely to be realised in mere form. Reality will be a mixture of policies that can not be predicted precisely.

[3] High Level Group on the Trans-European Transport Network, Report, June 2003

[4] See evidence from the UNITE project: Link, H., L. H. Stewart, C. Doll , P. Bickel, S. Schmid, R. Friedrich , S. Suter and M. Maibach (2001), *Pilot accounts for Switzerland and Germany* UNITE D5 Funded by EC 5th Framework Transport RTD; Nellthorp, J., T. Sansom, P. Bickel, C. Doll and G. Lindberg (2001) *Valuation conventions for UNITE* Funded by EC 5th Framework Transport RTD.

ICT policy is not developed so coherently as transport policy as to be able to identify specific infrastructures or pricing impacts. EU policies focus in 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 enlargement. 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 CEEC 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 EU 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 The Existing Territorial Imbalances and Regional Disparities in Transport and TEN Infrastructure

2.2.1 Regional Disparities in Transport Infrastructure

There are large, historically grown imbalances in the territorial endowment of transport and telecommunications infrastructure in Europe. Data collection and analysis of regional endowment with transport and telecommunications infrastructure are the tasks of ESPON 1.2.1 and 1.2.2, respectively. Here only a brief summary of these territorial imbalances, which form the point of departure of the transport and telecommunications policies addressed in ESPON 2.1.1, is given.

Figure 2.1 and 2.2 (kindly made available by ESPON 1.2.1) show the distribution of motorway and railway density in the 29 countries of the ESPON space.

There is a clear decline in motorway density from the most central north-western regions in Europe to the peripheral regions (Figure 2.1). In the present European Union, Portugal, Ireland, northern England and Scotland and northern Sweden and Finland and northern Greece have only few motorways. However, almost all parts of the candidate countries, with few isolated links around capital cities in Latvia, Romania and Bulgaria, are lacking motorways altogether.

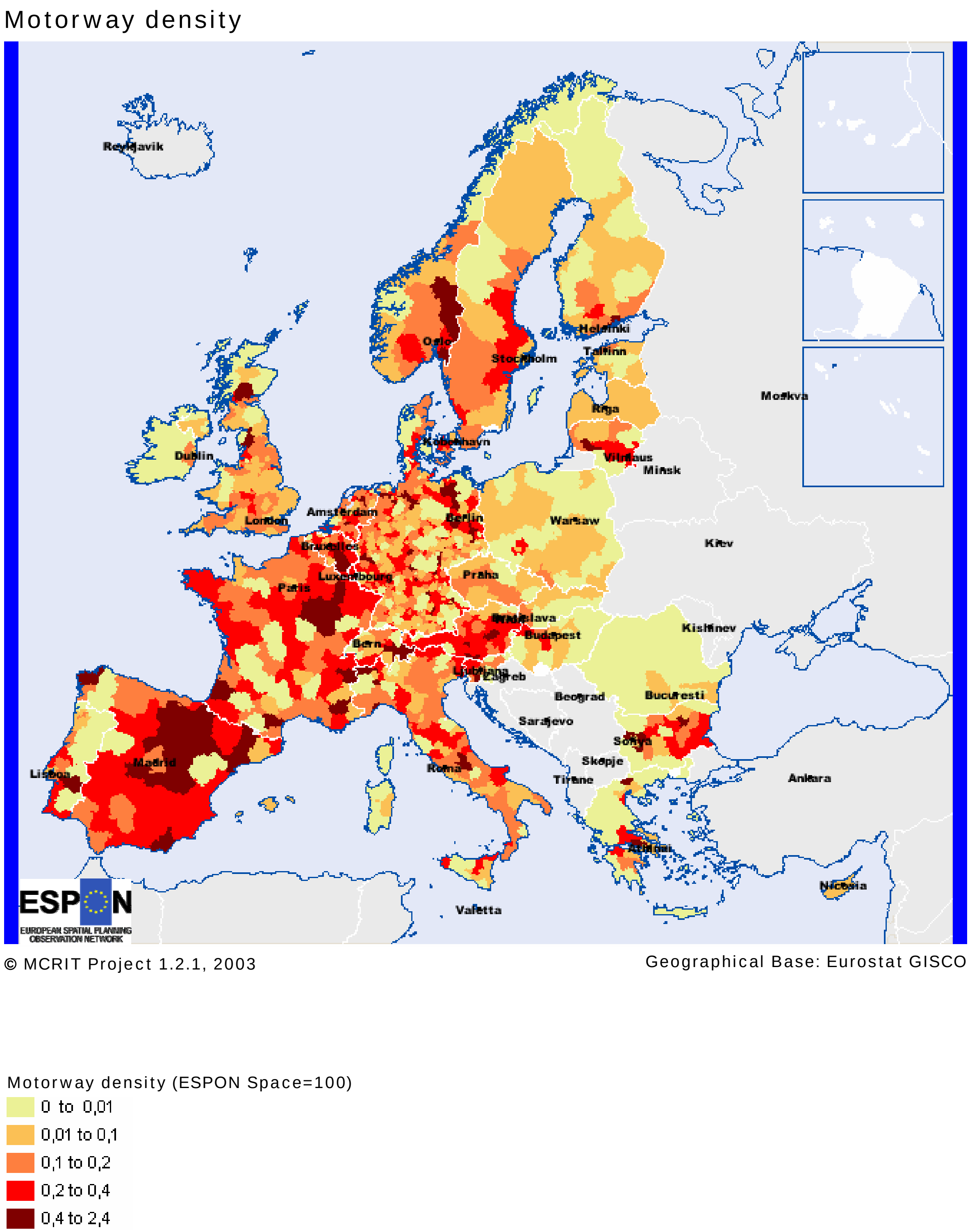


Figure 2.1. Motorway density by NUTS-3 region in 1999

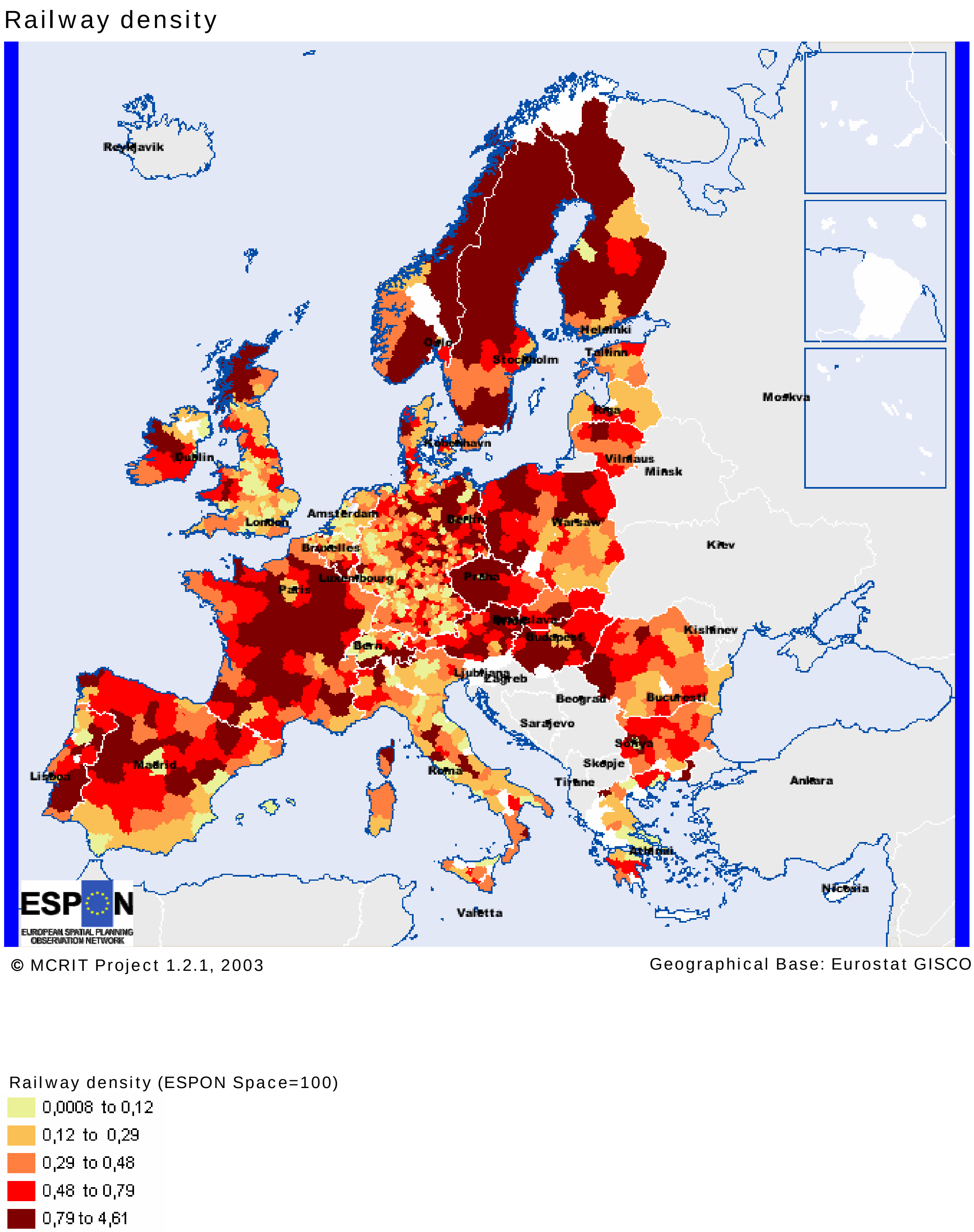


Figure 2.2. Railway density by NUTS-3 region in 1999

The situation is different with respect to railways (Figure 2.2). On a per-capita basis, most peripheral countries, such as Sweden, Norway, Finland, but also candidate countries as Poland, the Czech Republic and Hungary, have more kilometres of railways in operation than some of the most central countries, such as Germany, the Benelux countries or Italy. However, the dense railway networks in the candidate countries suffer from decades of lack of investment, whereas in many central European countries many no longer profitable lines have been closed down.

Figure 2.3 presents an overview of the disparities in transport infrastructure across modes (Eurostat, 2002) between the present EU member states and the candidate countries in central and eastern Europe (CEC), i.e. without Malta and Cyprus.

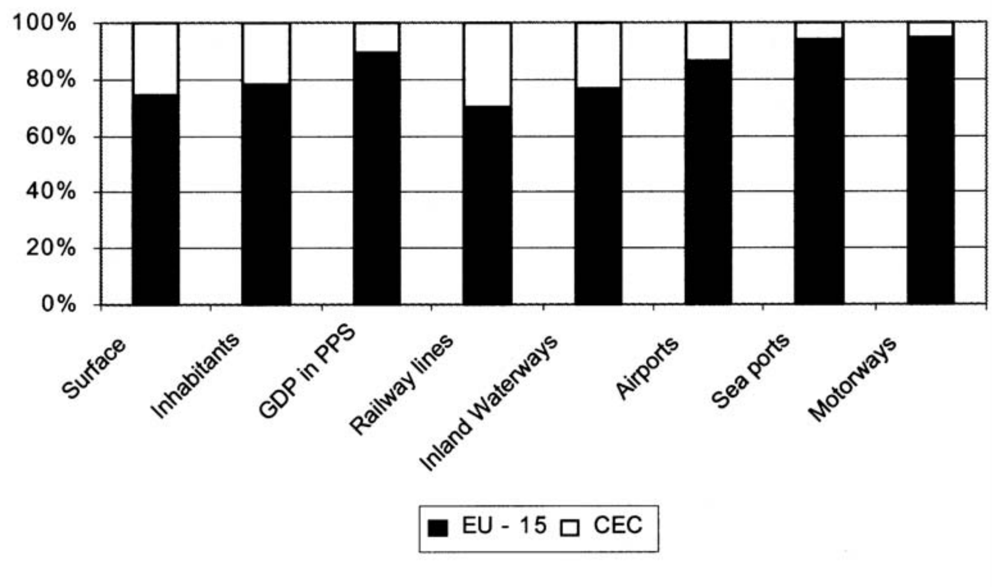


Figure 2.3. Transport infrastructure in EU and CEC countries in 1999 (Eurostat, 2002)

It can be seen that the ten CEC countries occupy about 25 percent of the territory of the EU and CEC countries together and about 21 percent of the population, however produce only about 10 percent of the GDP of the area. This imbalance is reflected in the endowment with transport infrastructure. All CEC countries have only 13 percent of the airports, 6 percent of the seaports and 5 percent of the kilometres of motorways in the EU+CEC countries together. Moreover, the imbalance in motorway infrastructure is increasing: whereas in the EU more than 1,000 km of motorway are added each year, less than 100 km are added in the CEC countries each year.

On the other hand, the CEC countries have an over-proportional share of rail and inland waterway infrastructure: 29 percent of all railway kilometres and 23 percent of all inland waterways kilometres are in the CEC countries. Two thirds of all railways in the CEC countries are in Poland, Romania and the Czech Republic, and the length of inland waterways is greatest in Poland, Romania and Hungary (Eurostat, 2002).

Even greater disparities exist in regional endowment in telecommunications infrastructure. As it will be shown in Section 2.2.2, there exists a steep centre-to-periphery gradation in fixed telephone penetration with south-west England and western Germany having the highest penetration. The same gap exists in the number of Internet connections. Here again south-west England and the Benelux countries, Denmark, Sweden and southern Finland are the leaders.

Time to Market

One way to measure disparities in accessibility beyond the market potential is the calculation of the average time to market of a region.

In general, the time to market is defined as follows:

$$\bar{c}_r = -\frac{1}{\beta}\log\left[\sum_s M_s \exp(-\beta c_{rs})\right] + \frac{1}{\beta}\log\left[\sum_s M_s\right] \quad (2.1)$$

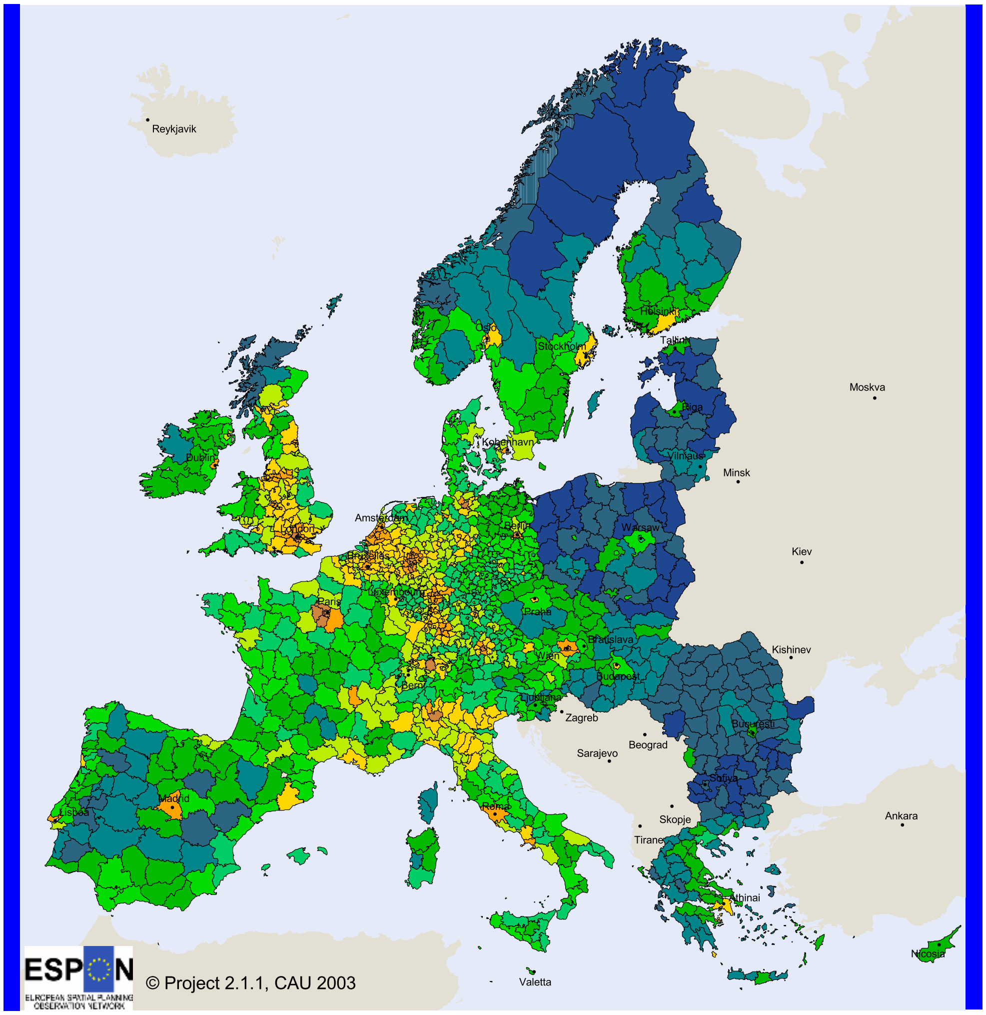
M_s is a mass variable, this can be GDP or population, in the cases presented GDP is used, β is the semi-elasticity, which determines the speed of decay, c_{rs} is the travel time from region *r* to region *s*. Other kinds of distance measures such as travel distance in kilometre, multimodal travel cost and others may be inserted instead of travel time, leading to a "distance to market", "cost to market" or similar indicator, respectively.

Data needs for the calculation are interregional transport times and an appropriate mass variables such as GDP or population to measure the size of the market of a NUTS-3 region. Time to market measures the expected average time a firm or household in region *r* would need in order to reach the market. It takes into account that larger markets must be visited more often, and that firms or households try to bias their interactions with the market in favour of those regions that are near by in order to save travel time. It is implicitly assumed that the choice is made according to a logit decision model, with number of opportunities proportional to the mass variable.

The indicator is standardised such that the reference is a hypothetical region that can reach all markets with zero travel time. That means an indicator equal to 100 minutes for a certain region *r*, say, means that from that region one would need 100 minutes on average to reach the market partners for buying a good, signing a contract or making use from any other opportunity offered in a destination and measured by the mass variable. In the hypothetical region with zero distances to all destinations one would need zero minutes, of course. The comparison takes into account, that the travel times affect the choices of destinations.

In the case of the meso scale, β is chosen such that the intensity of interaction is halved every 25 minutes of travel time, so that β is (log 2)/(25 minutes). 25 minute is the “half-life time” of spatial interaction in this case. For the macro scale the “half-life time” is 1000 minutes. This indicator has been calculated for both rail and road travel times, and with GDP and population as mass variables separately. For the development of an indicator of general access to infrastructure this indicator is calculated as a multimodal indicator, taking the logsum of the time of the transport mode rail and road. These indicators are presented in figures 2.4 and 2.5 for the meso and macro scale. In the typologies the distance to market with a half-life time of 25 minutes is taken as a centre/periphery indicator on a meso scale, the distance to market with a half-life time of 1000 minutes is taken as a centre/periphery indicator on a macro scale.

Time to Market, multimodal, meso scale



Time to market in minutes

- 150.58 - 206.43
- 206.43 - 236.08
- 236.08 - 258.65
- 258.65 - 277.9
- 277.9 - 296.48
- 296.48 - 319.06
- 319.06 - 347.67
- 347.67 - 379.84
- 379.84 - 417.2
- 417.2 - 505.21

Origin of data: own calculations

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 2.4 – Time to market at meso scale, weighted by GDP

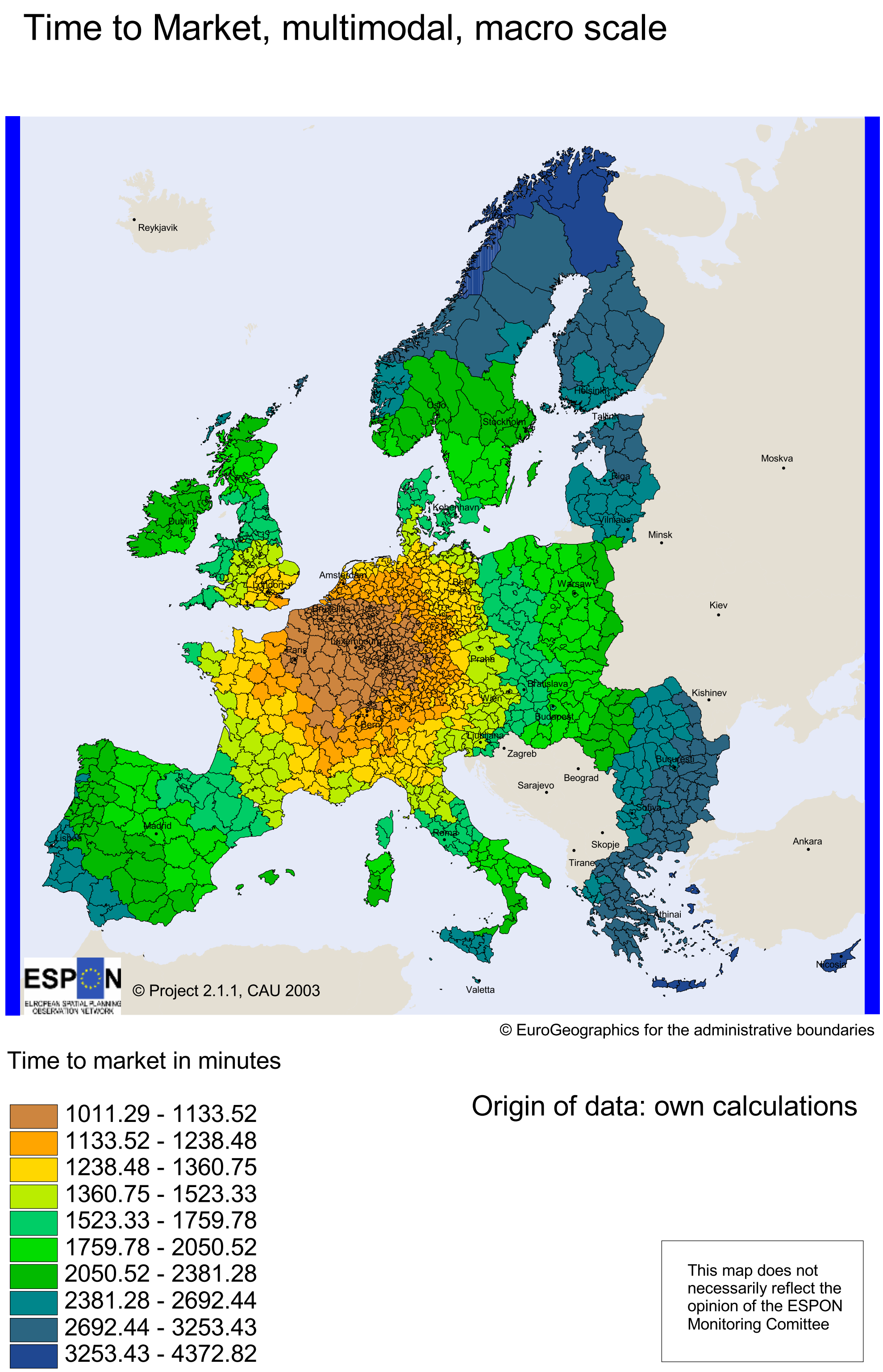
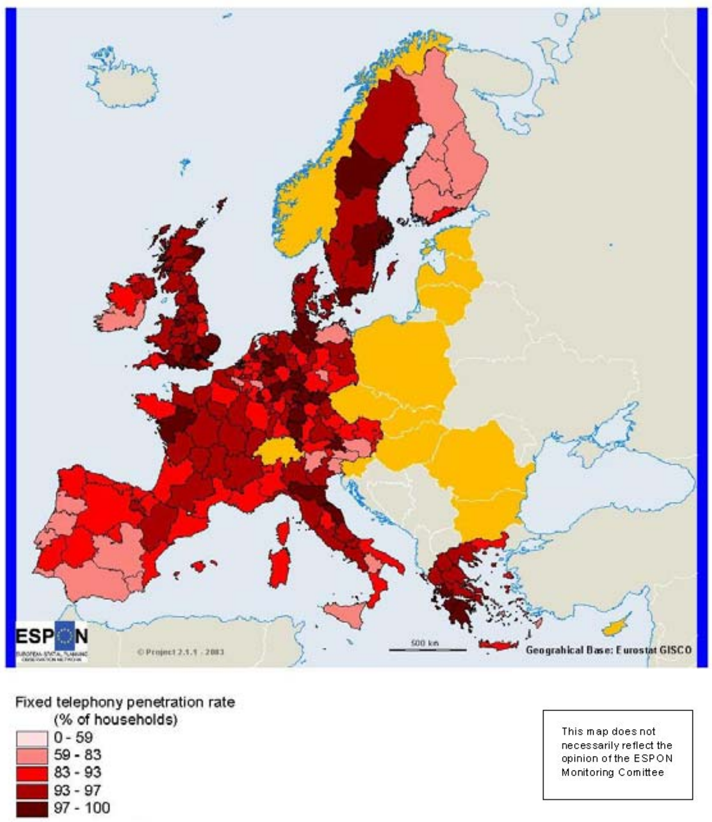


Figure 2.5 – Time to market at macro scale, weighted by GDP

2.2.2 *Regional Disparities in ICTs*

Current regional disparities in ICTs endowment, known as *digital divide*, are quite evident from the maps based on data extracted from the EOS Gallup Survey. In particular, here we present the maps concerning fixed telephony penetration (Fig. 2.6) and Internet connections (Fig 2.7), which are important indicators for our methodology, especially the second one.
The first map (Fig. 2.6) shows that the percentage of households having a fixed telephone is quite high everywhere, as it can be expected, due to the pervasive presence of the telephone in everyday life and its longer history. However, it is possible to highlight the presence of lower values in more peripheral countries with a lower GDP (Portugal, Spain, Ireland).

Figure 2.6 - Fixed telephony penetration



Also Finland shows low penetration rates for fixed telephone, but the reasons are different: here we find a leapfrogging phenomenon. In fact, in developed regions with low population density (like Finland and other Scandinavian regions), mobile and internet technologies developed at faster rates and conquered the market area of fixed telephones[5].

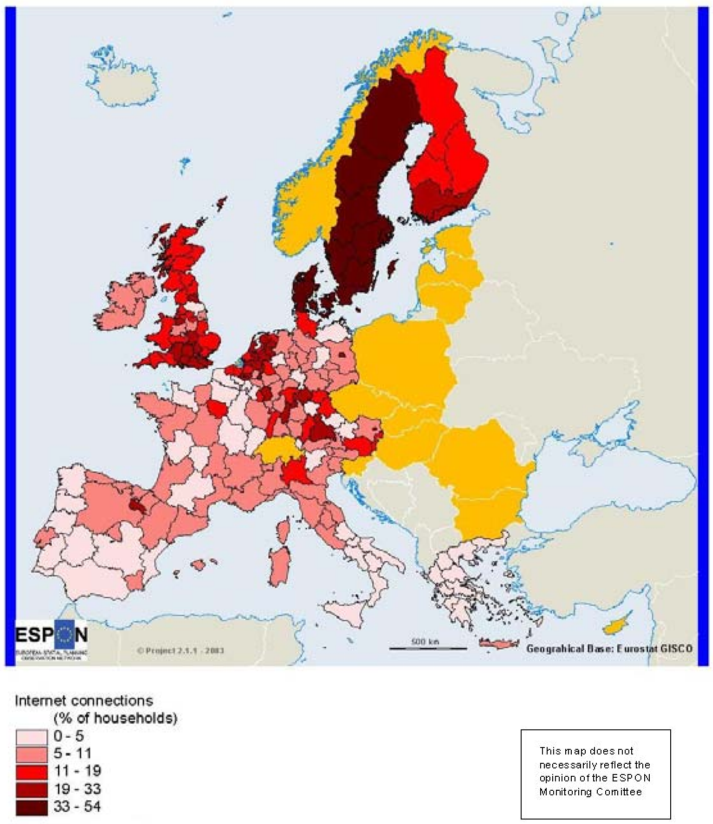
The Internet access at home is less widespread than fixed telephones (Figure 2.7), giving birth to a higher digital divide. This result, however, can be expected: this is a new technology and, compared to the fixed telephone, it is seen as less necessary. In this case, the correlation with the GDP is higher than for fixed telephones, with the exceptions of Sweden, Norway,

[5] It must be remembered that many important producers of mobile phones are located in Scandinavian Regions. For the maps of mobile telephony penetration rate, see EOS Gallup (1999).

Denmark and Finland, whose low population density favoured new communication technologies more than traditional ones. The most developed regions in terms of Internet connections are undoubtedly the Scandinavian regions, followed by the rich areas of central Europe.

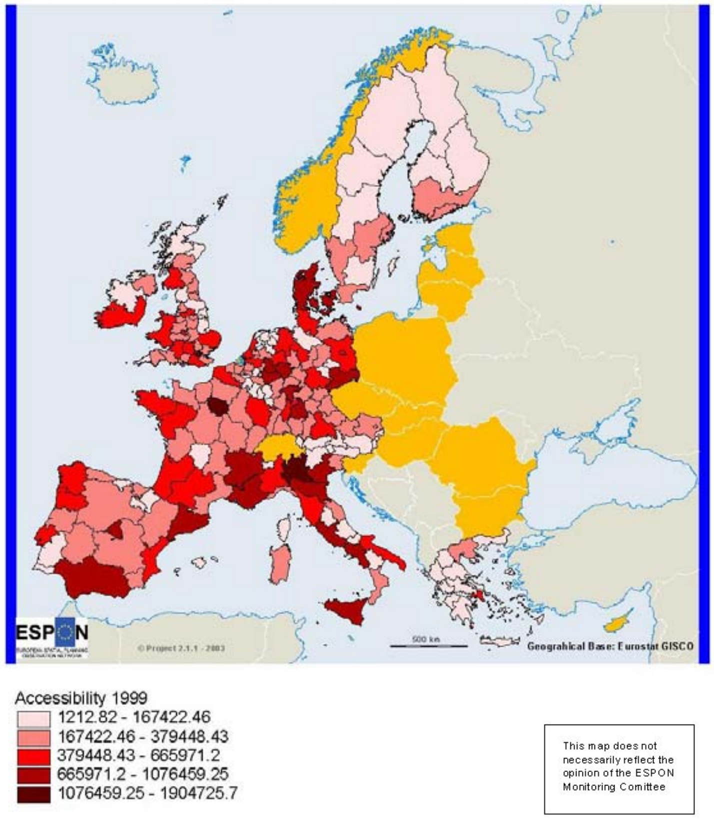
In order to estimate the per capita GDP, we built an accessibility indicator[6] which is in its turn important for the definition of current regional disparities, in terms of ICTs use (Fig 2.8). Our ICTs accessibility indicator, based on population and Internet use, highlights the good situation of geographically central and most populated regions, as expected, with some exceptions due to higher Internet use (southern Spain and Italy).

Figure 2.7- Internet connections



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

Figure 2.8 - ICTs Accessibility



2.3 Hypotheses and Expected Results

There is reason to believe that the 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 within the TEN and TINA programmes.

2.3.1 Hypotheses

However, transport and telecommunications policy must not be seen in isolation but must be put into the broader perspective of economic development in the enlarging European Union. Some hypotheses that appear to be plausible in the light of previous research are:

- Socio-economic and technical macro trends, such as ageing of the population, shifting labour force participation and increases in labour productivity may have a much stronger impact on regional socio-economic development than different transport infrastructure scenarios.

- Implementation of the TEN will lead to a slightly less polarised distribution of accessibility and GDP among European regions. This slight cohesion effect of the TEN will, however, not be able to reverse the general trend towards economic polarisation.

- The slight cohesion effect of the TEN are only visible if cohesion indicators measuring relative differences between TEN scenarios are applied. If absolute differences are considered, the results are ambiguous or may even indicate divergence in accessibility and economic development.

- Relatively large improvements in accessibility will translate into only relatively small increases in regional economic activity.

- Although the effects of European transport and telecommunications policies may be modest in a relative sense, they can still be substantial and significant with respect to some relevant aspects or regions concerned.

- Through the TEN and TINA projects most European regions will improve their accessibility and economic performance in absolute terms. However, numerous changes in the relative positions of regions and countries are to be expected. There may be relative losses of some regions, which can lead to absolute losses in the increasing economic competition between regions in the long run.

- The effects on polycentric development of European transport and telecommunications policies may depend on the specific combinations of pricing and network components. Pricing policies raising the general level of private transportation cost are likely to harm peripheral regions more than the centre, while congestion pricing mainly affects highly agglomerated and urbanised areas only. The latter are however not analysed in the modelling exercises of this report, and related hypotheses can not be tested.

- Apart from their effects on transport efficiency and economic benefits, European transport policies may support modal shifts from road to rail or waterways and relocate transport streams away from overloaded corridors.

- The impact of transport investments on economic development can be expected to be larger in regions with less developed networks than in regions with dense and well developed networks. In well developed networks, extensive investment programmes may be required to substantially change the accessibility pattern. However, the overall impact of transport investments will depend on the competitiveness of the regional economies: a peripheral area may benefit from better market access but its production may, on the other hand, be subject to a higher degree of competition from imports.

2.3.2 Expected Results

The main output of ESPON 2.1.1 will be model-based scenarios of the regional socio-economic impacts of European transport and telecommunications policies. Transport policies are analysed at the NUTS-3 level for the 15 present EU member states and the 12 candidate countries plus

Norway and Switzerland, while ICT policies are analysed only at NUTS-2 level for the 15 present EU members due to lack of data.

Scenarios to be studied are both retrospective (transport infrastructure scenarios for the decade 1991 to 2001) and prospective (to guide future European transport and telecommunications policy making). Scenarios to be studied include transport and telecommunications infrastructure as well as pricing policies (see Section 2.4).

These results will be presented in the form of maps, tables and diagrams and analysed with respect to spatial objectives, such as the polycentric spatial development objective and cohesion objective stated in the European Spatial Development Perspective (ESDP).

2.4 Policy scenarios

2.4.1 Transport Policy Scenarios

In this section the policy scenarios studied in the period reported in the Third Interim Report of ESPON 2.1.1 will be specified. The transport scenarios examined can be classified into infrastructure scenarios and pricing scenarios. The telecommunications scenarios will be presented separately in Section 2.4.2.

2.4.1.1. Infrastructure Scenarios

It is not feasible to model each possible combination of changes in the network separately, so we have taken a simple classification into road, rail and all projects (including air as a possible mode for substitution) and modelled the effects of the completion of each of these three groups separately. First this is done for those projects implemented between 1991 and 2001 (Scenarios A1 to A3). Secondly a judgement has been made on the most likely projects (in the same three broad groups) to be completed between 2001 and 2021 from the TEN, TINA and national lists (Scenarios B1 to B3).

The road and rail networks used in scenarios B1 to B3 are subsets of the pan-European network database developed by Institute of Spatial Planning of the University of Dortmund (IRPUD, 2001) comprising the trans-European networks specified in Decision 1692/96/EC of the European Parliament and of the Council (European Communities, 1996) and specified in the TEN implementation report (European Commission, 1998) and latest revisions of the TEN guidelines provided by the European Commission (1999a; 2002), the TINA networks as identified and further promoted by the TINA Secretariat (1999, 2002), the Helsinki Corridors as well as selected additional links in eastern Europe and other links to guarantee connectivity of NUTS-3 level regions. The strategic air network is based on the TEN and TINA airports and other important airports in the remaining countries and contains all flights between these airports.

The scenarios were implemented using the GIS-based European road, rail and air network database made available by the Institute of Spatial Planning of the University of Dortmund

(IRPUD). Parameters for transforming network information into cost estimates are imported from the SCENES project[7].

2.4.1.2 Pricing Scenarios

In order to provide a tractable set of alternatives we have defined three scenarios which aim to capture these alternative policy stances at a broad European level. The optimal pricing scenario (C3) assumes that all modes can be charged at close to their marginal social costs. For simplicity this would need to use average values for inter-urban transport, although it has to be recognised that most trips (passenger or freight) have both urban and inter-urban elements. Strictly speaking, we should allow for the local impacts when assessing the cost of using the high-level networks. But this would require a huge network loading model with congestion which is not available. Hence, repercussion from local congestion prices responsiveness to local congestion can not be dealt with in the quantitative approaches.

In practice, however, a move to the full optimum is not likely to occur in the short to medium term, for both policy and technological reasons. This makes it reasonable to define two policy scenarios which reflect the sort of policies which members states are using. First, we consider the effect of polices which aim to raise the cost of using road by a factor of 10 percent (Scenario C2). It is recognised that how this is done may have influences on behaviour and therefore on eventual outcomes – an across the board increase in licence fees or fuel tax would have very different impacts from a targeted use of 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[8], 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 payments being made by users of uncongested rural roads. We assume that a 10 percent increase would be a reasonable representation of the typical TEN corridor.

Secondly we defined the alternative scenario (C1) in which a better modal balance is sought by subsidising alternatives, in this case we model the effect of a 10 percent reduction in rail charges. Given the different contributions of road and rail to long-distance (especially international) transport it is arguable that more than a 10 percent reduction would be needed to have the same impact as a 10 percent increase in road charges, but we do not have sufficiently detailed evidence for the entire network to justify any alternative scenario.

For completeness we also defined a complete policy scenario (D) which combines all the planned infrastructure developments along with full marginal social cost pricing of all modes. There may be some inconsistency in such a scenario since it is clear that the imposition of a full marginal social cost pricing scenario 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. Scenario D should not be regarded as the ideal policy package.

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[7] See SCENES (2000)

[8] See evidence in Samson, T., C. Nash, P. Mackie, J. Shires and P. Watkiss (2001) *Surface transport costs and charges; Great-Britain 1998*. Institute for Transport Studies, University of Leeds, and evidence from the UNITE project *op cit*.

We have assumed that other policy elements relating to the organisation and competitive positions of the different modes are ultimately reflected in their cost to the user and hence we can model the impacts solely in terms of the impact of changes in costs on traffic. The interaction with other policy areas are assumed to work through the basic model inputs of GDP and population development.

Table 2.2 is a summary of the ten scenarios. Figures 2.9-2.11 show the trans-European road and rail networks and airports consisting of the TEN networks in the present European Union and the TINA networks in the east European candidate countries. The actual networks used in the scenario simulations B1-B3 and D are much more detailed but could not be represented at this scale. In all three maps, the TEN priority projects are highlighted. Figure 2.12 shows the trans-European waterway network, which, however, was not used in the present series of scenario simulations (this is intended for Year Two of ESPON 2.1.1, see Section 7.2).

Table 2.2. Summary of transport policy scenarios

Policy scenario		Scenario characteristics
Infrastructure (retrospective)	A1	Implementation of all rail projects 1991-2001
	A2	Implementation of all road projects 1991-2001
	A3	Implementation of all projects (road, rail) 1991-2001
Infrastructure	B1	Implementation of all most probable rail projects 2001-2021
	B2	Implementation of all most probable road projects 2001-2021
	B3	Implementation of all most probable projects (road, rail) 2001-2021
Pricing	C1	Reduction of the price of rail transport
	C2	Rise of the price of road transport
	C3	Full social marginal cost pricing of all modes
Pricing and infrastructure	D	Implementation of all most probable projects and full social marginal cost pricing of all modes (B3+C3)

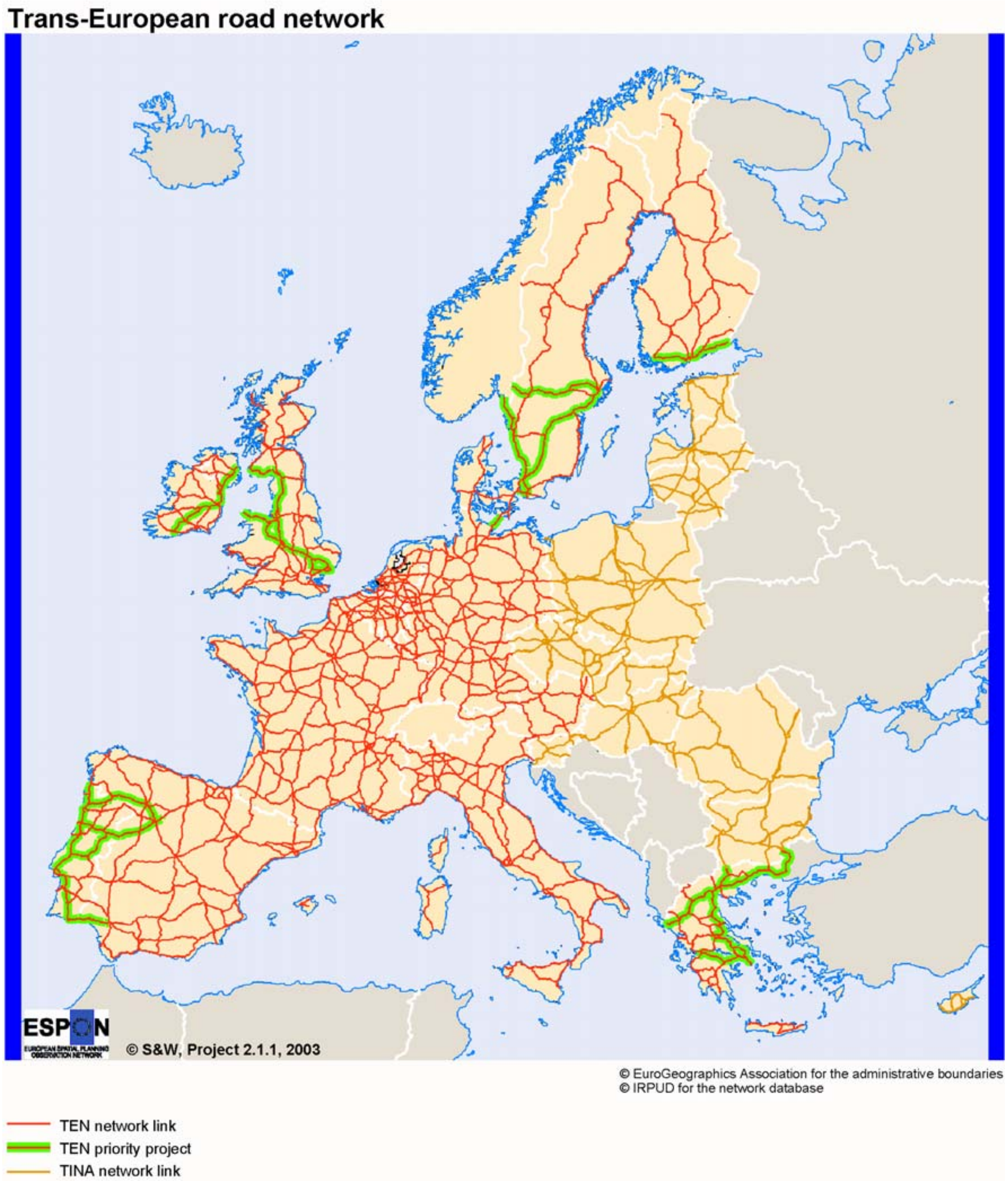

Figure 2.9: Trans-European road network

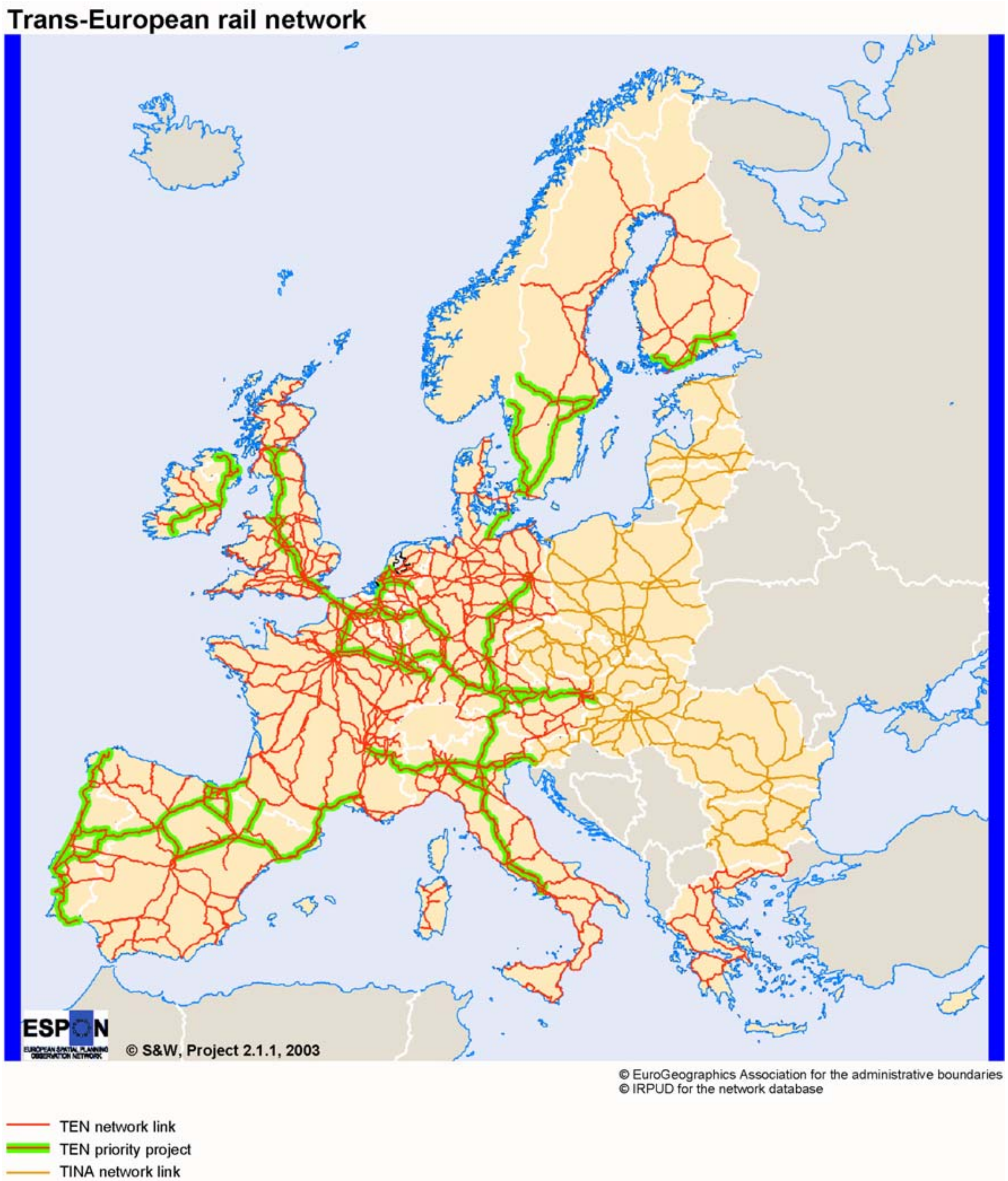

Figure 2.10: Trans-European rail network

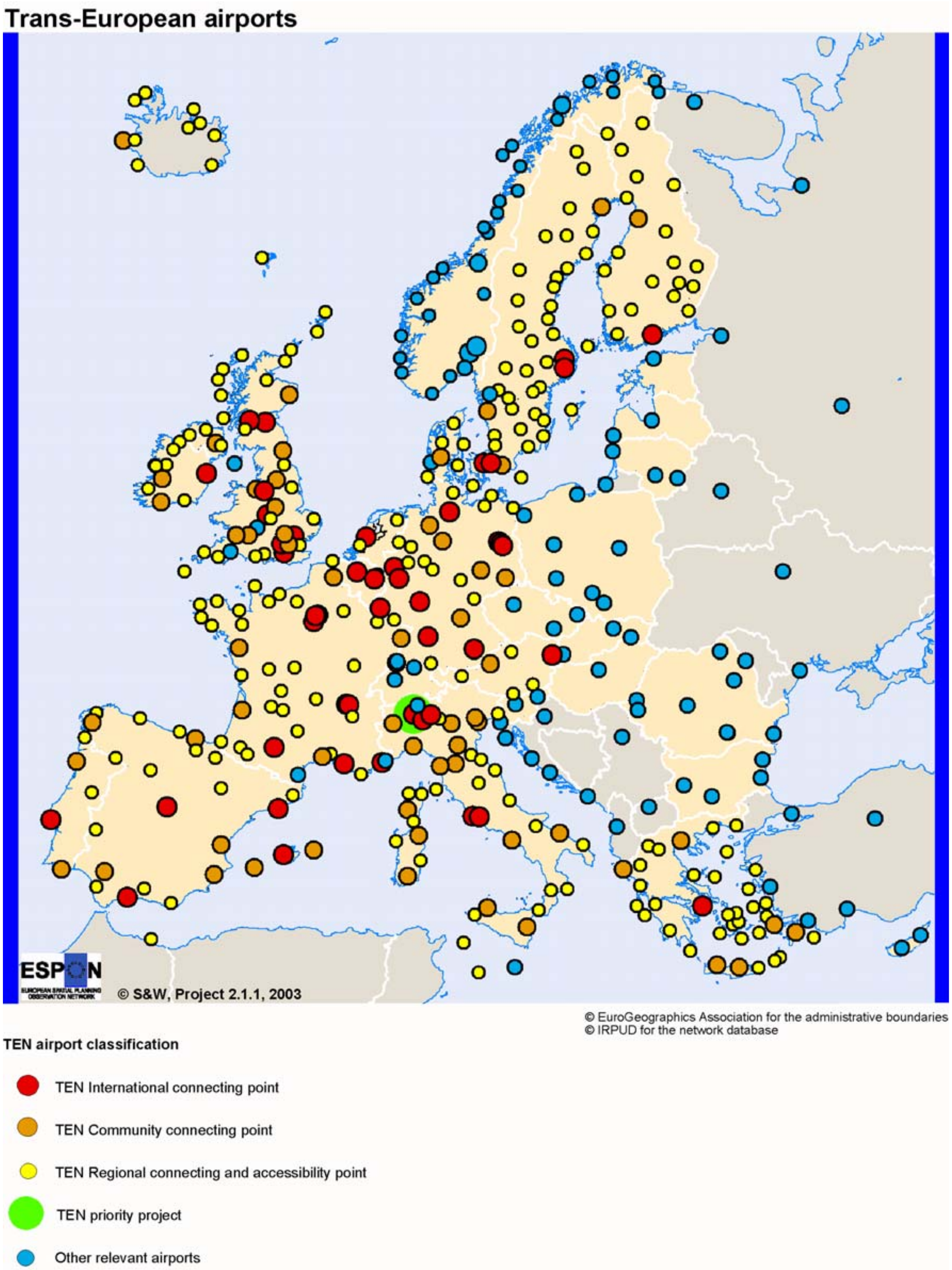

Figure 2.11: Trans-European airports

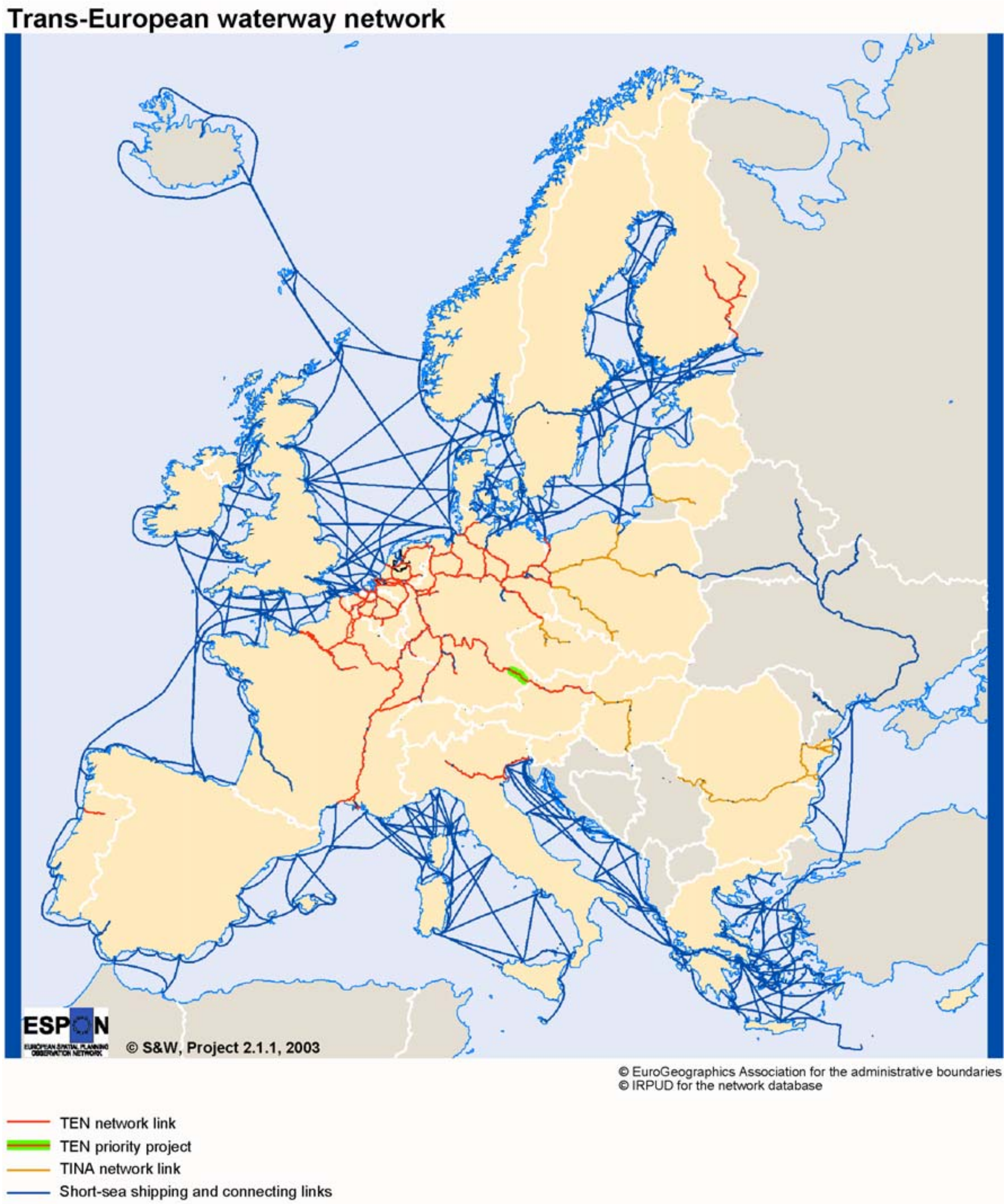

Figure 2.12: Trans-European waterway network

2.4.2 ICTs policy scenarios

The three main ICTs policies that the EU intends to implement are, according to the eEurope 2002 Action Plan of the Community:

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

These three policies have different impacts:

- the first policy generates positive effects that are captured by ICTs endowment increase. However, it does not act on real use (what we label “accessibility”). This policy can be applied to lagging areas to fill in 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 helps the adoption process in taking place (it acts on the degree of real 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, that 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 ICTs services (and their employment) in the economy, influencing long term efficiency of the whole productive system. In our model, this policy influences the high tech employment share.

Given a certain level of financial resources devoted to ICTs[9], three scenarios can be envisaged on the basis of the policies chosen (Table 2.3). Our time reference is a 20-year scenario, so we forecast the impact of the policy scenarios on regional per capita GDP at year 2020. These impacts are measured by a comparison of the future level of GDP in the respective scenario ("with"-case) with a do-nothing scenario ("without"-case). The percentage deviation of the with-case from the without-case is called the "growth rate" or just "growth" of the scenario. The growth rate of the do-nothing scenario is zero, by definition.

Scenario A: Indiscriminate ICTs scenario

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

Scenario B: Efficiency ICTs scenario

[9] The calculation method for the level of financial resources is presented in section 3.3.

The second scenario envisages the implementation of ICTs policies according to the higher marginal efficiency of the concerned ICTs factors.
In this scenario, 80% of financial resources in ICTs are devoted to non-lagging regions, that are more efficient, while the remaining 20% of investments goes to the lagging regions.

In each subgroup, investments are weighted by population, while, between subgroups, policies differ substantially:
- in objective 1 areas, ICTs accessibility policies are developed, with a 70% of regional resources, while limited resources are devoted to infrastructural development (30%);
- on the contrary, in advanced areas, ICTs infrastructure development policies are implemented with the 70% of regional resources, while the remaining 30% resources are devoted to ICTs accessibility.

The rationale behind this scenario lays in the different marginal efficiency of Internet connection and accessibility[10]: 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 overcome of the existing congestion effects. On the contrary, the peripherality of non-lagging areas could be reduced through an increase in accessibility, while the existing infrastructures are sufficient for the present regional needs.

Table 2.3 - Distribution of investments by regions and ICTs policies, according to the different ICTs scenarios

ICTs Scenarios	**Regions**	**ICTs Policies**
Scenario A *Indiscriminate scenario*	<u>All regions</u> Investments distributed according to regional population	<u>All regions</u> 33% Accessibility 33% Internet 33% High tech employment
Scenario B *Efficiency scenario*	<u>Lagging regions</u> 20% of total investments Investments distributed according to the share of lagging regions population <u>Non lagging regions</u> 80% of total Investments Investments distributed according to the share of non lagging regions population	<u>Lagging regions</u> 70% Accessibility 30% Internet <u>Non lagging regions</u> 30% Accessibility 70% Internet
Scenario C *Cohesion scenario*	<u>Lagging regions</u> 100% of total investments Investments distributed according to the share of lagging regions population	<u>Lagging regions</u> 33% Accessibility 33% Internet 33% High tech employment

[10] For marginal efficiency, see Table 3.17 in section 3.3.

Scenario C: Cohesion scenario

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

These scenarios provide very different territorial impacts:

1. the first scenario should highlight a weak impact on efficiency and a 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. The null effects on regional disparities is expected, since if any positive effect on efficiency is developed, it is equally distributed over regions;
2. the second scenario 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;
3. the third scenario is expected to provide a positive impact on regional disparities, since it is devoted to favouring the low-income regions.

2.5 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. These contents of these tables is shown in annex C.

Typologies provided be the ESPON database V2.2 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.

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.

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 part “polycentric connectivity”.)

Unemployment

The Basis of the typology of unemployment is a ranking by the unemployment rate 2000. This indicator is cut into three classes low, medium and high grouping a third of the ESPON space total population each.

Time to market

The time to market indicators building up several regional accessibility classifications based on the time to market (logsum) indicator calculated by CAU. There are two versions, the regional scope with a halftime parameter of 25 minutes (GDP, meso) and the continental scope with a half-life parameter of 1000 minutes (GDP, macro), as presented in Figures 2.4 and 2.5. The classes most central, central, medium, peripheral and most peripheral are defined by population quintiles (assuming the overseas as peripheral).

There is also a four class typology (time to market (weighted by GDP, micro vs. macro level) which a combination of the above in a three class version (breaks at 30 percent and 70 percent): Regions with the same class at both micro and macro level are classified as “central” or “peripheral”, regions with one level as central and the other as peripheral are classified as “contrary” and the remaining region are set to “medium”.

Multimodal Accessibility Potential:

This typology 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 Modelling the Territorial Impact of Transport and ICT Policies

3.1 SASI

The SASI model is based on an extension of the production-function approach in which the classical production factors are complemented by one or more variables representing the locational advantage or accessibility of a region. The SASI model was developed in the 4th RTD Framework SASI project and updated and extended in the 5th RTD Framework IASON project. In this section the application of the SASI model for ESPON 2.1.1 is presented. The presentation starts with a specification of the model as implemented for ESPON 2.1.1. Next the calibration of this version is briefly documented. Finally, preliminary results for the ten policy scenarios defined in Section 2.4 of this report are presented.

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.

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.

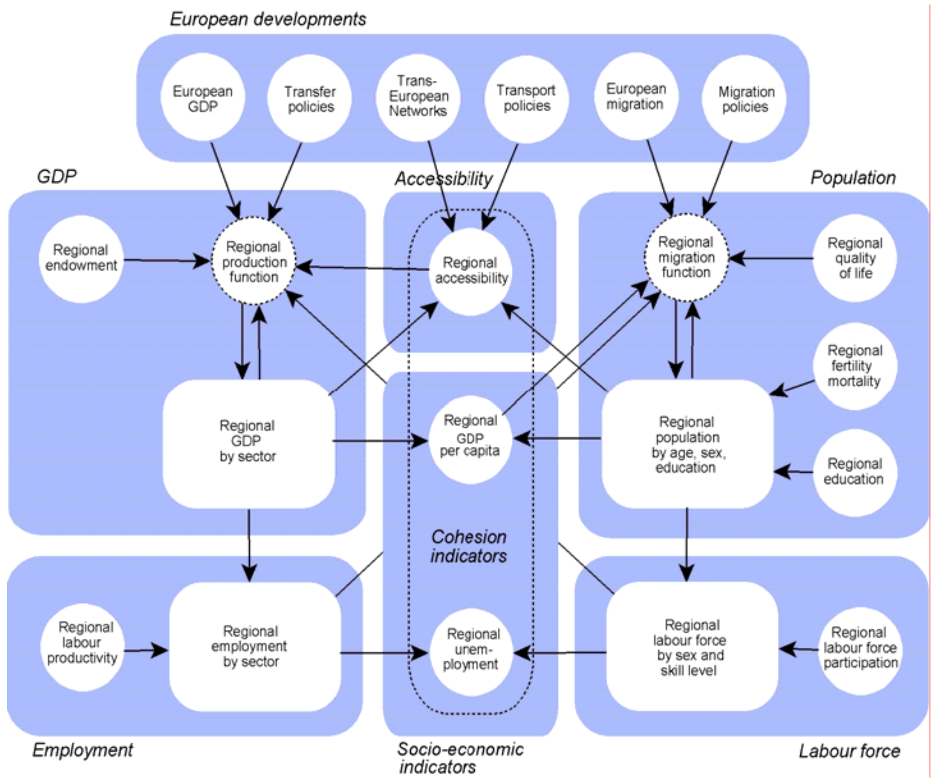

Figure 3.1. The SASI model

The *spatial* dimension of the model is established by the subdivision of the European Union and the 12 candidate 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 labour force. In addition cohesion indicators expressing the impact of transport infrastructure investments and transport system improvements on the convergence (or divergence) of socio-economic development in the regions of the European Union are calculated. The *temporal* dimension of the model is established by dividing time into periods of one year duration. 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 is contained in EUNET/SASI Deliverable 8 (Wegener and Bökemann, 1998). The implementation of the original SASI model was described in EUNET/SASI Deliverables 11 (Fürst et al., 1999) and 13 (Wegener et al., 2000). The results of the demonstration scenario simulations with the original SASI model were presented in EUNET/SASI Deliverable D15 (Fürst et al., 2000). The extended version of the SASI model used in the IASON project is described in IASON Deliverable D2 (Bröcker et al., 2002a) and the IASON Common Spatial Database used for the model in IASON is presented in IASON Deliverable D3 (Bröcker et al., 2002b).

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

The *European Developments* submodel is not a 'submodel' in the narrow sense because it simply prepares 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 12 candidate 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 to the model means that the model is prevented from making forecasts about the general increase in production through transport infrastructure investments, although in principle its parameters are estimated in a way that makes it capable of doing that.

(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 2001) received by the regions in the European Union during the period 1981 to 1997 and forecasts for the period 1998 to 2016. These data are provided only for those regions that actually received financial support in the past or are assumed to receive support in the future.

(4) *Assumptions about immigration policies by European countries*. Given the expected rapid population growth and lack of economic opportunity in many origin countries, total European immigration will largely be influenced by policy decisions by national governments. These assumptions are reflected by upper limits for annual immigration from non-EU countries to the countries of the European Union for the years 1981 to 1997 and forecasts for the years 1998 to 2016.

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 (TETN).* 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.

(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 2.4).

Regional Accessibility

This submodel calculates regional accessibility indicators expressing the locational advantage of each region with respect to relevant destinations in the region and in other regions as a function of the travel time or travel cost (or both) needed to reach these destinations by the strategic road, rail and air networks.

The method to calculate accessibility indicators used for the SASI model was described in Schürmann et al. (1997) and Fürst et al. (1999). Of the different accessibility indicators described there, for ESPON 2.1.1 potential accessibility was selected:

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

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 usually represented by population or GDP in s, and is $c_{rsm}(t)$ is the generalised travel cost between regions r and s.

The generalised travel costs $c_{kjm}(t)$ 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 converted to costs using a Europe-wide value of time. For the cost component, mode-specific cost functions made available by the SCENES project were used. The barrier component consists of border waiting times (only for road traffic) and political and cultural barriers expressed as time penalties – all converted to costs using the same Europe-wide value of time. The political barriers are 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.

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):

$$c_{rs}(t) = -\frac{1}{\lambda} \ln \sum_{m \in \mathbf{M}_{rs}} \exp[-\lambda\, c_{rsm}(t)] \qquad (3.2)$$

where $\boldsymbol{M}_{rs}$ is the set of modes available between regions r and s.

Regional GDP

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 six economic sectors in order to take different requirements for production by each sector into account. In order to be independent form region size, the regional production function used here predicts annual regional GDP per capita:

$$q_{ir}(t) = \mathrm{f}\,[\mathbf{C}_{ir}(t), L_{ir}(t), \mathbf{A}_{ir}(t), S_r(t), R_{ir}] \tag{3.3}$$

where q_{ir}(t) is annual GDP per capita of industrial sector i in region r in year t, $\boldsymbol{C}_{ir}(t)$ *is* a vector of endowment factors relevant for industrial sector i in region r in year t, $L_{ir}(t)$ is labour relevant for industrial sector i in region r in year t, $\boldsymbol{A}_{ir}$ is a vector of accessibility indicators relevant for industrial sector i in region r in year t, $S_r(t)$ are annual transfers received by the region r in year t and R_{ir} is a region-specific residual taking account of factors not modelled (see below). Note that, even though annual GDP per capita is in fact a flow variable relating to a particular time interval (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 results of the regional GDP per capita forecasts are adjusted such that the total of all regional forecasts meets the exogenous forecast of economic development (GDP) of the European Union as a whole by the *European Developments* submodel (see Section 3.1.1).

Regional GDP by industrial sector is then

$$Q_{ir}(t) = q_{ir}(t)\; P_r(t) \tag{3.4}$$

Regional Employment

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:

$$p_{ir}(t) = p_{ir}(t-1)\,\frac{p_{ir'}(t)}{p_{ir'}(t-1)} \quad \text{with } r \in \boldsymbol{R}_{r'} \tag{3.5}$$

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 $\boldsymbol{R}_{r'}$ 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

$$E_{ir}(t) = Q_{ir}(t) / p_{ir}(t) \qquad (3.6)$$

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

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. Here only a summary of the method is given; for full details see IASON Deliverable D2 (Bröcker et al., 2002a).

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. Both migration within the European Union and immigration from non-EU countries are modelled as annual regional net migration.

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

Regional Labour Force

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 (see IASON Deliverable D2 (Bröcker et al., 2002a).

Socio-Economic Indicators

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.
From the policy-relevant indicators so derived, equity or cohesion indicators describing their distribution across regions are calculated. 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. The SASI model calculates five types of cohesion indicator: (i) the coefficient of variation, (ii) the GINI coefficient, (iii) the ratio of the geometric and the arithmetic mean, (iv) the correlation between relative change and level and (v) the correlation between absolute change and level. These indicators are explained in detail in Section 4.3.

3.1.2 The Model Database

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

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 in 1981, 1986, 1991, 1996
  - Regional labour productivity by industrial sector in 1981, 1986, 1991, 1996
  - Regional endowment factors in 1981, 1986, 1991, 1996
  - Regional labour force in 1981, 1986, 1991, 1996
  - Regional transfers in 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 are reference data with which the model results in the period 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 or unobserved 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) in 1981, 1986, 1991, 1996, 2001
  - Regional GDP (by industrial sector) in 1981, 1986, 1991, 1996, 2001

Regional labour force (by sex) in 1981, 1986, 1991, 1996, 2001
Regional employment (by industrial sector) in 1981, 1986, 1991, 1996, 2001
Regional unemployment rate in 1981, 1986, 1991, 1996, 2001

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, 1981-2021
- Changes of node and link data of strategic rail network, 1981-2021
- Changes of node and link data of air network, 1981-2021

3.1.3 Model Calibration

The regional production function in the *Regional GDP* submodel and the migration function in the *Regional Population* submodel are the only model functions *calibrated* using statistical estimation techniques. All other model functions are *validated* by comparing the output of the whole model with observed values for the period between the base year and the present.

As explained in Section 3.1.1, a multiplicative Cobb-Douglas function was selected for the regional production function (Equation 3.3):

$$q_{ir}(t) = \boldsymbol{X}_{ir}^{\alpha}(t)\, L_{ir}^{\beta}(t)\, \boldsymbol{A}_{ir}^{\gamma}(t)\, S_{ir}^{\delta}(t)\, C_{i}^{\varepsilon} R_{ir} \quad (3.7)$$

The parameters of this function were estimated using multiple regression after logarithmic transformation of both sides of the equation. Table 1 shows the estimated parameters for the six sectors distinguished in SASI (1) agriculture, (2) manufacturing, (3) construction, (4) trade, tourism and transport, (5) financial services, and (6) other services.

Table 3.1 shows that despite the high spatial resolution and the very uneven quality of the data GDP per capita in manufacturing, construction, financial services and other services can be reasonably well predicted. GDP per capita in agriculture is difficult to predict because agriculture is particularly dominant in peripheral regions with general low GDP per capita. Trade, tourism and transport present special difficulties because they contain industries with very heterogeneous locational preferences. Figure 3.2 shows observed and predicted GDP aggregated over sectors and NUTS-2 regions in 1996.

Table 3.1. SASI model: calibration results

Variables	Regression coefficients					
	Agri-culture	Manu-facturing	Con-struction	Trade, tourism, transport	Financial services	Other services
Labour productivity	0.219680	0.775231	0.513157		1.119678	0.925795
Regional labour market		0.026143				
Multimodal accessibility		0.132848	0.156445	0.147456	0.254585	0.273964
Road accessibility freight	-0.863594					
Population density				0.123694		
Developable land				-0.417147		
Quality of life				1.018147		
Educational attainment			0.153949	0.839816		0.032991
R&D investment		0.234527	0.027240			
Soil quality	0.160915					
Agricultural subsidies	0.010099					
Constant	3.766711	-2.468403	-2.501576	1.322318	-4.25950	-3.648600
r^2	0.206	0.769	0.572	0.334	0.790	0.816

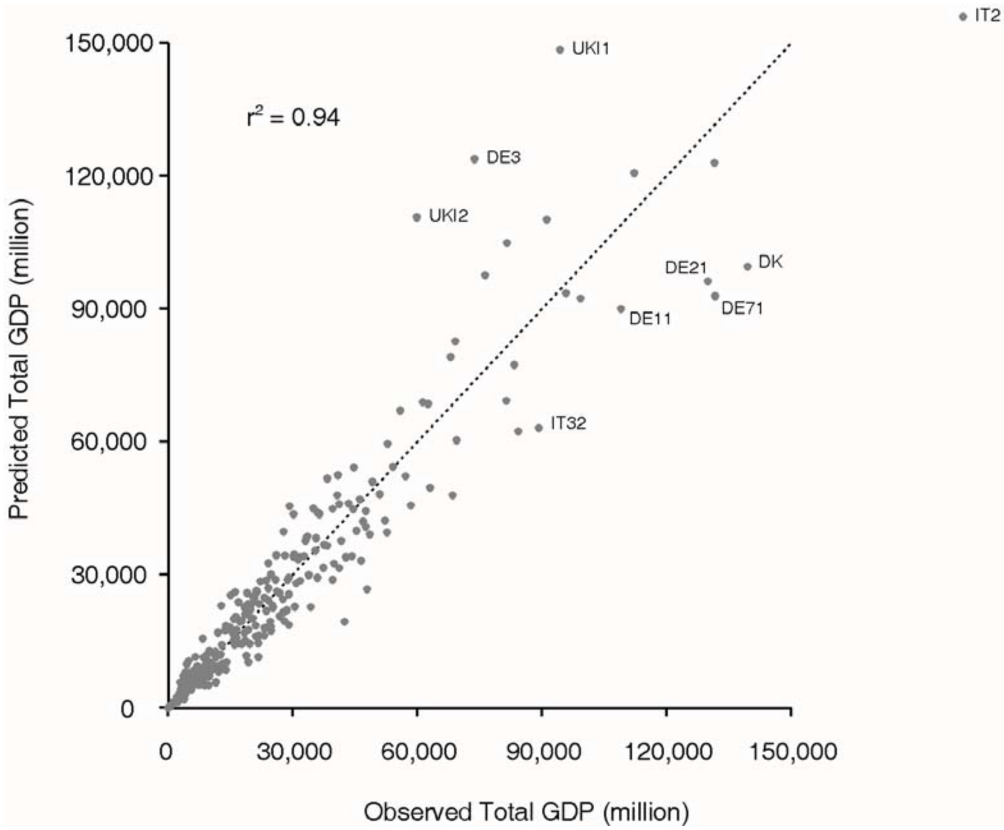

Figure 3.2 SASI model calibration results: total GDP in 1996

3.1.3 Model Results

With the calibrated model the ten transport policy scenarios defined for ESPON 2.1.1 (see Section 2.4) were simulated. As it was explained in Section 2.4, there are two sets of transport scenarios in ESPON 2.1.1. The retrospective scenarios A1-A3 cover the decade between 1991 and 2001. The prospective scenarios B1-D cover the period between 2001 and 2021. Accordingly, two different reference scenarios are needed:

- The retrospective scenarios A1-A3 are to analyse the spatial impacts of transport policies already implemented. Therefore the reference scenario for these scenarios is a scenario in which none of the transport infrastructure projects actually completed between 1991 and 2001 is implemented.

- The prospective scenarios B1-D are to analyse the likely effects of possible future transport policies. The reference scenario for these scenarios is therefore defined as one in which no transport infrastructure projects or pricing scenarios are implemented after 2001.

In this section the results of the ten policy scenarios defined in Section 2.4 are presented. The presentation always compares accessibility and GDP per capita in the policy scenarios with the corresponding values in the reference scenario in the years 2001 (for scenarios A1-A3) and 2021 (for scenarios B1-D).

Tables 3.2 and 3.3 show differences in accessibility and GDP per capita compared with the reference scenario for the present European Union, Norway and Switzerland, the candidate countries and the whole ESPON space. Figures 3.2-3.5 show, as examples, the spatial distribution of these differences for scenarios A3 and B3.

As to be expected, accessibility is improved in all A and B scenarios, as these assume infrastructure investments and improvements compared with their respective reference scenarios (Table 3.2). However, the situation is more complex in the pricing scenarios C1 to D1. Scenario C1, in which rail transport fares are reduced, results in an increase in accessibility, and scenarios C2 and C3, in which transport prices are increased results in a reduction of accessibility. Scenario D is a combination of infrastructure scenario B3 and social marginal cost pricing scenario C3, accordingly its net change in accessibility is somewhere between the gains in scenario B3 and the losses in scenario C3, but as the gains in B3 are much larger, the net result is still positive. It is important to note that these numbers are not changes over time but relative differences between the policy scenario and the corresponding reference scenario; over time *all* regions gain in accessibility.

The next thing to note is that the relatively large differences in accessibility translate into only very small differences in GDP per capita (Table 3). Despite the huge transport investments in some scenarios, no region gains more than a few percent in GDP per capita as a consequence of these investments – and this over a period of one (in scenarios A1-A3) or even two decades (in scenarios B1-D). And now the direction of the effects is not so straightforward. The SASI model takes account of interregional competition, and although (as the last row of Table 3 shows) it does not assume a zero-sum game, there are winners and losers. For instance, a new motorway or high-speed rail line connecting a peripheral region to the European core, may improve its possibilities to reach European markets but at the same time it also opens it up to possibly more efficient competitors from other regions. The effects are also small because no construction period effects are taken into account.

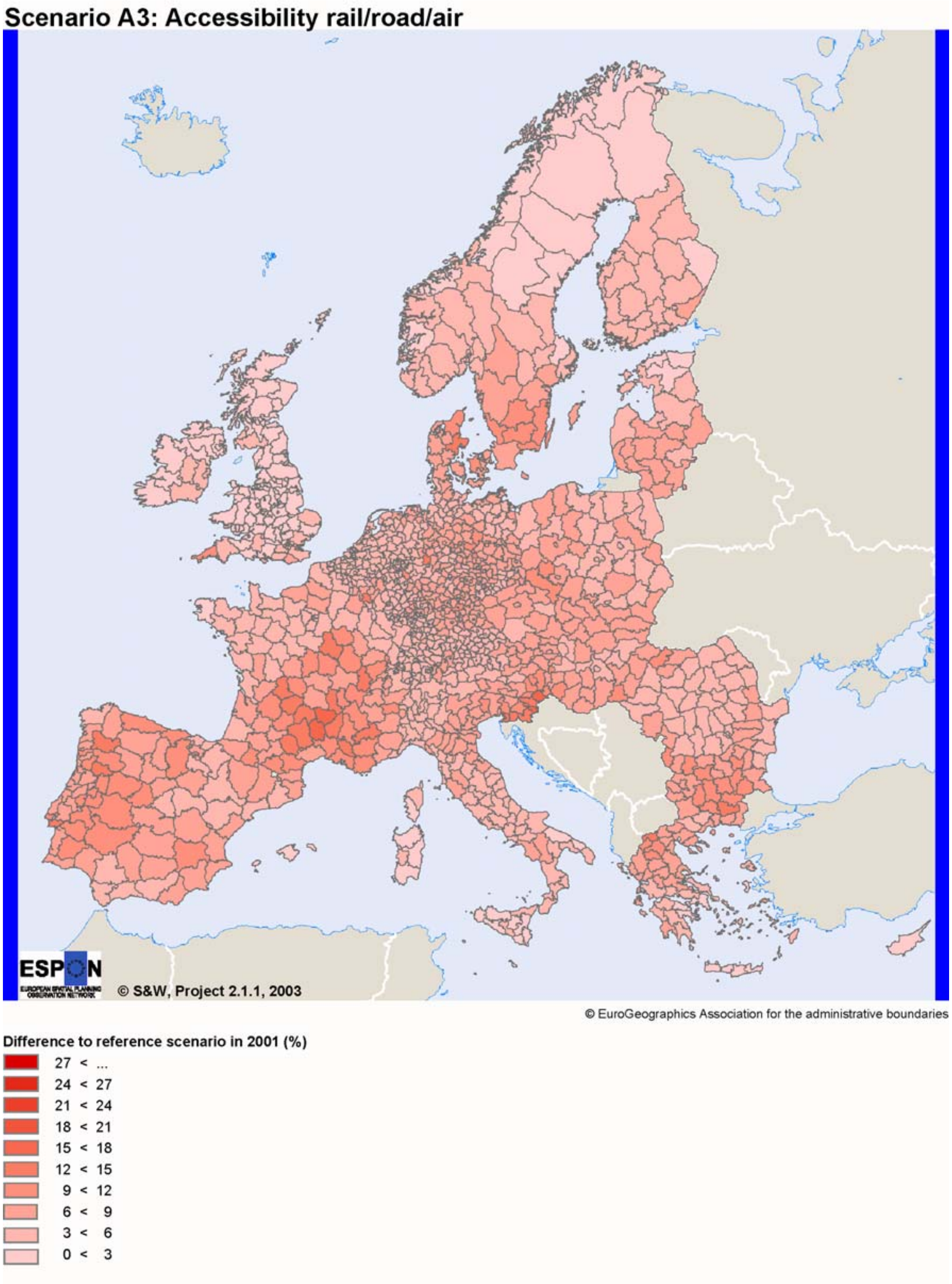

Figure 3.3: Scenario A3: accessibility difference (%) compared to reference scenario in 2001

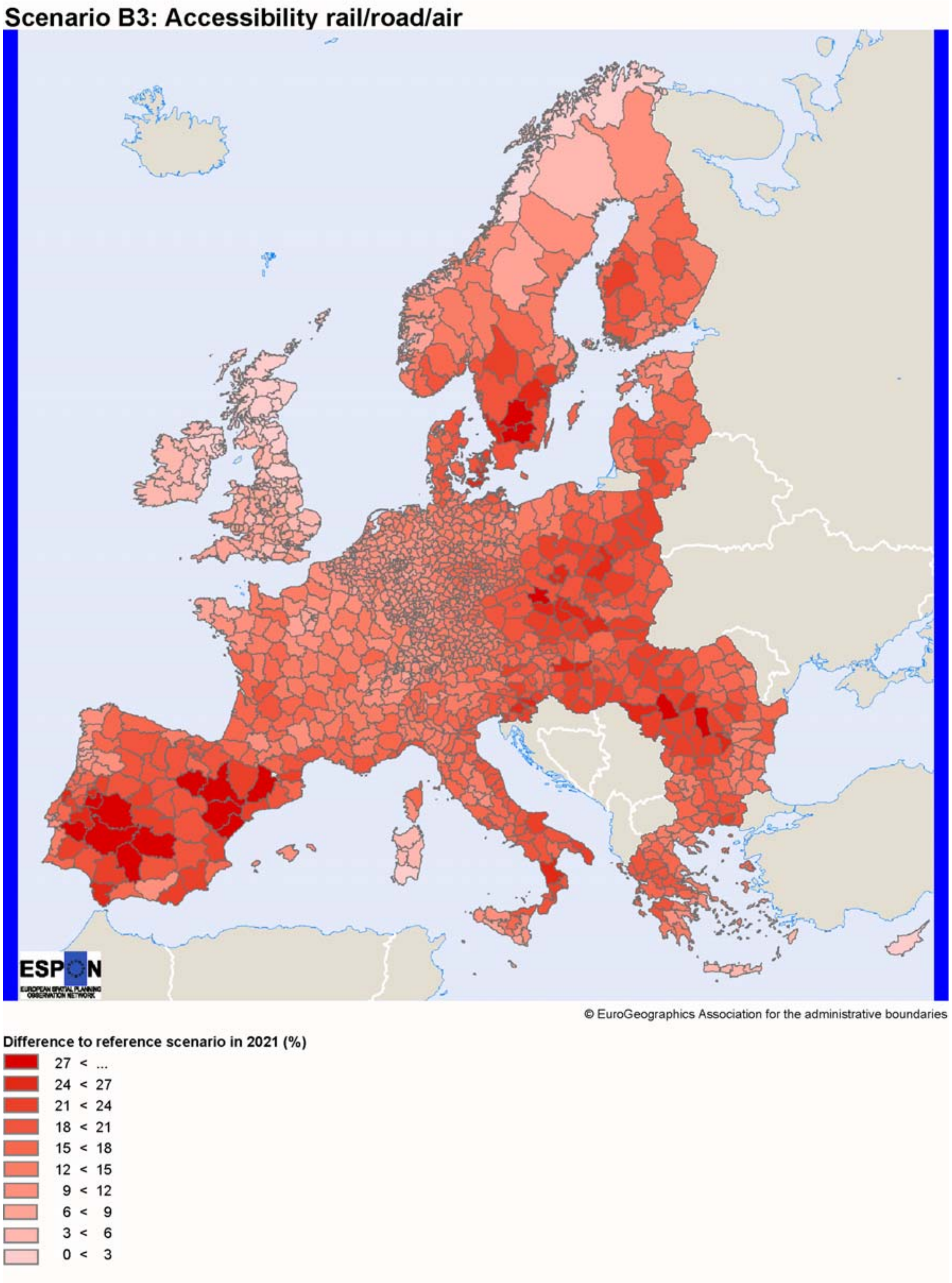

Figure 3.4: Scenario B3: accessibility difference (%) compared to reference scenario in 2021

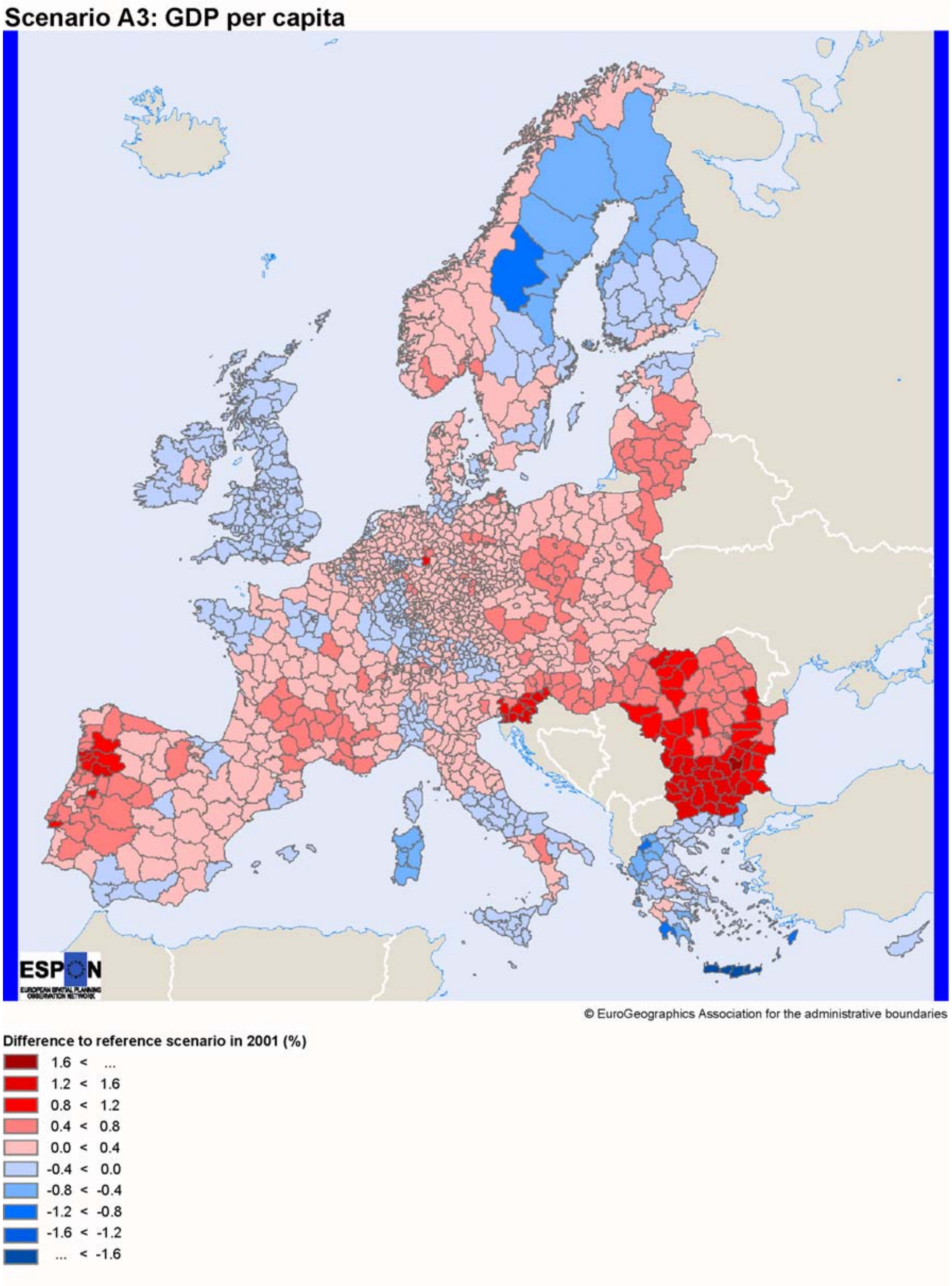

Figure 3.5: Scenario A3: GDP per capita difference (%) compared to reference scenario in 2001

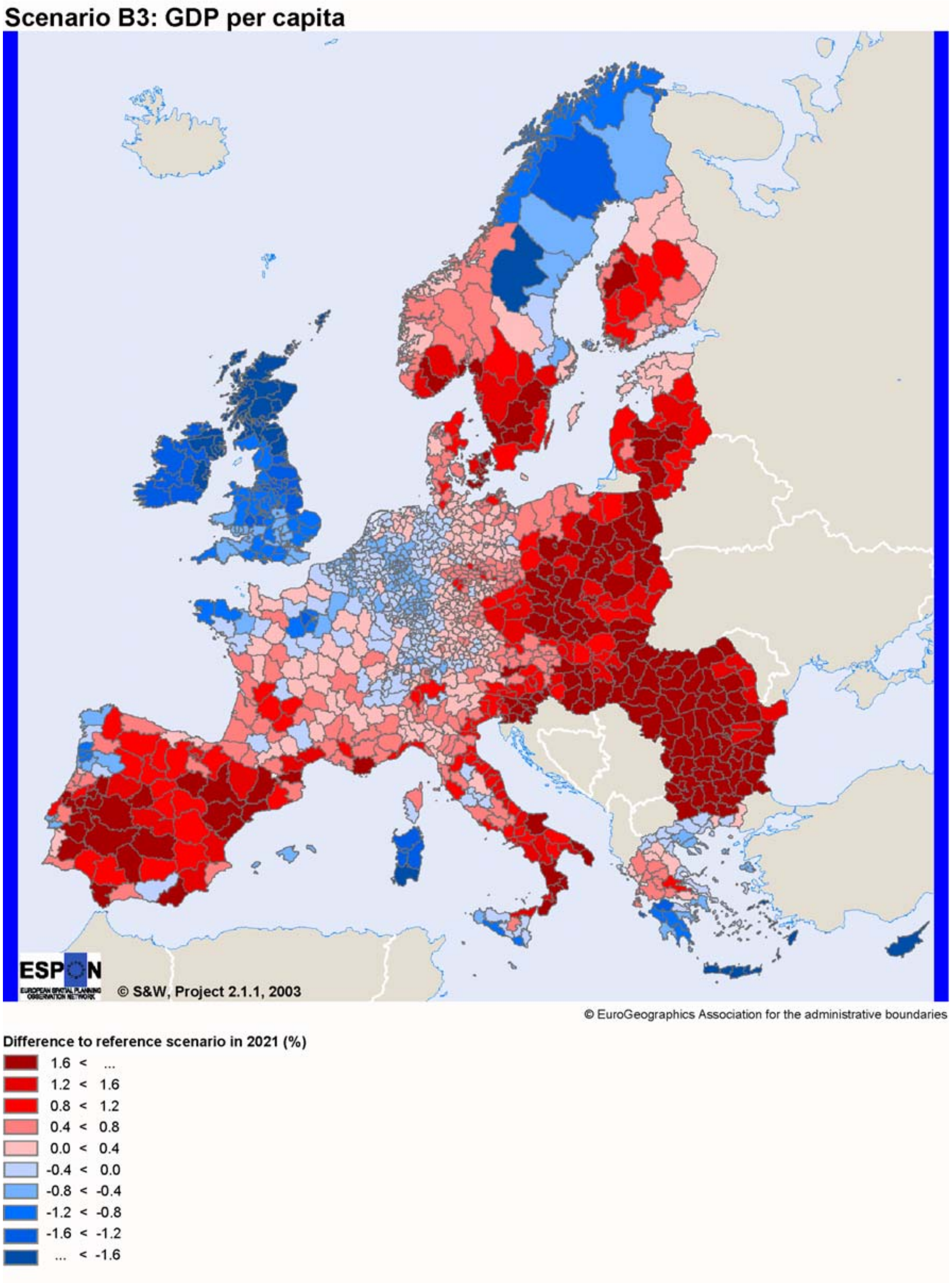

Figure 3.6: Scenario B3: GDP per capita difference (%) compared to reference scenario in 2001

Table 3.2. SASI model results: accessibility

Country	Accessibility differences compared with reference scenario (%)									
	2001			2021						
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1
EU15	+2.38	+3.27	+5.32	+9.32	+4.52	+12.47	+1.67	–1.78	–6.17	+5.77
CH+NO	+1.96	+3.45	+5.12	+6.21	+5.73	+10.71	+1.46	–1.83	–6.57	+3.87
CC12	+3.15	+3.56	+6.28	+11.86	+12.08	+20.12	+1.21	–1.17	–3.81	+15.80
EU27+2	+2.51	+3.33	+5.50	+9.74	+5.97	+13.88	+1.58	–1.67	–5.73	+7.63

Table 3.3. SASI model results: GDP per capita

Country	GDP per capita differences compared with reference scenario (%)									
	2001			2021						
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1
EU15	+0.00	+0.02	+0.02	+0.01	–0.01	+0.00	+0.00	–0.02	–0.01	–0.02
CH+NO	–0.36	+0.32	+0.29	–0.42	+0.65	+0.25	+0.00	–0.94	–1.32	–1.04
CC12	–0.39	+0.48	+0.55	+0.27	+1.72	+1.61	–0.06	–1.07	–0.77	+0.77
EU27+2	–0.04	+0.06	+0.06	+0.00	+0.11	+0.09	+0.00	–0.12	–0.12	–0.03

With this in mind, it can be seen that the huge investments for the trans-European transport networks (TEN-T) 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-D). The effects for Switzerland and Norway (CH+NO) and for the candidate countries (CC12) are much larger, in the future those for the candidate countries are even larger because of the expected implementation of the TINA projects. The overall effects for the whole ESPON space (EU29) are, of course, the weighted average of the effects for these three groups of countries. Again it has to be remembered that these 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.

In both the past and the future the effects of road infrastructure projects (scenarios A2 and B2) are significantly larger than those of rail infrastructure projects (scenarios A1 and B1). In the years 1991-2001 only few new high-speed rail lines were opened in scenario A1, mainly in France and Spain; therefore the relative effect for Switzerland and Norway and the candidate countries was negative.

The pricing scenarios C1-C3 are in general negative for the economy at large because they increase the costs of trade and mobility. A reduction of rail fares (scenario C1) has only little effect, if anything there is a slight negative effect for the candidate countries. The negative economic effects of road pricing (scenario C2) and general social marginal cost pricing of transport (scenario C3) are stronger and again more pronounced in the candidate countries, As with accessibility, the results for the combination scenario D1 lie somewhere in between scenarios B3 and C3.

Finally, the results will be analysed with respect to their cohesion effects, again for accessibility and GDP per capita. For this five cohesion indicators were calculated (i) the coefficient of variation, (ii) the GINI coefficient, (iii) the ratio of the geometric and the arithmetic mean, explained in Section 4.1, (iv) the correlation between relative change and level and (v) the correlation between absolute change and level.

Tables 3.4 and 3.5 summarise the results of this analysis. All five indicators are constructed in a way that a higher value indicates a higher degree of divergence or polarisation, or an increase in interregional disparities, whereas a lower value indicates more cohesion or convergence, or a decrease in interregional disparities. For easier interpretation, in Tables 4 and 5 indicator values were translated into cohesion effects where a plus sign indicates more cohesion and a minus sign more polarisation.

The two tables strongly underline the frequently expressed warning that the assessment of cohesion effects of policies critically depends on the choice of cohesion indicator. In this context it is of particular importance whether relative or absolute changes are considered. For instance, a policy which increases accessibility or GDP per capita in each region by the same percentage, is cohesion-neutral if relative differences are considered but obviously gives a much larger advantage to regions which already enjoy above-average accessibility or GDP per capita if absolute differences are taken into account.

Of the five indicators shown in Tables 3.4 and 3.5, four measure relative differences: The coefficient of variation, the GINI coefficient and the ratio of geometric and arithmetic mean give all more or less similar results. The coefficient of correlation between change in accessibility (or GDP per capita) and the level of accessibility (or GDP per capita) indicates the cohesion effect by its sign: if it is positive, growth occurs mainly in regions with above-average accessibility (or GDP per capita), if it is negative, mainly in lagging regions. The fifth indicator does the same but for absolute change and so is the only one that can reveal that a region may be a winner in relative terms but a loser in absolute terms.

With this perspective, all infrastructure scenarios (A1-B3) reduce disparities in accessibility in relative terms because they improve accessibility in the candidate countries more than in the present EU member states in relative terms (see Table 2). However, if absolute differences are considered, the peripheral countries turn from relative winners into absolute losers because their gains in accessibility are much smaller than those of the more central countries.

The transport pricing scenarios C1-C3 increase or reduce disparities in accessibility depending on the direction of cost changes. Reducing rail fares (scenario C1) has similar effects as building infrastructure: pro-cohesion in relative terms and anti-cohesion in absolute terms. The two pricing scenarios with cost increases (scenarios C2 and C3) increase disparities in accessibility but the effects in both relative and absolute terms are very small. Again the combination scenario D1 lies between scenarios B3 and C3, the coefficient of variation and the GINI coefficient indicate that this scenario at first increases but in the long run reduces disparities in accessibility.

Table 3.4. SASI model: accessibility cohesion effects

	Accessibility cohesion effects (+/–)									
	1991-2001			2001-2021						
Indicator	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Coefficient of variation	+	++	++	++	+	++	+	–	—	–/+
Gini coefficient	+	++	++	++	+	++	+	–	—	–/+
Geometric/arithmetic mean	+	++	++	+	+	++	+	–	—	+
Correlation, relative	+	+	+	++	+	++	+	0	0	+
Correlation, absolute	—	–	–	–	–	—	—	0	0	–

+/++ Weak/strong cohesion effect: disparities are reduced
–/— Weak/strong anti-cohesion effect: disparities are increased
–/+ Short term anti-cohesion and long-term cohesion effect
0 Little or no effect

Table 3.5. SASI model: GDP/capita cohesion effects

	GDP/capita cohesion effects (+/–)									
	1991-2001			2001-2021						
Indicator	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Coefficient of variation	–	+	+	+	+	+	–	–	–	–/+
Gini coefficient	–	+	+	+	+	+	–	–	–	–/+
Geometric/arithmetic mean	–	+	+	+	+	+	–	–	–	–
Correlation, relative	–	–/++	++	+	+	++	–	–	–	+
Correlation, absolute	–	–	–	–	–	–	–	–	—	–

+/++ Weak/strong cohesion effect: disparities are reduced
–/— Weak/strong anti-cohesion effect: disparities are increased
–/+ Short term anti-cohesion and long-term cohesion effect

The cohesion effects in GDP per capita are less clear because of the smallness of the effects. As Table 2 already suggested, rail scenario A1 in the past decade favoured mostly central European regions, whereas road scenario A2 had a clear cohesion effect (in relative terms). Because the effects of road infrastructure investments were much stronger, scenario A3, in which both road and rail projects were implemented, is very similar to scenario A2. The prospective infrastructure scenarios have a pro-cohesion effect (in relative terms); with the strongest effects in scenario B3, in which all road and rail TEN and TINA projects are assumed to be implemented. The pricing scenarios are anti-cohesion altogether, even scenario

C1, in which rail fares are lowered and disparities in accessibility are reduced (see Table 3.4). Scenario D, in which both infrastructure and pricing policies are combined, has a long-term cohesion effect after an initial period of increased regional disparities. If absolute differences are taken into account, all ten scenarios are anti-cohesion.

3.2 CGEurope

3.2.1 The Framework of the CGEurope Model

CGEurope is a comparative static non-monetary equilibrium model. The world is subdivided 1373 regions including 1321 of 1329 NUTS-3 regions of the ESPON space. Eight regions, which consist of 2 regions in Portugal, 2 regions in Spain and 4 regions in France have not been analysed, because these regions are remote regions, which are only very loosely connected to the European transport networks. Each region shelters a set of households owning a bundle of immobile production factors used by regional firms for producing two kinds of goods, non-tradable local goods and tradables. Firms use factor services, local goods and tradables as inputs.

The firms in a region buy local goods from each other, while tradables are bought everywhere in the world, including the own region. Produced tradables are sold everywhere in the world, including the own region. Free entry drives profits to zero; hence, the firms' receipts for sold local goods and tradables equal their expenditures for factor services, intermediate local and tradable goods and business travel. Goods trade is costly. For transferring goods from the origin to the destination, resources of two kinds are required, namely (1) information and service costs and (2) transportation costs for goods, including any kind of logistic costs. The former are assumed to come in the 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.

Regional final demand, including investment and public sector demand, is modelled as expenditure of utility maximizing regional households, who spend their total disposable income in the respective period. Disposable income stems from returns on regional production factors, which, by assumption, are exclusively owned by regional households, and a net transfer payment from the rest of the world. This transfer income can be positive or negative, depending on whether the region has a trade deficit or surplus. Transfers are held constant in our simulations. Households expend their income for local and tradable goods.

The factor supply is always fully employed due to the assumption of perfect price flexibility. We assume complete immobility of factors, which means that interregional factor movements as a reaction on changing transport costs is not included. Firms representing production sectors are of two kinds, producers of local goods and producers of tradables. Each local good is a homogeneous good, though one equivalently may regard it as a given set of goods, such that the good's price is to be interpreted as the price of a composite local good. The market for tradables, however, is modelled in a fundamentally different way, following the by now popular Dixit-

Stiglitz approach[11]. Tradables consist of a large number of close but imperfect substitutes. The set of goods is not fixed exogenously, but it is determined in the equilibrium solution and varies with changing exogenous variables. Different goods stem from producers in different regions. Therefore relative prices of tradables do play a role. Changes of exogenous variables make these relative prices change and induce substitution effects.

Households act as price taking utility maximizers. Firms maximize profits. Local goods producers take prices for inputs as well as for local goods sold to households and other firms as given. The production functions are linear-homogeneous nested-CD-CES functions. The lowest CES nest for intermediate inputs makes a composite out of the bundle of tradables. For the sake of simplicity it is assumed to be identical for all users and to be the same as the respective CES nest in the households' utility function. Due to linear-homogeneity the price of a local good equals its unit cost obtained from cost minimization under given input prices.

Tradable goods producers take only prices for inputs as given. They produce a raw output by a technology designed in the same way as for local goods producers. Instead of directly selling their output, however, they transform the homogeneous raw output into a final differentiated output. The respective technology is increasing returns, with a decreasing ratio of average to marginal input. Firms are free to compete in the market for a tradable good which already exists, or to sell a new one not yet in the market. The latter turns out to be always the better choice. Hence, each good is monopolistically supplied by only one firm, which is aware of the finite price elasticity of demand for the good. The firm therefore sets the price according to the rules of monopolistic mark-up pricing. This choice, of course, is only made if the firm at least breaks even with this strategy. If it comes out with a positive profit, however, new firms are attracted opening new markets, such that demand for each single good declines until profits are driven back to zero.

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 belong to different countries, then the tranfer costs between these regions are increased by a specific mark-up factor for this country pair.

[11] See Dixit, A. and Stiglitz, J.,. "*Monopolistic competition and optimal product diversity*", American Economic Review, 67:297-308, 1977.

The cost 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[12] 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. These transport cost are differentiated for all three transport modes road, rail and air transport, and two travel purposes, freight transport and business travel. Based on this, the shortest paths from each region to each region is calculated by a shortest route algorithm for the base year of each scenario. These shortest routes means 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. (Costs for waterways will by added in a future version of the model.) 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. This gives rise to the definition of an expected multimodal cost for each pair of region, accounting for the substitution between modes, which is responsive to cost differentials of modes for the specific origin destination pair. The definition is a modified logsum:

$$c_{rs} = -\frac{1}{\gamma}\log\left[\sum_m \exp(-\gamma c_{rsm} + \alpha_m)\right] + \frac{1}{\gamma}\log\left[\sum_m \exp(\alpha_m)\right]. \qquad (3.8)$$

The modification is that mode specific additive constants have been inserted. They represent preferences for specific modes, in order to be able to reproduce observed mode shares. Omitting these constants would assign weights to modes in the cost change calculations which are too far from reality. The reaction of the logsum to cost changes for a specific transport mode is dependent on the parameter γ, which models the switching reaction of users. A high γ means a high likelihood to change the preferred mode of transport, if it becomes cheaper.

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.

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

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

Using the CGEurope model, policy scenarios are evaluated by comparing 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. The analysis is comparative static, that means one compares two equilibria differing with respect to the transport cost scenario only, everything else held constant. The indicator of comparison is the utility change of households in the "with-world" in comparison to the "without-world". The 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. The reference situation is the year 1997 in all cases. The welfare measure takes income as well as price changes and changes in the access to product variety into account. 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 impact 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.

3.2.5 Analysis of Policy Scenarios

The impacts of specific projects are modelled by adding additional links with own characteristics to the network database, which are source node, destination node, speed limit and likelihood of congestion. Through this network database the shortest, which are in our case least costly routes for each region to each other region including the new links is calculated for each scenario. As already mentioned, policy scenarios are evaluated by comparing 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. The analysis is comparative static, that means one compares two equilibria differing with respect to the transport cost scenario only, everything else held constant.

In principle, this form of analysis is suitable to be pursued for specific transport projects case by case. In our report we concentrate on policy decisions that have been conducted over many years. Hence, these additional links coming into existence during these years are bundled to scenarios, in which all links to be analysed are integrated.

For each scenario, maps are presented that represent the spatial structure of the evaluated effects in the scenarios. The results are furthermore evaluated in the light of cohesion effects of the proposed scenarios. The following tables present the aggregated effects of the scenarios for each scenario, the correlation of the regional impacts with level of GDP per capita in the reference year, and the effects for specific types of regions based on meaningful typologies of regions available from BBR and other relevant thematic TPGs.

Table 3.6 shows aggregated effects for the entire ESPON space and the large subspaces in relative terms. Note that the overall level of impacts is small in relative terms, in the order of one third of a percent for the scenarios with all modes.

Table 3.6: Aggregated Effects by Policy Scenario, Percent of 1997 GDP

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
EU27+2	0.031	0.250	0.292	0.117	0.174	0.280	0.044	-0.276	-0.342	-0.050
EU15	0.032	0.253	0.296	0.121	0.160	0.269	0.044	-0.284	-0.350	-0.068
CC12	0.030	0.239	0.281	0.069	0.503	0.589	0.042	-0.273	-0.330	0.274

Tables 3.7 to 3.10 allow for a judgement about the distributional impact of scenarios, whether they have to be termed pro-cohesion, anti-cohesion, or neutral. Table 3.7 shows the inequality index in the reference situation. The index is infinity for maximal inequality (at least one region with zero income) and zero for perfect income equality. See Chapter 4.1 for further details. Table 3.8 shows the increase (positive sign) or decrease of this inequality index brought about by the respective policy scenario. Increases or decreases are shown as percentage changes of the inequality index. Note that the changes are small and would only be visible in the third digit of the inequality index. An decrease means that the respective policy is pro-cohesion, an increase means anti-cohesion, of course.

A similar information can be extracted from Table 3.9 showing correlations between relative welfare effects and GDP per capita in the reference year. A negative correlation indicates pro-cohesion, as relative changes tend to be larger in poorer regions. Note that Tables 3.8 and 3.9 give qualitatively exactly the same message as the signs in Table 3.8 and 3.9 coincide. Note however that the pattern is totally different if one correlates GDP per capita with absolute per capita welfare effects, as shown in Table 3.10. In absolute terms highest gains on average accrue to regions already richest in the base situation if the overall impact of a policy is welfare increasing. Highest losses accrue to richest regions for policies producing an overall loss. This is why the sign pattern in Table 3.10 coincides with that in Table 3.6.

Table 3.7: Inequality Index, GDP per capita 1997

EU27+2	0.234
EU15	0.072
CC12	0.219

Table 3.8: Percentage Change of Inequality Index

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
EU27+2	0.003	-0.086	-0.085	-0.000	-0.194	-0.211	0.001	0.044	0.047	-0.164
EU15	0.003	-0.292	-0.293	-0.134	-0.163	-0.279	-0.011	0.143	0.181	-0.107
CC12	0.008	0.065	0.078	0.093	-0.156	-0.092	0.013	0.098	0.095	0.024

Table 3.9: Correlations of GDP per Capita and Relative Welfare Impact

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
EU27+2	0.05	-0.13	-0.13	-0.00	-0.40	-0.43	0.02	0.23	0.18	-0.35
EU15	0.02	-0.18	-0.18	-0.21	-0.17	-0.27	-0.06	0.34	0.31	-0.12
CC12	0.20	0.08	0.09	0.41	-0.18	-0.11	0.24	0.51	0.44	0.03

Table 3.10: Correlations of GDP per Capita and Absolute Welfare Impact

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
EU27+2	0.64	0.36	0.42	0.47	0.40	0.56	0.59	-0.85	-0.83	-0.29
EU15	0.57	0.23	0.28	0.30	0.29	0.41	0.48	-0.81	-0.76	-0.24
CC12	0.76	0.62	0.65	0.68	0.60	0.77	0.73	-0.82	-0.93	0.51

Finally, Table 3.11 shows results by type of region according to several typologies. On the one hand, this allows for extracting additional information regarding pro-cohesion or anti-cohesion. On the other hand this table is most useful for evaluating whether a policy is in line with or contradicts the polycentricity objective. The more a policy favours peripheral or non-central regions, the safer it can be classified as supporting the polycentricity objective.

Table 3.11: Welfare Effects of Policy Scenarios by Types of Region, Percent of 1997 GDP

	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Objective 1	0.045	0.352	0.412	0.202	0.262	0.449	0.061	-0.340	-0.438	0.031
Objective 2	0.028	0.256	0.296	0.115	0.181	0.284	0.043	-0.287	-0.349	-0.053
Relative Rurality high	0.033	0.296	0.341	0.139	0.221	0.346	0.052	-0.310	-0.388	-0.029
Relative Ruralality medium	0.023	0.298	0.332	0.110	0.255	0.350	0.046	-0.298	-0.364	-0.001
Relative Rurality low	0.032	0.227	0.270	0.107	0.147	0.246	0.040	-0.256	-0.316	-0.058
PENTAGON-EU15	0.031	0.177	0.216	0.080	0.145	0.221	0.035	-0.257	-0.307	-0.074
Coastal Regions	0.038	0.282	0.336	0.164	0.178	0.323	0.060	-0.298	-0.393	-0.056

Border Regions	0.031	0.297	0.341	0.110	0.249	0.349	0.044	-0.293	-0.359	0.004
Lagging Regions	0.052	0.362	0.431	0.226	0.266	0.480	0.065	-0.350	-0.449	0.052
Potentially Lagging Regions	0.033	0.361	0.410	0.136	0.204	0.326	0.043	-0.319	-0.384	-0.042
Non Lagging Regions	0.028	0.203	0.240	0.094	0.151	0.236	0.041	-0.254	-0.315	-0.069
Settlement Type 1	0.034	0.176	0.219	0.138	0.121	0.247	0.043	-0.243	-0.308	-0.048
Settlement Type 2	0.024	0.161	0.191	0.068	0.088	0.153	0.031	-0.241	-0.289	-0.128
Settlement Type 3	0.040	0.194	0.242	0.146	0.121	0.258	0.048	-0.293	-0.362	-0.089
Settlement Type 4	0.034	0.230	0.274	0.135	0.146	0.271	0.045	-0.296	-0.360	-0.074
Settlement Type 5	0.038	0.338	0.397	0.101	0.216	0.307	0.048	-0.281	-0.348	-0.029
Settlement Type 6	0.031	0.176	0.216	0.087	0.171	0.252	0.039	-0.268	-0.322	-0.060
Settlement Type 7	0.027	0.337	0.375	0.085	0.251	0.332	0.040	-0.309	-0.364	-0.017
Settlement Type 8	0.032	0.474	0.526	0.160	0.276	0.418	0.057	-0.329	-0.422	0.013
Settlement Type 9	0.026	0.364	0.404	0.141	0.272	0.390	0.055	-0.325	-0.414	-0.012
Time to Market by Population, meso scale, central	0.031	0.176	0.215	0.103	0.114	0.209	0.038	-0.239	-0.296	-0.077
Time to Market by Population, meso scale, medium	0.034	0.275	0.321	0.124	0.187	0.300	0.046	-0.292	-0.359	-0.045
Time to Market by Population, meso scale, peripheral	0.028	0.365	0.407	0.134	0.282	0.398	0.053	-0.329	-0.414	-0.003
Time to Market by Population, macro scale, central	0.031	0.208	0.248	0.074	0.163	0.235	0.034	-0.259	-0.305	-0.058
Time to Market by Population, macro scale, medium	0.028	0.263	0.304	0.105	0.190	0.286	0.041	-0.277	-0.334	-0.035
Time to Market by Population, macro scale, peripheral	0.037	0.299	0.350	0.206	0.167	0.346	0.067	-0.306	-0.420	-0.062

3.2.5.1 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. While the model takes the costs of three modes of transport, road, rail and air, into account, scenarios only take transport cost changes for road and rail into consideration, because the impact of air transport infrastructure investment would be almost invisible, if compared to that of rail and road. Scenario A1 measures only the impact of rail infrastructure changes, scenario A2 measures the impact of road infrastructure, scenario A3 measures the combined impact of both.

Results are given in terms of equivalent variations, which measure the impact of transport cost changes on the households' welfare in the regions 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 welfare gains per capita. The dimension of the latter is € per annum.

The overall impact of rail infrastructure changes is small. No more than one tenth of the entire impact in the A-scenarios is due to changes in rail infrastructure, nine tenth is due to changes in road infrastructure. The average combined impact of both in the entire ESPON space is 0.30 % of GDP. Hence it is obvious that the spatial pattern of effects in A3 representing the combined rail and road effect is almost completely explained by the impact of roads, as can be seen from the correlation between A3- and A2-effects (0.99).

Regarding the spatial distribution of effects we only discuss those of A3 and A1, because A2 is so similar to A3 that it needs not be discussed separately. We begin with A3.

As long as we concentrate on relative impacts, A3 shows a pro-cohesion tendency, that is the effects tend to be higher in less developed, poorer and more peripheral regions. They correlate negatively with GDP per capita in the reference year (-0.13) across the entire ESPON space. The correlation within EU15 is negative as well (-0.18), but slightly positive across regions within CC12 (0.09). The average impact has a similar magnitude in EU15 and CC12 (0.30 % and 0.28 %, respectively). That means that the pro-cohesion tendency is mainly due to the fact that within EU15 infrastructure development has favoured poorer regions slightly more than richer ones.

This is also confirmed by the inequality measure. As expected, equality is highest within EU15. The distribution of GDP per capita is considerably more unequal within CC12, 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 by 0.08 % in the whole area, by 0.29 % in EU15 (though from a lower basis) and increases by 0.08 % in CC12. 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.

Finally, 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 potentially lagging regions (0.43 % and 0.41 %) than in non lagging regions (0.24 %). They are also considerably higher in objective-1 regions (0.41 %) then in the whole space (0.30 %).

Regarding polycentricity, scenario A3 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 (0.22 %) than the average points towards a gain in polycentricity. The same conclusion can be drawn from looking at effects by regions classified according to accessibility. Table 3.10 classifies regions according to two types of accessibility indices, time to market for a half-life distance of 1000 minutes travel time, and time to market for a half-life distance of 25 minutes travel time. The former can be interpreted as a macro scale accessibility indicator, the latter as a meso scale accessibility indicator. Regarding macro scale accessibility, effects of A3 are lowest in central regions, medium in medium regions and highest in peripheral ones.

A tendency in favour of polycentricity on the meso scale can be inferred from the observation that the impact is smallest in agglomerated regions (0.22 %), medium in urbanised areas

(0.32 %) and largest in rural regions (0.43 %). The same tendency appears from looking at effects by meso scale accessibility types, as just explained: effects increase monotonically from 0.20 % in most central regions to 0.41 % in most peripheral regions.

On the micro scale we infer on 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 considerably more (0.53 %) than the average, and also more than the less densely populated subtype of regions within rural areas (0.40 %).

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 0.42). This is even more so in the candidate countries (correlation of 0.65).

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 CC12, where the correlation is slightly positive. That means that within CC12 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 0.03 % percent of GDP for EU 15 as well as for CC12. 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 (0.045 %) and in lagging region (0.052 %). 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.

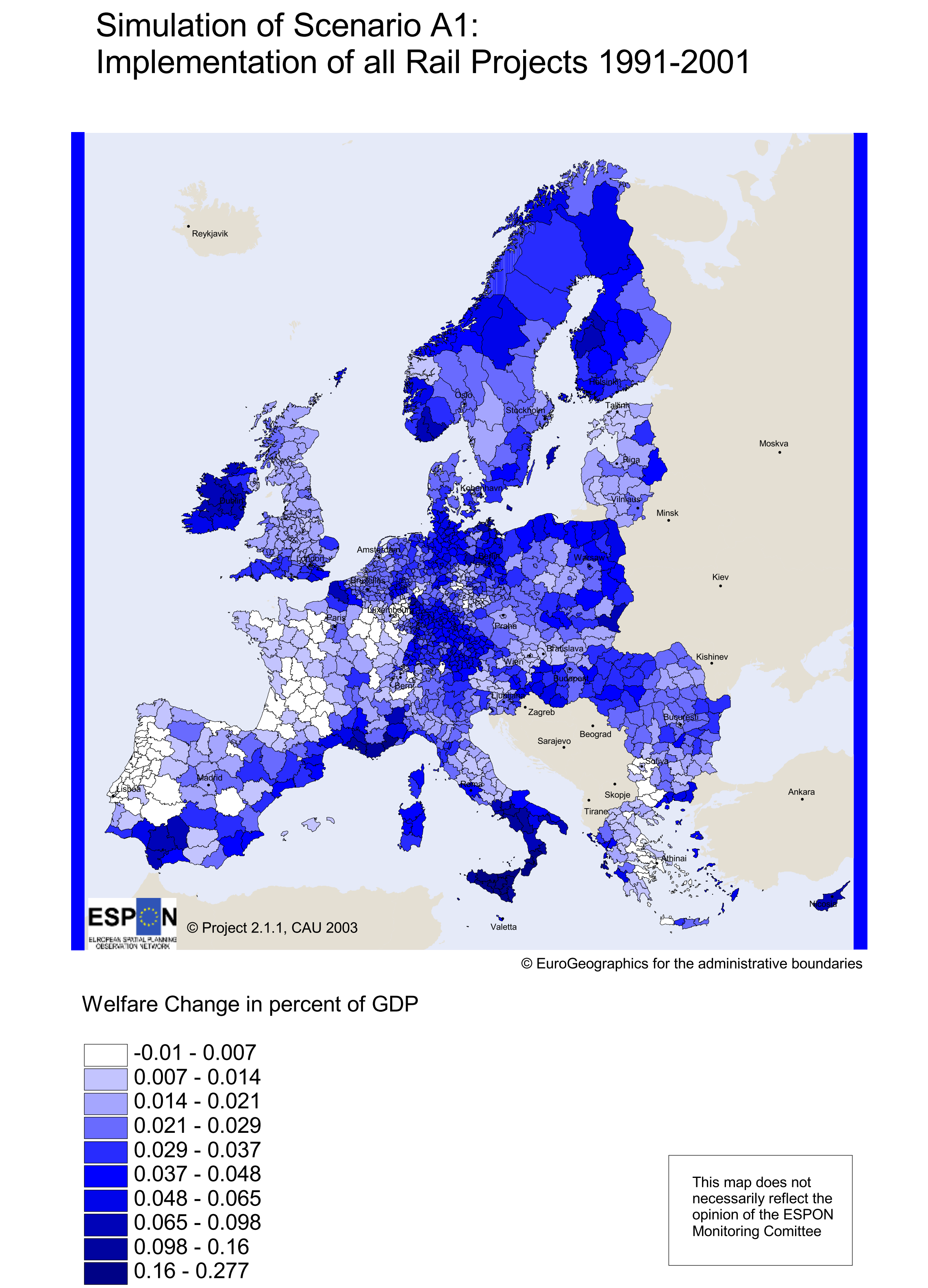


Figure 3.7: welfare change in scenario A1

Simulation of Scenario A2:
Implementation of all Road Projects 1991-2001

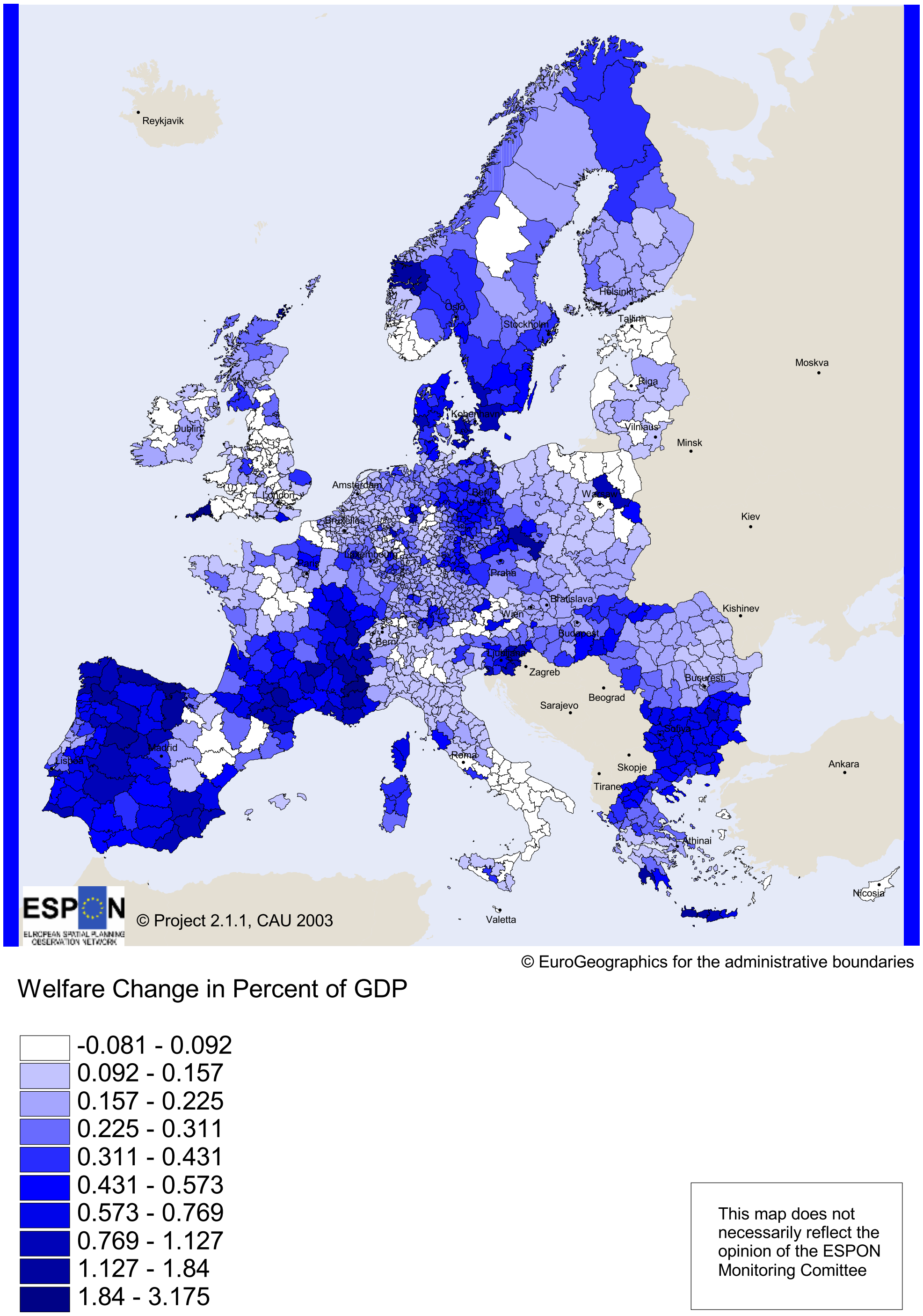
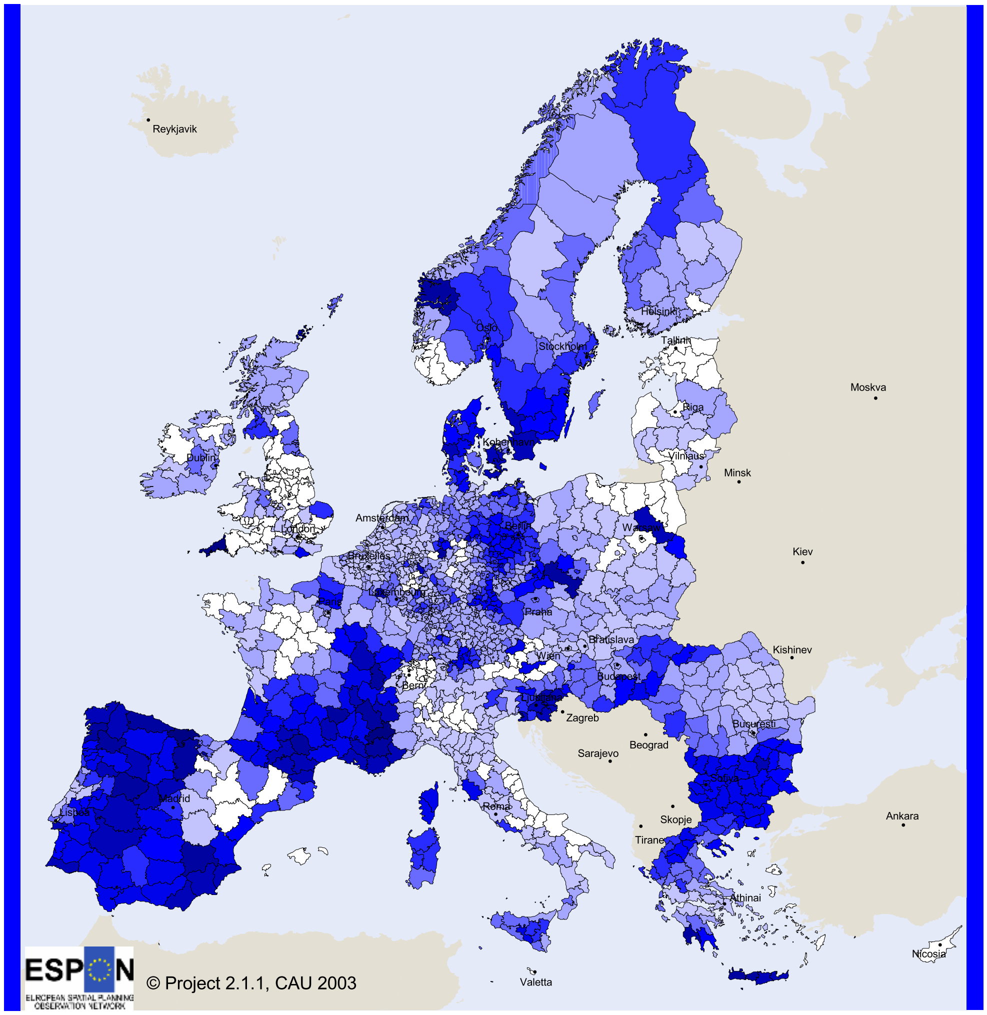


Figure 3.8: welfare change in scenario A2

Simulation of Scenario A3:
Implementation of all Road and Rail Projects 1991-2001



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Welfare Change in percent of GDP

- -0.034 - 0.129
- 0.129 - 0.197
- 0.197 - 0.27
- 0.27 - 0.359
- 0.359 - 0.476
- 0.476 - 0.614
- 0.614 - 0.812
- 0.812 - 1.166
- 1.166 - 1.888
- 1.888 - 3.32

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.9: welfare change in scenario A3

3.2.5.2 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. Scenario B1 measures only the impact of rail infrastructure changes, scenario B2 measures the impact of road infrastructure, scenario B3 measures the combined impact of both.

Results are given in terms of equivalent variations, which measure the impact of transport cost changes on the households' welfare in the regions 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 welfare gains per capita. The dimension of the latter is € per annum.

Different from the ex-post A-scenario, impacts of rail infrastructure improvements have a similar magnitude as those of road infrastructure improvements in the EU15. The average impact is 0.12 % for rail, 0.16 % for road and 0.28 % for both modes combined. In CC12 the rail effect is smaller (0.05 %), but the road effect considerably larger (0.50 %). Hence, the total effect of improvements for both modes is more than twice as large in CC12 (0.59 %) than in EU15 (0.27 %). For the spatial pattern of the total effect, as described by the B3-scenario, the spatial pattern of road effects is more important than that for the rail effects. This is shown by the correlations across regions: B1-effects correlate with B3-effects with a coefficient of 0.29, while B2-effects correlate with B3-effects with a coefficient of 0.90.

We begin the description of the spatial pattern again with the total effects for both modes. Like the A3-scenario, the B3-scenario is also 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 CC12 (-0.11). It is more in favour of cohesion for the whole area than for the two subspaces, because the cohesion effect is partly due to the fact, that the impact is more than twice as large in the poorer CC12 than in the richer EU15, as already mentioned. 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 CC12. 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 (0.48 % and 0.33 %) than in non lagging regions (0.24 %). They are also considerably higher in objective-1 regions (0.45 %) then in the whole space (0.28 %).

Regarding polycentricity, scenario B3 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 (0.22 %) 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 B3 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 smallest in agglomerated regions (0.23 %), medium in urbanised areas (0.29 %) and largest in rural regions (0.40 %). The same tendency appears from looking at effects by meso scale accessibility types: effects increase monotonically from 0.20 % in most central regions to 0.42 % in most peripheral 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 (0.42 %) than the average, and also slightly more than the less densely populated subtype of regions within rural areas (0.39 %).

Even though the spatial pattern of the ex-post scenario A3 has only some similarity with that of the ex-ante scenario B3 (correlation 0.21), the general conclusions with regard to cohesion and polycentricity are much the same for both scenarios.

Largely the same holds true for B2, which takes only the road effects separately. It is pro-cohesion, as effects correlate negatively with GDP per capita in both, EU15 and CC12, end even more so in the whole ESPON space. Inequality indices decrease in both subspaces and more so in the whole area. Gains are above average in objective-1 regions as well as in lagging and potentially lagging regions.

Regarding polycentricity on the macro scale, the fact that the Pentagon is favoured slightly less (0.15 %) than the average (0.17 %) points towards a gain in polycentricity, but the results by type of regions according to macro scale accessibility are not so clear cut as for B3. Gains are highest in the medium category.

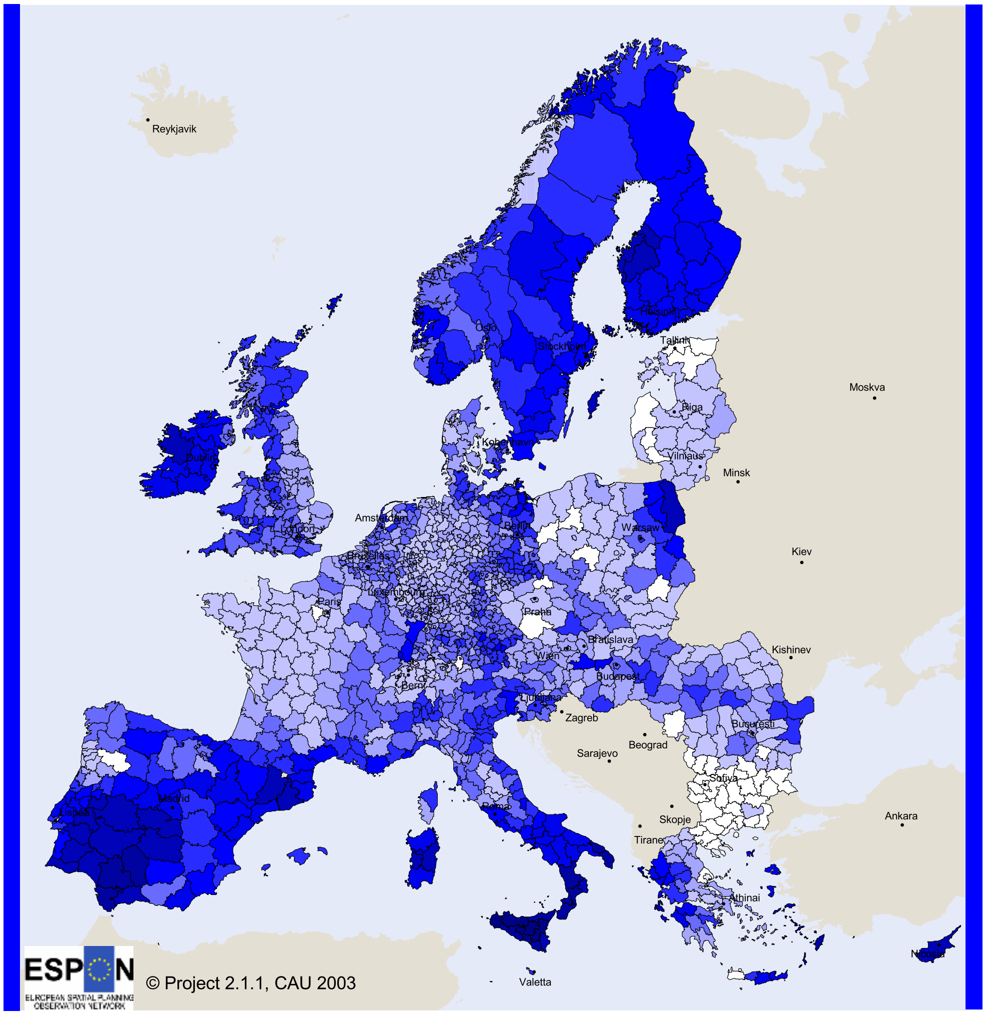
Regarding polycentricity on the meso scale exactly the same pattern emerges as for B3: the impact is smallest in agglomerated regions (0.12 %), medium in urbanised areas (0.20 %) and largest in rural regions (0.27 %). The same tendency appears from looking at effects by meso scale accessibility types: effects increase monotonically from 0.10 % in most central regions to 0.29 % in most peripheral regions. The micro scale pattern, however, does not reappear in the pattern of B2-effects.

Rail effects as modelled by the B1-scenario are more or less neutral with respect to the spatial income distribution for the whole ESPON space, slightly pro-cohesion within EU15, but interestingly clearly anti-cohesion within CC12. They correlate positively with GDP per capita within CC12 and make the inequality index increase by 0.08 %. An observation in favour of a cohesion effect is that objective-1 regions gain more (0.20 %) than the average (0.12 %), and that lagging regions gain more (0.23 %) than non lagging regions (0.09 %).

Regarding polycentricity on the macro scale, the fact that the Pentagon is favoured slightly less (0.08 %) than the average (0.12 %) points towards a gain in polycentricity also for the rail scenario B. Results by type of regions according to macro scale accessibility point into the same direction: effects increase monotonically from central to peripheral types.

Regarding polycentricity on the meso scale, observations for regions by type of meso scale accessibility support to some extent the conclusion of B1 of favour meso scale polycentricity, but results by type of settlement structure are not clear cut. Detailed results by subtypes of settlement types are not clear cut either, so that there is no clear pattern, neither in favour nor to the detriment of polycentric development.

Simulation of Scenario B1:
Implementation of all Rail Projects 2001-2021



Welfare Change in Percent of GDP

- -0.112 - -0.009
- -0.009 - 0.044
- 0.044 - 0.078
- 0.078 - 0.114
- 0.114 - 0.167
- 0.167 - 0.243
- 0.243 - 0.339
- 0.339 - 0.496
- 0.496 - 0.745
- 0.745 - 1.122

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.10: welfare change in scenario B1

Simulation of Scenario B2:
Implementation of all Road Projects 2001-2021

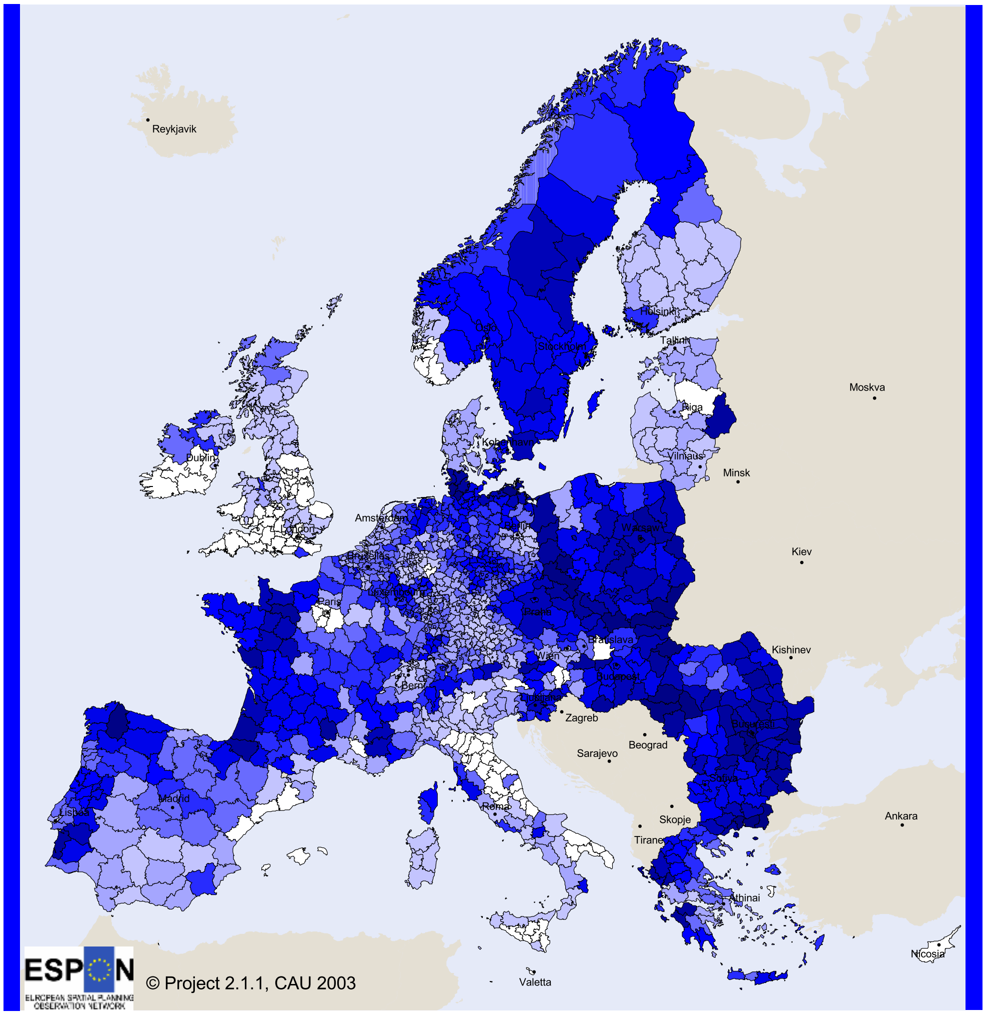
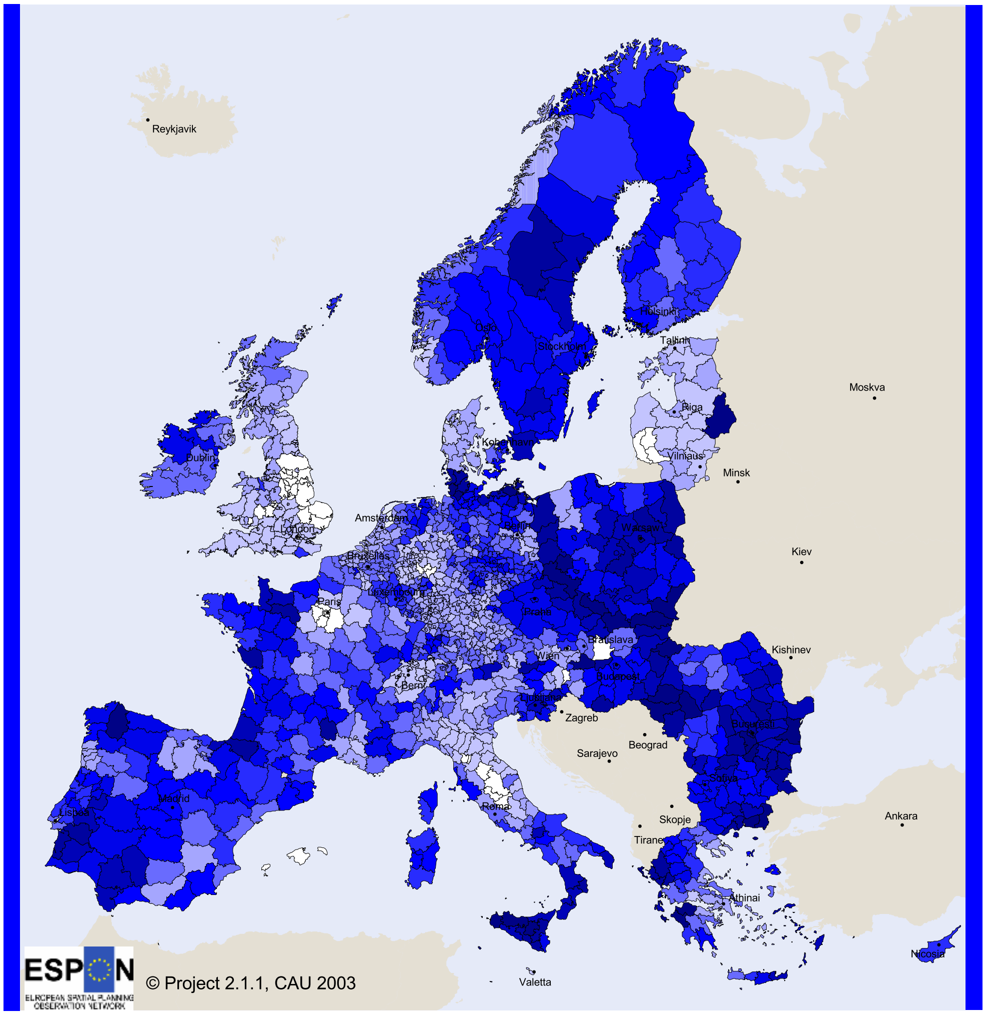


Figure 3.11: welfare changes in scenario B2

Simulation of Scenario B3:
Implementation of all Rail and Road Projects 2001-2021



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Welfare Change in percent of GDP

-0.019 - 0.11
0.11 - 0.175
0.175 - 0.239
0.239 - 0.311
0.311 - 0.393
0.393 - 0.479
0.479 - 0.582
0.582 - 0.732
0.732 - 0.959
0.959 - 1.47

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.12: welfare changes in scenario B3

3.2.5.3 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 as begin with the impact of reduced rail costs, which could result from subsidiation as well as from higher cost efficiency due to deregulation. With respect to cohesion, this would be neutral except for CC12, where it would be anti-cohesion; that means it would favour rich regions more than poor ones within CC12. On the other hand, objective-1 regions would gain more than the average (0.061 % versus 0.044 %) and lagging regions would gain more than non lagging ones (0.065 % versus 0.041 %). Hence, results for the spatial income distribution are mixed.

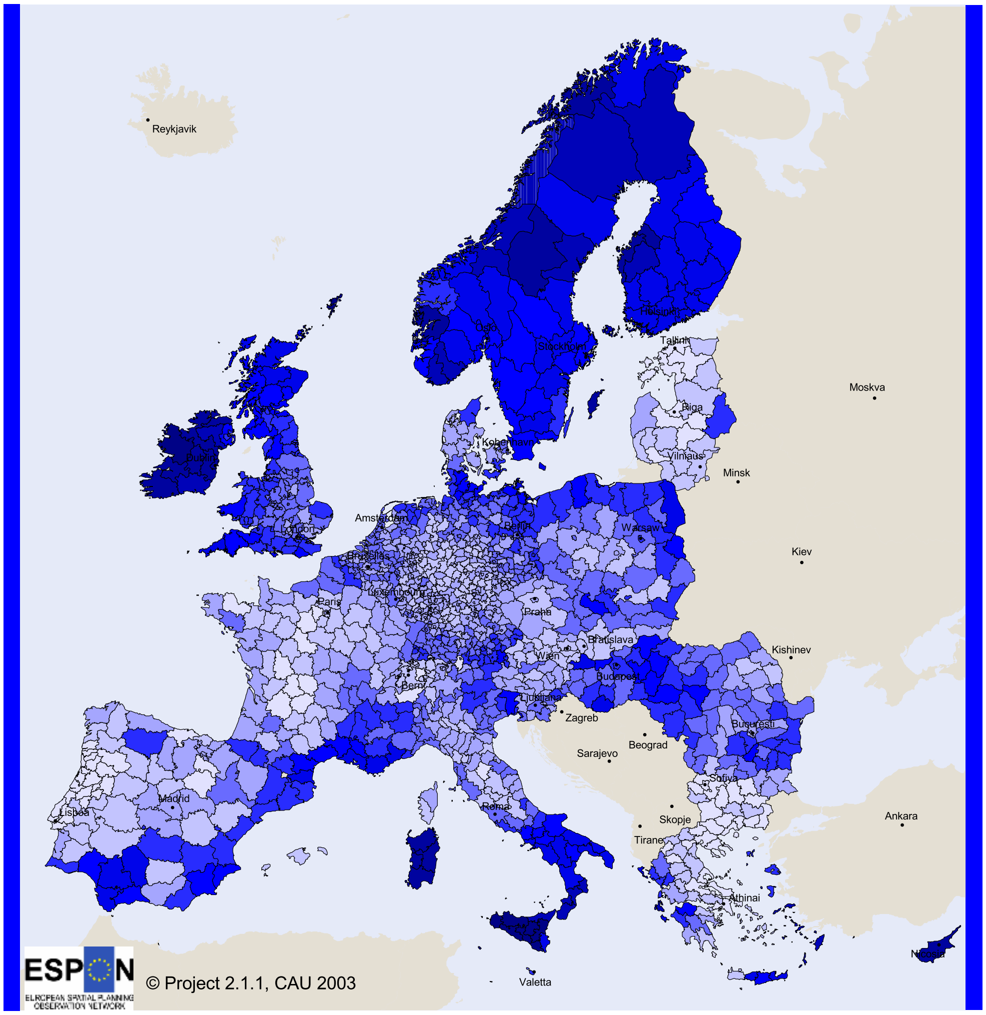
The centre-periphery pattern of effects is however clear cut. Gains are below average in the Pentagon-regions, and they are the larger, the more peripheral a region is. This is true for both types of accessibility classifications. With regard to settlement structures, we observe above average gains in 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 0.88. Both are inequality increasing, as shown by the positive correlations of the effects with GDP per capita for EU15 (0.34 and 0.31 for road and rail, respectively), for CC12 (0.41 and 0.44 for road and rail, respectively). This corresponds to the observation that the 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, the better the accessibility in the reference situation, the smaller the losses. It is furthermore well visible from Fig. 3.15, 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.

Simulation of Scenario C1:
Effects of a Reduction of the Price for Rail Transport



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Welfare Change in Percent of GDP

- -0.008 - 0.016
- 0.016 - 0.027
- 0.027 - 0.035
- 0.035 - 0.045
- 0.045 - 0.058
- 0.058 - 0.075
- 0.075 - 0.104
- 0.104 - 0.147
- 0.147 - 0.199
- 0.199 - 0.267

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.13: welfare change in scenario C1

Simulation of Scenario C2: Effects of a Rise of the Price for Road Transport

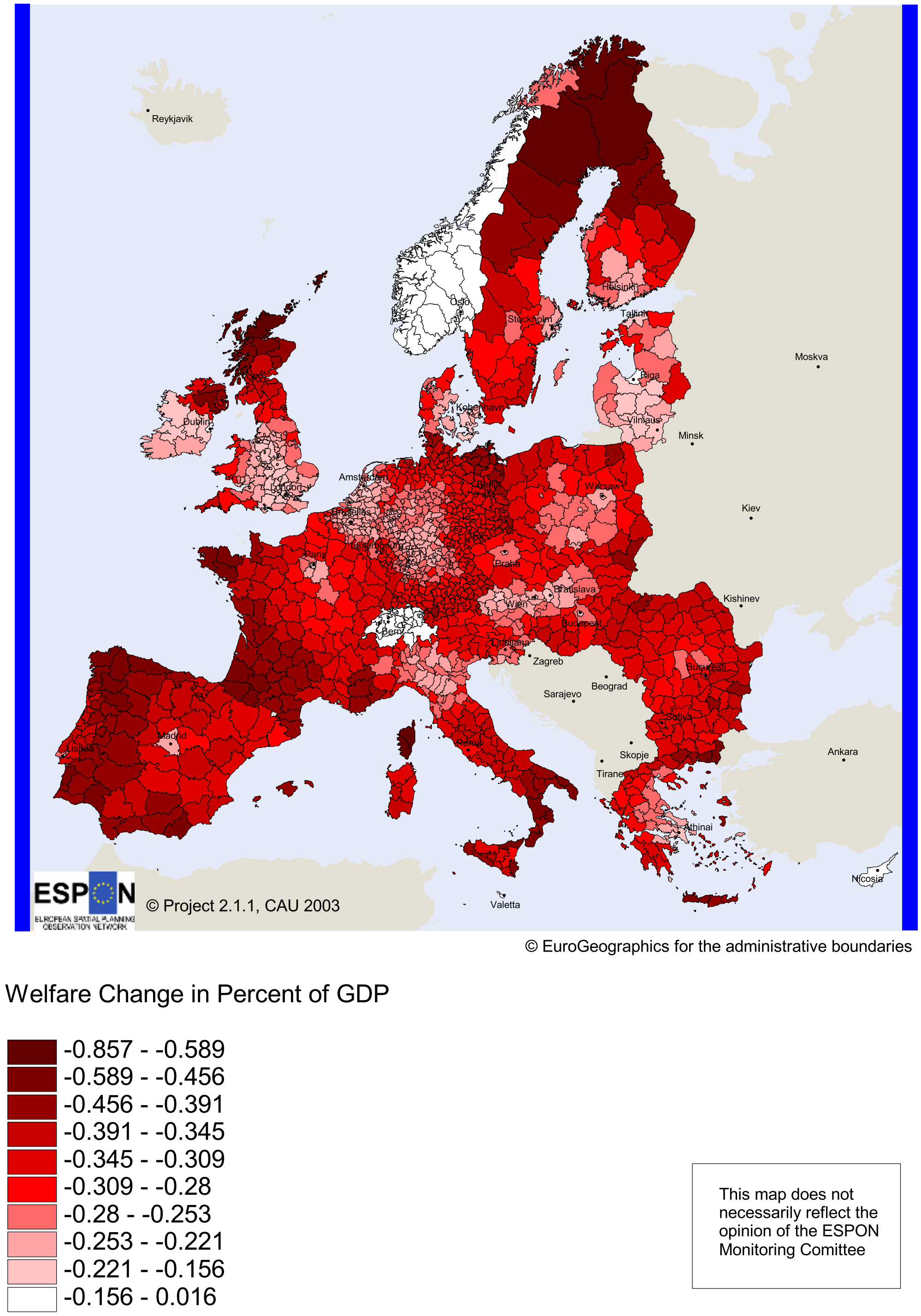
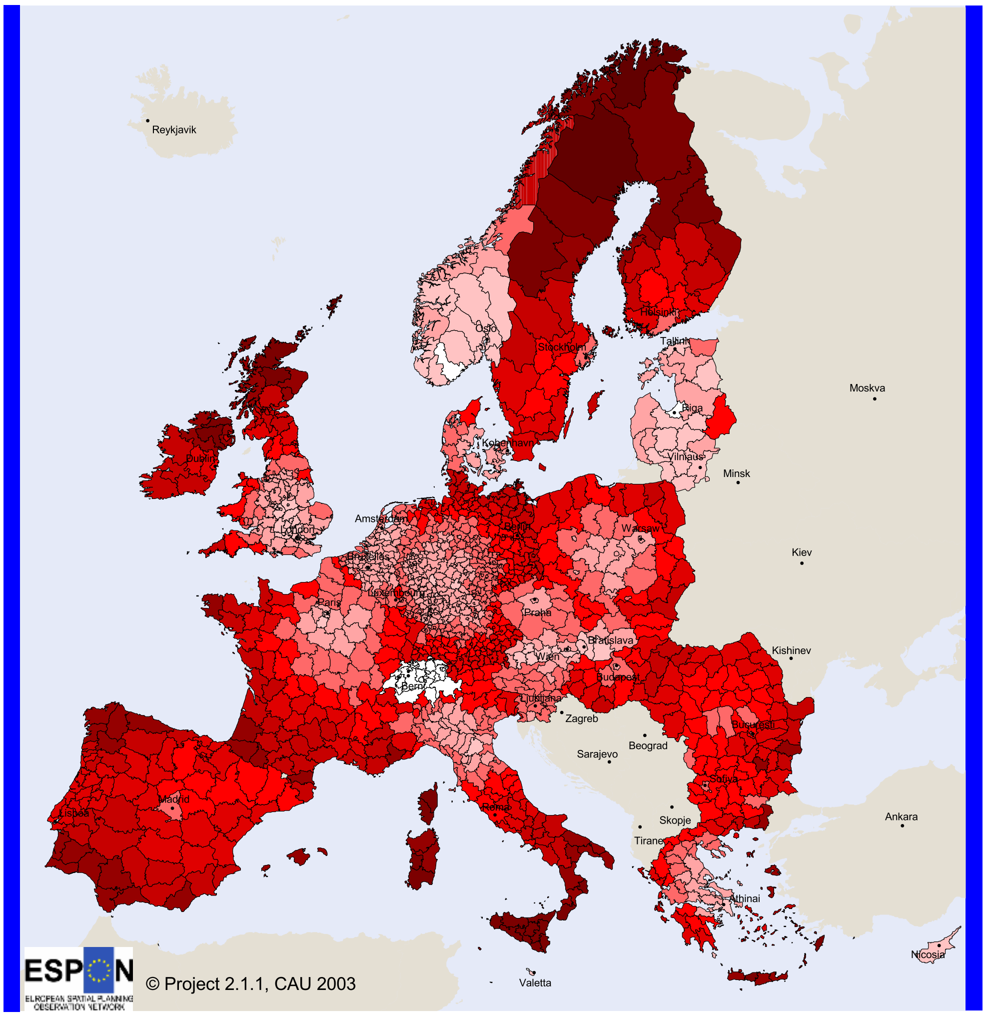


Figure 3.14: welfare change in scenario C2

Simulation of Scenario C3:
Effects of a Rise of the Price for Rail, Road and Air Transport



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Welfare Change in percent of GDP

- -1.382 - -1.048
- -1.048 - -0.661
- -0.661 - -0.527
- -0.527 - -0.444
- -0.444 - -0.393
- -0.393 - -0.35
- -0.35 - -0.311
- -0.311 - -0.27
- -0.27 - -0.186
- -0.186 - -0.084

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.15: welfare change in scenario C3

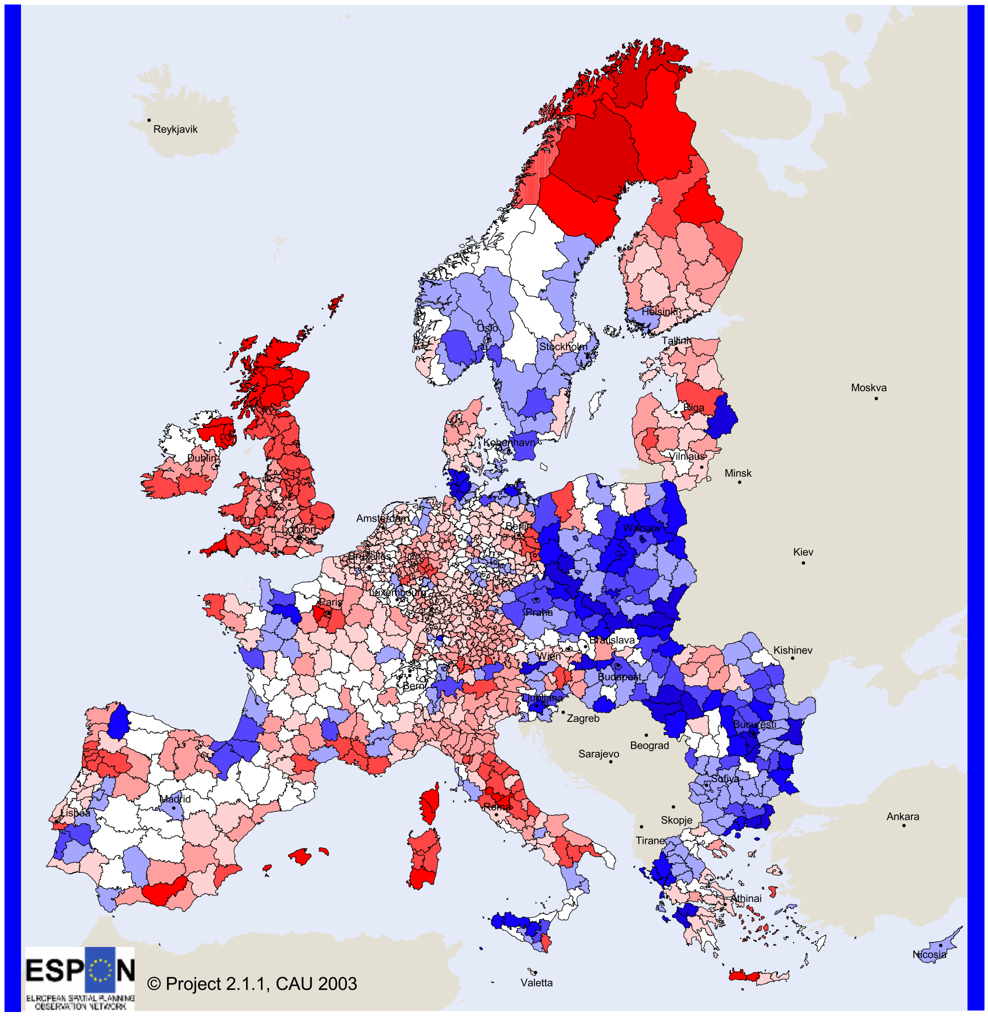
3.2.5.4 D-scenario

The D-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 show the highest coefficient for B2 and B3. 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 CC12. This corresponds to the changes of the inequality index: It decreases for the whole space and for the EU15, but not for CC12. The increase of equality in the whole area is largely due to the fact the CC12 gain 0.27 % on average, while the EU15 loses 0.07 %. Gains in objective-1 regions (0.03 %) and lagging regions (0.052 %) 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, but there is no monotone relation to macro accessibility. But this is different on the meso scale: the more central a region is classified according to the meso scale accessibility indicator, the smaller its loss or higher its gain. 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.

Simulation of Scenario D:
Implementation of all Road and Rail projects 2001-2021
and Rise of Prices for all Modes of Transport



Welfare Change in Percent of GDP

- -1.021 - -0.581
- -0.581 - -0.295
- -0.295 - -0.174
- -0.174 - -0.097
- -0.097 - -0.017
- -0.017 - 0.086
- 0.086 - 0.211
- 0.211 - 0.372
- 0.372 - 0.57
- 0.57 - 1.028

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 3.16: Welfare change in Scenario D

As a summary of cohesion results and for ease of comparison with SASI results we add Table 3.12 showing 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 3.12. CGEurope model: GDP/capita cohesion effects

	GDP/capita cohesion effects (+/–)									
	1991-2001			2001-2021						
Indicator	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Coefficient of variation	0	+	+	+	+	+	0	–	–	+
Gini coefficient	0	+	+	+	+	+	0	–	–	+
Geometric/arithmetic mean	0	+	+	0	+	+	0	–	–	+
Correlation, relative	0	+	+	0	++	++	0	—	–	++
Correlation, absolute	—	—	—	—	—	—	++	++	++	—

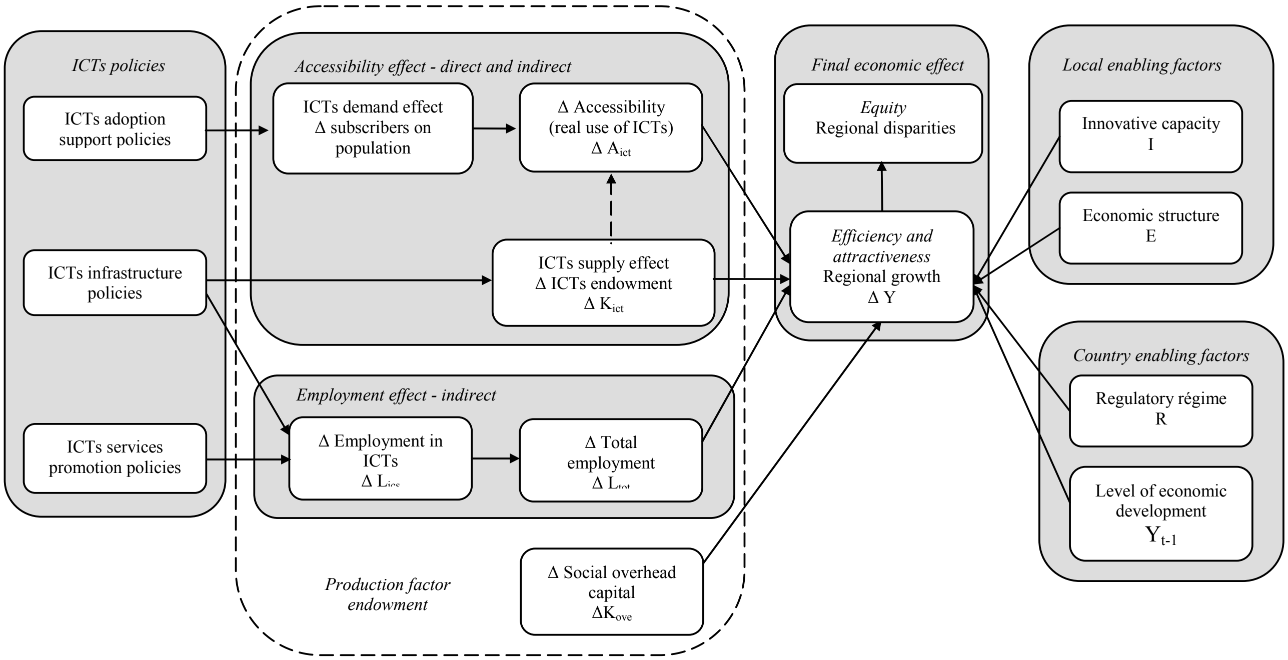
+/++ Weak/strong cohesion effect: disparities are reduced
–/— Weak/strong anti-cohesion effect: disparities are increased

3.3 STIMA

3.3.1 The conceptual framework of the STIMA model

The conceptual framework of our STIMA (Spatial Telecommunications IMpact Assessment)[13] model for ICTs spatial economic impact assessment is presented in Fig. 3.17.

Figure 3.17 - the STIMA model



From the conceptual point of view, the framework of STIMA is based on the idea that of ICTs infrastructures and services are production factors which, together with the traditional labour and capital factors, explain GDP level. Moreover, the linkage between ICTs adoption, 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 regard 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 *quasi production function*, and it allows measuring the role that ICTs play on 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 levels (per capita) attained after implementing the different policies; as a measure of equity,

[13] In Italian, "stima" means estimate, assessment and esteem.

we will use the differences in regional per capita income among different regions, generated by the impact of different policies.

STIMA estimates the following quasi production function:

$$Y_{rt} = f\,(L_{TOTrt}, K_{OVErt}, K_{ICTrt}, A_{ICTrt}, I_{rt}, E_{rt}, Y_{r(t-1)}, R_{rt}) \qquad (3.9)$$

which summarises the conceptual framework presented in Figure 3.17: 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] 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. To this purpose is devoted the next section.

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.

Concerning the ICTs, as stated also in the SIR, we had a lot of problems in finding data at regional level. At the beginning of this work package, we decided to buy the ITU World Telecommunication Indicators Database, which covers many interesting indicators, and long time series, but contains data only at NUTS-0 level.

After long networking with ESPON project 1.2.2 partners[14], we realised that the best data come from a survey commissioned by the European Commission to EOS Gallup. This survey took place in the second half of 1999 and was based on over 44,000 household interviews in 130 regions of the 15 Member States[15]. It is by far the largest survey at a European level that has been undertaken in the sector. A second survey is taking place at the moment, but the

[14] In particular CURDS, University of Newcastle.
[15] EOS Gallup (1999).

results will not be available until the end of the year. The areas considered are NUTS-2 regions. Unfortunately, it has been impossible to find NUTS-3 data. Moreover, the EOS Gallup survey covers only the 15 EU member states, so we have no data on eastern European countries.

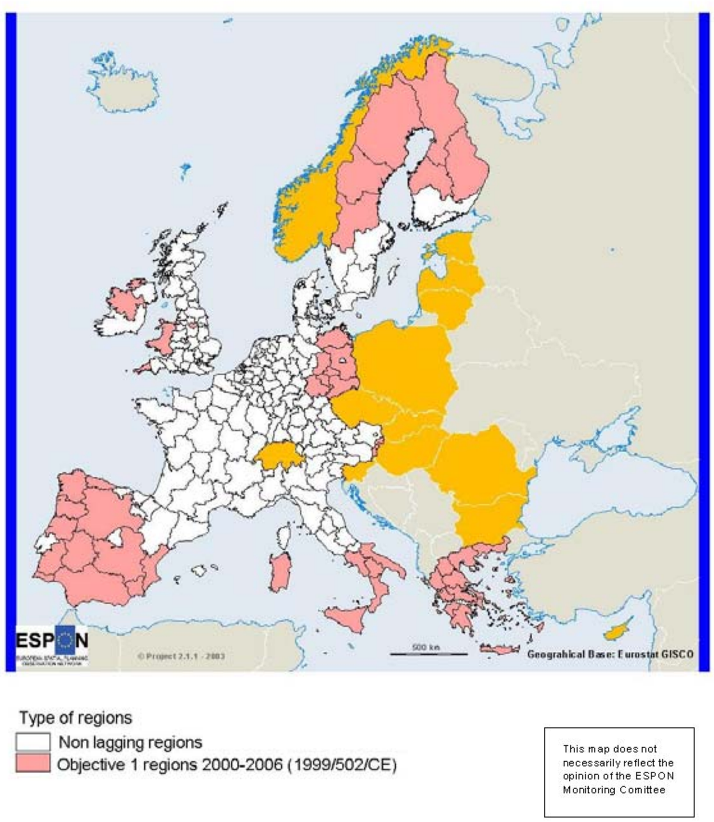
Despite some weaknesses of these data, related to their sample nature and to the lack of time series (only 1999 data are available), we judge the availability of these kinds of regional data as an extremely positive result, which allows, as far as we know, a first study on ICTs policy scenarios.

In order to analyse the regional disparities, we built a dummy variable, that splits the regions in lagging and non-lagging, following the criteria expressed by the European Commission for the definition of Objective 1 NUTS-2 regions for the period 2000-2006[16]. The objective 1 regions should meet one of the following requirements (Fig. 3.18):

- 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).

At the end of the proceeding of database construction, we have variables for NUTS2 European regions (about 200 regions), covering all aspects involved in the STIMA model.

Figure 3.18 - Lagging and non lagging regions

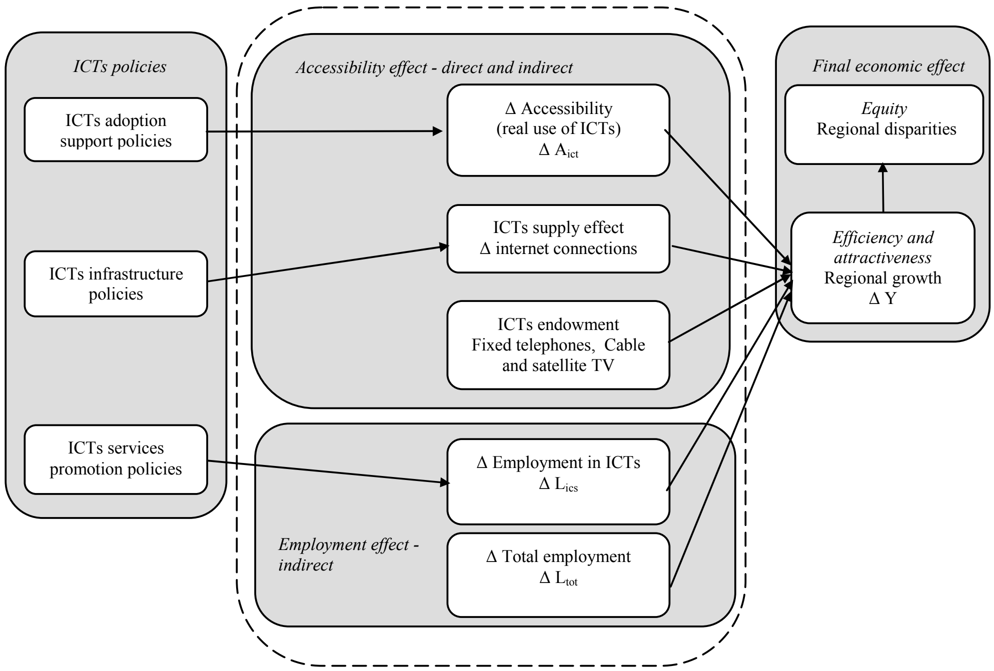


[16] European Commission, 1999.

3.3.3 The STIMA model: indicators

Given the data availability, the indicators used in STIMA are presented in Fig 3.19.

Figure 3.19 - 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 of social overhead capital and of the enabling factors. In any case, their absence does not change the interpretative power of ICTs variables and therefore does not interfere with our final results.
The most interesting indicators concern accessibility and employment.

Accessibility

For this submodel, we need two kinds of indicators: one concerning the physical endowment of infrastructures, and one concerning the degree of accessibility of these regions, in terms of "real" accessibility (how many people is possible to reach through ICTs networks), based on the intensity of use of the ICTs.

As a measure of physical endowment, the few indicators available at NUTS2 level[17] concern: number of Internet connections, number of cable and satellite TV, fixed telephony penetration, expressed by the percentage of households equipped with such technologies. We decided not to build a single indicator, but to leave different ICTs indicators alone, in order to have a more detailed view of their role in GDP creation.

[17] EOS Gallup (1999).

For the accessibility indicator, we need an indicator of ICTs use. The EOS Gallup database contains series concerning use of Internet as a e-commerce vehicle[18]. At the end, we run a gravitational model, in which the population is used as mass, and the percentage of households using Internet as e-commerce vehicle is used as the inverse of the spatial friction:

$$A_{ICT_{rt}} = \left(\sum_s P_{st} / d_{sr}^{g_{rt}} \right) \qquad (3.10)$$

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 a 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 Internet as e-commerce vehicle

Employment

In our hypothesis, we thought to run an economic-base model, that relates the total employment to the ICTs employment, weighted by the share of specialised sectors[19]. However, due to the scarcity of data, it has been impossible to find the sectorial data in order to build a vector of the share of specialised sectors for all regions. Thus, we decided to put the indicators of total employment and high-tech employment directly in the simulation model.

3.3.4 The results of the STIMA model

The first step of the forecast methodology is to estimate our STIMA model[20]. The first estimated model is the following (Table 3.13)[21]:

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

[19] This model was first developed by Hoyt in the 1930s, following a supply-oriented approach. The model considers two kind of sectors, the basic and non-basic sectors. The basic sectors are the sectors capable to pull the growth of the area. We identify as "basic sectors" the specialised sectors, i.e. the sectors with a localisation quotient higher than 1.

The localisation quotient is: $Q = \frac{L_{ir}}{L_r} \Big/ \frac{L_{ic}}{L_c}$ where L = number of employees; r = region; c = Country; i= sector.

The model is constituted by the following equations:

$L_{TOTrt} = L_{brt} + L_{nbrt}$ and $L_{nbrt} = b\, L_{TOTrt}$

By substitution, we obtain: $L_{TOTrt} = 1/(1-b_{rt}) * L_{brt}$

In terms of changes , the relation becomes: $\Delta L_{TOTrt} = 1/(1-b_{rt}) * \Delta L_{brt}$

where L_{TOTrt} = total employment in region r in year t; L_{brt} = employment in basic sectors in region r in year t L_{nbrt} = employment in non-basic sectors in region r in year t; $b_{rt} = L_{nbrt}/L_{TOTrt}$ (share of non-basic sectors in region r in year t).

[20] 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.

[21] 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.

L_gdp99p = f (L_acc, L_fixtel, L_intcon, L_cabsat, L_totemp, L_hitech) [Model 1]

where

the prefix "L_" indicates the conversion in natural logarithm (ln)
L_gdp99p = per capita GDP 1999
L_acc = accessibility 1999
L_fixtel = percentage of households with a fixed telephone in 1999
L_intcon = percentage of households with a Internet connection in 1999
L_cabsat = percentage of households with a cable or satellite TV in 1999
L_totemp = total employment in 1999
L_hitech = high tech employment in 1999

Table 3.13 - 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 $p < 0.01$

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 tech employment in each region. The fit of the second model is quite good, with a R^2 index around 0.6, 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.

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[22].

There are two types of spatial dependence:

1. *spatial interactions (or spatial lag)*, which means that the behaviour of one individual affects another individual, like spillover or externalities effect;
2. *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.

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, we have first to run some statistical tests to detect the presence of spatial dependence. In order to do this, we need an indicator of the closeness of our observations: the spatial weights matrix[23] W whose elements wij 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[24]. Once we built W, we can run the tests to detect spatial dependence.

The spatial autocorrelation tests for our model[25] highlighted the presence of both spatial lag and spatial error. However, the first is more important, as it shows higher indexes.

Table 3.14 - Tests for spatial autocorrelation

Test	**Statistic**	**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

[22] For more details concerning the spatial dependence problems, see Anselin (1988), Anselin (1992), Anselin and Hudak (1992), Anselin et al. (1996).
[23] 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.
[24] Pisati (2001).
[25] 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), we built a new regression model that introduce the variable ρ to take into account this relationship. The new estimated model is a *spatial lag model* (Table 3.15):

$$L\_gdp99p = constant + \beta_1 * L\_acc + \beta_2 * L\_fixtel + \beta_3 * L\_intcon + \beta_4 * L\_cabsat + \beta_5 * L\_hitech2 + \beta_6 * L\_totemp + \rho * W * L\_Y$$

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

Table 3.15 - 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)**
ρ	0.437 (5.14)**
Dependent variable: L_gdp99p	

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

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

Finally, to obtain a better fit with real data, we calibrated the model (Table 3.16).

Table 3.16 - 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
ρ	0.437	0.300	-0.137
Dependent variable: L_gdp99p			

3.3.5 Forecasting methodology

Thanks to the estimate of our STIMA model, we are able to forecast per capita GDP at 2020, according to different ICTs scenarios. Our forecasting methodology can be summarised in a step-by-step graphic (Fig. 3.20). The first step is to build an indicator of the level of European countries investments in ICTs, based on the sum of the ITU data on national investments in ICTs from 1990 to 2000 in the 15 EU member states, at 2000 prices.

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[26]. The hypothesis of 2% stems from some considerations on previous EU efforts[27] in this field and on new accession countries[28]. This amount has been multiplied by 20, in order to be consistent with a 20-year scenario (2nd step).

The total EU investments are distributed to regions in different ways, according to the different scenarios[29] (3rd step).

The 4th step concerns the estimate of the marginal efficiency if ICTs factors in which ICTs policies act (Internet connections, accessibility, high tech employment). Regression models between the ICTs factors and capital invested in ICTs have been run. Capital invested in ICTs have been calculated by cumulating the investments 1990-2000 at 2000 prices[30]. The results of the three regressions are presented in table 3.17. Even at first look, it is evident that investments in Internet connections proved to be much more efficient.

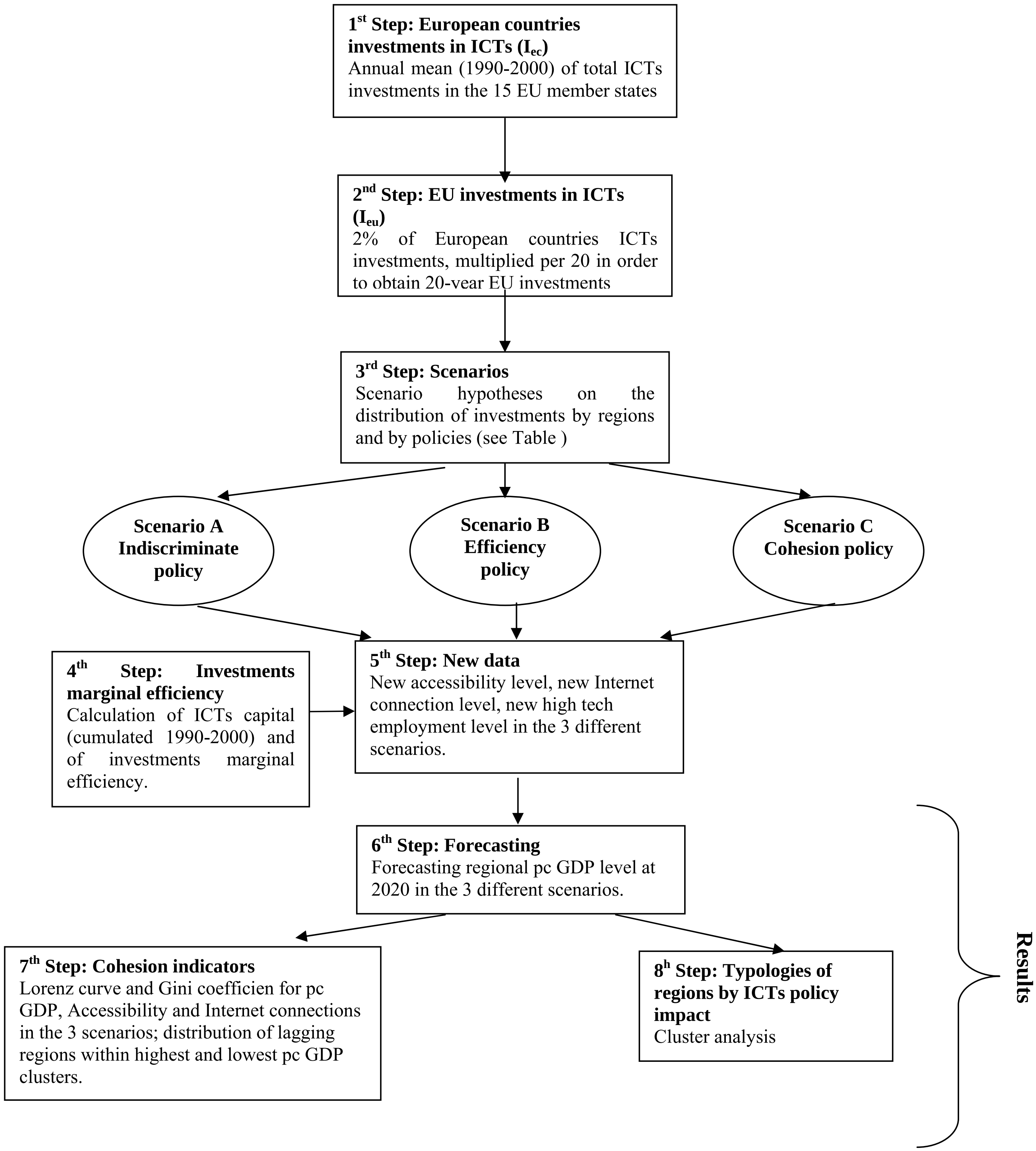
[26] See next section for details on calculation.
[27] This can be quantified around 4% of total European Countries financial investments.
[28] Given the same amount of resources devoted by the European countries to ICTs (due to little investments by the new accession countries), the percentage of EU investments will decrease to 2%.
[29] For the scenarios, see section 2.4.2.
[30] Summing the investments levels of last ten years at constant prices is the technique adopted by the Italian Industrial Association (Confindustria) to calculate the invested capital.

Table 3.17 - Investments marginal efficiency

Indicator	Investments marginal efficiency
Accessibility	0.252 (1.71)
Internet	0.964 (2.36)*
High tech employment	0.222 (2.13)*
Independent variable: per capita invested capital 1990-2000	

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

Figure 3.20 - Forecasting methodology step by step



We use the regional investments level, according to the different scenarios, and the marginal efficiency coefficient, to calculate the new levels of Internet connections, accessibility and high tech employment (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)[31]. Finally, it is possible to create a typology of regions according to the different impact of ICTs policies (8th step)[32].

3.3.6 Forecasting results

Applying the methodology described in the previous section, we achieved the following results:

- 1st step: European countries investments in ICTs (Table 3.18)

Table 3.18 - European countries investments in ICTs (1st step)

Country	**Average annual investments in ICTs 1995-2000 (in Mio. € at 2000 prices)**
Austria	1,563
Belgium	1,158
Denmark	742
Finland	792
France	6,442
Germany	13,288
Greece	793
Ireland	397
Italy	7,699
Luxembourg	89
Portugal	1,276
Spain	3,949
Sweden	1,208
The Netherlands	2,162
United Kingdom	8,777
Total	**50,338**

- 2nd step: EU investments in ICTs

EU investments are 2% of the EU countries investments: € 1,006 Mio
multiplied by 20 to obtain investments over 20 years: € 20,135 Mio.

Thus our starting point is approximately 20 billions euros for the European Union investments in ICTs in 20 years. It seems quite a reasonable hypothesis, when compared to the results of other studies[33].

As stated also in SIR, the change in regional income (ΔY_{rt}), due to the decisions in ICTs policies, is our efficiency indicator. Consequently, the first elements to which we will point

[31] The results of the forecasting exercise will be presented in the next section, as well as the efficiency indicators. The cohesion indicators will be analysed in section 3.3.8.
[32] This will be done with a cluster analysis. The results will be presented in section 3.3.7.
[33] Technopolis et al. (2002).

our attention are the average growth rates of per capita GDP in the different scenarios[34]. In Table 3.19 we present the average growth rates for the whole sample, and for the two subdivisions into lagging and non-lagging regions. The maps presented in the following pages represent the growth rates for GDP and the absolute growth in accessibility and in Internet connections for each region in the different scenarios (Fig. 3.21- Fig 3.23). As already mentioned, our do-nothing scenario is zero; thus, if no ICTs investments are spent, GDP growth is equal to zero.

Table 3.19 - per capita GDP average growth rate in the scenarios

Scenarios	**Pc GDP growth rate**		
	Lagging regions	**Non lagging regions**	**Total**
0 - Do-Nothing	0.00	0.00	0.00
A - Indiscriminate	1.06	0.97	0.99
B - Efficiency	1.02	1.11	1.09
C - Cohesion	1.34	0.00	0.30

In the indiscriminate scenario (A), the average growth is around 0.99%, with a slightly higher effect on lagging regions (+1.06%) and a lower on non-lagging ones (+0.97%). Fig 8a shows that the GDP growth is equally distributed in most regions, with some peaks (positive or negative) that are explained by statistical effects. Most of the regions show per capita GDP growth rates between 0.5 and 1.2%. Thus, as expected, this scenario affects all regions almost in the same way.

A look at the changes in accessibility and in Internet endowment (Fig. 3.21b and Fig 3.21c) reinforces this conclusion: also these indicators show a distributed pattern throughout Europe. This scenario, as its label implies, does not discriminate among regions and the map of the growth rates appears quite flat.

In the efficiency scenario (B), on the contrary, there is a strong discrimination in favour of more efficient regions, towards which the main part of investments is directed. Moreover, a second differentiation is done, in terms of different policy mixes for the two kinds of regions[35]. This scenario presents the highest average growth rate for GDP for all the regions, near to 1.10%: this result is coherent with its orientation towards efficiency. Moreover, the non-lagging regions show a growth rate (1.11%) higher than lagging ones (1.02%), as their higher efficiency suggests. The lagging regions grow less than in the indiscriminate scenario.

As shown in Fig 3.21a, this scenario presents higher rates of GDP growth for the advanced 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). A lower increase is shown by the weaker regions of Germany (Eastern regions), Scandinavia and United Kingdom. However, the total impact of this scenario is higher than that of scenario A and it is quite different among regions. GDP values are a bit flattened by some statistical effects, due to a low population density or a low per capita GDP value.

[34] Note that we have defined growth rates of scenarios as percentage deviations of the "with-case" in 2020 from the do-nothing case. Hence, the growth rate of the do-nothing scenario is zero, by definition.
[35] See Table 2.3 for details on scenarios.

On the contrary, the maps of changes in accessibility and Internet connection (Figure 3.21b and Figure 3.21c) are more contrasting. Accessibility increases in the peripheral regions, as our scenario envisaged, especially the Mediterranean lagging regions (south of Spain and Italy) and Portugal, while it shows rates similar to scenario A in more developed or central regions. This result implies a weak effect of accessibility on the GDP growth, while Internet increase explains much more of the GDP increase, because of the higher returns from the investments (see Table 3.17). Internet connections increase strongly in the non-lagging areas like Northern Italy, southern UK, The Netherlands and Belgium, where the presence of congestion may require higher investments, while a weaker effect is shown on lagging areas.

Figure 3.21a - Scenario A: change in GDP

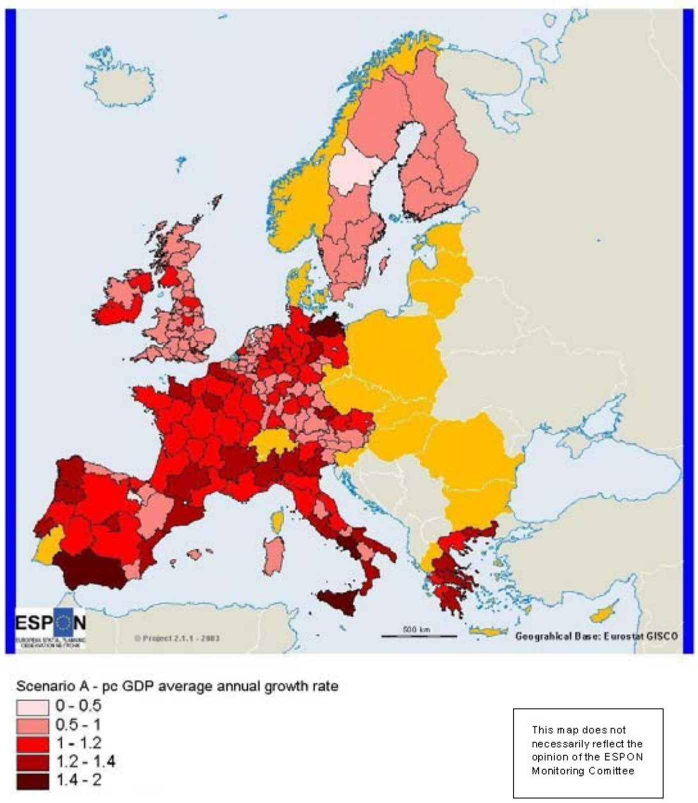


Figure 3.21b - Scenario A: change in accessibility

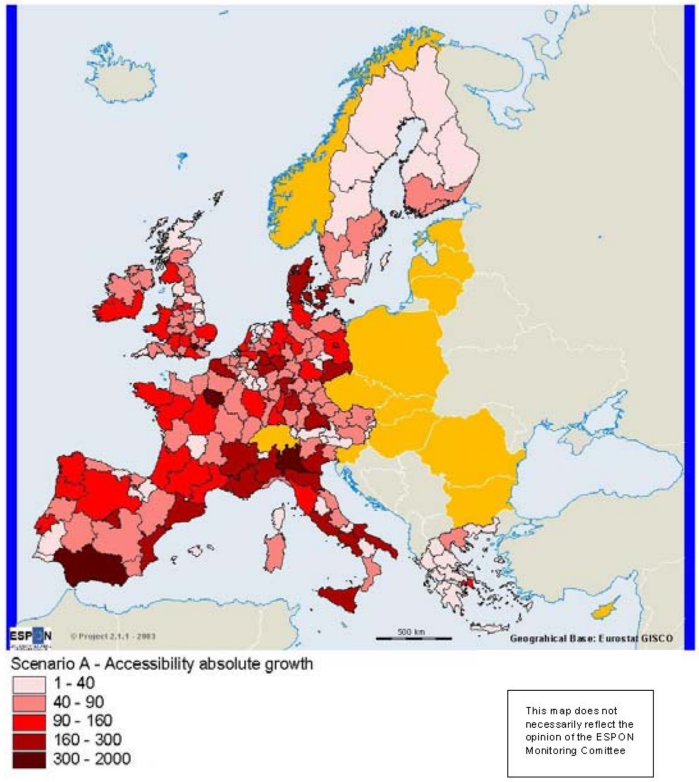


Figure 3.21c - Scenario A: change in internet connections

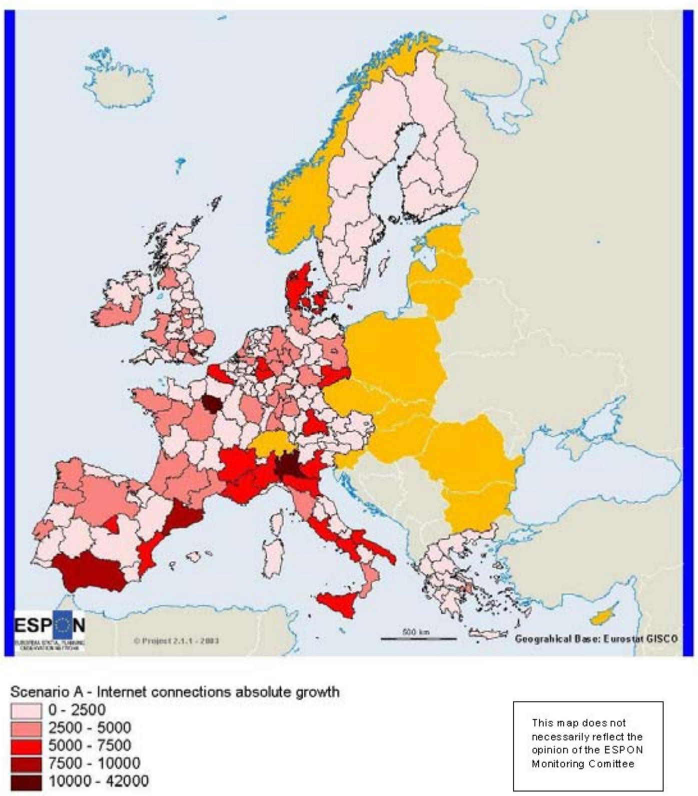


Figure 3.22a - Scenario B: change in GDP

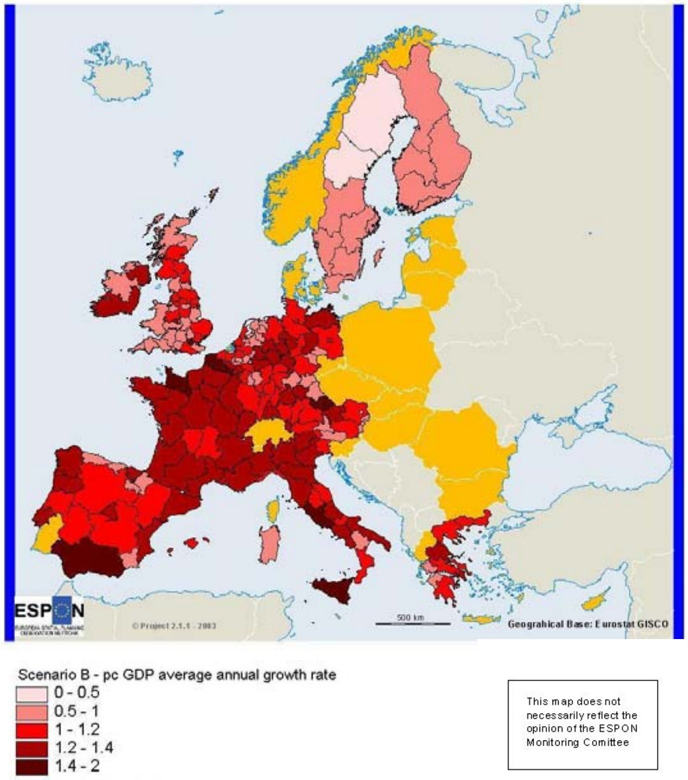


Figure 3.22b - Scenario B: change in accessibility

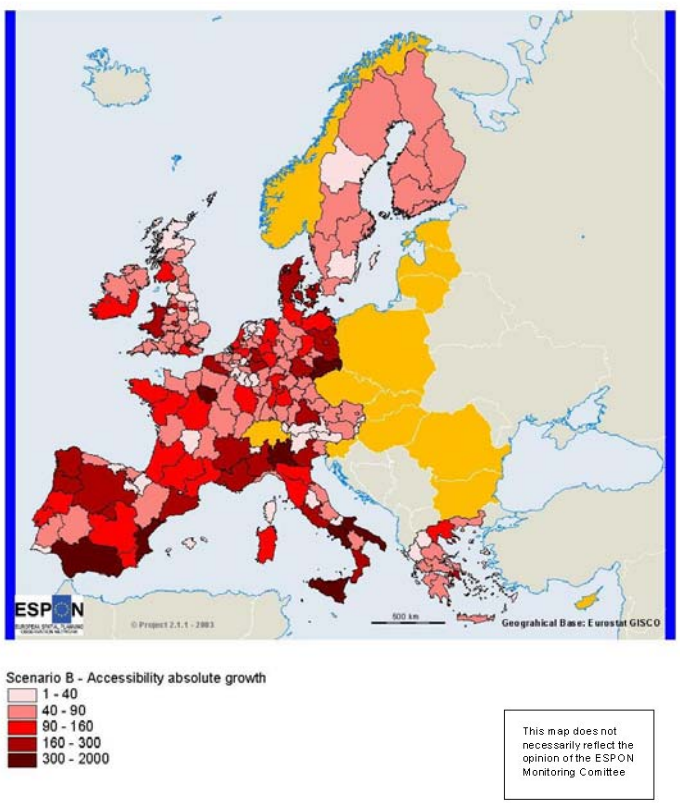


Fig 3.22c - Scenario B: change in internet connections

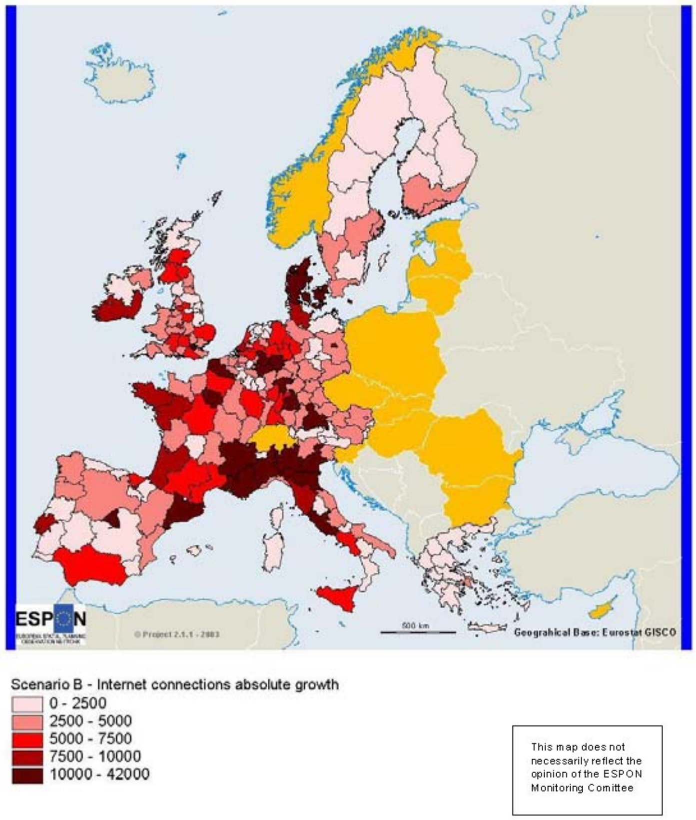


Figure 3.23a - Scenario C: change in GDP

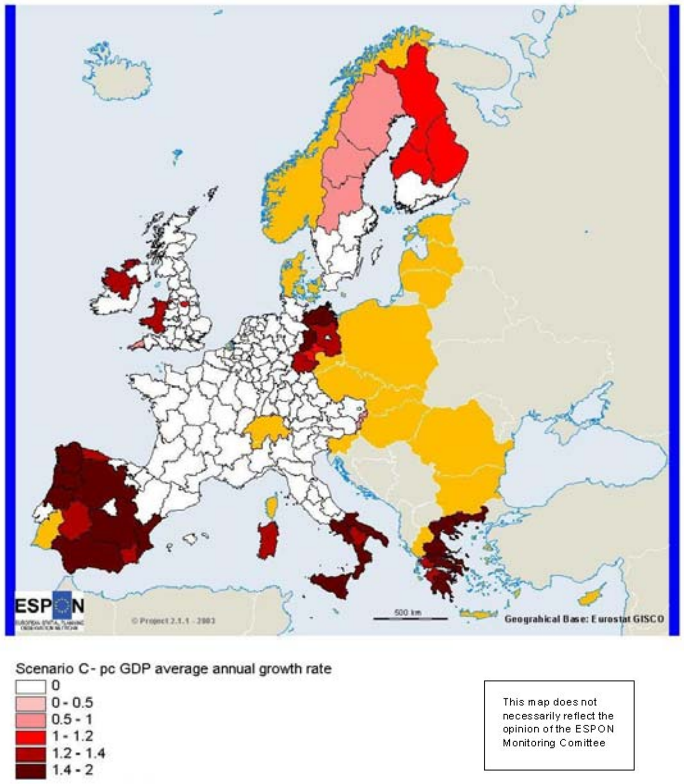


Figure 3.23b - Scenario C: change in accessibility

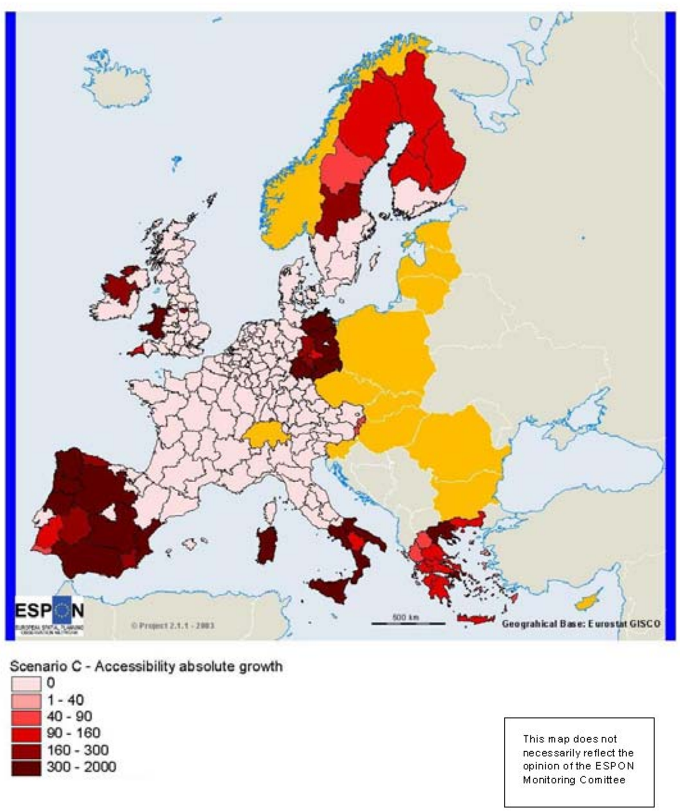
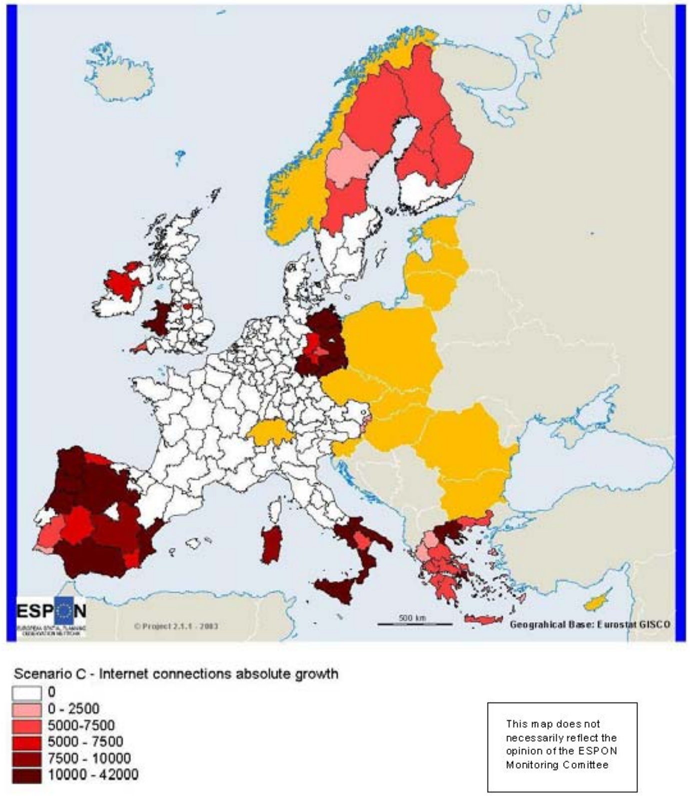


Figure 3.23c - Scenario C: change in internet connections



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

This section is dedicated to forecast the impact of the different policy scenarios. From the point of view of efficiency, scenario B is obviously the most appropriate. However, the European Union has another important goal, beside efficiency: equity, or cohesion. Section 3.3.8 deals with this theme.

3.3.7 Regions by Type of Impact

This section deals with the creation of a typology of regions according to the different impact of ICTs policies applied. In fact, despite the differences among policies, the impacts are influenced also by regional characteristics, and some regularities may be found. We run a *cluster analysis*[36] on GDP and Internet connections in the three scenarios, to group the regions by type of impact. We found 4 different kinds of regions, according to the different reactions

[36] See annex B for a more detailed explanation of the cluster analysis.

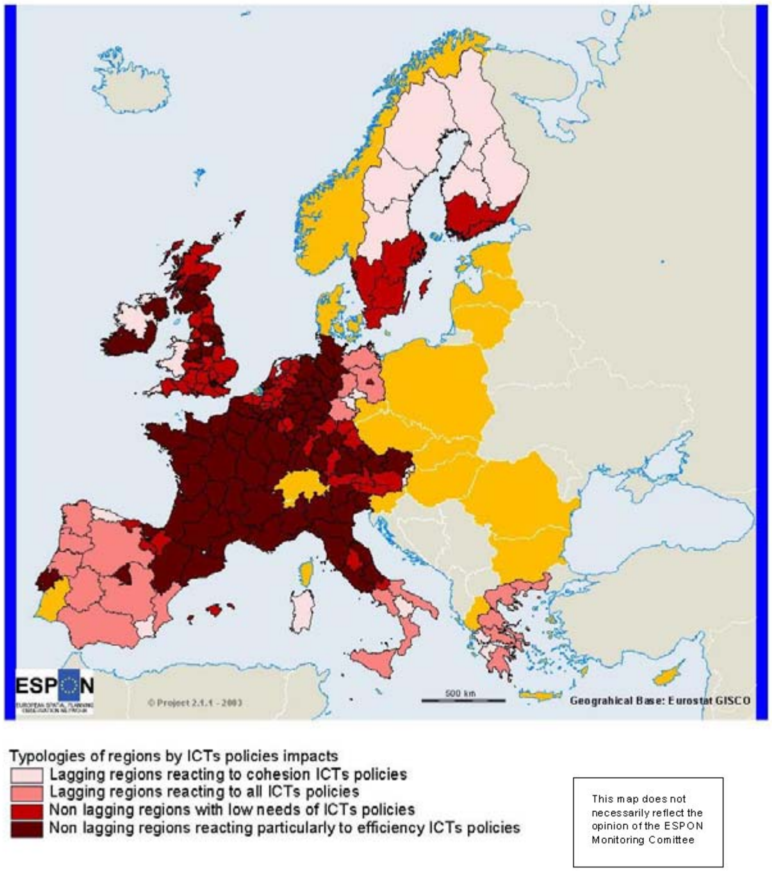
to ICTs policies: two clusters composed by lagging regions and two clusters of non-lagging regions (Table 3.20 and Fig. 3.24).

The first cluster contains lagging regions that improve their condition only in scenario C: these, probably weaker, regions need specific cohesion policies to show an increase in per capita GDP. On the contrary, in the second cluster we found lagging regions whose GDP shows an increase in all scenarios: consequently, these regions can be labelled “lagging regions reacting to all ICTs policies”. These are probably developing regions, ready to take the opportunity given by new technologies. Cluster 3 contains non-lagging regions whose GDP is not much improved by ICTs policies. However, these are developed regions, that may be already endowed will infrastructure and skills. Finally, the last cluster contains non lagging regions that shows a strong increase in GDP in scenario B: these regions react in particular to efficiency policies, probably because these policies eliminate some congestion effects and allow a better exploitation of the current endowment of ICTs and skills.

Table 3.20 - Regions by type of impact of ICTs policies: cluster analysis results

Indicator	**Cluster 1 Lagging regions reacting to cohesion ICTs policies**	**Cluster 2 Lagging regions reacting to all ICTs policies**	**Cluster 3 Non lagging regions with low needs of ICTs policies**	**Cluster 4 Non lagging regions reacting particularly to efficiency policies**	**Mean**
Number of cases	19	22	63	81	185
Scenario A indicators					
Per capita GDP	-0.79	1.35	-0.93	0.54	0.00
Internet connections	-0.77	1.38	-0.91	0.56	0.00
Scenario B indicators					
Per capita GDP	-1.42	0.68	-0.76	0.74	0.00
Internet connections	-1.37	0.73	-0.72	0.79	0.00
Scenario C indicators					
Per capita GDP	1.33	2.22	-0.51	-0.51	0.00
Internet connections	1.19	2.09	-0.56	-0.56	0.00
% of lagging regions	46.3	53.7	0.0	0.0	22.2
% of non lagging regions	0.0	0.0	43.7	56.3	77.8

Figure 3.24 - Map of the typologies of regions by ICTs policies impacts



3.3.8 Cohesion effects in ICTs policy scenarios

In this section, we compare the three different ICTs scenarios from the point of view of cohesion goals, and we will analyse three important indicators: first of all, per capita GDP, then accessibility and Internet connections.

By comparing the new levels of regional income to the old 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 growth rate and the EU average growth rate: in this way, we can identify the regions that achieve more advantages from the different scenarios.

Scenario A (Fig. 3.25) records some peaks, for the low density of population or the low level of GDP, as stated above. However, in general very few regions present consistent differences from the EU mean (northern Italy, some regions in France), and the effect in terms of income distribution is very low.

In scenario B (Figure 3.26), the impact on income distribution is stronger: a high number of regions shows growth rates different from the mean. The highest rates can be found in France, northern Italy, Belgium and The Netherlands, while the lowest in Scandinavian regions and Spain. The regional disparities worsen, because the regions with higher GDP grow more than weaker regions, which in their turn grow less than in the indiscriminate scenario.

Scenario C shows the highest GDP growth rate for lagging regions, as expected, while non-lagging regions are not concerned by the ICTs policies. Among the lagging regions, the impact of this scenario is quite distributed (Figure 3.27).

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

$$R = 1 - \frac{2}{n-1}\sum_{i=1}^{n-1} Q_i \qquad \text{with } i = (1,n) \qquad (3.11)$$

where
n = number of cases

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

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

In this case, we use regional per capita GDP as x. A higher R coefficient means a more uneven distribution of regional income, i.e. higher regional disparities. If R=0, then each region has the same income per capita, 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 3.21. Concerning GDP distribution, scenario A shows a coefficient very similar to the current situation, as expected, while scenario B seems to worsen the regional disparities and scenario C to improve them. These results can be represented through a Lorenz curve (Fig. 3.28): it is better considering the zooming area, because the curves are very close to each other. 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.

Table 3.21 - Gini coefficients

Scenarios	Pc GDP	Accessibility	Internet
Current situation	0.1978	0.3992	0.4089
Scenario A	0.1983	0.4383	0.4106
Scenario B	0.2002	0.4382	0.4476
Scenario C	0.1867	0.4382	0.8608
Equal distribution	0.000	0.000	0.000

Looking at Fig. 3.28, we can notice that scenario C, obeying to its cohesion objective, reduces the regional disparities, by creating a more equitous distribution. Scenarios A and B shows quite similar curves, however, as we can see in the zooming area, the efficiency scenario shows a lower Lorenz curve, a signal of worsening of the income distribution.

Fig. 3.25 - Scenario A: differences in GDP growth rates

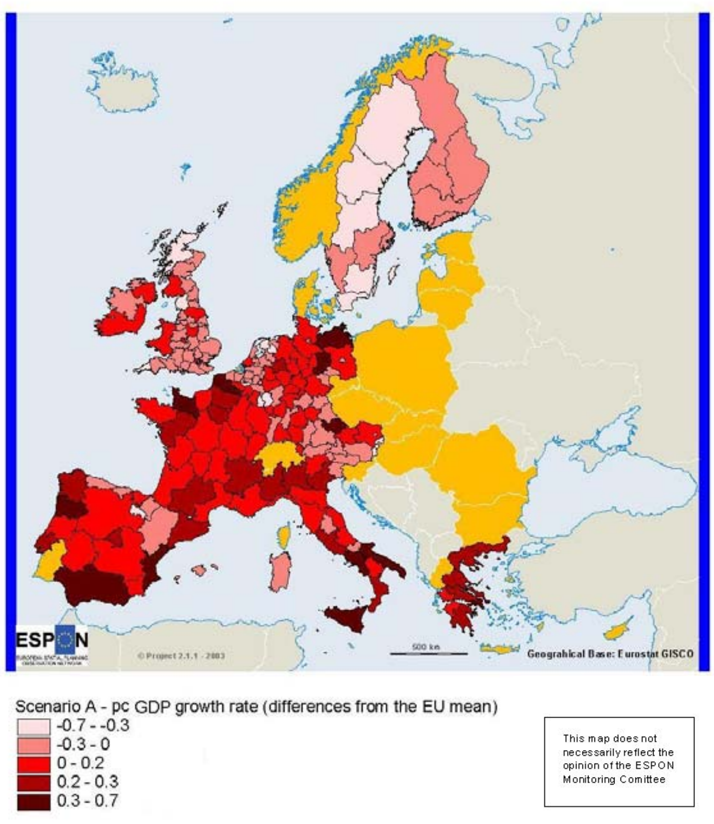


Figure 3.26 - Scenario B: differences in GDP growth rates

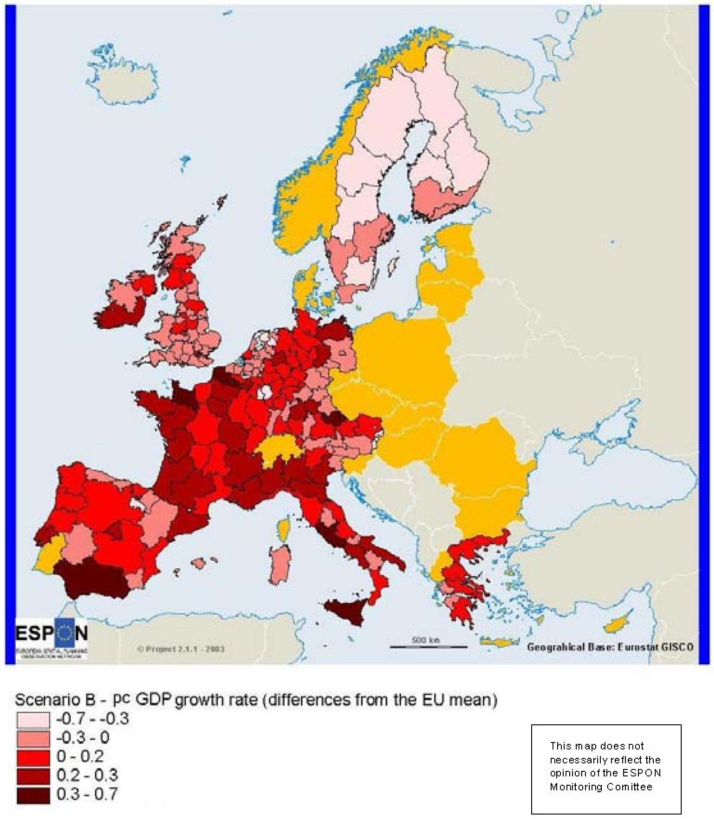
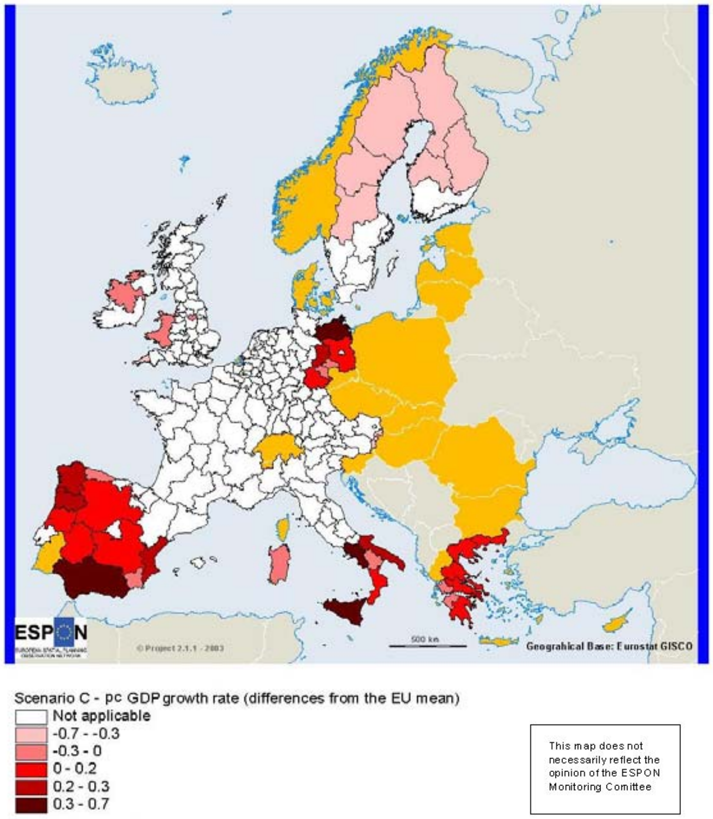


Figure 3.27 - Scenario C: differences in GDP growth rates



Concerning the two important indicators (accessibility and Internet), we can trace different conclusions: accessibility (Figure 3.29) shows very similar curves in the three scenarios, due to the low marginal efficiency of the investments in this case[37].

On the contrary, Internet shows high returns in terms of marginal efficiency, and the three scenarios present quite different curves (Figure 3.30). Scenario C, in particular, shows a more concentrate distribution, but we must underline that in scenario C the most equipped regions in terms of internet connections are the regions previously under-endowed. Scenario C, in fact, due to the very high returns of investments in Internet, made the lagging regions jump at the top of the curve. Disparities increase with regard to the Internet connections, but, since the most favoured regions are lagging ones, income disparities are reduced (see Fig. 3.28).

This result is better explained by using a chart, where are plotted the levels of per capita GDP of the clusters with highest or lowest GDP in the three scenarios[38]. The other axe shows the share of lagging regions in the cluster (Figure 3.31).

[37] See Table 3.17. Remember that our results are based on the hypothesis of no change in investments marginal efficiency.
[38] The results of this cluster analysis are presented in the Annex (Table B.1).

Figure 3.28 - Lorenz curve: per capita GDP distribution in the three scenarios

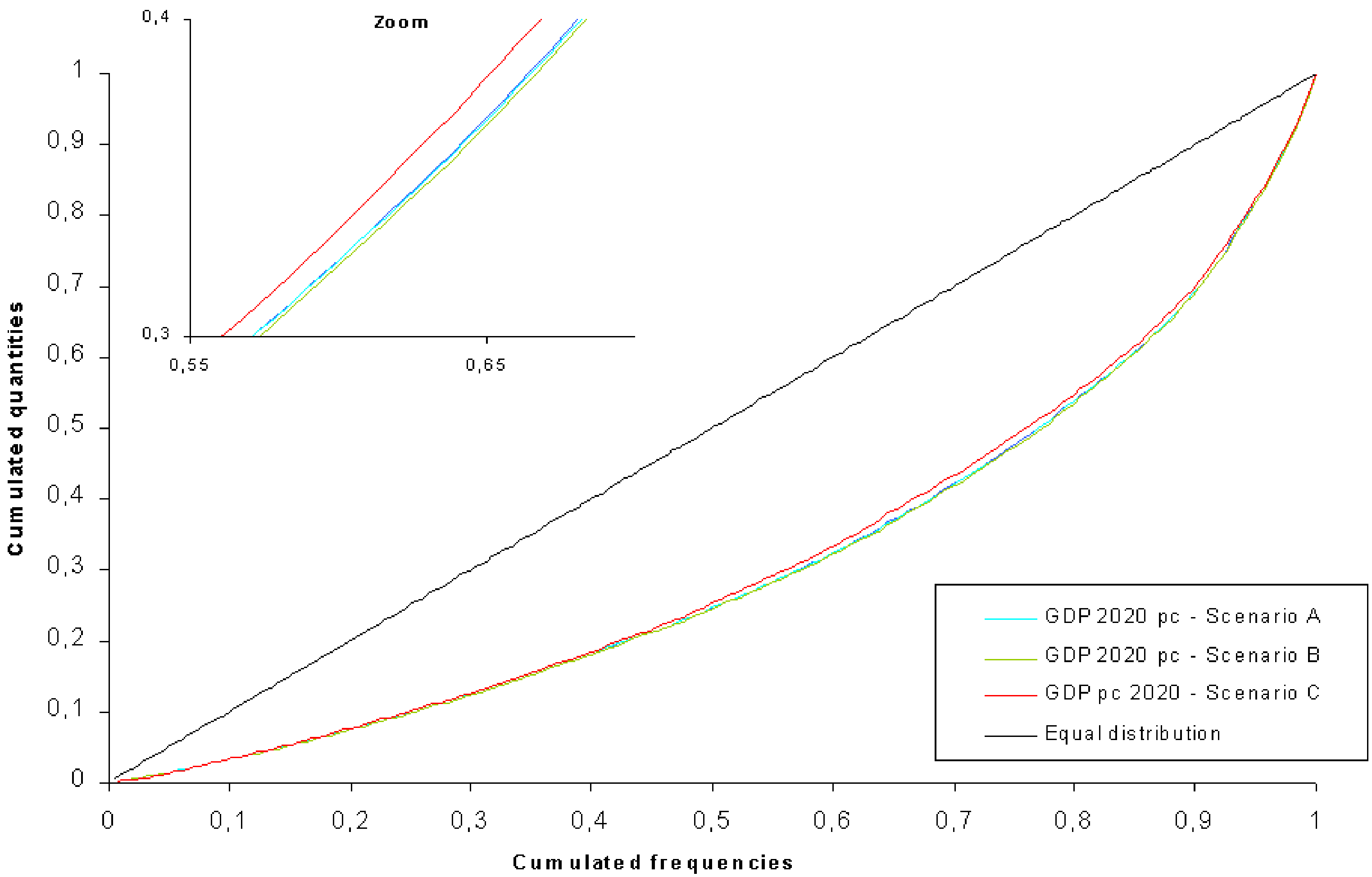


Figure 3.29 - Lorenz curve: Accessibility distribution in the three scenarios

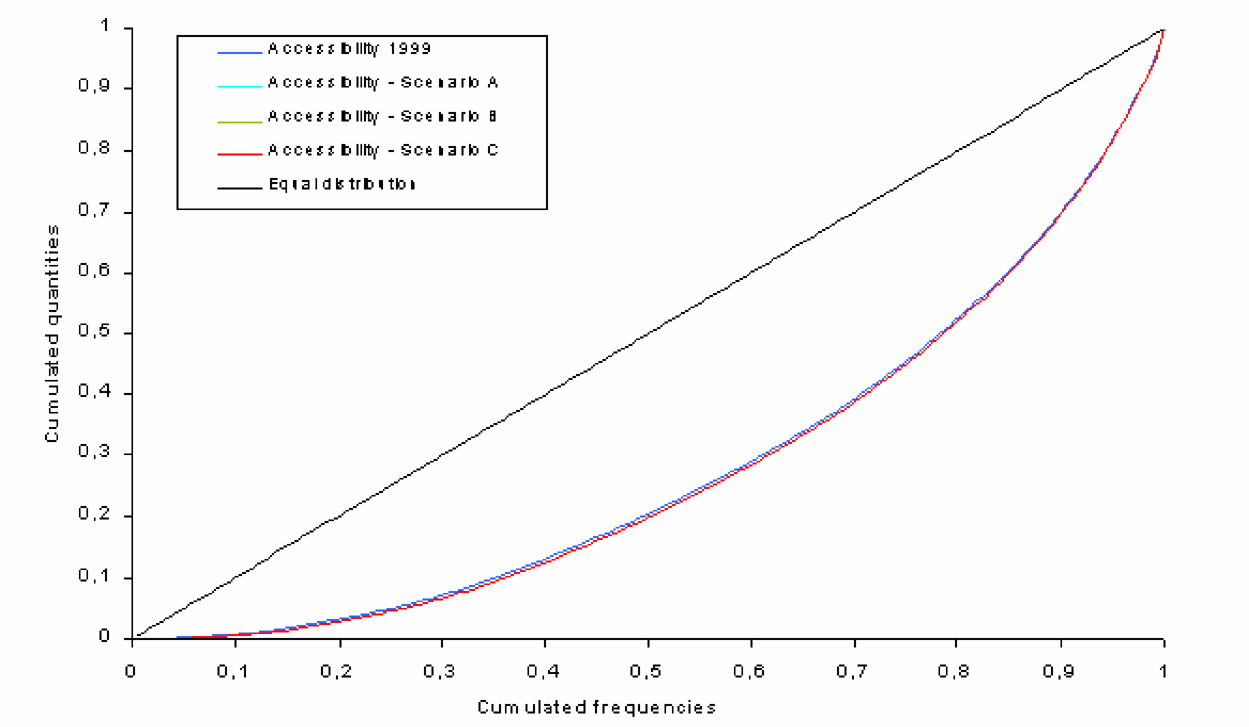
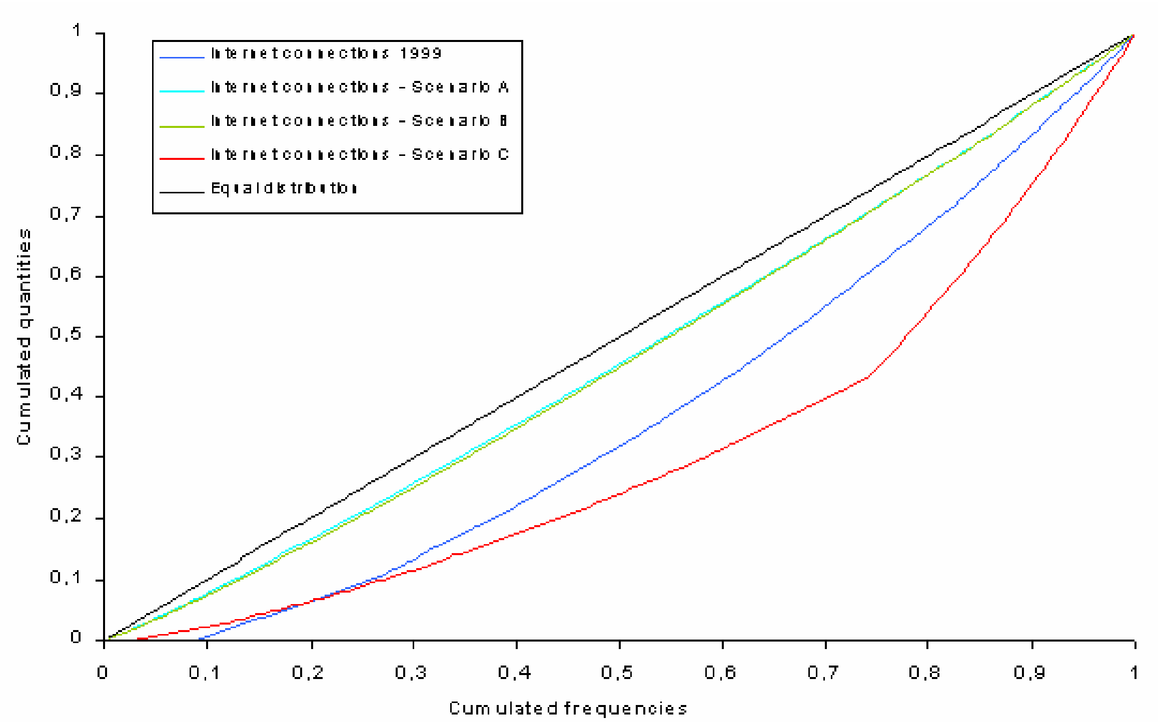
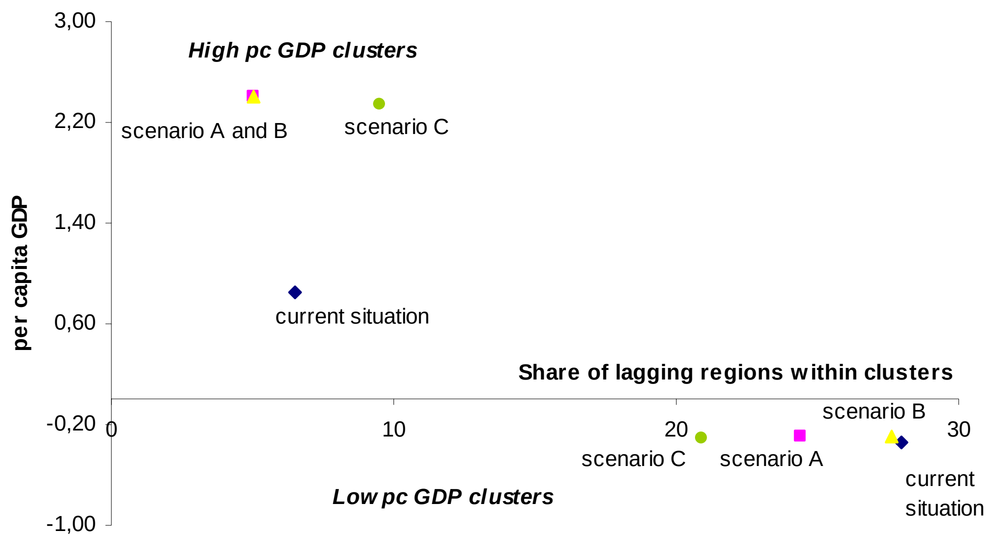


Figure 3.20 - Lorenz curve: Internet distribution in the three scenarios



The share of lagging regions in the richest clusters decreases in scenario A and B, if compared to the current situation, and increases in scenario C: this result implies that many lagging regions shows high income growth rates. On the other hand, the share of lagging regions in the lowest GDP clusters remains the same in scenario B, decreases in scenario A, due to a general growth, and decreases much more in scenario C, as expected.

Figure 3.31 - Distribution of lagging regions within highest and lowest pc GDP clusters



3.3.9 Concluding remarks

This third interim 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, the EU policies in this sector are extremely relevant, both for 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. The ICTs policies suggested by the eEurope Action plan could lead to very different scenarios, depending on their regional implementation. Our hypothesis envisages three scenarios, very different from the point of view of features, objectives and impacts on GDP: the indiscriminate scenario (A) shows an average growth rate equal to 0,99%, while

the efficiency scenario (B) shows a higher rate (1,1%), as expected, and the cohesion scenario (C) shows the highest rate for lagging regions (1,3%)[39].

4. These three scenarios provide a different impact on income distribution, too. While scenario A does not affect the 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.

5. The study is also able to demonstrate that within different typologies of regions (objective 1 regions or more advanced regions), different reactions to a specific ICTs policy exist. Within lagging regions, some areas are able to take advantage from all policies applied, while others react exclusively to cohesion policies; similarly, there are non-lagging regions that react dynamically to ICTs policies, while others seem more static.

[39] For more details on the GDP growth in the different scenarios, see 3.18.

3.4 Polycentric Connectivity and Overloaded Corridors

The ESDP focuses on interregional connectivity at different levels. 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*.

3.4.1 Polycentric Connectivity

The first part of this analysis is operationalized by a systematic and structured selection of abstract links that connect places within the polycentric hierarchical system of centres all over the ESPON space. The construction of priority links and the network evaluation is demonstrated with data available from the ESPON data base V2.2 and preliminary passenger road transport accessibility data.

Centres and interregional Priority Links

Base data for the construction of priority links is the list of FUAs (2003-07-11) provided by the project 1.1.1 TPG. With the overall typology European centres are grouped by the three classes MEGA city, transnational/national city and regional/local city.

In order to match the cities to the accessibility cost matrices calculated within the ESPON 2.1.1 project, they have to be allocated to NUTS3 regions. Therefore all regions are labelled by the centre of the highest level. In cases with more than one centre of this level the city with the highest population is selected leading to a set of 907 regions classified by functional level.

Based on this framework two kinds of abstract spatial priority links are generated from the geographical position of settlements by following a recursive hub and spoke principle:
- links that connect centres of one level (non-directional interconnections)
- links that connect centres of different, but adjacent levels (directional connections)

Table 3.22. Selected Links Connecting Regional Centres

regions (cities)			links			
centre level	#	# incl. higher levels	type	from	to	#
MEGA (European)	62		I	● ↔	●	174
			II	↗		264
transnational/national	264	326	III	● ↔	●	965
			IV	↗		581
regional/local	581	907		●	○	

The resulting links are supposed to strengthen the polycentric structure when improved by transportation policies. The following table shows the role of links in the concept of polycentricity.

Table 3.23 Link Types

link type	relation	orientation
I	connecting neighboured MEGA cities	non-directional
II	connecting transnational/national cities to nearest MEGA cities	directional
III	connecting neighboured transnational/national cities	non-directional
IV	connecting regional/local cities to nearest transnational/national cities	directional

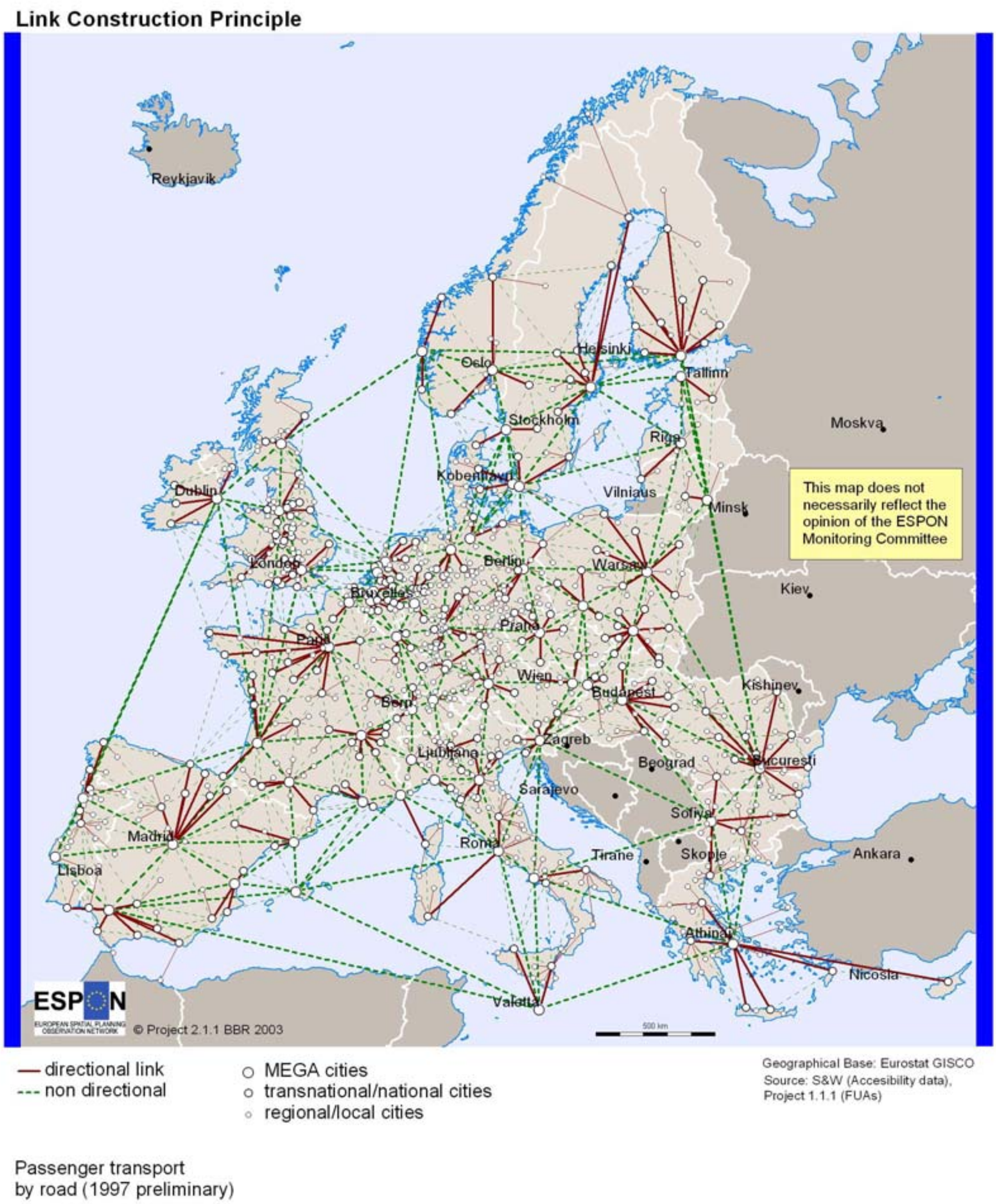


Figure 3.32 Link Construction Principle

The hub and spoke principle is realised with sets of links derived from the geographical position of cities. At this stage barrier effects due to waterbodies, mountains or boundaries are not taken into account yet as well as relationships form historical integration of cities. In the final version the links will be checked for plausibility.

The ESPON 2.1.1 scenarios only deal with road and rail projects. Thus some long distance links across sea may be dropped. Of course ferry links have to remain included considering the effects of lower travel speed standards.

So the hierarchical system of centres is mapped to different types of links with according specific levels of service. The whole set of links then will be classified by accessibility deficiencies regarding the appropriate standard levels of service of every link type. The set of links is not designed to meet specific transport modes. It is important for the determination of threshold values for accessibility standards to select a subset of the multimodal links that is suitable for the analysed transport mode.

The selected links are classified regarding accessibility quality by measuring beeline 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 impact of detour routes is measured too. The table shows thresholds for passenger road transport analysis based on a preliminary data set.

Table 3.24 Classification Example of Accessibility Deficits

link type	standard	substandard	high grade substandard
I	v greater than 55 km/h	v 40 up to 55 km/h	v less than 40 km/h
II	v greater than 50 km/h	v 40 up to 50 km/h	v less than 40 km/h
III	v greater than 45 km/h	v 30 up to 45 km/h	v less than 30 km/h
IV	v greater than 40 km/h	v 30 up to 40 km/h	v less than 30 km/h

v: passenger transport by road (1997) beeline speed

Alternatively other indicators like travel times especially for the directed links focussing more on criteria of supply. Also it is intended to evaluate thresholds by distance classes.

Two Aspects

Two important aspects of polycentric connectivity will be distinguished: polycentric accessibility and structurally lagging regions.

- Polycentric accessibility. Based on the methodological approach developed in the review of the Federal Transport Infrastructure and Investment Plan of Germany two kinds of abstract spatial priority links will be generated by following a recursive hub and spoke principle from the geographical position of settlements.
  The procedure is using the urban typology elaborated by project 1.1.1 of the ESPON framework. The hierarchical system of centres is mapped to different types of links with corresponding specific levels of service. The whole set of links will be classified by accessibility deficiencies regarding the appropriate standard levels of service of every link type and transport mode.

- Structurally lagging regions. To emphasise the balanced polycentric development each priority link is also classified by the structural strength respectively backwardness of the two connected centres. The regional typology used here is the same as used in the evaluation of model outputs in section 2.5 and D (Synthesis of modelling results – impacts by type of region).
  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".

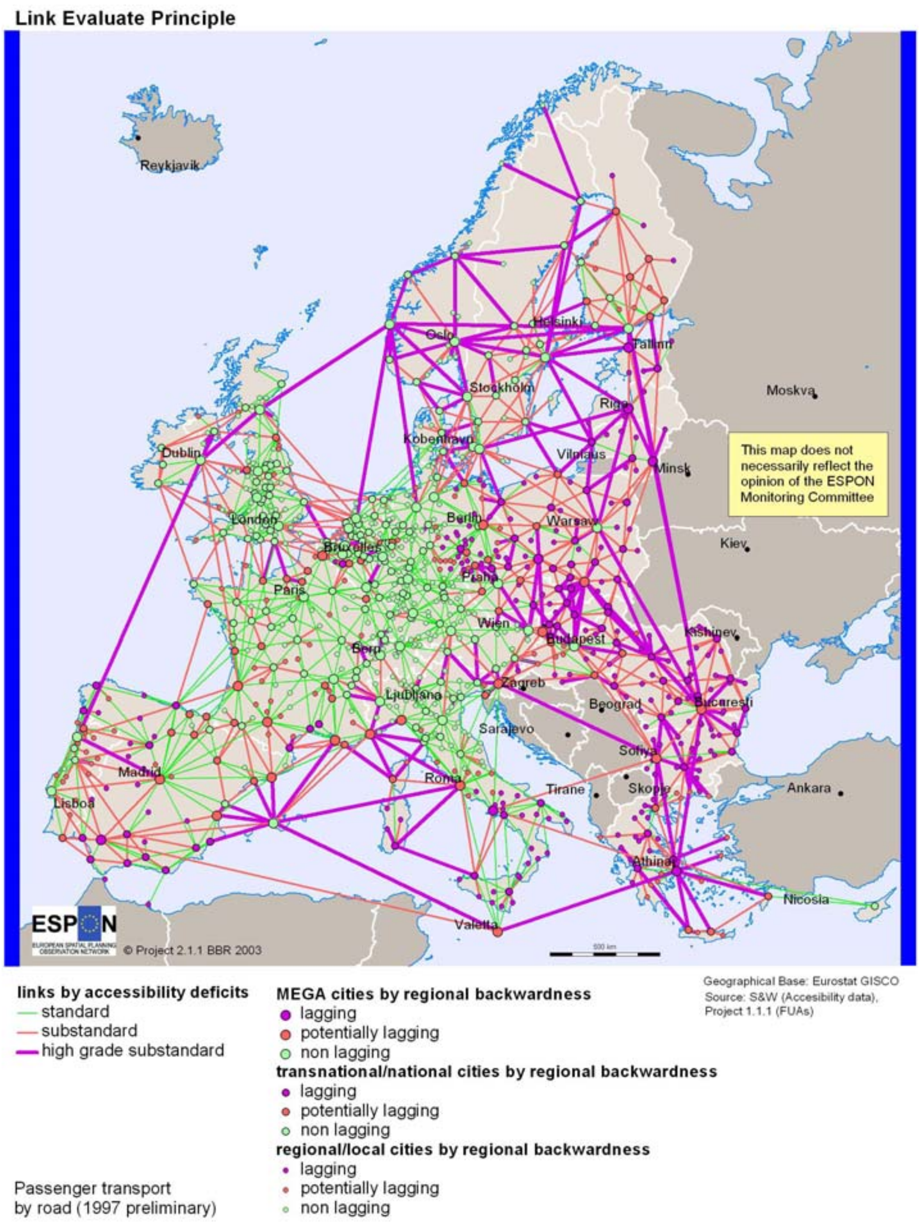


Figure 3.33: Link Evaluate Principle

The combined attributes, the quality of accessibility today compared to a specific average standard level and on the other hand the classification of the connected regions reflecting their economic situation can be weighted and scaled for each link in an evaluation matrix.

Table 3.25. Priority Links Evaluation Matrix

	economic backwardness		
accessibility deficit	non lagging	potentially lagging	lagging
standard link	○○○○	○○○●	○○●●
substandard link	○○○●	○○●●	○●●●
high grade substandard link	○○●●	○●●●	●●●●

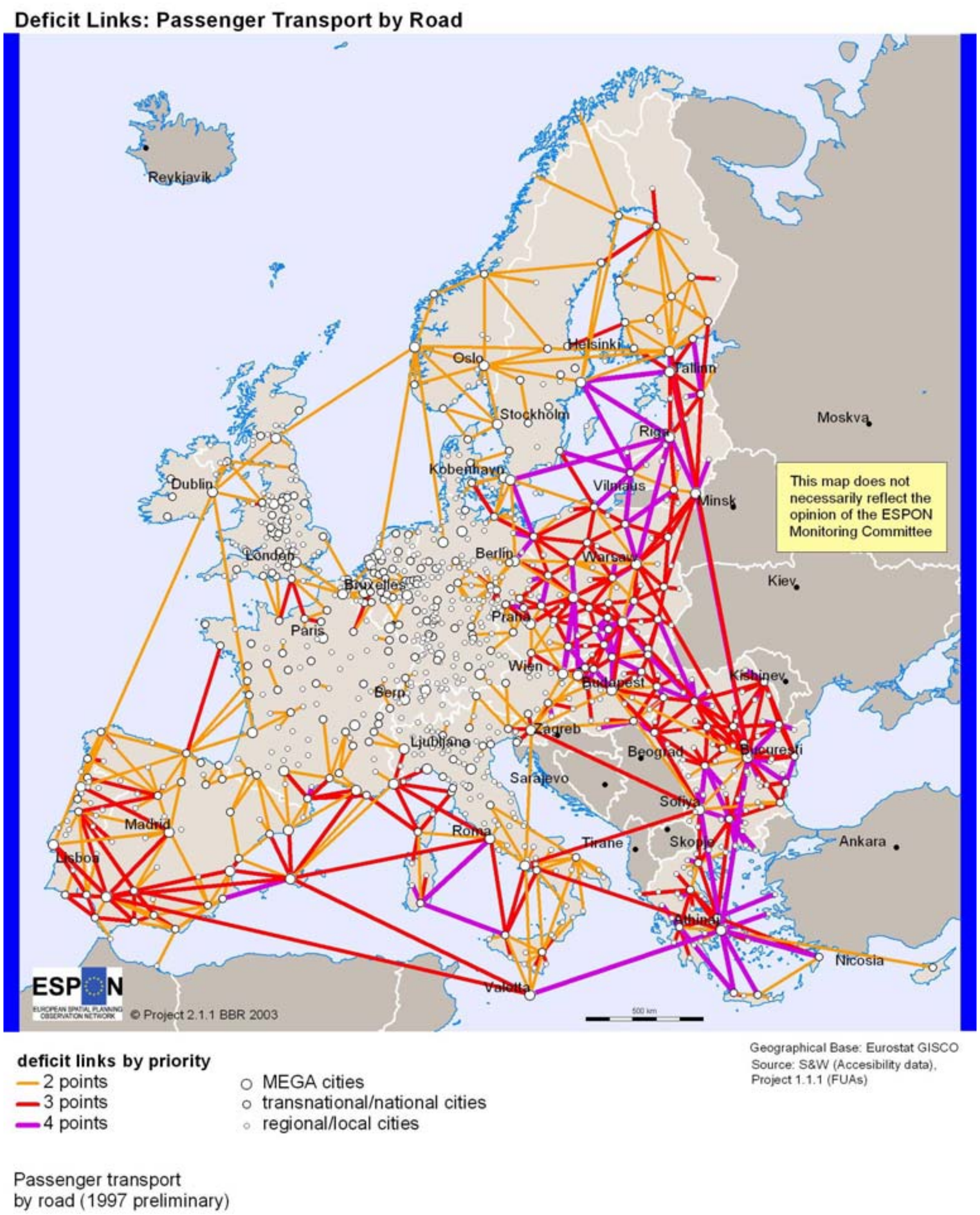


Figure 3.34: Deficit Links: Passenger Transport by Road

The resulting pattern of classified links provides the spatial priority evaluation framework of high priority links for TEN project evaluation in order to further a balanced polycentric development within the ESPON space (by reduced travel times or higher beeline speeds).

The polycentric link system is not to be used to identify requirements for expansion of transport networks in the sense of an ideal conception. It is rather a spatial raster to locate impacts of planned project regarding their impact on strengthening polycentric development.

The leading hypothesis is, that besides the TEN measurements operating on transport efficiency and economy benefits they can more or less support a polycentric and balanced development.

The spatial distribution of this support can be evaluated by testing the TEN measurements impacts on defined polycentric priority links.

At last the TEN projects are examined regarding their contribution to improve priority links. Whenever an improvement of accessibility is significant, the weighted value of each improved relevant priority link directly can be assigned to the causing project based on the evaluation matrix.

Expected Results

Within the framework of this methodology no absolute indicator measuring polycentrism is to be calculated. However, a relative measure for a strengthened polycentric development is given by the comparison of the current status (the “without” scenario) to the status after realisation of TEN policies (several “with” scenarios). The results can be visualized by mapping improved priority links (as line signatures) or gaining centres/regions at its ends (as points/polygons signatures).

The significance of a comparison of two single indices expressing the overall accessibility deficiencies of two different network conditions appears limited compared to the regional distribution of priority link improvements.

4 Cohesion and Development Potential: Further Findings

4.1.1 Implications of Transport Policy Scenario Results for Welfare and Inequality

4.1.1.1 Introduction

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.

4.1.1.2 The reference case

We start our analysis with a brief consideration of the reference case. The effects of transport policy will be studied in the difference they make with respect to this reference case. The reference case considers three years: 1991, 2001 and 2021. Table 4.1 gives average income (defined as per capita GDP) and inequality for each of these years for EU-15 and the new members. The Table shows that in the EU-15 average income is high and growing. Inequality within countries is highest in Germany and lowest in Sweden. There is no clear trend between 1991 and 2001, but it is expected on average to decrease until 2021. Inequality between countries is steadily decreasing.

For the 12 candidate members income is low, but growing faster than in EU-15. Inequality within countries is small when compared to EU-15, but one may suspect that this has something to do with the quality of the statistics. For instance, the very low value for Bulgaria is striking. Inequality between countries is much higher than in EU-15, indicating that the candidate members are less homogeneous than EU-15. The Table indicates divergence between 1991 and limited convergence until 2021.

4.1.1.3 Policy scenarios

The indicator discussed above has been used to interpret the results of the various models for the transport policy scenarios. Table D.1 in the Annex shows the percentage changes in inequality for the two subspaces EU15 and CC12. It allows for a further differentiation of inequality changes by showing the two components of inequality changes: (1) inequality change within countries, (2) inequality change between countries within the respective country group.

Table 4.1 Average income and inequality in the reference case

1a Average income in EU15

Country	Av. GDP 1991	Av. GDP 2001	Av. GDP 2021
Austria	18.41	27.59	51.01
Belgium	16.75	23.73	41.29
Germany	19.66	28.63	50.01
Denmark	21.32	31.05	54.37
Spain	9.36	14.44	25.32
Finland	16.61	22.05	37.43
France	17.19	24.12	42.64
Greece	7.87	11.31	20.36
Ireland	12.69	19.37	34.44
Italy	13.25	19.52	35.34
Luxembourg	27.84	42.20	74.93
Netherlands	16.75	23.47	40.61
Portugal	6.60	10.12	19.99
Sweden	20.22	27.49	46.86
United Kindom	13.15	17.78	30.07
EU-15	15.17	21.76	38.17

1b Inequality in EU15

Country	Inequality 1991	Inequality 2001	Inequality 2021
Austria	0.053	0.051	0.046
Belgium	0.033	0.032	0.031
Germany	0.102	0.104	0.102
Denmark	0.011	0.010	0.011
Spain	0.023	0.025	0.019
Finland	0.029	0.029	0.025
France	0.052	0.052	0.052
Greece	0.014	0.014	0.014
Ireland	0.025	0.025	0.026
Italy	0.045	0.047	0.045
Luxembourg	-	-	-
Netherlands	0.021	0.020	0.019
Portugal	0.066	0.064	0.058
Sweden	0.009	0.009	0.008
United Kingdom	0.052	0.052	0.047
Av. Within	0.054	0.055	0.051
Between	0.038	0.035	0.033
EU-15	0.092	0.089	0.084

Table 4.2 Average income and inequality in the reference case

2a Average income CC12

Country	Av. GDP 1991	Av. GDP 2001	Av. GDP 2021
Bulgaria	6.70	10.16	18.55
Cyprus	8.86	13.00	22.62
Czech	3.59	5.47	10.36
Estonia	2.13	3.07	5.27
Hungary	3.02	4.45	8.25
Lithuania	1.94	2.74	4.82
Latvia	1.55	2.19	3.99
Malta	7.10	10.42	20.28
Poland	2.76	4.17	8.09
Rumania	1.10	1.61	3.07
Slovenia	6.70	10.19	19.63
Slovakia	2.73	4.16	8.06
CEU-12	2.90	4.35	8.19

2b Inequality in CC12

Country	Inequality 1991	Inequality 2001	Inequality 2021
Bulgaria	0.000	0.000	0.000
Cyprus	-	-	-
Czech	0.029	0.038	0.028
Estonia	0.121	0.120	0.120
Hungary	0.069	0.068	0.060
Lithuania	0.007	0.010	0.010
Latvia	0.049	0.076	0.078
Malta	0.000	0.000	0.000
Poland	0.018	0.024	0.024
Rumania	0.016	0.023	0.020
Slovenia	0.319	0.453	0.470
Slovakia	0.054	0.071	0.053
Av. Within	0.031	0.040	0.036
Between	0.144	0.151	0.148
EU-15	0.175	0.191	0.184

In interpreting the figures in the table, it should be kept in mind that the contribution of average income to welfare is typically much larger than that of inequality. For instance, Table 4.1 indicates that for EU15 inequality has the effect that welfare is 8-9% lower than it would have been had income been distributed completely equally over the NUTS-3 regions. This implies that if average income increases with 1% while inequality increases by 10% the result will typically be an improvement in welfare. Of course, there is a value judgement involved here, and that is one reason why we have chosen to present both figures separately.

The figures in Table D.1 are usually small, indicating that transport policies should not be expected to result in dramatic changes in economic development in the European Union. This should come as no surprise, since the resources devoted to such policies are also small in comparison to total income. For a proper evaluation, benefits (measured, for instance, in terms of changes in average income and inequality) should be compared to cost. In this chapter only the benefits are indicated.

4.2 Impact of Transport Scenarios on Development Potential

Polycentricity

Polycentric development has emerged as a key concept during the European Spatial Development Perspective (ESPD) process. In ESPD (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."

Methodology

As outlined in the SIR of ESPON 2.1.1 and in the presentation at the Lead Partner Meeting in Brussels on June 16, 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*. 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 approach used by the "Study on the construction of a polycentric and balanced development model for the European territory" (CPMR, 2002) for producing typologies of urban systems. The methodology is also strongly related to the approach to be used by ESPON 1.1.1 for a typology of MEGAs (Metropolitan European Growth Areas).

Indicators

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. The values of each indicator in each scenario are normalised by the their respective maximum values in the reference scenario (00) and multiplied by 100. Hence, for the reference scenario (00) 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:

- <u>Development potential</u>: 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.

Differences in development potentials between any policy scenario and the reference scenario are used to illustrate the effects of specific policies. Since development potential is an inherently prospective concept and with the aim of a focused presentation, the following discussion is confined to three such comparisons:

- Effects of transport investments: difference between development potentials of scenario B3 and of the reference scenario 00
- Effects of marginal cost pricing of all modes: difference between development potentials of scenario C3 and of the reference scenario 00
- Combined effects of transport investments and marginal cost pricing of all modes: difference between development potentials of scenario D and of the reference scenario

Results

The transport investments have a positive impact on total GDP while the increasing transport costs have a somewhat larger negative impact. The combined effects on total GDP are slightly negative. The total impacts on GDP are small however (around ±0.1%). It should be observed 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.

The transport investments have a larger positive impact on total development potential (sum of development potential over all NUTS 3 regions) than on total GDP (around 3.1%). The negative impacts on development potential of increasing transport costs are about half as large (around -1.5%). Hence, the impact on total development potential of the combined scenario D is positive (around 1.6%).

The resulting spatial patterns of impacts on development potentials are shown in Figures 4.1-3.

According to Figure 4.1 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. Also positive impacts are observed in the south part of East Central Europe.

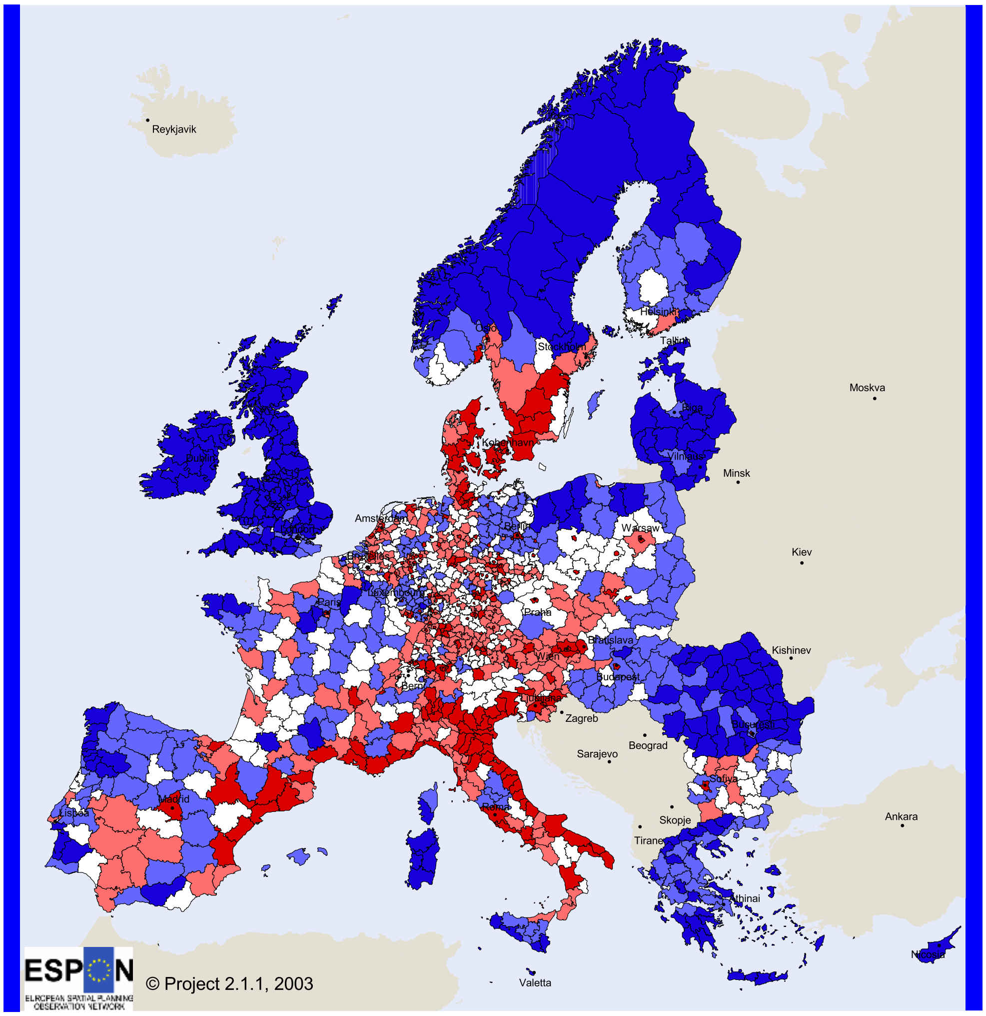
The marginal cost increases lead to least negative impacts on the development potential in the eastern part of EU27 and in the inner part of the Iberian Peninsula and France, see Figure 4.2. The most negative impacts are found in a dispersed set of regions including parts of Scandinavia, UK, Switzerland and Italy.

Finally, the effects of the combined investment and marginal cost pricing scenario (Figure 4.3) is similar to the impacts of investments but with relatively improved positions of regions in East Central Europe and with a large share of positive impacts outside the “pentagon”.

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 pricing scenario mainly extends the regions with improved relative position 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.

The impacts on regional welfare (CGEurope) and GDP/capita (SASI) resulting from the models show quite different spatial patterns of transport investments (positive impacts on most regions outside the “pentagon”, in particular on eastern and peripheral regions) and of marginal cost pricing (incur the most negative effects in peripheral regions and mostly so in the case of CGEurope). The combined scenario results in welfare and GDP/capita impacts, which are more similar to those reported above for the effects on the development potential (however with more relative improvements in eastern regions).

Differences in development potential (geometric average) between scenario B3 and reference scenario (based on SASI)

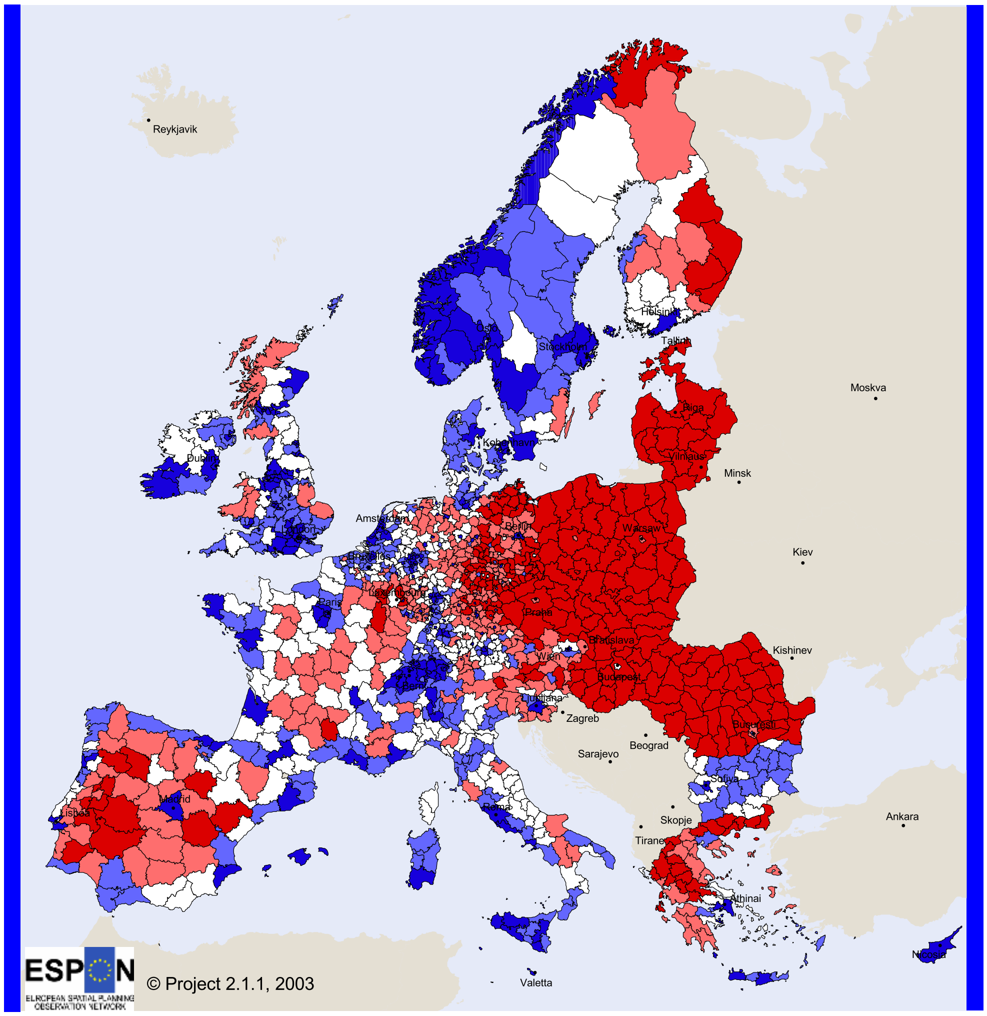


- -0.225 - 0.165
- 0.165 - 0.257
- 0.257 - 0.336
- 0.336 - 0.452
- 0.452 - 2.337

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 4.1: Differences in development potential between scenario B3 and reference scenario

Differences in development potential (geometric average) between scenario C3 and reference scenario (based on SASI)

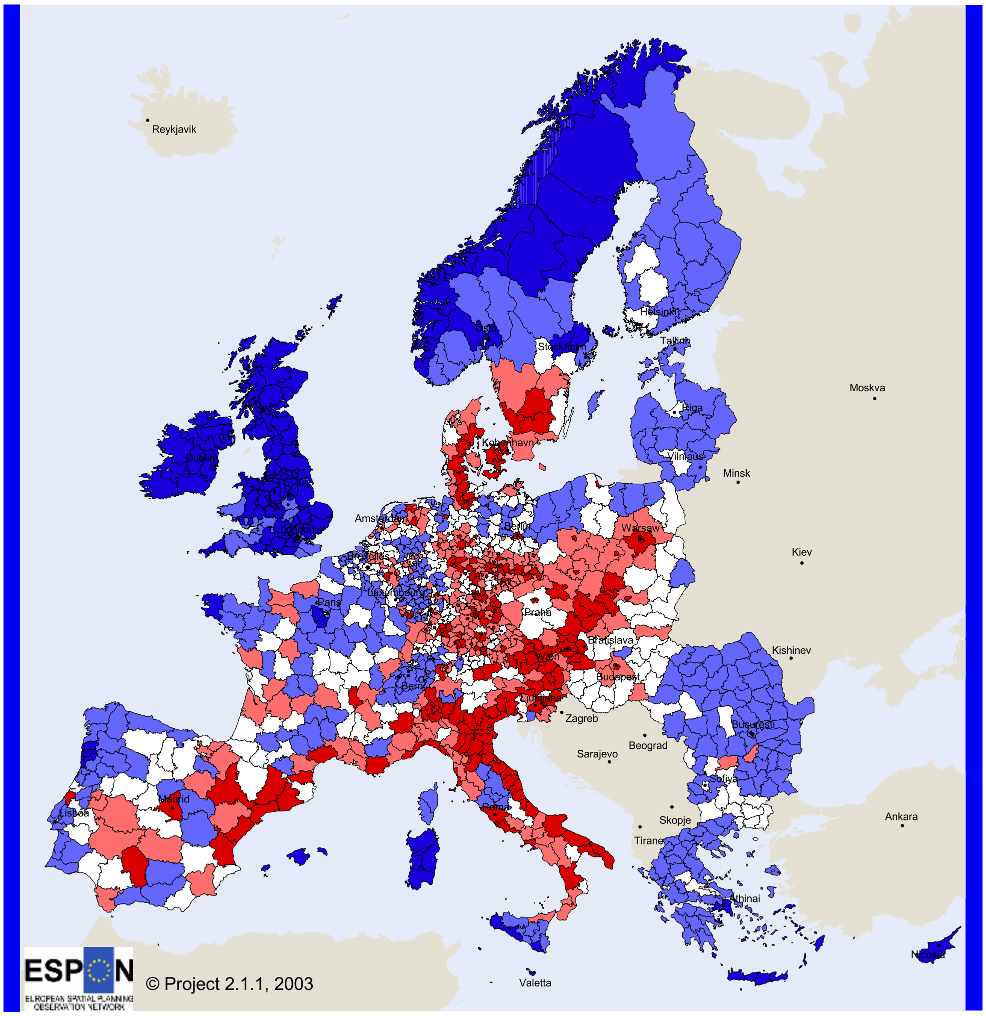


- -1.079 - -0.208
- -0.208 - -0.153
- -0.153 - -0.118
- -0.118 - -0.079
- -0.079 - -0.011

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 4.2: Differences in development potential between scenario C3 and reference scenario

Differences in development potential (geometric average) between scenario D and reference scenario (based on SASI)



- -0.791 - -0.065
- -0.065 - 0.139
- 0.139 - 0.205
- 0.205 - 0.29
- 0.29 - 1.444

This map does not necessarily reflect the opinion of the ESPON Monitoring Comittee

Figure 4.3: Differences in development potential between scenario D and reference scenario

5. Institutional Issues and Policy Interactions

5.1 Interaction between Transport and TEN Policies and other Spatially Relevant Policies

The previous Interim Reports have established a set of EU policies with which EU Transport and TEN policies interact. These Reports have discussed the broad nature of the interaction and the identification of the current policy from relevant EU documents.

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, and mainly 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 study did not look quantitatively at the extent to which expenditure within each policy area conflicted with each other in the sense that although each policy on average was redistributive, each policy may be going to different regions and in some cases failing to support each other. The 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.

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. 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. 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 have used the interaction matrix (Table 5.2) which was defined in the Second Interim Report. This provides a means of summarising the interactions which have been identified and the extent to which these are seen as having a positive or negative interaction effect. In this section we look in more detail at the opportunities and threats which these policy interactions pose.

[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

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 Framework for Horizontal Policy Analysis

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	++ -	+++ --	++ --	+ -	++ -	+ -	++ --

In this section we concern ourselves solely with the interaction of EU policies and look in particular at the 2001 White Paper *European Transport Policy for 2010: The Time to Decide* as the statement of current EU transport policy together with the 2003 Report of the High Level Group on the Trans-European Transport Network as a statement of current TENs policy. 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.

A detailed study of the policy documents reveals the unsurprising finding that there is very little attention paid to interactions between policies expect where they address the same principal objective. As seen in the previous study of the EU's overlty spatial policies there is some recognition of the impact which transport will have on the spatial distribution of activity, or environmental policy on transport and vice versa, of agricultural policy on the economic and social development of rural regions. We can add to this ICT policy which is clearly seen to have an impact on cohesion. 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.

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. Improvement of the EU's physical infrastructure play 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 5.2 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 basis 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[41] has noted the small number of the priority projects identified in the 1994 Essen list which would be expected to

[41] High Level Group on the Trans-European Transport Network, Report, June 2003

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 not an 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 labour costs through the thickening of labour markets. 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.

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 form 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 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 problems 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 for 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 xxx, 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 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 initiatives 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 xxx show that infrastructure development, that in the past as well as that planned for the future, generally favours rural regions more than non-rural ones, while externality pricing has just 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 provides an attempt to allocate some overall interaction effect based on both the likelihood and the strength of any interaction. This leads to the shaded cells which are those which the analysis identifies as the most critical.

5.2 Interaction between EU and National Transport Policies

In section 5.1 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 recognition of a common transport policy, most policy intervention is through subsidiarity 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 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. The effect of the legislative process in each member state is to refract the policy measure, that is 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 dominate, 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 conflict potentials can be replicated at the sub-national level.

Table 5.3 EU/National Policy Interaction Summary

	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			

The Final Report of the TENASSESS project[42] 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;
- 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

We felt this was rather restrictive given our need to consider all aspect 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 used the grid shown in Table 5.3. A copy of this has been completed for all the countries of the EU29 for which a current national transport policy statement could be identified.[43]

This poses certain 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.[44] 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. Belgium is a particular example of this problem where it has been difficult to identify a clear statement of national policy, but there is a statement of the position of Wallonia.

Our primary impression from sifting this large quantity of information is of the following broad situation:

- EU15:

[42] ICCR *et al*. (1999) *Euro: TEN-ASSESS Final Report*, European Commission Transport RTD 4th Framework Programme

[43] A list of identified web-sites is appended to this chapter

[44] 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.

  - little direct use is made of EU policy or TENs in formulating national policy priorities;
  - 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 means 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, in some senses, 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

Reference to 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.

Reference to 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.

Reference to 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).

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 members states (e.g. the Netherlands) – issues which they can typically only affect marginally, but where they have some need to influence the decisions of their bigger neighbours.

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.

Reference to cohesion

National policy clearly addresses national cohesion issues and not EU cohesion issues. The primary concern is over addressing 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 the mechanism by which the decisions relating to infrastructure in one member state may have a more substantial impact on the economy of another (not necessarily adjacent) member state is largely missing. A good example of this is the Benelux-Ireland link which is one of the original 14 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 members state making the decisions. In theory transferring projects to the private sector should 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[45] 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.

Reference to competitiveness

For 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.

Link to 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

[45] See De Borger, B. and S. Proost (ed.) (2001) *Reforming Transport Pricing in the European Union*, Cheltenham: Edward Elgar.

include the burgeoning markets of the accession countries as well as the need for new forms of transport in rapidly developing countries such as Chin. The competition between the main European train makers for potential high speed rail 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..

Reference to macro 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.

Concern with 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.

Framework for regional/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.

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.

5.3 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 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.

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 make 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 do 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.

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6. Conclusions and Recommendations on the Improvement of Sector Policies and Selected Instruments

After less than half of the project duration of ESPON 2.1.1, it is hardly possible to draw conclusions and make recommendations for the improvement of EU sector policies and selected instruments. Data collection and data analysis are still ongoing, the forecasting models have only recently been calibrated for the more then 1,300 regions of the ESPON Space, and the results of the model simulations are therefore preliminary and need to be thoroughly tested and validated. It would be a violation of sound scientific principles to make bold policy recommendations directed at specific sectoral policy fields or policy instruments based on these preliminary and yet to be validated results.

Nevertheless it is possible to draw some preliminary conclusions and make a few cautious and tentative recommendations based on the modelling exercise so far and prior experience from earlier related projects. The discussion will as much as possible refer to the hypotheses on the spatial impacts of EU transport and telecommunications policy presented in Section 2.3 of this report.

The first observation is that, if temporary local effects during the construction period are left aside, the overall effects of transport infrastructure investments 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. All these trends may have a much stronger impact on regional socio-economic development than transport infrastructure scenarios. If one considers that under normal economic circumstances the long-term growth of regional economies is in the range between two and five percent *per year*, additional regional economic growth rates of less than one or two percent over *twenty years* predicted by the two models are less than spectacular – even though it can be argued that one or two percent of total GDP of the 29 ESPON countries is a huge sum compared to the costs of the infrastructure.

The second related observation is that even large increases in regional accessibility will translate into only very small increases in regional economic activity. However, this statement needs to be qualified, as the magnitude of the effect seems to depend strongly on the already existing level of accessibility. For regions in the European core with all the benefits of a central geographical location *plus* an already highly developed transport and telecommunications infrastructure, additional gains in accessibility through even larger airports or even more motorways or high-speed rail lines may will bring only little additional incentives for economic growth. For regions at the European periphery or in the accession countries, however, which suffer from the remote geographical location *plus* an underdeveloped transport infrastructure, a gain in accessibility through a new motorway or rail line may bring significant progress in economic development. But, to make things even more complex, also the opposite may happen if the new connection opens a formerly isolated region to the competition of more efficient or cheaper suppliers in other regions.

The comparison of the rail-only scenarios A1 and B1 with the road-only scenarios A2 and B2 seems to indicate that new roads are much more effective than improvements of the rail network. However, this conclusion needs to be drawn with caution. The larger effects of road projects may be caused by two factors: first because today more than 80 percent of all passenger travel and goods transport occur by road and second because the volume of money for road construction has been and is likely to be in the future far larger than the money that goes into rail construction.

Another possible comparison is the one between the retrospective infrastructure scenarios A1-A3 and the prospective infrastructure scenarios B1-B3. Both simulation models agree that there is not much difference between the two simulation periods 1991-2001 and 2001-2021. In both periods development is largely determined by the road construction programme despite large and highly visible rail infrastructure extensions, such as the high-speed rail lines in France, Germany and Spain.

The effects of the pricing scenarios C1-C3 depend on the direction of cost changes. Reducing rail fares as in scenario C1 improves accessibility but has little or no overall effect on regional economic performance because of the small modal share of rail. Making road transport or all modes more expensive, as in scenarios C2 and C3, respectively, reduces both accessibility and regional economic activity. This effect, which is unequivocally produced by both models, reveals a conflict between the policy objectives of efficiency, equity and environmental sustainability: while subsidies to rail and road pricing aim at the promotion of a modal shift from road to rail for environmental reasons and at the same time at a more equitable distribution of the social costs of transport, road user charges are clearly a locational disadvantage for economic activities in the affected regions.

This goal conflict becomes even more obvious when the cohesion effects of the simulated scenarios are examined. Before this can be discussed, first a comment on how cohesion effects can be measured is required. The most frequently used measures of cohesion, such as the coefficient of variation or the Gini coefficient, measure *relative* differences between regions; these cohesion indicators would classify a policy as pro-cohesion if economically lagging regions would grow faster (in relative terms) than economically more advanced, i.e. more affluent regions. However, one percent growth in a poor region is in absolute terms much less than one percent growth in a rich region. Even if poorer regions grow faster than rich regions (in relative terms), in most cases the income gap between rich and poor regions (in absolute terms) is widening. Which of the two concepts of cohesion (or convergence or divergence) is used, is a matter of definition. It is therefore of great importance to clearly state which type of cohesion indicator is used.

In ESPON 2.1.1 five types of cohesion indicator are used: (i) the coefficient of variation, (ii) the GINI coefficient, (3) the ration of the geometric and the arithmetic mean, (iv) the correlation between relative change and level and (v) the correlation between absolute change and level. The first four of these measure relative differences, and only the fifth one measures absolute differences.

Both forecasting models, SASI and CGEurope, agree to a large extent on the cohesion effects of the transport infrastructure scenarios A1-B3. These scenarios are in general pro-cohesion in relative terms but anti-cohesion in absolute terms, i.e. they reduce relative disparities in income but increase the absolute gap between rich and poor regions. The retrospective scenarios A1-A3 and the prospective scenarios B1-B3 differ with respect to the role of rail investments. In the past decade 1991-2001 new rail infrastructure was predominantly built in the western parts of Europe which resulted in slight anti-cohesion effect, whereas in the future two decades 2001-2021 rail projects are more evenly distributed between east and west Europe resulting in a slight pro-cohesion effect. In both cases the rail effects are overshadowed by the much larger road effects, which, as road projects tend to be more evenly distributed in space, tend to be pro-cohesion.

The two models come to partly different results on the cohesion effects of the pricing scenarios C1-C3. They agree that in relative terms the pricing scenarios are anti-cohesion. Even though the pricing policies are applied only in the member states of the present European Union, these countries are advantaged. If rail fares are lowered, they benefit more and if road user charges are increased, they suffer less because of their more central location. However, the models disagree on the effects if absolute differences are taken into account. In the SASI model the central countries suffer so little that even in absolute terms their losses are smaller than those of the peripheral countries. In the CGEurope, however, the relative losses are similar in both central and peripheral countries, which means that in absolute terms the central countries suffer more. The most likely explanation for these differences is that the two models assume different price elasticities of travel and goods transport. It is possible that in the SASI model the more central regions are better able to respond to higher transport costs by making less and shorter trips and buying goods from regions closer by, whereas in the CGEurope model all regions continue to make long trips and buy goods from distant regions. These differences between the two models deserve further examination.

The combination scenario D, in which the assumptions of transport infrastructure scenario B3 and pricing scenario C3 are combined, responds in every respect, as to be expected, somewhere in between the two scenarios.

As scenario D was designed to resemble the most likely policy mix of the future EU transport policy, it well illustrates the fundamental conflict of European transport policy between the policy goals of competitiveness, cohesion and environmental sustainability.

The infrastructure components of scenario D are intended to serve the two former goals, competitiveness and cohesion; and as has been shown in the discussion of the transport infrastructure scenarios A1-B3, these two goals are already in conflict. If transport infrastructure is built where demand is greatest and its economic benefits are greatest, they will be built in the most central regions and primarily benefit the already most affluent regions. If, however, transport infrastructure would be built with cohesion as the number-one priority, it would have to be built in the peripheral regions, where their relative effect might be great but their absolute effects would be little.

The pricing components in scenario D serve the two latter goals, cohesion and environmental sustainability. In particular scenario C3, in which social marginal cost pricing of all transport modes is assumed, is intended to achieve a more equitable distribution of transport externalities and a shift to more sustainable transport modes. However, increasing transport costs are obviously negative for the economic performance of the affected regions.

This conclusion, which was brought out with great clarity in the scenario simulations, leads to the only policy recommendation for the transport sector that can be given at this point. The recommendation is that this fundamental goal conflict of European transport and telecommunications policy needs to be brought to the open and be discussed in the political arena.

The conclusion is different for ICT policies. First, results seem to suggest a stronger potential for ICT policies to influence the spatial structure of the economy, even though this finding needs further scrutiny in ongoing research. As a matter of fact, the respective regression results suggesting this strong impact may suffer from a causality problem. To some extent they might show the impact of growth on ICT rather then the reverse. But still, there is some evidence of a strong impact. Furthermore, there is less risk of conflict with other policy fields. Unlike transport, communication policies supporting cohesion and polycentricity by improving the access of the periphery do not get into conflict with environmental objectives.

The report shows that that the spatial impact of ICT policies could vary sharply, depending on the way of regional implementation. One can infer from the evidence that for the future, ICT policy might be more a case for emphasizing the spatial perspective of sector policy rather than transportation. Furthermore, recent theoretical research in economic geography (Martin 1999a, 1999b) shows that there is also a regional policy case for investing into communication rather than transportation for the following reason: transportation investments favouring the periphery may hamper overall efficiency because they weaken agglomeration advantages. This is not so for policies aiming at an improvement of peripheral access to information and communication.

7 Further research

7.1 Polycentricity

Polycentricity is the main topic of ESPON 1.1.1 "The Role, Specific Situation and Potentials of Urban Areas as Nodes of Polycentric Development". However, as polycentric development is one of the major goals of the European Spatial Development Perspective (ESDP), polycentricity is also of great importance for ESPON 2.1.1 which has among its objectives the assessment of impacts of European transport and telecommunications policy TEN and TINA on the polycentric spatial structure of the enlarged Europe. Polycentricity is there a primary area of co-operation between ESPON 1.1.1 and ESPON 2.1.1.

In ESPON 1.1.1 the current pattern of polycentricity in Europe is being analysed at three spatial levels: at the regional and local level, at the national level and at the European level, including transnational urban systems. As units of analysis, 'functional urban areas' were defined in each country using seven criteria: population, transport (airports, ports), tourism (hotels), industry (gross value added), knowledge (universities), corporate decision making (headquarters) and administrative function. The selected centres were classified using a typology of global, European, national, regional and local importance. In a parallel approach, polycentricity was analysed based on the relational logic of territories ("the space of flows") proposed by Castells (1989) focussing on trans-border co-operations (Interreg IIa and IIIa), air traffic and co-operations between universities.

This section summarises a methodology that will be used in ESPON 1.1.1 to identify centres in the European urban system and to measure the degree of polycentricity of urban areas, the urban systems of individual countries and the European urban system at large. This approach is of particular interest for ESPON 2.1.1 because it will permit, in conjunction with the regional economic models used in ESPON 2.1.1, to quantify the impacts of EU transport and telecommunications policies on the polycentric spatial structure in Europe. The actual implementation of the methodology is planned for Year Two of ESPON. The planned methodology is presented in detail in the Third Interim Report of ESPON 1.1.1.

7.1.1 Problem Statement

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.

However, until today the concept of polycentricity has remained largely at the level of rhetoric without a precise operational definition (which puts it into a class with similarly vague concepts such as 'city networks' or 'industrial clusters'). There exists neither a method to *identify* or *measure* polycentricity at different spatial scales nor a method to *assess* the impacts of polycentricity (or the lack of it) with respect to policy goals such as efficiency (competitiveness), equity (cohesion) and sustainability. It is therefore not possible to determine an *optimal* degree of polycentricity between centralisation and decentralisation or,

in other words, between the extremes of monocentricity and dispersal. This makes it difficult to formulate well-founded policy recommendations as to which cities should be developed with priority.
It is therefore necessary to develop an operational concept of polycentricity and operational methods for identifying and measuring the existing polycentricity of the European urban system. The methodology should allow (i) to *measure* the degree of polycentricity of a region, a national urban system or the European urban system at large, (ii) to *evaluate* it with respect to the policy objectives of European Spatial Development Perspective competitiveness, cohesion and environmental sustainability and (iii) to *forecast* the likely impacts of European, national or regional economic, transport and telecommunications policies on the degree of polycentricity and the three policy goals.

7.1.2 The Method

The proposed approach measures polycentricity by identifying three dimensions of polycentricity: the *size* or importance of cities (population, economic activity, human capital, higher education, cultural importance, administrative status etc.), their *distribution in space* or *location* and the *spatial interactions* or *connections* between them.

Size

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. Rank-size distributions of cities in European countries differ significantly. Figure 7.1 shows the rank-size distribution of cities with a population of more than 50,000 in France, Germany, Italy and Spain. It can be seen that France has a predominantly monocentric city-size distribution, whereas Germany has a historically grown polycentric urban system.

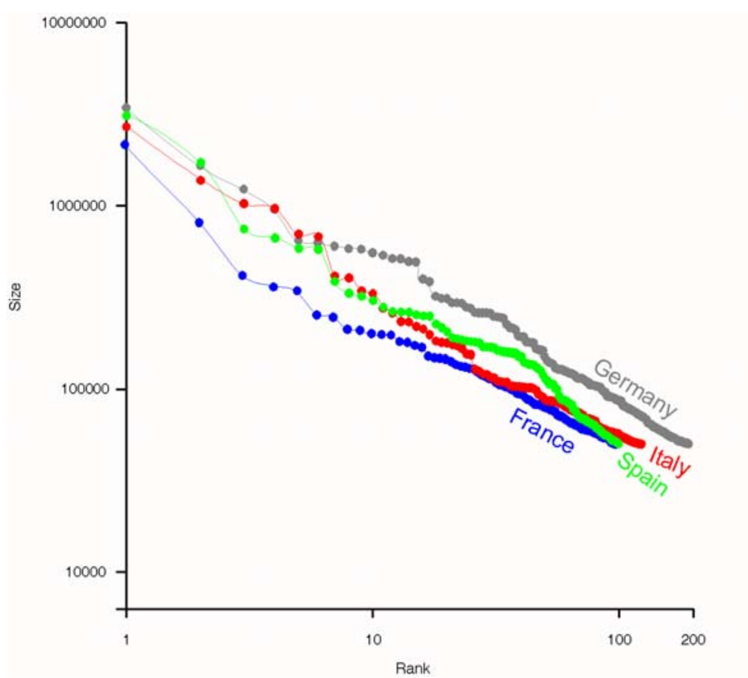

Figure 7.1. Rank-size distribution of cities in France, Germany, Italy and Spain

A first step in analysing polycentricity of an urban system is therefore to derive its population rank-size distribution. A possible indicator of the size dimension of polycentricity are the residuals of the rank-size distribution from the regression line of the logarithmic transformed population values: the smaller the residuals, the more polycentric is the urban system. Alternatively, a combined indicator of city size and importance may be used, such as economic activity, human capital, higher education, cultural importance, administrative status etc.

Location

The second prerequisite of a polycentric urban system is that its centres of equal size or rank are equally spaced from each other – this prerequisite is derived from the optimal size of the catchment area or 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 of equal size or rank over the territory. One possible approach is to subdivide the territory of each country into catchment areas (Thiessen polygons) of each centre. The indicator of the location dimension of polycentricity is then the squared sum of deviations of the areas or populations served by each centre from the average area or population served by a centre in the whole country. The smaller the squared sum of deviations, the more polycentric is the urban system. Instead of airline distance also the logsum of the travel times and/or travel costs by road and rail (and at higher levels of the hierarchy also by air) could be used. Figure 7.2 shows the subdivision so derived for Germany.

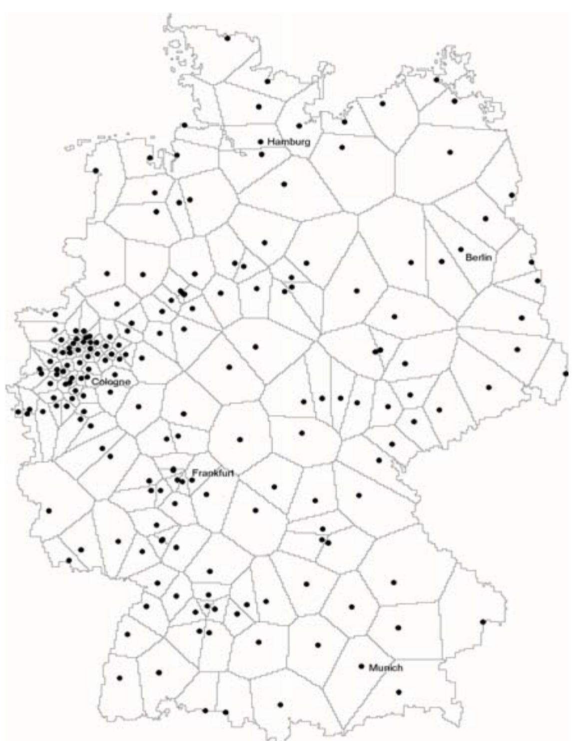

Figure 7.2. Catchment areas of cities over 50,000 population in Germany

Connectivity

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 are 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 on the territory.

There principally two ways to measure connectivity. One is to measure actual interactions, such as flows of goods or services, travel flows, 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. Another way is to simply measure proximity between centres, because if two centres are close to each other, the probability and feasibility that functional division of labour is implemented is higher than if the two centres are distant from each other.

Figure 7.3 is a very simple analysis of connectivity as proximity. The map shows the same cities in Poland with a population of more than 50,000 population used for Figure 7.1. Each city is represented by a circle the area of which is proportional to its population and connected by a line to the nearest city with larger population. Here airline distance was used. However, the analysis could also be repeated with travel time and/or travel cost via networks and so measure not only geographical proximity but also the quality of the infrastructure.

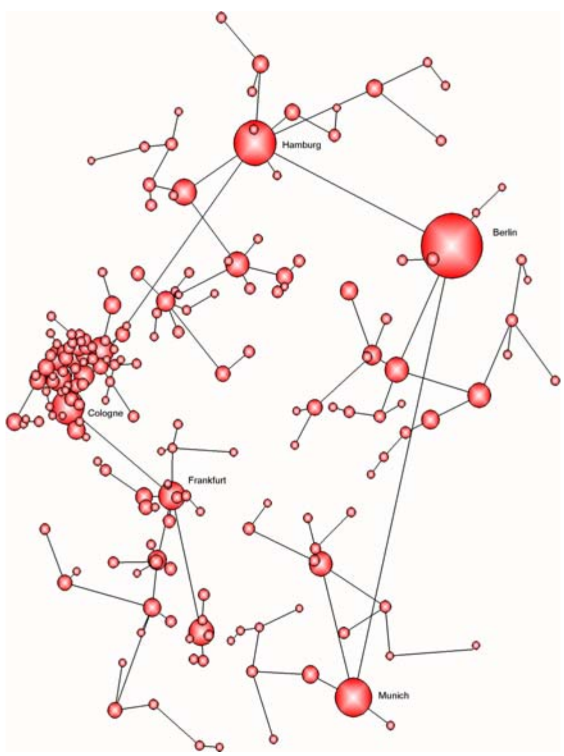

Figure 7.3. Cities in Germany connected to the nearest large city.

In a further step, the travel times and/ travel costs between cities could be used to calculate hypothetical interactions, such as commuter flows, business trips or tourist visits. If the same behavioural parameters are applied all over Europe, countries and regions could be compared with respect to the efficiency and ease of spatial interactions, for instance in terms of average speed.

What could be an appropriate indicator of connectivity derived from these results? Simply to give a premium to high speeds and large volumes of traffic between cities would be misleading as it would ignore equity and sustainability objectives. It will be necessary to develop a connectivity indicator which recognises the need for a balance between efficiency, equity and sustainability.

7.1.3 Policy Applications

With these three partial indicators of polycentricity, size, location and connectivity, a comprehensive indicator of polycentricity can be constructed. The indicator will classify each country on a continuous scale of polycentricity and at the same time assign each city a place and level in the national and European urban hierarchy.

In the context of ESPON 2.1.1, the method will be used to quantify the impacts of EU transport and telecommunications policy on the polycentric urban system in Europe. For this purpose the scenario results of the forecasting models applied in ESPON 2.1.1, such as regional population and economic activity, will be analysed with respect to whether they decrease or increase the level of polycentricity in particular countries or groups of countries or Europe as a whole relative to a scenario in which these policies are not implemented. From a methodology point of view, the analysis will be constrained by the fact that the models used in ESPON 2.1.1 deal with NUTS-3 regions and not cities. However, it is likely that the method to measure polycentricity will be sufficiently sensitive to the regional changes predicted by the models to make reasonable and policy-relevant forecasts.

It is particularly here where co-operation with ESPON 1.1.1 will be important for ESPON 2.1.1. ESPON 1.1.1 will provide the database for analysing cities, functional urban areas and polycentric urban regions in the enlarged European Union under different assumptions about further integration of the world economy and intensification of the competition between regions and cities and the development of energy cost, transport technology and the further diffusion of telecommunications. It will be important to harmonise these assumptions in order to arrive at a consistent set of scenarios.

7.2 Model Refinements

The four forecasting models applied in ESPON 2.1.1 will be refined and extended and more thoroughly tested in Year Two of ESPON. In this section the intended model refinements are summarised.

7.2.1 SASI

Because of the limited time available not all planned model extensions could be implemented until the Third Interim Report. In Year Two of ESPON, the SASI model will be updated and extended in several dimensions:

- *Regional production function*. The efforts to include suitable variables representing the size and diversity of regional labour markets will be continued. Because regional labour markets extend beyond NUTS-3 regions, a meso-scale accessibility to labour force linked to the commuter model in SASI was introduced. The specification of this accessibility indicator will be reviewed and the model will be re-calibrated to incorporate this variable.

- *Productivity*. Regional sectoral labour productivity will be forecast endogenously as a function of accessibility and other variables instead of using exogenous productivity forecasts.

- *Migration*. 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.

- *Unemployment.* The present forecasts of regional unemployment suffer from inconsistencies in the population and labour force data. These inconsistencies will be removed, and the interaction between the population, migration, labour force and unemployment submodels will be reviewed and re-calibrated.

- *Accessibility*. The accessibility submodel will be extended to incorporate short-sea shipping and inland waterway and will be fully integrated into the SASI model (it is presently run offline).

It is expected that these changes will improve the reliability, stability and usability of the SASI model.

7.2.2 Model Integration

Efforts will be made to integrate the four forecasting models used in ESPON 2.1.1 with respect to their database and comparability of their results:

- *Regional data*. The regional data bases used in the SASI and CGEurope models will be compared and made compatible as far as possible.

- *Network data*. The already full integrated network database of the SASI and CGEurope models will be extended by data on short-sea shipping lines and ports.

- *Causality analysis*. The SASI model will be validated by using the econometric results from the Causality Analysis between regional production and accessibility .

- *SASI-STIMA*. It will be explored whether the regional production functions of the SASI model can incorporate variables from the production functions of the STIMA model and vice versa. It will be examined whether in a further step the two models can be merged.

- *Crossvalidation*. The results of the SASI and CGEurope models will be systematically compared using sensitivity analysis in order to learn from differences and similarities between the model results.

The long-range goal of these efforts will be the establishment of a common data base and modelling toolbox for forecasting long-term effects of European transport and telecommunications policies.

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B 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 B.1 - 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

C Impacts by Types of Regions

Table C.1: CGEurope Typology Evaluation

TYPOLOGY	CLASSES	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1
total		0.03	0.25	0.29	0.12	0.17	0.28	0.04	-0.27	-0.34	-0.05
objective 1		0.04	0.36	0.41	0.20	0.27	0.45	0.06	-0.34	-0.43	0.04
non objective 1		0.03	0.23	0.27	0.10	0.15	0.25	0.04	-0.27	-0.33	-0.07
no data		0.03	0.19	0.22	0.07	0.22	0.28	0.05	-0.12	-0.20	0.08
objective 2		0.03	0.25	0.29	0.11	0.17	0.27	0.04	-0.28	-0.34	-0.06
non objective 2		0.04	0.25	0.30	0.13	0.17	0.29	0.05	-0.28	-0.36	-0.06
no data		0.03	0.19	0.22	0.07	0.22	0.28	0.05	-0.12	-0.20	0.08
relative rurality	high	0.03	0.29	0.34	0.14	0.22	0.34	0.05	-0.31	-0.38	-0.03
	medium	0.02	0.29	0.32	0.11	0.25	0.35	0.05	-0.29	-0.36	0.00
	low	0.03	0.23	0.27	0.11	0.15	0.25	0.04	-0.25	-0.31	-0.06
	no data	0.02	0.16	0.18	0.13	0.07	0.19	0.07	-0.35	-0.46	-0.27
pentagon	inside	0.03	0.18	0.21	0.08	0.14	0.22	0.04	-0.26	-0.31	-0.08
	outside	0.03	0.31	0.35	0.15	0.20	0.33	0.05	-0.29	-0.37	-0.03
settlement structure	agglomerated	0.03	0.18	0.22	0.12	0.11	0.23	0.04	-0.25	-0.31	-0.07
	urbanised	0.03	0.27	0.32	0.09	0.21	0.29	0.04	-0.28	-0.34	-0.04
	rural	0.03	0.39	0.43	0.15	0.27	0.40	0.06	-0.32	-0.41	0.00
coastal		0.04	0.28	0.33	0.16	0.17	0.32	0.06	-0.29	-0.39	-0.06
non coastal		0.03	0.23	0.26	0.09	0.17	0.26	0.04	-0.26	-0.31	-0.05
border		0.03	0.29	0.34	0.11	0.25	0.35	0.04	-0.29	-0.35	0.01
non border		0.03	0.24	0.28	0.12	0.16	0.26	0.04	-0.27	-0.34	-0.06
lagging		0.05	0.37	0.43	0.22	0.27	0.48	0.06	-0.35	-0.45	0.06
potentially lagging		0.03	0.36	0.41	0.14	0.21	0.33	0.04	-0.32	-0.38	-0.04
non lagging		0.03	0.20	0.24	0.10	0.15	0.23	0.04	-0.25	-0.31	-0.07
unemployment	high	0.05	0.34	0.41	0.18	0.21	0.37	0.06	-0.33	-0.41	-0.02
	medium	0.03	0.26	0.30	0.10	0.18	0.26	0.04	-0.28	-0.34	-0.06
	low	0.03	0.19	0.22	0.10	0.15	0.24	0.04	-0.24	-0.31	-0.05
time to market (GDP, micro)	most central	0.03	0.16	0.20	0.10	0.10	0.20	0.04	-0.23	-0.29	-0.08
	central	0.03	0.18	0.23	0.11	0.14	0.24	0.04	-0.25	-0.31	-0.06
	medium	0.03	0.33	0.38	0.13	0.20	0.32	0.05	-0.30	-0.37	-0.04
	peripheral	0.03	0.33	0.37	0.12	0.25	0.35	0.04	-0.33	-0.39	-0.02
	most peripheral	0.03	0.36	0.41	0.16	0.28	0.42	0.06	-0.32	-0.42	0.00
time to market (GDP, macro)	most central	0.03	0.22	0.27	0.08	0.18	0.25	0.03	-0.27	-0.32	-0.05
	central	0.02	0.19	0.23	0.08	0.15	0.23	0.03	-0.24	-0.29	-0.05
	medium	0.03	0.28	0.33	0.09	0.22	0.30	0.04	-0.27	-0.33	-0.02
	peripheral	0.03	0.20	0.23	0.14	0.14	0.26	0.05	-0.30	-0.36	-0.09
	most peripheral	0.04	0.37	0.43	0.23	0.18	0.38	0.07	-0.30	-0.44	-0.04
time to market (GDP, micro vs. macro)	central	0.03	0.17	0.21	0.07	0.13	0.19	0.03	-0.24	-0.28	-0.08
	medium	0.03	0.26	0.30	0.12	0.18	0.29	0.04	-0.28	-0.34	-0.04
	peripheral	0.03	0.37	0.42	0.20	0.24	0.41	0.08	-0.32	-0.45	-0.03
	contrary	0.03	0.24	0.27	0.13	0.15	0.27	0.04	-0.27	-0.34	-0.06
multimodal accessibility potential	very central	0.03	0.14	0.17	0.08	0.07	0.15	0.03	-0.21	-0.26	-0.10
	central	0.03	0.19	0.24	0.10	0.15	0.24	0.04	-0.25	-0.31	-0.05
	intermediate	0.03	0.28	0.32	0.12	0.18	0.29	0.05	-0.28	-0.35	-0.05
	peripheral	0.03	0.35	0.40	0.17	0.28	0.42	0.06	-0.34	-0.44	0.00
	very peripheral	0.03	0.40	0.45	0.20	0.22	0.40	0.05	-0.35	-0.45	-0.05

Table C.2: SASI Typology Evaluation

TYPOLOGY	CLASSES	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
total		-0.02	0.04	0.03	-0.01	0.05	0.03	0.00	-0.08	-0.10	-0.07
objective 1		-0.01	0.06	0.08	0.52	0.18	0.61	-0.04	-0.08	-0.28	0.36
non objective 1		0.00	0.01	0.01	-0.09	-0.03	-0.11	0.01	-0.02	0.01	-0.11
no data		-0.41	0.38	0.36	-0.37	0.85	0.46	-0.02	-1.07	-1.33	-0.86
objective 2		-0.03	0.02	0.01	0.05	0.01	0.04	0.01	-0.04	-0.04	0.00
non objective 2		0.04	0.02	0.03	-0.04	0.00	-0.03	-0.01	-0.02	-0.05	-0.08
no data		-0.41	0.38	0.36	-0.37	0.85	0.46	-0.02	-1.07	-1.33	-0.86
relative rurality	high	-0.08	0.07	0.06	0.04	0.14	0.16	0.00	-0.14	-0.20	-0.04
	medium	-0.14	0.08	0.08	0.07	0.39	0.33	0.03	-0.20	-0.22	0.11
	low	0.02	0.02	0.03	0.00	-0.01	0.00	0.00	-0.05	-0.03	-0.03
	no data	-0.04	-0.02	-0.26	-1.08	-0.69	-1.48	-0.12	0.08	-0.48	-1.99
pentagon	inside	0.05	-0.03	0.00	-0.29	-0.03	-0.27	0.02	-0.01	0.18	-0.12
	outside	-0.08	0.09	0.06	0.21	0.10	0.28	-0.02	-0.14	-0.34	-0.04
settlement structure	agglomerated	0.03	-0.02	-0.02	-0.03	-0.15	-0.12	-0.01	-0.02	-0.05	-0.17
	urbanised	-0.03	0.06	0.08	-0.12	0.21	0.05	0.02	-0.09	0.03	0.05
	rural	-0.14	0.14	0.11	0.21	0.29	0.41	-0.02	-0.22	-0.47	-0.03
coastal		0.02	-0.01	-0.02	0.13	-0.15	0.02	0.01	-0.03	-0.39	-0.33
non coastal		-0.05	0.06	0.06	-0.09	0.16	0.04	0.00	-0.11	0.06	0.08
border		-0.11	0.14	0.15	0.03	0.39	0.33	0.00	-0.25	-0.16	0.15
non border		0.00	0.01	0.01	-0.02	-0.03	-0.03	0.00	-0.05	-0.09	-0.12
lagging		-0.02	0.08	0.14	0.71	0.23	0.86	-0.04	-0.18	-0.31	0.57
potentially lagging		-0.07	0.08	0.07	0.33	0.02	0.33	-0.02	-0.09	-0.14	0.21
non lagging		-0.01	0.02	0.01	-0.21	0.02	-0.17	0.01	-0.06	-0.06	-0.25
unemployment	high	0.03	0.03	0.06	0.49	-0.03	0.45	-0.01	-0.05	-0.18	0.30
	medium	-0.06	0.02	0.00	-0.12	0.02	-0.09	0.01	-0.07	-0.03	-0.13
	low	-0.01	0.06	0.05	-0.18	0.11	-0.08	0.00	-0.11	-0.13	-0.22
time to market (GDP, micro)	most central	0.05	-0.05	-0.05	-0.14	-0.23	-0.27	0.00	0.02	-0.03	-0.29
	central	0.03	0.02	0.03	-0.15	-0.02	-0.15	0.01	-0.07	-0.04	-0.20
	medium	-0.04	0.07	0.08	0.12	0.11	0.20	0.00	-0.09	-0.05	0.15
	peripheral	-0.14	0.13	0.10	0.07	0.36	0.33	-0.02	-0.19	-0.09	0.23
	most peripheral	-0.13	0.09	0.09	0.30	0.35	0.52	0.00	-0.20	-0.54	0.01
time to market (GDP, macro)	most central	0.03	0.05	0.08	-0.28	0.26	-0.06	0.00	-0.06	0.24	0.14
	central	-0.05	0.05	0.06	-0.10	0.14	0.01	0.01	-0.13	0.10	0.08
	medium	-0.04	0.04	0.09	0.14	0.22	0.28	0.06	-0.13	-0.09	0.17
	peripheral	-0.02	-0.02	-0.07	0.12	-0.25	-0.05	0.01	-0.06	-0.25	-0.29
	most peripheral	-0.04	0.05	-0.04	0.25	-0.30	0.02	-0.08	-0.02	-0.78	-0.66
time to market (GDP, micro vs macro)	central	0.07	-0.02	0.02	-0.34	0.01	-0.29	0.02	-0.03	0.19	-0.14
	medium	-0.04	0.05	0.05	0.06	0.10	0.14	0.01	-0.11	-0.08	0.05
	peripheral	-0.06	0.01	-0.02	0.41	0.00	0.35	-0.01	-0.12	-0.81	-0.38
	contrary	-0.06	0.08	-0.01	-0.17	-0.17	-0.26	-0.07	-0.02	-0.20	-0.44
multimodal accessibility potential	very central	0.09	-0.08	-0.04	-0.32	-0.24	-0.45	0.02	0.00	0.09	-0.38
	central	0.04	-0.01	0.01	-0.06	0.03	-0.03	0.01	-0.03	0.08	0.03
	intermediate	-0.07	0.08	0.05	-0.03	0.07	0.02	0.00	-0.09	-0.15	-0.13
	peripheral	-0.11	0.09	0.07	0.31	0.23	0.47	-0.03	-0.20	-0.43	0.06
	very peripheral	-0.19	0.21	0.25	1.02	0.31	1.23	-0.05	-0.50	-0.76	0.49

Table C.3: STIMA Typology Evaluation

typology	case	A_MED[46]	B_MED[47]	C_MED[48]	A_ACC[49]	A_INT ASS[50]	B_ACC ASS[51]	B_INT ASS[52]	C_ACC ASS[53]	C_INT ASS[54]
total		1.06	1.18	0.19	144.9	4225.1	151.4	8414.5	80.9	2358.3
objective 1		1.18	1.15	1.46	131.6	3835.7	249.6	3118.4	594.2	17324.2
non objective 1		1.04	1.18	0.00	147.0	4284.8	136.4	9226.9	2.1	62.6
objective 2		1.05	1.19	0.01	150.7	4395.0	140.1	9453.3	3.5	100.7
non objective 2		1.11	1.15	0.80	125.1	3648.6	189.7	4890.0	343.6	10017.6
pentagon	inside	1.05	1.19	0.03	162.6	4740.2	151.7	10173.4	6.3	183.6
	outside	1.07	1.17	0.35	127.9	3728.8	151.1	6719.7	152.7	4453.7
settlement structure	agglomerated	1.10	1.23	0.15	189.5	5525.8	193.8	11177.2	85.9	2505.7
	urbanised	1.01	1.13	0.10	107.1	3122.1	105.3	6483.3	29.2	850.8
	rural	1.04	1.13	0.45	82.9	2416.7	110.2	3859.8	156.1	4550.4
coastal		1.06	1.16	0.31	126.2	3679.2	144.3	6826.4	128.1	3735.9
non coastal		1.06	1.20	0.07	163.3	4761.6	158.4	9975.3	34.4	1004.4
border		1.09	1.21	0.16	150.3	4383.6	155.3	8802.0	75.6	2205.1
non border		1.04	1.16	0.21	140.7	4101.2	148.4	8111.4	85.0	2478.1
lagging		1.28	1.25	1.45	155.8	4542.2	289.6	3932.3	676.0	19710.6
potentially lagging		1.13	1.23	0.34	133.1	3879.6	147.8	7374.6	114.8	3347.4
non lagging		1.02	1.16	0.02	146.6	4274.9	136.5	9188.7	4.1	119.3
unemployment	high	1.21	1.25	0.82	151.8	4426.1	220.0	6337.6	370.1	10790.2
	low	0.97	1.11	0.04	125.4	3657.6	119.1	7769.2	14.2	413.1
	medium	1.09	1.22	0.06	162.2	4728.5	152.9	10084.0	13.7	399.4
time to market (GDP, micro)	most central	1.07	1.20	0.11	212.7	6201.5	208.1	12918.9	53.2	1552.4
	central	1.04	1.18	0.02	136.6	3982.2	128.6	8498.4	10.8	316.3
	medium	1.10	1.21	0.27	122.1	3559.7	146.4	6330.7	155.5	4535.0
	peripheral	1.09	1.18	0.37	114.7	3343.8	136.9	5971.8	143.2	4175.3
	most peripheral	0.93	1.00	0.49	50.9	1484.8	66.0	2442.2	87.7	2557.8
time to market (GDP, macro)	most central	1.03	1.17	0.08	116.1	3385.9	118.1	6872.2	50.0	1456.8
	central	1.11	1.24	0.03	226.2	6596.1	210.4	14184.6	5.5	161.6
	medium	1.06	1.21	0.00	138.8	4047.4	128.4	8733.2	0.0	0.0
	peripheral	1.03	1.14	0.24	121.2	3533.1	137.8	6585.3	119.6	3486.5
	most peripheral	1.08	1.13	0.70	113.9	3319.9	165.0	4756.4	277.3	8084.5
time to market (GDP, micro vs. macro)	central	1.09	1.23	0.00	212.7	6202.9	196.7	13384.3	0.0	0.0
	medium	1.06	1.19	0.14	131.8	3843.2	136.0	7723.8	65.5	1910.2
	peripheral	0.96	0.99	0.85	86.5	2522.7	145.6	2797.5	304.8	8886.3
	contrary	1.09	1.19	0.33	131.6	3838.1	156.2	6889.2	160.4	4676.4
multimodal accessibility potential	very central	1.11	1.25	0.00	295.8	8624.0	273.5	18608.3	0.0	0.0
	central	1.06	1.19	0.05	154.2	4496.8	150.4	9389.5	36.1	1052.5
	intermediate	1.04	1.17	0.14	115.3	3361.4	119.7	6726.3	60.7	1769.5
	peripheral	1.10	1.15	0.74	98.6	2875.0	153.6	3687.2	289.9	8451.6
	very peripheral	0.73	0.70	1.01	27.2	793.5	51.6	645.1	122.9	3583.9

[46] Average annual growth rate of per capita GDP in scenario A, at 2020
[47] Average annual growth rate of per capita GDP in scenario B, at 2020
[48] Average annual growth rate of per capita GDP in scenario C, at 2020
[49] Accessibility absolute growth in scenario A
[50] Internet absolute growth in scenario A
[51] Accessibility absolute growth in scenario B
[52] Internet absolute growth in scenario B
[53] Accessibility absolute growth in scenario C
[54] Internet absolute growth in scenario C

Table C.4: CGEurope National Evaluation

Case	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
Total	0.03	0.25	0.29	0.12	0.17	0.28	0.04	-0.27	-0.34	-0.05
AT	0.02	0.17	0.20	0.07	0.18	0.25	0.03	-0.24	-0.28	-0.01
BE	0.02	0.15	0.18	0.08	0.17	0.25	0.04	-0.23	-0.28	-0.03
BG	0.02	0.58	0.62	-0.04	0.51	0.58	0.02	-0.33	-0.38	0.19
CH	0.02	0.11	0.14	0.03	0.13	0.16	0.02	-0.08	-0.12	0.05
CY	0.09	-0.03	0.05	0.40	-0.02	0.38	0.16	0.02	-0.21	0.15
CZ	0.02	0.28	0.32	0.05	0.52	0.62	0.03	-0.28	-0.33	0.31
DE	0.04	0.23	0.28	0.08	0.19	0.26	0.04	-0.28	-0.33	-0.06
DK	0.03	0.54	0.59	0.10	0.22	0.29	0.04	-0.23	-0.29	0.01
EE	0.02	0.02	0.03	-0.01	0.10	0.17	0.02	-0.20	-0.23	-0.06
ES	0.03	0.55	0.60	0.28	0.17	0.42	0.04	-0.36	-0.43	0.01
FI	0.04	0.19	0.25	0.25	0.11	0.35	0.10	-0.27	-0.45	-0.09
FR	0.03	0.39	0.43	0.07	0.21	0.27	0.03	-0.32	-0.36	-0.08
GR	0.01	0.31	0.33	0.08	0.27	0.36	0.02	-0.26	-0.33	0.05
HU	0.03	0.28	0.32	0.10	0.50	0.59	0.05	-0.28	-0.36	0.25
IE	0.07	0.15	0.24	0.30	0.07	0.34	0.16	-0.18	-0.44	-0.09
IT	0.05	0.12	0.18	0.20	0.10	0.29	0.06	-0.30	-0.38	-0.07
LT	0.02	0.12	0.15	0.01	0.10	0.15	0.02	-0.19	-0.22	-0.08
LU	0.01	0.30	0.32	0.08	0.25	0.33	0.04	-0.27	-0.32	0.01
LV	0.02	0.09	0.11	0.01	0.18	0.23	0.02	-0.18	-0.20	0.03
MT	0.04	0.00	0.04	0.14	0.00	0.14	0.05	-0.05	-0.12	0.02
NL	0.02	0.15	0.19	0.09	0.16	0.24	0.04	-0.24	-0.29	-0.04
NO	0.03	0.28	0.34	0.15	0.26	0.35	0.09	-0.13	-0.28	0.06
PL	0.03	0.20	0.24	0.06	0.59	0.66	0.04	-0.28	-0.34	0.34
PT	0.00	0.46	0.47	0.13	0.21	0.30	0.01	-0.34	-0.41	-0.10
RO	0.03	0.19	0.23	0.06	0.61	0.67	0.04	-0.32	-0.38	0.29
SE	0.03	0.40	0.46	0.18	0.40	0.51	0.07	-0.31	-0.43	0.10
SI	0.03	0.75	0.83	0.11	0.46	0.57	0.04	-0.27	-0.33	0.27
SK	0.02	0.17	0.19	0.05	0.47	0.53	0.03	-0.26	-0.30	0.25
UK	0.02	0.13	0.16	0.10	0.05	0.14	0.05	-0.24	-0.31	-0.17

Table C.5: SASI National Evaluation

case	A1	A2	A3	B1	B2	B3	C1	C2	C3	D
total	-0.02	0.04	0.03	-0.01	0.05	0.03	0.00	-0.08	-0.10	-0.07
AT	-0.04	0.19	0.22	0.26	0.58	0.64	-0.01	-0.07	0.23	0.85
BE	0.18	-0.07	0.01	-0.35	-0.04	-0.33	0.07	0.03	0.28	-0.09
BG	-1.13	1.34	1.29	-0.09	2.33	2.02	-0.17	-2.75	-2.54	-0.59
CH	-0.36	0.36	0.29	-0.65	0.65	0.06	-0.06	-0.84	-0.64	-0.61
CY	-0.13	0.03	-0.30	-1.50	-0.59	-1.77	-0.31	-0.34	-2.14	-3.86
CZ	-0.20	0.22	0.28	0.49	1.67	1.64	-0.05	-0.40	0.02	1.60
DE	0.06	0.03	0.07	-0.28	0.26	-0.07	0.00	-0.01	0.29	0.17
DK	-0.13	0.10	0.18	0.50	1.39	1.24	0.14	0.04	-0.33	1.00
EE	0.00	-0.09	-0.04	0.35	0.00	0.35	-0.12	-0.19	-0.06	0.29
ES	-0.10	0.11	0.06	1.38	-0.34	1.07	-0.07	0.02	-0.40	0.77
FI	0.13	-0.25	-0.17	0.90	-0.63	0.47	0.01	0.23	-0.49	0.16
FR	-0.21	0.10	0.06	-0.19	0.03	-0.12	0.01	-0.17	0.01	-0.14
GR	-0.11	-0.31	-0.46	-0.39	-0.12	-0.54	-0.24	0.09	-0.62	-0.94
HU	-0.21	0.28	0.34	0.47	1.78	1.69	-0.03	-0.51	-0.17	1.49
IE	-0.05	0.22	-0.04	-1.13	-0.68	-1.52	-0.13	0.04	-1.01	-2.53
IT	0.08	-0.03	0.01	0.80	-0.10	0.63	-0.02	-0.04	0.00	0.65
LT	-0.22	0.27	0.59	0.78	0.77	1.35	-0.02	-1.07	-0.67	0.54
LU	-0.26	0.06	-0.06	-0.65	0.11	-0.45	-0.02	-0.07	0.36	-0.17
LV	0.03	-0.06	0.20	0.76	0.31	0.93	-0.06	-0.32	0.00	0.88
MT	-0.01	-0.06	-0.27	-0.39	-0.67	-0.75	-0.21	-0.17	-1.43	-2.08
NL	0.13	-0.01	0.07	-0.32	-0.06	-0.31	0.06	-0.01	0.20	-0.14
NO	-0.37	0.26	0.28	-0.03	0.65	0.57	0.09	-1.11	-2.43	-1.74
PL	-0.09	0.10	0.27	0.35	1.55	1.46	0.02	-0.43	0.00	1.35
PT	-0.17	0.86	0.62	0.16	-0.21	-0.04	-0.27	-0.05	-0.64	-0.53
RO	-0.59	0.69	0.75	0.18	2.38	2.08	-0.11	-1.86	-1.59	0.44
SE	0.20	-0.20	-0.10	0.46	0.75	0.69	0.18	0.16	-0.93	-0.05
SI	-0.57	0.97	1.11	0.82	1.76	2.13	0.02	-1.37	-1.09	0.97
SK	-0.17	0.27	0.29	0.39	1.49	1.49	-0.07	-0.46	-0.04	1.40
UK	0.05	-0.12	-0.19	-0.63	-0.68	-1.03	0.02	0.07	-0.17	-1.23

Table C.6: STIMA National Evaluation

case	A_MED[55]	B_MED[56]	C_MED[57]	A_ACC[58]	A_INT ASS[59]	B_ACC ASS[60]	B_INT ASS[61]	C_ACC ASS[62]	C_INT ASS[63]
total	1.06	1.18	0.19	144.9	4225.1	151.4	8414.5	80.9	2358.3
AT	0.92	1.06	0.02	52.2	1523.1	48.6	3276.0	1.2	34.8
BE	0.90	1.04	0.00	49.1	1430.4	45.4	3086.4	0.0	0.0
BG									
CH									
CY									
CZ									
DE	1.06	1.18	0.11	125.4	3657.6	129.0	7367.3	60.5	1763.1
DK				231.7	6754.3	214.2	14574.0	0.0	0.0
EE									
ES	1.20	1.26	0.72	181.0	5277.1	245.0	8256.6	360.5	10512.5
FI	0.78	0.87	0.31	56.1	1636.7	60.2	3196.8	38.6	1124.4
FR	1.20	1.34	0.00	230.9	6733.8	213.6	14529.7	0.0	0.0
GR	1.25	1.21	1.53	80.2	2339.8	152.2	1902.2	362.5	10568.0
HU									
IE	1.15	1.25	0.24	105.3	3069.8	105.4	6300.4	37.3	1086.6
IT	1.23	1.34	0.36	212.6	6198.7	236.2	11778.7	183.9	5362.0
LT									
LU	0.65	0.79	0.00	18.7	545.0	17.3	1175.9	0.0	0.0
LV									
MT									
NL	0.85	0.99	0.00	89.6	2612.3	82.9	5636.6	0.0	0.0
NO									
PL									
PT	1.24	1.30	0.76	131.5	3834.8	180.6	5897.7	273.8	7982.6
RO									
SE	0.67	0.78	0.14	60.3	1757.5	60.6	3598.0	22.4	652.5
SI									
SK									
UK	0.92	1.05	0.09	92.5	2695.6	92.4	5536.7	32.2	939.8

[55] Average annual growth rate of per capita GDP in scenario A, at 2020
[56] Average annual growth rate of per capita GDP in scenario B, at 2020
[57] Average annual growth rate of per capita GDP in scenario C, at 2020
[58] Accessibility absolute growth in scenario A
[59] Internet absolute growth in scenario A
[60] Accessibility absolute growth in scenario B
[61] Internet absolute growth in scenario B
[62] Accessibility absolute growth in scenario C
[63] Internet absolute growth in scenario C

D Effects of Transport Scenarios on Inequality Measure

Table E.1 Effects of transport policy scenarios on Atkinson's equality measure

		SASI			CGEurope		
		A1	A2	A3	A1	A2	A3
EU15	Ineq. Within	0.119	-0.145	0.005	-0.008	-0.198	-0.210
	Ineq. Between	0.079	-0.165	-0.015	-0.029	-0.219	-0.254
CC12	Ineq. Within	0.287	-0.404	-0.504	-0.014	-0.072	-0.095
	Ineq. Between	-0.438	0.583	0.425	0.001	0.408	0.416

		SASI			CGEurope		
		B1	B2	B3	B1	B2	B3
EU15	Ineq. Within	-0.736	0.723	-0.230	-0.198	-0.055	-0.227
	Ineq. Between	-0.339	-0.279	-0.561	-0.136	-0.213	-0.330
CC12	Ineq. Within	0.190	-0.187	-0.164	0.013	-0.066	-0.083
	Ineq. Between	-0.300	-0.031	-0.159	-0.020	-0.047	0.012

		SASI			CGEurope		
		C1	C2	C3	C1	C2	C3
EU15	Ineq. Within	0.149	-0.028	0.705	-0.031	0.137	0.202
	Ineq. Between	0.038	0.082	0.152	-0.041	0.188	0.246
CC12	Ineq. Within	0.030	1.069	0.825	-0.005	0.178	0.173
	Ineq. Between	-0.050	-0.494	-0.722	0.002	0.007	-0.005

		SASI	CGEurope
		D1	D1
EU15	Ineq. Within	0.388	-0.035
	Ineq. Between	-0.374	-0.101
CC12	Ineq. Within	0.784	0.086
	Ineq. Between	-0.0885	0.007